Social Dimensions of Public Large-Scale Wi-Fi Networks: The Cases of a Municipal and a Community Wireless Network

A dissertation presented by

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Submitted to the

Faculty of Communication Sciences

Università della Svizzera italiana

for the degree of

Ph.D. in Communication Sciences

May, 2018

Executive Summary

Wireless networks play an increasingly important role in today's mobile and interconnected society. People use mobile devices such as smartphones, tablets or portable game consoles on a regular basis to interact, retrieve and share information, and to orient and entertain themselves. However, in order to be fully performant these devices need to be connected to the Internet. Thanks to very good broadband penetration in Switzerland, this is not so much an issue in private homes and offices where local Wi-Fi networks allow mobile devices to connect to the Internet. Nonetheless, in public spaces, good working wireless networks, even though increasing, are still not very frequent and generally cover only limited areas. Alternative, provider-centered mobile data (3G/4G/LTE) is still expensive especially for visitors because of high roaming rates but also for Swiss people, whose majority still did not have unlimited data contracts in 2016.

Public large-scale wireless networks can thus play an important role in providing Internet connectivity to people on the go. This dissertation studies two different approaches to the provision of Wi-Fi broadband connectivity in public spaces: on the one hand, municipalities providing Wi-Fi access in some areas of the city through so-called ***Municipal Wireless Networks (MWN),*** and on the other hand, communities with members sharing part of their home broadband connection with other community members, building so-called ***Community Wireless Networks (CWN)***. Wireless communities can either be purely self-organized (pure wireless communities) or have a for-profit company managing the community (hybrid communities).

While existing studies have analyzed business and ownership models, technical solutions and policy implications of public wireless networks, this research is interested in their social dimensions, focusing on the role of individuals using and contributing to these networks. To do so, two main research goals are addressed: 1) understanding what motivates people to join and actively participate in a hybrid CWN and what hinders them from doing so, and 2) understanding who the users of a MWN are and how they use the network in order to identify various user types and usage practices, which will in turn help municipalities design networks that address the needs of various users.

In order to study users' motivations and concerns for joining and actively participating in a hybrid wireless community, the ***Fon community*** (Fon, 2018b) has been analyzed, which at the time of this study was the largest worldwide hybrid CWN. A mixed research approach has been applied. First, an existing model on motivations in pure communities (Bina & Giaglis, 2006a) has been adapted with the help of semi-structured exploratory interviews of 40 Swiss Fon members and then refined through a quantitative online survey addressed to Swiss and foreign Fon members. The resulting model shows which motivations attract members to the community, and which concerns have a dissuasive

function. In a second step, 268 valid survey answers have been used for structural equation modeling (SEM) in order to assess which motivations actually result in a higher level of active participation.

In order to analyze usage and users of a MWN, the ***"WiFi Lugano" MWN*** of the city of Lugano has been chosen. Lugano is located in the Italian-speaking southern part of Switzerland, is a popular tourist destination and the region's economic capital. In collaboration with the electricity company in charge of implementing the Wi-Fi network (Aziende Industriali Luganesi – AIL), technical network data (log-data) and user-provided information – users were asked to fill-in a short survey after they logged-in to the network – have been collected and analyzed in combination (the two data sets have been merged). In a first step, usage profiles of leisure tourists, business travelers and residents have been created and described applying descriptive statistics to data of three summer months (June – August 2013). In a second step, cluster analysis has been applied to one-year data (June 2013 – May 2014), in order to identify relevant groups of users.

Outcomes suggest that in a hybrid CWN, members are ***motivated to join*** the community mainly by a mix of utilitarian (e.g. getting free Internet access) and idealistic motivations (reciprocity and altruism), while intrinsic and social motivations are less important. This confirms that motivations are similar to those in pure CWNs but have different weights. In fact, in pure CWNs, intrinsic and social motivations seem to be stronger while in hybrid CWNs, utilitarian motivations prevail.

Two types of active participation have been identified in the Fon community, each one driven by a different mix of motivations: "***participation by sharing***" – putting effort into actively sharing one's own Internet connectivity – is mainly driven by idealistic motivations related to community values and reciprocity, while "***social participation***" – being socially involved in the community by interacting with and helping other community members – is driven by social (communicating, learning from each other) and technical reasons (experimenting with technologies). Surprisingly, utilitarian motivations do not have a significant effect on either of the two participation types, even though they are the most relevant ones in attracting new members.

With regard to the MWN "WiFi Lugano", five different usage practices have been identified: two business-oriented ones ("E-mailer" and "Mobile-worker"), two tourism-oriented ones ("Tourism information seeker" and "Always-on traveler"), and one corresponding to the practices of locals ("Local social networker"), each one having different characteristics. The "WiFi Lugano" network thus acts as a business, tourism, and social inclusion enabler, actively favoring various eGovernment relationships: government to business (G2B), government to visitors (G2V), and government to citizens (G2C). Based on these outcomes it has been possible to define a series of suggestions to help cities take advantage of their MWNs and improving them accordingly. Cities could

for example provide different landing pages to different publics in order to promote the city in a targeted way, ensure a high quality service of their MWNs, use the Wi-Fi networks to promote tourist attractions and vice-versa (e.g. mark Wi-Fi areas on city maps, build Wi-Fi areas near to tourist attractions, and provide a description of the attraction on the Wi-Fi network's landing page), share the network with small businesses in the area and extend the reach of the network to relevant areas.

Acknowledgements

This PhD dissertation would have never been possible without the precious support of many people who are part of my life. Some professionally guided me through this journey, others enriched my thoughts and ideas through interesting and sometimes challenging discussions, some helped me out with my children, allowing me to dedicate time to my research and attend conferences, and others again regularly encouraged and spurred me to persevere in my research and finally bring this journey to an end. I am infinitely grateful to all these people who always believed in me.

First of all, I would like to express my sincere gratitude to professor ***Lorenzo Cantoni***. You were an excellent supervisor, teacher and motivator able to guide me through this long and, sometimes, tedious journey. You inspired my thoughts but always left room for my own ideas. You regularly proposed new challenges to me, which allowed advancing my research. I admire your knowledge, your curiosity, your passion for research and your modesty. In particular, I appreciate your attitude of always looking for how not only science but also society can benefit from the work we do and, thus, I enjoyed discussing research results and their practical applications in real life with you. Thank you for your patience, kindness and professionalism.

When I started my PhD, I had the pleasure of collaborating with ***Giovanni Camponovo***. He introduced me to research practices, taught me how to write scientific papers and allowed me to discover the pleasure and satisfaction of discussing ideas and results together in and attempt to identify the best suitable solutions. Thank you for your guidance, friendship and constructive inputs.

I want to extend my gratitude to ***Catherine Middleton*** who, in summer 2012, hosted me at the Ryerson University in Toronto. Thank you for sharing your experience on CWNs and MWNs with me, for organizing and attending together with me a meeting with Gabe Sawhney of Wireless Toronto and for hunting and measuring Wi-Fi signals in various bars and cafés in Toronto. It was fun and enriched my research experience. You profoundly inspired my work and taught me to believe in my ideas and methods.

Special thanks also go to ***Jost Reinhold*** who co-authored two of my recent publications. He shared his knowledge in statistics with me and together we involved in long reflections to find suitable statistical solutions for this research.

In this occasion, I also want to thank the ***Swiss National Science Foundation***, for financing my participation in the Wi-Com project (grant number 100014-127006), which laid the basis for this PhD dissertation. Furthermore I want to express my gratitude to ***Fon*** for promoting our survey to its members through a newsletter, their forum and twitter channel and the ***staff of AIL*** (especially CFO Lucas Bächtold, assistant manager Luca Bortone and his predecessor Igor Francetic) for its interest and

collaboration in studying usage of the “WiFi Lugano” network and in particular for sharing the network’s log-data with us and allowing us to place a survey on the landing page of “WiFi Lugano”.

Moreover, I would like to thank my research colleagues at the NewMinE lab and, in particular, my dear friend ***Sara*** who started her PhD journey together with me. In these years, you became more than a friend and I look back with gratitude at the many fun, exciting and enriching moments we spent together. Thank you, ***Marta***, for the many interesting discussions, for your friendship and especially for your precious encouragements. ***David***, you brought a touch of lightness to the NewMinE lab with your fun, open and smart spirit and taught us how, with a lot of passion and dedication, it is possible to improve people’s lives in your country, Mozambique. Dear ***Paolo***, I gratefully look back at our many conversations and friendship, you taught me smart and innovative ways of presenting my work and shared your views on the world with me. I admire the passion, engagement and commitment you put in all you did. I will always remember you! A big thank also to ***Ema, Luca, Isa, Amalia, Chrysa and Francesca***. It was a pleasure working with you at the NewMinE lab.

My gratitude also goes to my colleagues at webatelier.net and eLab, in particular to ***Stefano***, director of eLab, who left me space to develop and progress my research during my activities at the eLab and provided precious advice whenever needed. Thank you ***Silvia, Elena, Nadzeya, Jingjing, Emanuele, Hiroshi, Katharina and Puspita*** for listening to my research presentations and discussing them with me. Your constructive feedbacks and critical thoughts particularly stimulated and improved my research activities. A special thank you also to ***Rebecca***, who encouraged me during my last weeks of PhD and proved that sitting in the same office is a great opportunity to share professional and personal experiences. The same is true for my colleagues at the eLab, with whom I shared an office for several years. Thank you ***Christian, Goran, Riccardo, Mattia, Yann, Giorgia, Elisabetta and Shondel*** for your friendship, collaboration, informal chats and the many lunches we had together! I am proud to be part of this innovative group of people working to improve eLearning at our university. Particular thanks also to my CCdigitallaw colleagues: ***Laura***, who became a special friend and supported me in various difficult moments, ***Selene***, who helped me dealing with Refworks and ***Danielle***. Thanks also to ***Elide*** for the accurate proofreading of this dissertation.

I want to express my gratitude also to my friends and fellow mothers who regularly helped me out with my children giving me time to focus on my research and attend conferences abroad or who were simply there to listen to me. Thank you ***Perihan, Manuela, Zaklina, Héloïse, Rossella, Loredana, Valentina, Sabrina, Elena, Lena, Asyl, Sue and Bang Trinh*** for your friendship and most precious help.

But above all I want to thank my ***family***: my three children ***Aaron, Kian and Amélie*** who were very patient and never complained when I was dedicating time to my PhD studies instead of doing something with them and at the same time showed interest and curiosity in what I was doing. You are the best thing that ever happened to me! Many thanks also to my ***husband Leonardo*** and my ***parents-in-law,*** who with love took care of my kids when I was busy and to my ***sister Giuliana*** and ***brother Giancarlo*** who morally supported me during this journey.

Yet, more than anything else I want to thank ***my parents and my grandmother*** who always believed in me. You contributed to this dissertation with your unconditional love, interest, enormous support and regular encouragement. You guided me through my entire education, fostered my curiosity, patiently answered the many questions I had since I was a little kid and most importantly taught me the importance of always pursuing my dreams and goals. This work is dedicated to you! *Liebe Mamma, Papa und Nonna, diese Doktorarbeit ist euch gewidmet, für eure uneingeschränkte Liebe, und Unterstützung! Danke von ganzem Herzen.*

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Acronyms

AIL	Aziende Industriali Luganesi / Lugano Industrial Enterprises
ADSL	Asymmetic Digital Subscriber Line
AP	Access Point
AVG	Average
CH	Confederatio Helvetica
CHF	Swiss Francs
CWN	Community Wireless Network
DSL	Digital Subscriber Line
EU	European Union
G2G	Government to Government
G2V	Government to Visitor
G2B	Government to Business
G2NP	Government to Non-profit Organization
G2E	Government to Employee
ICT	Information and Communication Technology
IP	Internet Protocol
ISP	Internet Service Provider
MAC	Media Access Control
MIT	Massachusetts Institute of Technology
MWN	Municipal Wireless Network
NR	Number
OFCOM	(Swiss) Federal Office of Communication
P2P	Peer-to-Peer
SCT	Social Cognitive Theory
SEM	Structural Equation Modeling
SSID	Service Set Identifier (= primary name associated with a wireless local area network)

SNMP	Simple Network Management Protocol
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
U.S.	United States (of America)
UTAUT	Unified Theory of Acceptance
VFI	Volunteer Functions Inventory
VoIP	Voice over Internet Protocol (also Voice over IP or IP telephony)
WISP	Wireless Internet Service Provider
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WMN	Wireless Mesh Network
3G/4G	3rd/4th generation mobile technologies

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1 Introduction

"People lack many things: jobs, shelter, food, health care and drinkable water. Today, being cut off from basic telecommunications services is a hardship almost as acute as these other deprivations, and may indeed reduce the chances of finding remedies to them."

(UN Secretary General, Kofi Annan, 1999[1])

This dissertation studies two types of ***large-scale Wi-Fi networks available in public space:*** on the one hand, ***Community Wireless Networks (CWN)***, where people share part of their wired home Internet connection with other members of the community through Wi-Fi; on the other hand, ***Municipal Wireless Networks (MWN)***, where a municipality provides Wi-Fi connectivity in some areas of a city. While Wi-Fi networks are a multidisciplinary research topic and have been studied from many different points of view (e.g. technical solutions, business and ownership models, policy regulations), this dissertation focuses on their ***social dimensions*** and more precisely on the ***role of individuals*** using this technology. Even though the technical aspects of an innovation are intriguing and stimulating, also the most advanced technology is useless if it does not serve a specific function in society. Only if a technology is considered relevant and useful, people will actually adopt and use it. This is why it is so important to concentrate on how a new technology can address the real needs of people and, thus, become useful and usable. To do so, users and their ways of adopting and using a technology need to be studied. This is exactly what this dissertation wants to do with public Wi-Fi networks: it wants to understand ***motivations*** for joining and actively participating in CWNs and get a deeper understanding of ***users and usage practices*** of MWNs.

The following sections briefly illustrate why studying public wireless networks and their social dimensions is relevant from a personal, societal and scientific point of view.

1.1 Personal Study Motivation

Some years ago, I travelled with my family to Bologna to spend a weekend together with friends. We stayed in a very simple and essential hostel operated by a religious community, where no TV, radio or Wi-Fi were available. Once the kids were asleep, I decided to quickly turn on mobile data to read my favorite online newspaper. I was aware of the fact that using mobile data abroad is expensive, but I just wanted to download a few articles,

[1] In a keynote address to the International Telecommunication Union, Oct. 9, 1999 (Mandviwalla et al., 2008, p.72).

which I did not expect to generate a large amount of traffic. I thus turned on data roaming, downloaded three articles and after a few seconds turned roaming off again. You can image my surprise when I received the bill at the end of the month: 80 CHF for using mobile data abroad. Only then, I realized that, before turning on mobile roaming, I forgot to turn off all the automatic updates (e.g. e-mail) and thus downloaded a much larger amount of data than expected. My mistake, yes, but why in the era of Internet and mobile devices, is it still so difficult and complicated to access to the Internet without generating huge costs when out of home and office? This is just one example of the difficulty of connecting to the Internet when ***abroad*** and the risks that come with it. During my many trips abroad in recent years, mainly in urban areas, I regularly encountered problems in accessing the Internet. Maybe the airport had a Wi-Fi network, but you had to pay for it or it simply did not perform well enough to be usable. The same was true for hotel Wi-Fi: even though most hotels nowadays offer free Wi-Fi Internet, this does not mean that the available connectivity actually works well enough to do a Skype call with your family back home. Time and again I found myself looking for Wi-Fi networks that were easy to use and performed well enough to read news, check e-mails, consult a map, look up opening hours of e.g. shops, museums or restaurants, buy online tickets to tourist attractions or simply call my family back home over VoIP (Voice over Internet Protocol). And time and again I was disappointed. Most of the times when I really needed connectivity, there was no Wi-Fi network in reach, and when there was, it was either so complicated to connect to it or it performed so badly that it was not worth the effort. This might be changing in the near future, especially within the EU, where roaming rates have been abolished, but even in other countries where mobile operators offer "roam like home" deals with flat rate data offers. However, even though also in Switzerland there are offers that include a certain amount of roaming data, it is still very expensive especially if you want to be online at a good speed and regualarly.

The situation is not much different within ***my own country***. One day I brought my three-year-old daughter to the hairdresser to cut her hair. As you can imagine, after the first five minutes of enthusiasm, she got bored and did not want to sit still. Hence, I decided to make use of modern technology and gave her my mobile phone to show her some cartoons on YouTube. This worked great, the hairdresser was able to cut her hair without any problems in just 20 minutes. However, this was enough to consume the entire monthly high-speed (4G) data volume included in my data contract so that for the rest of the month I had to struggle with low connectivity speed when using the Internet outside my home and office. Would it not have been great to have access to a Wi-Fi network in this situation? It would have been a nice additional service simplifying my life.

I wonder, how is it that everyone owns mobile devices and uses them on a regular basis, but it is still so difficult to find connectivity that actually allows these devices to be performant and useful, especially when on the go?

My participation in the ***Wi-Com project***[2]**,** whose goal was to study member motivations of the hybrid wireless community Fon, combined with my research interest in Information and Communication Technologies (ICTs) and their social implications, laid the basis for this dissertation. Thanks to a scientific collaboration with Aziende Industriali Luganesi (AIL[3]), the company in charge of Lugano's MWN "WiFi Lugano", I was able to extend the scope of the research to include MWNs and thus I decided to dedicate my PhD dissertation to a better understanding of public wireless networks in general, with a special focus on their users, usage practices and motivations. The aim of this is to help communities and municipalities plan and develop Wi-Fi networks that address the real needs of people and thus become useful and usable for various publics in various situations.

1.2 Relevance for Society

Having access to broadband Internet connectivity is a fundamental requirement in today's increasingly connected world. Before the advent of mobile devices, the Internet was mainly confined to homes and offices where people connected their desktop computers through wires to the Internet. However, with the fast proliferation of mobile devices such as smartphones and tablets, and the emergence of new communication applications and services (e.g. Facebook, WhatsApp, Twitter), an increasing need for wireless Internet access emerged (Damsgaard et al., 2006). Nowadays, people use the Internet for many different aspects in their daily lives, "including communications, entertainment, and information-seeking in the home, at work and at school" (Wong & Clement, 2007, p.275). More and more people want to be connected to the Internet anywhere and at anytime in order to fully exploit the potential of their mobile devices. With the advent of wireless technologies this became more feasible. At least within private homes and offices Wi-Fi networks became a common solution to connect mobile devices to the Internet without the need of wires, although a fixed connection is needed to provide a Wi-Fi network. In fact, connectivity is generally not an issue anymore when people are at home or at work. Most private houses and offices (in Switzerland) have well-working broadband access – in fact Switzerland is among the OECD countries with the highest broadband penetration rates with 50.1 fixed/wired broadband subscriptions per 100 inhabitants in December 2016 (Federal Communications Commision - ComCom, 2017). Furthermore, 3G/4G technologies provided in a top-down approach by mobile operators (mainly Internet service providers – ISPs) offer nearly ubiquitous and continuous (Lehr & McKnight, 2003) connectivity also outside the walls of private homes or offices. However, especially when

[2] The Wi-Com project (www.wi-com.org) has been funded by the Swiss National Science Foundation under grant number 100014-127006 and lasted for two years from January 2010 to December 2011.

[3] AIL – www.ail.ch

used abroad, they are still expensive. Even though nowadays in Switzerland many people have data contracts that include a certain amount or even unlimited data, there are still many people who have to pay for mobile data (Fueter, 2016; Odermatt & Brunner, 2014). Hence, Wi-Fi networks reaching public spaces can be a viable and cheap alternative to operator-centric 3G/4G technologies for both citizens and travelers.

Another important motivation for the deployment of public Wi-Fi networks is the fact that the capacity of 3G/4G cellular networks increases much slower than mobile data traffic. Hence, Wi-Fi networks are increasingly more important to ***offload data*** volumes from cellular networks (L. Gao et al., 2014; Tefficient, 2016).

With the growing mobility of citizens, public Wi-Fi networks are particularly relevant for leisure and business travelers, and for citizens that move around their towns. This shows an increasing relevance of public Wi-Fi networks for the ***eTourism*** and ***eGovernment*** fields, which could actually take advantage of these infrastructures in order to offer better services to tourists, business travelers and citizens. Often, the deployment of public Wi-Fi networks is part of cities' efforts towards becoming "smart" and technology-oriented (Redondi et al., 2016). Providing access to the Internet in public spaces is one way for cities to employ ICTs to "connect[] a local community and drive growth, efficiency, productivity and competitiveness" (Yovanof & Hazapis, 2009, p.445)) and thus to "realize the vision of smart cities" (Redondi et al., 2016, p.44).

It has to be noted that there have been ***different waves of research on public Wi-Fi*** and that the ***environment*** in which people use public Wi-Fi has changed over the years. There was a boom in projects in the early to mid-2000s, with a lot of research on these early initiatives, followed by and apparent gap in research from about 2008 on. This dissertation is thus part of a resurgence of interest in the phenomena mainly due to the different technological era we live in today. Today everybody owns smartphones and uses them on a regular basis to connect to friends, colleagues and family using social media apps. This is a big change with regard to the context of the early Wi-Fi initiatives, where people mainly used laptops to connect to Wi-Fi. It is important to keep this changed context in mind, as in some cases past research may not provide particularly useful insights to explain current behaviors.

1.3 Scientific Relevance

A technology needs to be socially anchored in order to acquire relevance. It has to be meaningful and useful to someone in order to be adopted and regularly used. Without this, also the most ingenious technology is useless. This is why understanding the role of people in adopting and using a technology is particularly important. In existing research, wireless networks have been studied from various points of view. Many studies focused on technical solutions, business and ownership models, and policy regulations related to the

deployment of public Wi-Fi network (Bar & Galperin, 2004; Meinrath, 2005; Powell & Shade, 2006; Sandvig, 2004). However, not much attention has been dedicated to their social relevance. This dissertation, thus, wants to contribute to a better understanding of the people using this technology, their motivations and usage practices.

For CWNs, understanding what motivates or hinders people from joining and actively participating in wireless communities has been recognized as a central research issue (Bina & Giaglis, 2005). In order to work well and become useful, wireless communities need to be able to attract a critical mass of members and this can be successfully achieved only by understanding people's motivations and drivers. Existing research mainly studied motivations in ***pure*** self-organized communities. However, more recently, ***hybrid*** wireless communities, supported by a for-profit firm, proved to be much more successful in attracting members. This suggests that the presence of a managing firm inside a community influences people's motivations for joining and participating. It is thus expected that people in hybrid communities join for a different mix of motivations. Hence, this dissertation wants to contribute to a better understanding of ***motivations for joining and participating in hybrid communities***. To do so, it builds on a first theoretical model that has been developed to explain motivations in pure CWNs but that only considered a ***limited set of motivation theories***, mainly linked to self-determination theory (SDT) (Deci & Ryan, 1985). Hence, this study aims at adapting the existing theoretical model to the hybrid community context by considering a much larger set of motivational theories and by collecting qualitative and quantitative data from members of the Fon community to provide further empirical evidence.

MWNs, too, have already been studied from various points of view, but the role of the user has somewhat been neglected. Many initial municipal Wi-Fi initiatives have failed in their intent to build successful and sustainable public Wi-Fi networks mainly because of a combination of technical-, policy- and business-related reasons, which resulted in these networks not being used as much as expected. Often it has simply been taken for granted that MWNs were something that people really wanted, without however understanding beforehand which target groups might have had an interest in these networks, what they would have needed them for, and what their real expectations and needs were. It has thus been recognized that ***understanding users and usage practices*** is an important research issue to help municipalities implement networks that address the needs and expectation of various publics in various situations, and thus become a useful service. In the past, various studies analyzed the usage of public and semi-public Wi-Fi networks, but more from a technical than from a social, user-oriented perspective and only few studies focused specifically on MWNs. To investigate usage, most studies either analyzed purely technical log data, generated when the network is used, or user-provided data collected through interviews or surveys. The goal of this dissertation is to combine both technical network data with user-provided data in order to get a better and more comprehensive picture of

user practices. To do so, this research combines user data collected through a mobile survey placed on the landing page of Lugano's MWN "WiFi Lugano" with the corresponding log-entry generated on the network in that moment. This allowed the authors to identify user profiles and various usage practices and to ***identify strategies*** that allow cities to implement useful and usable public Wi-Fi networks and to take advantage of this infrastructure to improve relationships with citizens, businesses and visitors. In fact, even though many providers of Swiss public Wi-Fi networks actually monitor and analyze network data to get insights into how Wi-Fi networks are used, no scientific research has been conducted so far on usage of a Swiss large-scale Wi-Fi network.

1.4 Study Overview

This dissertation is structured into ***three main parts:*** a first part introducing the concept of ***public Wi-Fi networks*** (chapter 2) and two subsequent parts dedicated to the study of two different types of public Wi-Fi networks: ***CWNs*** (chapter 3) and ***MWNs*** (chapter 4).

This dissertation is a cumulative one: it includes four published papers, two dedicated to the study of CWNs and two to the study of MWNs.

While the ***current chapter*** introduced the scope of the study from a personal, societal, and scientific point of view and provided an overview and reading guide of the whole work, ***chapter 2*** starts defining what "public large-scale Wi-Fi networks" are (2.1) and introduces three different types of such public large-scale Wi-Fi networks (2.2). Section 2.3 frames Wi-Fi networks within different domains, describing their technical, economical, policy, and social aspects and implications, while section 2.4 explains the various goals that communities and municipalities want to achieve with the deployment of public Wi-Fi networks. Section 2.5 presents an overview of public large-scale Wi-Fi networks in Switzerland with the help of a model for categorizing them according to the driving forces involved in each initiative. Finally, the two Wi-Fi networks analyzed in this dissertation (Fon and "WiFi Lugano") are introduced in section 2.6.

Chapter 3 is dedicated to CWNs. It first introduces the concept of CWNs and describes how they emerged and evolved from technology- to community-centered groups and from pure to hybrid communities (3.1). Section 3.2 provides an overview of motivation theories that are most relevant to the context of CWNs, while section 3.3 introduces existing literature on motivations in pure and hybrid CWNs. Section 3.4 identifies the research gap, formulates the research questions and shows how this study contributes to existing knowledge. Finally, section 3.5 presents the two publications included in this cumulative dissertation reporting the results on motivations in hybrid CWNs.

Chapter 4 is dedicated to MWNs. Similarly to chapter 3, it first describes what MWNs are, how the first MWNs have emerged and the various types of problems they have

encountered, how this has helped implement a new and more focused and user-oriented vision of how to deploy MWNs and why understanding users and usage has become crucial for this 2nd wave of municipal initiatives (4.1). The following section (4.2), provides an overview of existing studies analyzing usage of public and semi-public Wi-Fi networks, while section 4.3 describes the research gap, the research questions, and how this study contributes to a better understanding of users and usage practices of MWNs. Last but not least two publications presenting the study results (4.4) conclude this section.

A final chapter (***Chapter 5***) draws the conclusions of this work, evidences its limits, and suggests further lines of research.

Table 1 provides an overview of the whole study and indicates in which sections information on the various parts of the study can be found.

<table>
<tr><th></th><th colspan="4">Public Wi-Fi networks and the role of individuals using them (social component)</th></tr>
<tr><td></td><td colspan="2">CWN – Motivations – Case of Fon</td><td colspan="2">MWN – Usage practices – Case of “WiFi Lugano”</td></tr>
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Motivations in pure & hybrid CWNs (chap. 3.3)</td><td colspan="2">Usage studies on public and semi-public Wi-Fi networks (chap 4.2)</td></tr>
<tr><td>Research Contribution</td><td colspan="2">Focus on hybrid CWNs
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Combine user-provided data with corresponding technical network data (chap. 4.3)</td></tr>
<tr><td>Research Questions</td><td>RQ1: What motivates people to JOIN a hybrid CWN and what hinders them from doing so? (chap. 3.4.2)</td><td>RQ2: What motivates people to actively PARTICIPATE in a CWN and what hinders them from doing so? (relationship between motivations and active participation) (chap. 3.4.2)</td><td colspan="2">RQ3: Who are the users of a MWN? What for, why, when, with whom, where, and with what devices do they use the MWN? (chap 4.3.2)
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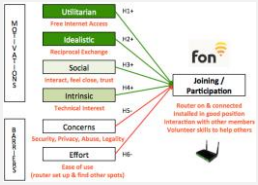
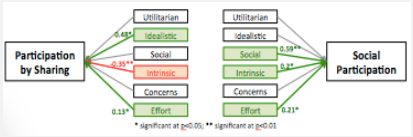
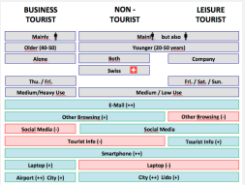
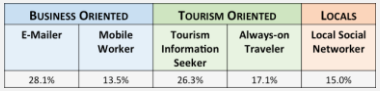
→ Descriptive statistics (SPSS) (chap. 3.5.1.5)</td><td>Quantitative Confirmatory Analysis:
Survey with 268 Fon members
→ Structural Equation Modeling (chap. 3.5.2.6)</td><td colspan="2">Quantitative analysis of 2 combined data sets:
- technical log-data of the “WiFi Lugano” MWN
- user-provided data from a mobile survey placed on the landing page of “WiFi Lugano”
3 months data (Jun-Aug2013):
27’945 sessions / 1’939 surveys
→ Descr. Stat. & User Groups (4.4.1.5)
1 year data (Jun 2013 – May 2014):
73’594 sessions / 4’115 surveys
→ Cluster Analysis (chap. 4.4.2.5)</td></tr>
<tr><td>Outcomes</td><td> 
(chap. 3.5.1 / 3.5.1.6)</td><td> 
(chap. 3.5.2 / 3.5.2.7)</td><td> 
(chap. 4.4.1 / 4.4.1.6 / 4.4.1.7)</td><td> 
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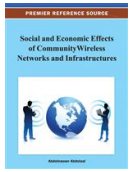
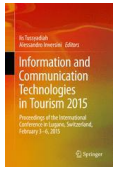
  </td><td>Motivations and barriers for participation in a hybrid wireless community: the case of FON
  </td><td>Tourists and Municipal Wi-Fi Networks (MWN) The case of Lugano (Switzerland)
  </td><td>Usage practices and user types of a municipal Wi-Fi network: The case of “WiFi Lugano” – best paper award
  </td></tr>
</table>

Table 1 – Research Overview

1.5 Methodology Overview

Methodologies are introduced, justified, discussed and applied in each article of this cumulative thesis. Here below a short summary of the applied methodologies is provided.

A ***mixed-method approach*** has been used in order to identify and understand motivations for joining and actively participating in a hybrid CWNs. In a pre-study, Bina & Giaglis's (2006a) first theoretical model on motivations in CWNs, which was mainly based on the self determination theory (Ryan & Deci, 2000), has been used as basis, extended by considering additional motivations theories (e.g. Intentional Decision Making in Technology Adoption, Prosocial Behavior/Volunteering, Innovation Diffusion and Expectation Confirmation) and finally refined through a content analysis of 1100 threads of Fon community forums (Camponovo & Picco-Schwendener, 2010).

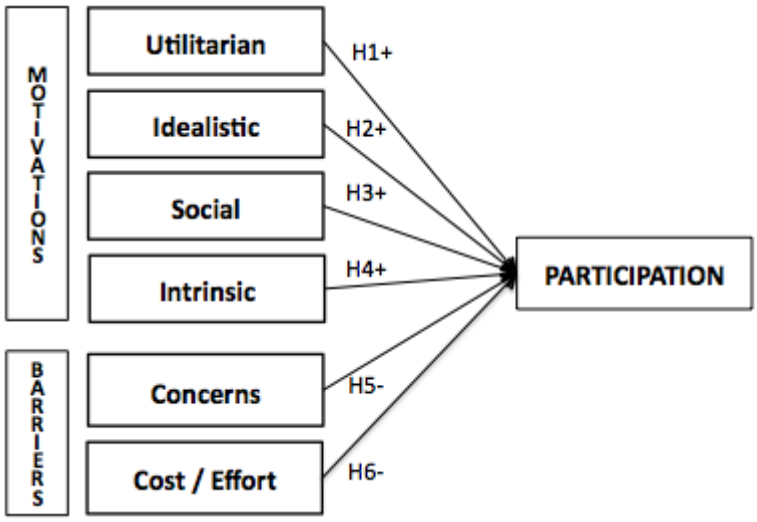


Figure 1 - Motivations and Barriers in a Hybrid CWN

A ***survey*** (see appendix 2) with questions about four main themes: 1) membership and experience, 2) participation and contribution to the community, 3) motivations and concerns, and 4) demographic data, has been developed based on earlier surveys (Bina, 2007; Shaffer, 2010) and tested measurement scales as shown in appendix 3, to empirically test the model in figure 1. ***Descriptive statistical analyses*** have then been conduced in SPSS with survey data of 292 respondents (mainly Swiss Fon members) to empirically thest the model and understand, which motivations are strongest in attracting members to the community. The results of 40 semi-structured interviews with Swiss Fon members have been used to further interperate and explain the obtained results (3.5.1.5).

In the second part of the study on CWNs ***structural equation modeling*** was applied to 268 survey answers of the same survey as in part one. As this analysis puts motivations directly in relation with members' active participation, this time only the results of respondents being member of Fon were considered (in part one also those respondents who were not part of the community were used as valid answers). More detail on how structural equation modeling was used can be found in section 3.5.2.6.

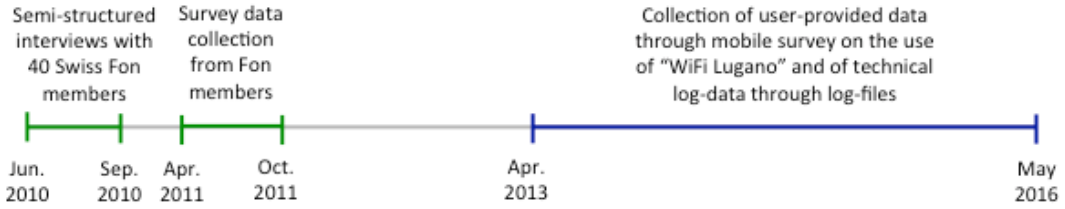
In order to identify usage practices and user types of a MWN, two different data sets on Wi-Fi usage of the "WiFi Lugano" network have been combined. The first data set contained technical log-data while the second one user-provided data from a mobile survey placed on the landing page of "WiFi Lugano". The two data sets have been matched based on the session and survey start date/time, as this was the only unique identified available because the survey tool was not able to collect the MAC (Media Access Control) address of the device used to answer the survey. In total the mobile survey was active for three years between April 2013 and May 2016. Matching the two data set allowed to infer the country of origin, eliminate duplicate survey answers from the same device and do some consistency checks.

The first study used ***three months data*** (June – August 2013) with 27'945 valid sessions and 1'939 survey answers to analyse Wi-Fi usage behavior of three different user groups with the help of ***descriptive statistics***. The three users groups (business tourist, non-tourist, leisure tourist) have been based on the reason for being in Lugano provided in the mobile survey. More details on this approach can be found in section 4.4.1.5.

In the second part of the study, the used data set has been ***extended to one year*** (June 2013 – May 2014) with 73'594 valid sessions and 4'115 survey answers. This time ***cluster analysis*** has been applied in order to identify meaningful groups of users. This method allows classifying data into groups without any preconceived notion of what clusters may arise, by creating groups of users whose behavior is similar to each other and different to those in other cluster. The ***2-step-clustering algorithm in SPSS*** has been chosen as it works well with large data sets and because it can handle both continuous and categorical variables. With the nine input variables based on the activities users declared to do on the "WiFi Lugano" network (e-mail, social media, tourist info, maps, free-time activities, VoIP, apps, other browsing, others) the algorithm automatically proposed 13 clusters but it has been decided to stop the clustering process at five clusters as any further splits would have created groups that were hardly explainable. The five clusters showed a good cluster quality (0.5) and a ratio of sizes between the larges and smallest cluster of 2.08. More details on how the cluster analysis was used can be found in section 4.4.2.5.

Data has been collected over various years and the two studies on CWNs and MWNs have been carried out during two different time periods. Figure 2 shows a time-line with the different data collection periods:

Figure 2 - Timeline of Data Collection



In order to ***perform the literature reviews*** on motivation theories relevant to the community context (section 3.2), motivations in pure and hybrid CWNs (section 3.3) and on usage of public Wi-Fi networks (chapter 4.2) the following literature databases have been used: Google Scholar, ISI Web of Knowledge, ACM Digital Library. Relevant articles have been listed in an Excel File together with information such as title, authors, year of publication, topic, type, methodology, geographical region, interesting literature and a relevance scale (very high, high, medium, low). This allowed on the one hand to go through the references of highly relevant articles and identify further relevant publications and look for more recent publications of authors who wrote relevant articles. The built Excel file then allowed to filter literature according to the different metadata of each listed publications.

For pure and hybrid CWNs, motivation theories and motivations in pure and hybrid CWNs a a good basis of literature was already available thanks to previous, related studies of a senior researcher in the same lab.

The main key words for finding literature on ***usage of public Wi-Fi networks*** were: Wi-Fi, public, municipal Wi-Fi, Wi-Fi usage, wireless networks, city Wi-Fi, urban Wi-Fi, college Wi-Fi, user behavior, etc.; while for finding ***literature on motivations in pure and hybrid CWNs*** the following terms have been used: community wireless networks, motivations, community, wireless community, hybrid community, pure community, Wi-Fi sharing, Internet sharing, Fon, etc.

The goal of each performed literature review was to understand what has already been done in each field (e.g. what kind of motivation theories have been considered, what kind of Wi-Fi usage profiles have been made) and what kind of methodologies have been applied in order to then identify research gaps and key research issues.

2 Public Large-Scale Wi-Fi Networks

"The digital revolution that has been taking place for the past two decades propelled by major breakthroughs in the ICT field has changed the way we communicate, work, travel, live—and even the way we use public space."
(Yovanof & Hazapis, 2009)

The goal of this chapter is to introduce and define Wi-Fi networks and especially public large-scale Wi-Fi networks. Furthermore, it aims at framing Wi-Fi networks within different research domains and describing their technical characteristics and economical, policy and social dimensions and implications. As public Wi-Fi networks have been built for a variety of reasons and motivations, section 2.4 provides an overview of municipalities' and communities' goals for providing public Wi-Fi access. The subsequent sections show what types of public large-scale Wi-Fi networks can be found in Switzerland's public space with the help of a model identifying the major driving forces of the different initiatives. Last but not least, the two public large-scale Wi-Fi networks chosen for this study – the wireless community Fon and Lugano's MWN "WiFi Lugano" – are briefly illustrated.

2.1 Framing Public Large-Scale Wi-Fi Networks

The aim of this section is not to provide a technical description of wireless networks (a detailed description of their technical characteristics will be provided in section 2.3.1.1) but rather to explain their function and to introduce the terms "public" and "large-scale" as they are used in this dissertation when referring to Wi-Fi networks.

The main function of ***wireless or "Wi-Fi"*** networks is to provide wireless Internet access in the near surrounding through radio waves, and thus to allow holders of mobile devices such as smartphones, tablets or laptops to connect to the Internet without using a physical wire connection (Damsgaard et al., 2006; Fuentes-Bautista & Inagaki, 2005; Techopedia, n.d.). Wi-Fi networks are most commonly used in homes or offices but are getting more and more popular also in public and semi-public spaces. In order to understand how this dissertation uses the term "public Wi-Fi networks" it is important to understand what ***"public"*** and "***semi-public"*** actually mean. For urbanists "public space may be distinguished from private space in that access to the latter may be legally restricted" (Hampton & Gupta, 2008, p.834). It typically comprises urban spaces such as cities' streets, parks, squares and places of public accommodation (Hampton & Gupta, 2008; Hampton et al., 2010), or in other words "places where individuals spend a considerable amount of their time outside of home and work" (Balachandran et al., 2002, p.195). Private spaces, on the other hand, refer to more intimate residential or commercial spaces (Ojala

et al., 2011). Semi-public spaces are defined as something in between public and private and are often "recognized for the role that they play in public life" (Hampton & Gupta, 2008, p.834). They are more private settings located in the public space and typically serve a general public. Examples are restaurants, shops, hotels and bars, namely places in which generally some type of consumption is required or at least expected, but also university campuses. In fact, "truly public sites do not require additional consumption" (Fuentes-Bautista & Inagaki, 2005, p.20). Public Wi-Fi networks can thus be considered as "the provisioning of broadband Internet services to the public through wireless fidelity platforms (IEEE 802.11x family) in spaces other than home or office, under non-discriminatory terms and conditions" (Fuentes-Bautista & Inagaki, 2005, p.4). Hence, the term "public" is used "regardless of the ownership structure of such networks" (Middleton et al., 2006, p.8) and does not mean managed or owned by a public entity like a village, city or region. It refers to infrastructures located in public or semi-public spaces that "provide public benefits" (Middleton et al., 2006, p.8) and serve the public interest (Clement & Potter, 2008) by providing "wireless connectivity as a service to passing users" (Bar & Galperin, 2004, p.54). In order to be beneficial for the users, Middleton (2006; 2008) suggest that public Wi-Fi networks should be ubiquitous, widely useful (allowing for a various applications), usable, accessible, affordable, reliable and of high quality, healthy (respecting the limits for electromagnetic radiation emissions), cost-effective, secure, privacy enabling, open and neutral, accountable and responsive. These characteristics are described in their "Desiderata for Public Wireless Internet Infrastructure" (Middleton et al., 2006).

"Public" does not necessarily mean that the network has to be open to everybody, but at least to a vast part of the local and visiting population. Generally, the use of the network is cheap or free of charge for the end users as it is subsidized by governments, communities or local businesses (Lehr & McKnight, 2003). Examples are hotel or restaurant Wi-Fi networks or those offered by malls, shops, cafés, libraries and community centers but also those available in hospitals, airports, train stations, universities, convention centers and public transports (Balachandran et al., 2002; Bar & Galperin, 2004; Damsgaard et al., 2006; Middleton & Crow, 2008; Rao & Parikh, 2003a). Furthermore, wireless networks deployed by private (ISPs) in the public space are considered public Wi-Fi networks.

This dissertation further distinguishes between ***small- and large-scale networks***. Wi-Fi networks that cover smaller, geographically limited areas are considered to be ***small-scale*** networks. They are typically provided by smaller commercial entities like single coffee shops, restaurants, hotels but also airports, libraries or shops. Usually each commercial entity sets up its own small Wi-Fi network to offer clients Wi-Fi access. Exceptions are restaurant chains such as McDonalds and Starbucks (Starbucks Corporation, 2016), which allow clients to connect with the same Service Set Identifier (SSID) (e.g.

"STARBUCKS") in all their branches in the same country. They can thus be considered as large-scale networks.

On the other hand, ***large-scale*** Wi-Fi networks are available over larger areas and in different places. They allow users to register to a network with a single SSID and use it in different places within a city, region or even a country. Popular examples of public large-scale networks are: Community Wireless Networks, where private people share part of their home Internet connection with the community; Municipal Wireless Networks, where municipalities provide Wi-Fi access in some areas of a city; but also networks created by public transportation (e.g. Swiss Railways – SBB), private ISPs (e.g. Swisscom) or restaurant chains (e.g. McDonalds, Starbucks).

There are many different ways to distinguish and characterize public large-scale Wi-Fi networks such as, different business and ownership models (see section 2.3.2.2), technical solutions (see section 2.3.1), rationales (see section 2.4) or philosophies and regulatory approaches (see section 2.3.3) (Fuentes-Bautista & Inagaki, 2005; Heer et al., 2010a). In this dissertation, public large-scale Wi-Fi networks are distinguished based on their ***driving forces or in other words on the interplay of different players in the provisioning of Wi-Fi connectivity***. In cities, there are three main players offering Wi-Fi services: 1) municipalities/local government, 2) communities or individual citizens, and 3) commercial organizations (Bar & Galperin, 2004; Bar & Galperin, 2005; Fuentes-Bautista & Inagaki, 2005; Middleton et al., 2006; Middleton & Potter, 2008; Middleton et al., 2008). In the case of ***MWNs***, the municipality provides Wi-Fi Internet access in some public areas of a city, while in the case of ***CWNs***, members of the community share part of their wired home Internet connectivity with other people of the community using Wi-Fi technology (Evenepoel et al., 2012). CWNs can be further distinguished into ***pure***, that is purely self-organized non-profit communities (Bina & Giaglis, 2006a), and ***hybrid*** communities, where a company supports members sharing Wi-Fi connectivity (Middleton et al., 2008). The main difference between CWNs and MWNs is that "communities provide wireless access in an unplanned and non-orchestrated way" (Heer et al., 2010a, p.588), while municipalities typically follow a structured and designed approach to network deployment. The two types of large-scale Wi-Fi networks also differ in intent and philosophy (Heer et al., 2010a): while MWNs mainly have public-utility-oriented goals such as digital inclusion, fostering participation, sustaining economic development and attracting businesses and tourists, CWNs mainly aim at extending the availability of free Internet connectivity (Cho, 2008). The third players implementing public large-scale Wi-Fi networks are ***commercial providers***, which have more business-oriented motivations, such as selling subscriptions (e.g. commercial Wireless Internet Service Providers – WISPs), attracting customers, improving their experience and encouraging them to buy further products. Such products could be a meal in a restaurant or a night in a hotel (Bar & Galperin, 2004). A further important motivation especially for private ISPs is offloading

data traffic from 3G/4G cellphone networks as for example Swisscom does in Switzerland through its Swisscom Public WLAN – (Swisscom, 2018).

2.2 A Definition of Public Large-Scale Wi-Fi Networks

Based on the concepts introduced in the previous chapter, the author provides her own definition of public large-scale Wi-Fi networks for the purpose of this research. She defines public large-scale Wi-Fi networks as ***networks…***

- ***providing wireless Internet access*** through radio waves using the IEEE 802.11 specifications
- available through APs with the ***same SSID*** (network name) and thus sharing authentication, usage conditions and promoter
- made available in ***spaces open to the public*** (including public and semi-public spaces) – PUBLIC
- covering ***several*** in-and/or out-door ***sites and/or premises*** (i.e. street, park, train station, square, tourist attraction, neighborhood, museum, stadium, library, recreational area, botanic garden, restaurant, coffee shop, public administration or private building, city hall, conference or exhibition center) being either contiguous and thus forming larger geographical Wi-Fi areas or being disjoined and dislocated over vaster areas (i.e. city, region, country or even worldwide). – LARGE-SCALE

This results in more or less dense and widespread grids of sites/premises, which in their turn can considerably vary in size (there are different sizes of public large-scale Wi-Fi networks).

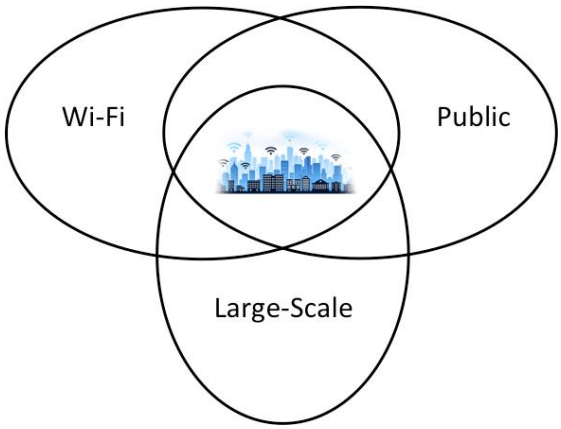


Figure 3 - Public Large-Scale Wi-Fi Networks

As it will be shown and described in detail in section 2.5, such public large-scale Wi-Fi networks are generally made available by one or more of the following four types of players:

- Public administration entities (***municipality-driven***)
- Group of individual users sharing their home broadband Internet connectivity, which implies the active involvement of end-users (***user-driven***)
- (Commercial) ISPs (***provider-driven***)
- A range of other entities not belonging to the other three types (***3rd - party-driven***) such as
    - ***For-profit or not-for-profit companies and associations*** (e.g. retail stores, malls, community centers, libraries, restaurants, hotels, tourism association, etc.) whose core business is not providing Internet access
    - For-profit or not-for-profit ***groups/associations***, which encourage and actively support the creation of Wi-Fi networks with different levels of involvement ranging from installing, managing and maintaining APs to providing support to the people and business who agree to host an AP). Examples are Freifunk, Île-sans-Fil, Wireless Toronto, Fon, etc.
    - ***Associations of universities*** (e.g. Eduroam)

In most cases public large-scale Wi-Fi networks are provided by an interplay of two or more different players and/or player types. This can be a bi-directional collaboration or an unilateral (service) contract where for example an ISP provides a service to a municipality. This is why the interplays in the model (figure 4) are represented with bi-directional arrows.

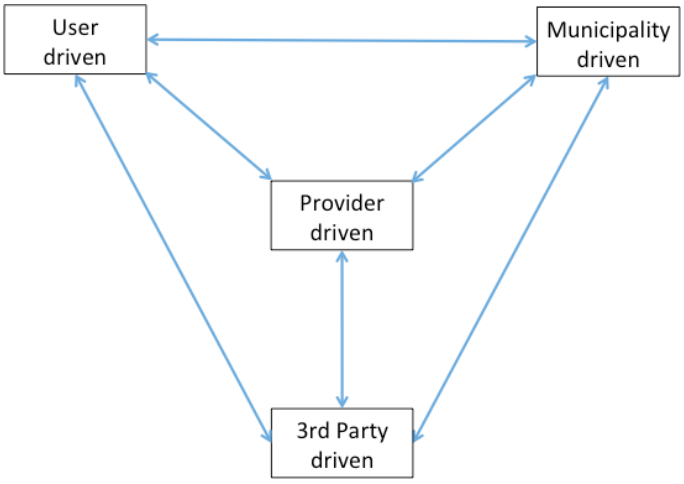


Figure 4 - Model of Public Large-Scale Wi-Fi Networks Based on the Different Entities Involved in the Provision of Wi-Fi and their Interplay (Extension of Heer et al. (2010a)'s Organization of Large Scale Wi-Fi Networks)

This dissertation focuses on two types of public large-scale Wi-Fi networks, which will be described in more detail in chapter 3 (CWN) and 4 (MWN).

1. ***MWNs***, which are provided by public administration entities (municipalities), usually in collaboration with other player types.
2. ***CWNs,*** which interpreted within the above-proposed framework, might refer to different configurations of providers and can thus be distinguished in two main groups:
    a. Mainly ***user-driven CWNs***, where groups of individuals share their personal home broadband connectivity through Wi-Fi with others, either in a completely self-organized way (***pure CWNs***) or supported by a for-profit company like Fon or by a not-for-profit association like Île sans fil (***hybrid CWNs***) - chap.
    b. Mainly ***3rd-party-driven CWNs***, where a group of individuals plan, install and maintain APs in a specific area to serve a specific community (e.g. volunteers setting up mesh-networks in a neighborhood). In this case there is no involvement of users sharing Wi-Fi connectivity.

    In this thesis the term CWN is used to refer to user-driven wireless networks, which are created through the active involvement of users by sharing their home broadband Internet connectivity (user-driven).

This research focuses on ***public large-scale*** wireless networks. Possible synonyms of public large-scale wireless networks are Wi-Fi networks in the public or semi-public space or city-wide or country-wide wireless networks. These terms are used interchangeably in this dissertation and always refer to the definition provided in this chapter.

2.3 Contextualizing Wi-Fi Networks within Different Domains

Wi-Fi networks are an interdisciplinary research topic, in which elements from various disciplines come into play. For understanding Wi-Fi networks and their impact four domains play a major role: ***technology*** (security, network deployment, management, performance & evaluation, roaming), ***business/economy*** (players, suitable business- and ownership-models, sustainability), ***telecommunication policy*** (impact on the telecommunication industry, policy and regulation), and ***social/individual*** (importance of motivation and participation, user needs, usage) (Abdelaal et al., 2009; Bina & Giaglis, 2005; Meinrath, 2005).

Much research on MWNs and CWNs has been done focusing on "understanding types of network deployments, policy issues around network ownership, and technical issues of infrastructure design and capability" (Middleton et al., 2006, p.15). In fact, most existing research does not put the user at the center of its study but focuses on either technology, or business, or policy related aspects of Wi-Fi networks.

Still, only a good understanding of all four domains and their intertwining will lead to solutions, which take the phenomenon of public Wi-Fi networks into account as a whole and in all its facets.

The following sections briefly introduce the main aspects of each of the four above-mentioned domains, which are necessary to the overall comprehension of the topic of public Wi-Fi networks and allow to sketch a general picture of the issues involved in the study of Wi-Fi networks.

2.3.1 Technology Domain

In this part, the technological aspects linked to Wi-Fi networks are explained. In order to understand wireless networks it is important to have a basic understanding of the underlying technologies and their advantages and drawbacks.

2.3.1.1 Wireless Technologies: 3G vs. Wi-Fi

In the last years of the 20th century, different wireless technologies have emerged. The two dominant ones, which nowadays allow users to access the Internet wirelessly with their mobile devices, are 3G/4G (3rd/4th generation) cellular and Wi-Fi technologies (Gass & Diot, 2010). They are the result of the parallel evolution of the Internet and mobile telephone services (Lehr & McKnight, 2003). While the Internet has brought access to information and new ways of communication, mobile services have favored a "follow-me-anywhere/always on" approach to the Internet (Lehr & McKnight, 2003, p.352).

Both 3G/4G and Wi-Fi technologies are so-called “access-network”, “edge-network” or “last mile” technologies and, as such, they are an alternative to the last kilometer/mile wireline network (Lehr & McKnight, 2003; Strover & Mun, 2006). Even though both technologies are wireless and allow providing broadband data services, they have major technical and commercial differences.

3G/4G technologies are supplied by mobile service providers that own and operate their own wireless networks in a top-down business approach and sell mobile services to end-users and businesses (Lehr & McKnight, 2003). They are designed to provide integrated data and voice services and while at the beginning their focus was mainly on voice telephony, this has now shifted towards data services (Lehr & McKnight, 2003). These technologies use licensed spectrum and telecommunication companies do major investments for purchasing spectrum licenses. Mobile operators build networks with interconnected and overlapping base stations that allow for nearly ubiquitous and continuous signal coverage (Lehr & McKnight, 2003). This results in a very usable service for the user, who can move around without ever losing the signal and remains constantly connected to the Internet, allowing for so-called “true mobility” (Middleton & Bryne, 2011). However, these networks are expensive to deploy and performance depends on the number of users connected in a single cell (Gass & Diot, 2010).

Wi-Fi stands for “wireless fidelity”. It is a type of WLAN (wireless local area network) based on the IEEE 802.11 specifications[4] and allows users to connect to the Internet using short-range radio signals (Dingwall, 2006; Mandviwalla et al., 2008; Schmidt & Townsend, 2003; Wong & Clement, 2007). It operates on unlicensed spectrum (Dingwall, 2006; Lehr & McKnight, 2003), which makes it a technology with low implementation and infrastructure costs and low power consumption if compared to 3G/4G technologies (Ullah, 2012), and thus favors the provision of end-user-centric and decentralized bottom-up services (Lehr & McKnight, 2003). However, unlike 3G/4G, it is not an “always-on” technology because of the sparse and often not coordinated deployment of access points (APs) and because of its short signal length (Gass & Diot, 2010). Often the terms WLAN and Wi-Fi network are used interchangeably as Wi-Fi is the most common type of WLANs.

The biggest ***advantage*** of Wi-Fi technology is its good cost-performance ratio (Ullah, 2012). It is easy to implement and use, it is cost-effective, offers good bandwidth and as such plays an important role in providing “last mile” connectivity (Escudero, 2003; M.

[4] IEEE 802.11 is a set of specifications for implementing WLAN communication operating on 900 MHz, 2.4, 3.6, 5 and 60 GHz frequencies. They are developed by a working group of the Institute of Electrical and Electronics Engineers (IEEE) (D'Ambrosia, 2017).

Estevez, 2006; Gillett, 2006; Mandviwalla et al., 2008). An additional advantage of Wi-Fi is "its capacity to communicate multiple types of media over the same protocol: text, voice, images and video" (Sevtsuk et al., 2009, p.327). Furthermore, it allows for many different types of business models (Rao & Parikh, 2003a) – see section 2.3.2.2.

On the other hand, its major ***drawbacks*** are the short signal range (Bar & Galperin, 2005; Cho, 2008), path loss and interferences due to the operation in unlicensed spectrum (M. Estevez, 2006; González Rodríguez, 2010; Gunasekaran & Harmantzis, 2008), and the fact that it does not travel well through walls (Hudson, 2010). A further issue is network security (M. Estevez, 2006; González Rodríguez, 2010). Because of these weaknesses and the fact that Wi-Fi has mainly been designed for indoor settings and stationary users, at first glance it did not seem to be the best technology to implement wireless networks in outdoor public spaces with many mobile users (Vural et al., 2013). Nevertheless, it quickly proved to be well suited and widely adopted to "provide Internet services to cafes, hotspots and public places" (Ullah, 2012, p.3).

Besides Wi-Fi and 3G/4G there are also other wireless technologies such as WiMAX, and Bluetooth. However, they are out of the scope of this research and hence are not described in further detail.

Table 2 provides a comparison between the main characteristics of 3G/4G and Wi-Fi technologies.

	3G/4G technologies	**Wi-Fi technology**
	Wireless Technologies; providing "last mile" access to broadband Internet connectivity	
Business Approach / Service provisioning / Business Models	Top-down	Bottom-up (decentralized, end-user centric) / Top-down
Service Providers	Operator-centric: commercial telecom operators, cable companies, specialized wireless service companies	Users / communities / municipalities / startup companies
Spectrum	Licensed (to pay for)	Unlicensed (free)
Range	Near ubiquitous & continuous coverage	Confined to limited areas / short signal length
Cost	Expensive to implement and available to end-users on a paying basis	Cheap implementation / often available to the end user for free or against a low fee

Table 2 – Comparison between 3G/4G and Wi-Fi Technology

2.3.1.2 Emergence of Public Wi-Fi Networks

In parallel to the development of Wi-Fi technologies, Wi-Fi networks or so-called WLANs emerged (Sanusi & Palen, 2008). A Wi-Fi network is created when two or more devices

are connected using Wi-Fi technology to form a network. At the beginning, these networks were mainly used to ***connect PCs, laptops and other computing devices with peripherals*** such as printers, servers or shared storage devices ***inside private homes or offices*** (Bina & Giaglis, 2005; Lehr & McKnight, 2003) and to connect computers and mobile devices to the Internet through a single DSL (Digital Subscriber Line) or cable modem connection (Damsgaard et al., 2006). Nowadays, Wi-Fi networks in homes allow playing music and films on different devices and even controlling lighting, heating and security systems (Öffentliches WLAN boomt, 2014). Wi-Fi networks have also increasingly been implemented outdoors in public spaces to provide Internet access to travelers, business people and citizens, for example in airports, hotels, cafes, parks, libraries, malls, convention centers and hospitals (Bar & Galperin, 2004; Damsgaard et al., 2006; Dingwall, 2006; Ojala et al., 2011), leading to a so-called Wi-Fi popularization. This was an unplanned use of Wi-Fi technology, as it had originally not been developed to facilitate Internet access in outdoor public places but just to connect devices inside homes or offices (Bar & Galperin, 2004; Schmidt & Townsend, 2003; Strover & Mun, 2006). However, according to Schmidt & Townsend (2003), Wi-Fi technology even has the power to become "an outdoor amenity that transforms the urban landscape" (p. 47).

While there are ***different networking models*** for creating wireless networks, public Wi-Fi projects usually focus on three types: independent or linked hotspots, hub-and-spoke systems or dynamic mesh networks (Powell & Shade, 2006). ***Hotspots***, also called Access Points (AP) are "points at which broadband Internet signals are broadcast wirelessly to the immediate geographical area" (Powell & Shade, 2006, p.383). Hotspots usually operate independently and are not connected to each other. This is not necessary as each hotspot is connected directly to the Internet. Hotspots can either be organized in a decentralized way or form centralized networks (Forlano, 2008a), which is generally the case of MWN. Centralized networks of hotspots or mesh networks allow end-users to connect to a single network without having to switch between different, decentralized hotspots (Vural et al., 2013).

Hub-and-spoke systems are particularly useful to bring Wi-Fi signals to isolated areas. A powerful antenna, usually connected to the wired Internet and placed for example on a hill broadcasts Wi-Fi signal to many different points (e.g. homes) around it. They are often used to "disseminate a signal in areas where fiber-optic cable cannot be laid due to geographic or economic limitations" (Powell & Shade, 2006, p.3).

In a dynamic ***mesh network,*** different nodes are connected to each other and only some are connected directly to the wired network (Bar & Galperin, 2004; Forlano, 2008a). The different nodes are "programmed to detect nearby devices and spontaneously adjust routing when new devices are added, or to find ways around devices that fail" (Bar & Galperin, 2004, p.59). This allows creating very robust local area networks with self-

healing capabilities (Vincenzi et al., 2010). Thanks to this structure it is possible to deploy mesh networks in an incremental way to "gradually extend connectivity and capacity" (Vincenzi et al., 2010, p.255). To implement functional mesh networks, it is important that "a certain number of individuals or organizations […] are willing to share their Internet backbone" (Powell & Shade, 2006, p.383).

Figure 5 shows the structures of the three previously described networking models.

Figure 5 - Hotspot, Hub-and-Spoke and Mesh Networking Models

With the fast proliferation of public networks, the issue of ***security*** becomes more and more important. In fact, wireless networks are inherently at risk for security problems. Signals travelling through the air can easily be intercepted by unauthorized users and any security lack in a Wi-Fi network can be utilized by hackers to either steal bandwidth or data (Rao & Parikh, 2003a). Even though nowadays there are various technical solutions to successfully deal with security problems, people still perceive security as a critical aspect or even a threat, and this might prevent them from using public Wi-Fi networks. According to Rao & Parikh (2003a), "as more users use wireless commons, advance level of authentication, authorization, and encryption technologies will be needed" (p.486). Hence, it is important to continue addressing security issues and research for solutions that might further increase security of public Wi-Fi networks (Benkler, 2002; Bina & Giaglis, 2005; Rao & Parikh, 2003a; Schmidt & Townsend, 2003).

In order to evaluate and improve network performance of Wi-Fi networks much research has been dedicated to the ***study of technical network usage data recorded when the network is used*** (i.e. connection date/time, amount of downloadad and uploaded data, MAC address of connected device, IP (Internet Protocol) address of APs, etc.), mostly focusing on technical aspects (e.g. Aguayo et al., 2004; Bicket et al., 2005; Castignani et al., 2013; Robinson et al., 2008; Solarski et al., 2006; Zhou et al., 2017; Zola & Barcelo-Arroyo, 2011). Section 4.2 will provide a detailed overview of studies analyzing usage of public Wi-Fi networks with a focus on their social dimension.

2.3.1.3 Contribution of Technology to the Emergence of Public Wi-Fi Networks

The creation of such public Wi-Fi networks has been favored by technology's low barriers to entry: ***cost-free unlicensed spectrum*** has avoided initial investments in licenses (Bina & Giaglis, 2006a) and the technology has allowed to relatively ***easily set up and implement*** networks (M. Estevez, 2006). In fact, "little public disruption is required (generally streets do not have to be dug up)" (Gillett, 2006, p.592) to install and deploy Wi-Fi networks. Municipalities often have free access to public infrastructures such as lamp poles and traffic lights, which are ideal for installing base stations and APs (Mandviwalla et al., 2008; Sirbu et al., 2006). Furthermore, Wi-Fi's ***good technical performance*** allowing for high speeds and industry-wide standardization has fueled the emergence of public Wi-Fi networks (Bar & Galperin, 2004; Gunasekaran & Harmantzis, 2008).

2.3.2 Economic / Commercial Domain

This section reports on the different players involved in the deployment of public Wi-Fi networks, introduces the discussion on various types of business and ownership models, and describes the particular telecommunication market situation at the turn of the 21st century in the United States (U.S.), Canada and Europe.

2.3.2.1 Players Getting Involved in the Deployment of Wi-Fi Networks

At the turn of the 21st century ***different actors/players*** from outside the telecom sector (Markendahl & Makitalo, 2007) started deploying Wi-Fi networks in order to provide Internet access in public spaces using different types of business models. ***Communities*** of technical enthusiasts and ***municipalities*** were among the first entities to experiment with this new technology (Auray et al., 2003; Bar & Galperin, 2004; Gillett, 2006). They tested technical implementations, different kind of business models, thought of various types of applications, and studied different policy approaches (Bar & Park, 2006) with the main goal of offering affordable, if not even free Internet connectivity to everyone living the public space (Schmidt & Townsend, 2003). Generally, Wi-Fi services offered by communities, ***individuals*** or the private sector are provided on a "best effort" basis without making any promise on service quality and coverage extension (Ojala et al., 2011). In return, most non-commercial networks are cheap if not even free (Middleton & Bryne, 2011).

However, Wi-Fi technology has attracted also the interest of ***commercial players*** such as restaurants, hotels, shops, WISPs like Boingo[5] and even traditional telecommunication

[5] Boingo – www.boingo.com.

operators. Starbucks, for example, has been among the first commercial entities to invest in Wi-Fi technology by equipping most of its coffeehouses with free Wi-Fi access for their clients by 2004 (Auray et al., 2003). Often the idea behind these free commercial offers is to attract clients, enrich their experience, and promote the primary activity of the provider. Eventhough, today some business discourage clients from spending all day using the free Wi-Fi, they still offer it, as they know that it is an important factor attracting clients to the business.

2.3.2.2 Business and Ownership Models

Much effort has been put into identifying and understanding suitable and sustainable business models for the development and maintenance of public wireless networks and to evaluate different forms of ownership (Bar & Galperin, 2004; Bar & Galperin, 2005; Bar & Park, 2006; Forlano, 2008a; E. Fraser, 2009; Fuentes-Bautista & Inagaki, 2005; Middleton, 2007; Tapia et al., 2005). Most proposed business models describe the relationship between a municipality or community and the service provider that implements the network (Middleton, 2007), and research focuses on understanding the value of "different public/private partnerships in relation to network ownership, architecture and management" (Lambert et al., 2014, p.45.2). Middleton (2007), for example, describes five business models, which have been identified by the consulting company Civitium (Informa UK, 2006; Neff, 2007). In a ***private consortium***, a municipality makes an agreement with a private company to develop and maintain a wireless network for them; this results in privately-owned networks (Forlano, 2008a). In a ***cooperative wholesale***, the municipality develops and operates the network itself and resells connectivity to local ISPs. In the following two models either a ***public utility*** or ***non-profit*** organization develop and operate the network and resells connectivity to municipalities while in the last model a ***grassroots community*** provides Internet connectivity in different location usually for free (Middleton, 2007).

Chesley (2009) distinguishes between the following six ownership models in which cities take more or less control and risks and bear more or less costs: a very popular model of early initiatives has been a ***public-private partnership*** – this was the case of the famous project of wireless Philadelphia cooperating with the ISP Earthlink (Breitbart et al., 2007). In this case, an ISP builds the network for the city, which in turn allows using city properties and existing infrastructures like light poles or traffic light for installation. In ***private contract*** systems, a municipality simply stipulates a contract with an existing ISP to develop the network. In ***community non-profit groups***, communities develop a network with their own funding. In ***business cooperative*** model, local businesses use their own resources to implement a wireless network in order to attract customers. In ***municipally-owned*** networks, the local government owns and manages the network infrastructure (e.g.

Fred eZone in Fredricton, Canada). Finally, in a ***federal loan/grant*** system, federal programs fund municipal Wi-Fi projects (Chesley, 2009).

Similarly, Forlano (2008a) distinguishes between ***privately-owned networks, public-private partnerships, publicly-owned and community-owned networks***. She highlights that most American cities implemented networks that were owned by private companies like Earthlink or other ISPs, which build, manage and own the infrastructure (Forlano, 2008a). For Bar & Park (2006) two questions guide the discussion on business and ownership models: 1) who ***owns*** the network and 2) who ***operates*** it. For each question, they propose three answers: 1) the city, 2) one private player (e.g. an ISP or a company like Google in San Francisco) or 3) multiple others (e.g. different local merchants, CWNs, multiple ISPs). By combining the three options for each answer, they came up with a grid of nine different business models. The panOULU MWN included ***academia*** as an additional player (Ojala et al., 2011). It is "provided jointly by a triple-helix consortium of thirteen organizations: five municipalities, four public research and educational institutions, and four commercial ISPs" (Ylipulli et al., 2014, p.149).

To summarize, it can be said that MWNs use different models involving public and private players for network ownership, operation and service provisioning (Ojala et al., 2011), while CWNs generally build on a bottom-up, grassroots basis with self-organized users and no central authority to manage the network (Bina & Giaglis, 2005). Nevertheless, even though Wi-Fi networks "require less capital than their wired counterparts, they still have to be funded and maintained" (Bar & Park, 2006, p.108). Especially initial public Wi-Fi initiatives had difficulties in identifying suitable and sustainable business models, with the result that many initiatives have been discontinued only shortly after their initial deployment (e.g. Philadelphia, San Francisco or Chicago) (Chesley, 2009; Forlano, 2008a; E. Fraser, 2009; Hudson, 2010; Jassem, 2010; Ojala et al., 2011). Rolla Huff, chief executive of EarthLink Inc. commented the failure of Wireless Philadelphia as follows: "This was about a business model that simply didn't work […] It was a great idea, it wasn't a great business" (LaVallee, 2008, p.1). The problem was that EarthLink deployed the whole network on its whole expenses but then the service did not attract enough users to pay off for the initial investment (LaVallee, 2008).

With regard to the above described business models, the model used as basis for this dissertation (see figure 4) focuses on the different entities involved in the provision of Wi-Fi and their interplay more than on the different roles (ownership, financing, operator, etc.) they assume in the interplay. In fact, from none of the above business models the involvement of users emerged, as in general users are neither owning nor financing public large-scale Wi-Fi networks but can very well be a driving force providing Wi-Fi connectivity. While most of the above business models represent public Wi-Fi networks in general, the model used for this dissertation focuses on public ***large-scale*** Wi-Fi networks.

It would be certainly of interest having a more detailed picture of what the current state of business models for public Wi-Fi is and understanding which ones have survived and which new ones have emerged, now, more than ten years after the initial roll out of public Wi-Fi networks. However, it is out of the scope of the current study to analyze business models in details. Business models have been included simply to present a more complete literature on what has been done so far.

2.3.2.3 Telecommunication Market

Another important factor that influenced the fast growth of non-commercial public Wi-Fi networks were ***poor wired residential broadband penetration rates*** in the U.S. at the turn of the 21st century, lagging behind many other industrialized countries (Bar & Park, 2006; Dingwall, 2006; Hudson, 2010; Tapia & Ortiz, 2008b; Van Audenhove et al., 2007). Even though the U.S. were initially among the most connected countries, they did not manage to keep up with the fast evolution of broadband technologies and the "development of a formal, national-level telecommunications policy in the U.S. is being outpaced by technological change" (Tapia & Ortiz, 2008a, p. 257). Moreover, mobile networks at that time were less developed "in terms of coverage, standardization and bandwidth" than in Europe (Van Audenhove et al., 2007, p.131). This has pushed municipalities and communities to use this novel and apparently well-performing and cost-effective technology to bring broadband connection to peoples' homes and thus providing primary Internet access (Middleton et al., 2006).

In the same period, in ***Canada*** municipal Wi-Fi was less of an issue as it had strong broadband penetration rates offering good quality connectivity at reasonable prices (Frieden, 2005; Powell, 2008b). This left a lot of space for ***community initiatives*** in Canadian cities like Montreal, Toronto and Vancouver to experiment with Wi-Fi's technical, social and policy issues (Powell, 2008b).

The market situation in ***Europe*** was more similar to Canada and had relatively good broadband penetration rates (OECD, 2018). As Europe is much more densely populated and has less rural areas than Canada and the U.S., the need for public Wi-Fi networks was initially less strong. In fact, in Europe, public Wi-Fi networks spread later than in the Americas and thus promoters of Wi-Fi initiatives had the advantage of learning from the mistakes of early U.S. and Canadian initiatives. The good broadband penetration rates allowed cities to focus on the provision of secondary Internet connectivity, hence, providing Wi-Fi as an additional service without bringing it to residences (Middleton, 2007). However, until now European Wi-Fi initiatives have received less attention in existing literature (R. Kramer et al., 2006; Van Audenhove et al., 2007).

2.3.3 Policy Domain: Two Different Approaches in the U.S. and Europe

With the emergence of first plans to develop MWNs in the U.S., a heated policy debate took off on whether municipalities should enter the telecommunication market and provide wireless Internet connectivity to their citizens (Forlano, 2008a; Gibbons & Ruth, 2006; Gillett et al., 2004; Shaffer, 2007). If municipalities enter the broadband Internet market it means that governments become direct competitors with the private sector. Whether this makes sense or not is strictly linked to the key question whether high-speed access to the Internet should be considered a ***public utility or good*** and, hence, be provided by municipalities in the same way as electricity and water or as they build roads, water sewerage and power lines (McGuire, 2006; Middleton, 2007; Shaffer, 2007).

It is actually widely acknowledged that broadband access to the Internet is fundamental in today's information society, yet it is still not available to all (Tapia et al., 2011). In fact, at the beginning of the new millennium, broadband diffusion in the U.S. lagged behind many other countries and especially less-densely populated, rural areas did not have access to good quality Internet connectivity. Thus, advocates of municipalities providing Internet services through the deployment of cities' Wi-Fi networks argue that MWNs can be seen as a response to market failure in order to foster digital inclusion (Lehr et al., 2006). For others, instead, it constitutes a severe market intervention and unfair competition as municipalities can use public assets (light polls or traffic signs having built-in electrical supply) (Bar & Park, 2006). These opponents claim that municipalities have better funding perspectives and might eventually push smaller private companies out of the market and hinder fair competition (Chesley, 2009; Strover & Mun, 2006). This might lead to a lack of competition and consequently of innovation as the few players are not motivated to innovate their services and to lower prices (McGuire, 2006). Furthermore, the lobby against municipal broadband provisioning argues that private companies have better technological knowhow (Strover & Mun, 2006). Other concerns are linked to censorship: if a local government provides Internet access it has the power to limit access to contents. According to Nolan (2005) this might be appreciated if aggressive, violent or pornographic contents disappeared, but can become very dangerous if it happened for example to online political or religious content. In today's data-centered world the collection and monitoring of user and usage data might be a further issue. MWNs might be perceived as a way of controlling and observing citizens and visitors while they use public broadband services (McGuire, 2006). Last but not least, if public funds are used for the creation of public Wi-Fi networks, they are taken away from other important investment areas such as education, security or public works, investments that are already cut in many cities (New Millennium Research Council, 2005).

In any case, telecommunication providers in the U.S. and to a lesser extent in Canada did not appreciate the intrusion of municipalities and governments into their market and tried

to avoid it with all means. They put a lot of effort into ***lobbying*** against municipalities entering the telecommunication market (Gillett, 2006; Middleton, 2007; Ojala et al., 2011; Strover & Mun, 2006; Tapia et al., 2005). Even though the Telecommunications Act of 1996 (TA)[6] says that no state may prohibit "any entity" from offering telecommunication services, in 2004, the Supreme Court decided that municipalities could not be considered as "entities". With this decision, states had the power to prohibit the creation of MWNs. In fact, by 2006 more than nineteen states issued regulations for limiting Wi-Fi provisioning by local governments (Chesley, 2009; Dingwall, 2006; Forlano, 2008b).

Consequently, the U.S. went into the direction of limiting and controlling the entrance of municipalities in the broadband market (Strover & Mun, 2006). In many other cases, American jurisdiction followed the claims made by the private sector and issued legislations that prevented public ownership and provision of telecommunications (Powell & Shade, 2006; Powell, 2008b; Strover & Mun, 2006). Legislators considered that "government-supported, universal access to information infrastructure was inherently dangerous for competitive telecom development" (Powell & Shade, 2006, p.401). This means that a major threat especially for U.S.' MWNs arrived from the policy side (Gunasekaran & Harmantzis, 2008). However, according to Gillett (2006) the debate should actually focus less on whether municipalities should be allowed to provide broadband services or not, as there are many good reasons why they should and will, but it should focus on understanding "what types of state and federal oversight are necessary to ensure that city wireless initiatives do not lead to corruption of the local government's role" (Gillett, 2006, p.592).

Differently, ***in Canada***, the Broadband Task Force recommended that communities get involved in the planning of public Wi-Fi networks in order to fully take advantage of local potentials (National Broadband Task Force, 2001).

In ***Europe***, municipal Wi-Fi initiatives emerged later than in the U.S., and this allowed promoters of such initiatives to at least in part learn from the mistakes and pitfalls of their American counterparts. Similarly to Canada, the European Union (EU) favored public investments from the very beginning to spread broadband Internet diffusion especially in rural and disadvantaged areas (e.g. European Commission, 2006). The EU holds the position that MWNs are not a substitute for existing services as it would be unlikely that users dismiss their primary Internet service contract with an ISP because of Wi-Fi availability in some areas of a city. It further advocates that it should not impact negatively on the market if a city deploys a Wi-Fi network to satisfy its own needs for Internet

[6] 47 U.S.C. § 253(a)

connectivity instead of procuring it to private ISPs (Chesley, 2009). However, EU Competition Commissioner and author of the Prague decision Neelie Kroes highlights that "state subsidies for such networks are only acceptable if they address a well-defined market failure or cohesion problem" (Chesley, 2009, p.27).

Therefore, the EU continues to invest in broadband initiatives and infrastructures without caring too much about the impact on commercial providers as they primarily invest in areas that are not very attractive to private providers. Hence, the approach regarding broadband diffusion and expansion of the EU strongly contrasts with the one adopted in the U.S. (Strover & Mun, 2006).

Recently the European Commission launched the ***WiFi4EU initiative,*** which wants to "promote free Wi-Fi connectivity for citizens and visitors in public spaces such as parks, squares, public building[s], libraries, health centers, and museums everywhere in Europe" (European Union, 2018a). According to Commission president Jean-Claude Juncker "[e]veryone benefiting from connectivity means that it should not matter where you live or how much you earn. So we propose today to equip every European village and every city with free wireless Internet access around the main centers of public life by 2020" (Jean-Claude Juncker - State of the Union speech, Sep. 2016 in European Union, 2018a). In May 2017, the European Parliament, the Council and the Commission reached an agreement on the WiFi4EU initiative and its funding. The WiFi4EU initiative is thus part of the EU's strategy to fully connect Europe especially in those places where Internet is currently limited and goes in parallel with the EU's decision to ***abolish roaming rates*** for cellular networks within the EU in June 2017 (European Union, 2016; European Union, 2018b).

The funding agreement consists of a commitment by the three institutions to fund equipment for public free Wi-Fi services in 6'000 to 8'000 municipalities of member countries for a total amount of 120 million euros. This means that municipalities that would like to offer Wi-Fi in areas where no similar public or private service exists can apply for funding (European Union, 2017a; European Union, 2017b).

The WiFi4EU initiative is part of the revision of the EU telecoms rules, which wants to address Europe's growing connectivity needs and help boost its competitiveness. However, Vice-President in charge of the Digital Single Market Andrus Ansip states that still "much more needs to be done to achieve high-speed connectivity across the whole EU territory – such as improving Europe-wide coordination of spectrum and stimulating investments in the high-capacity networks that Europe needs" (European Union, 2017a).

In Switzerland the situation is different. According to the Swiss Federal Office of Communications (OFCOM[7]), in Switzerland at the moment there are no plans to subsidize Wi-Fi networks at national level. Press spokeswoman of the OFCOM Silvia Canova confirmed that "Switzerland participates at various other activities related to a common digital strategy, for example in the role of observer in the field of education or partner in cybersecurity" (Castellano, 2017). Furthermore the OFCOM doubts whether such an initiative might be profitable in Switzerland at all, as there are already various public Wi-Fi initiatives in Swiss cities (see 2.5) (Castellano, 2017).

Policy and regulations on public Wi-Fi in the U.S. and Canada have been included as part of the literature review. It would be interesting to deepen how policy in the U.S. and Canada evolved, how the current state of regulations is and how it compares to European and Swiss policy. However, this is out of the scope of this paper but might be achieved in future studies.

2.3.4 Social Domain: Understanding Users and Their Behavior

The social domain places the user at the center of the attention and points at understanding human behavior (Bina & Giaglis, 2005). In fact, technologies acquire relevance only if put into a social context and if used by individuals. A technology per se that is not adopted and used by individuals is, in fact, useless. According to (Powell, 2008b) "technology and society mutually construct one another" (p.1070). Understanding ***what motivates*** or pushes users to adopt and to regularly use a specific technology becomes thus fundamental. To do so, it is important to know that the ***adoption of a technology*** is strictly linked to previous individual experiences with similar technologies, specific user needs, and values (Ylipulli et al., 2014). Often the belief that technology per se solves social problems persists, while instead it is the people and the way they use technology at their disposal that do that (Tapia & Ortiz, 2008a; Tapia & Ortiz, 2008b).

The biggest challenges are thus not of technical nature (e.g. deploying a wireless network) but of a social, which implies understanding what exactly people need and expect from a technology. It is in fact fundamental that a technology in general and Wi-Fi networks in specific meet the needs of their users. A technology and its implementation have, therefore, to be adapted according to the needs of its users in order to become truly useful. This is true for both CWNs and MWNs. While for CWN it is fundamental to understand what motivates users to join and actively participate in the community by sharing their home Wi-Fi signal, for municipalities it is important to understand the needs of potential users by analyzing usage of existing public Wi-Fi networks. The value of a CWN, in fact,

[7] OFCOM - https://www.bakom.admin.ch/bakom/en/homepage.html.

increases proportionally to the number of its members, the more members there are the more valuable the community becomes for each single member. For CWNs it is thus crucial to understand how to reach a critical mass of participating users (Rao & Parikh, 2003a). For MWNs, on the other hand, knowing potential users, their needs and usage practices allows determining where, how and to whom connectivity should be provided. Furthermore, knowledge on users makes it possible to learn beforehand what aspects of wireless connectivity are particularly relevant to users (e.g. user friendly, quick and simple registration procedures, good quality networks, ease of use) and what might hinder them from using public Wi-Fi networks (e.g. security and privacy issues). Ojala et al. (2011) suggest that the "final challenge is to rigorously measure the societal impact of a [M]unicipal [W]ireless [N]etwork once the network has been deployed" (p.120). Moreover, Ylipully et al. (2014) are convinced that "people play a pivotal role in cities becoming 'smarter'" (p.146). Tapia & Ortiz (2008b) underline the importance of building "users instead of networks" (p.16). People and their needs must be considered during the whole deployment process of public Wi-Fi networks: they have to be involved in the planning, their needs must be grasped and addressed and after implementation they have to be informed and educated on the availability of the new technology, its utility and potential.

Another interesting aspect of the social domain is ***how technology impacts*** on the environment in which it is used and on the people using it. The increased presence of Wi-Fi in public places is for example creating opportunities for new forms of digital interactions (Sanusi & Palen, 2008). Until now there has only been limited empirical evidence of social implications of Wi-Fi networks in public spaces (Hampton & Gupta, 2008). It is thus necessary to further study social and cultural practices emerging from the use of these new information technologies (Ylipulli et al., 2014). For this reason, this dissertation wants to contribute to a better understanding of public Wi-Fi networks' social dimensions by studying users and their behavior.

2.4 Rationales for the Deployment of CWNs and MWNs

In the previous sections, Wi-Fi networks have been framed and contextualized within various domains to show how each domain contributes to a better understanding of public Wi-Fi networks. At this point it is important to consider "what […] the purpose of public wireless networks [is]" (Middleton, 2007, p.1), and which rationales and goals actually move communities and municipalities to implement public Wi-Fi infrastructures. Communities and municipalities share some common goals while other aims are specific to one or the other promoter.

It is important to stress that different stakeholders involved in the implementation of public Wi-Fi networks might have different and sometimes even contradictory goals

(Mandviwalla et al., 2008). In the same way, different initiatives pursue a large variety of different objectives (Ojala et al., 2011). While European initiatives are more oriented towards fostering economic development, American projects primarily aim at bridging the digital divide (Ojala et al., 2011).

2.4.1 Common Goals

Among the most important and frequently cited goals there is certainly fostering ***digital inclusion*** by providing cheap if not free access to broadband Internet connectivity and also allowing those who otherwise would not have access to the Internet to get connectivity (Ballon et al., 2009; Powell & Shade, 2006). This important goal is pursued by both municipalities and communities.

Improving ***digital inclusion*** means addressing inequalities in the access of ICTs, in this case, inequalities in the access to broadband Internet. These inequalities are also called "digital divide" (Gibbons & Ruth, 2006; Middleton et al., 2006; Neff, 2007; Tapia et al., 2011). At the beginning of the third millennium, broadband penetration rates in the U.S. lagged behind those of other countries, and this led to the fact that especially low-income people and those living in rural areas did not have access to this technology and were somehow cut off from today's information society (e.g. in terms of access to educational, professional and social opportunities). UN Secretary General Kofi Annan effectively summarized the problem with the following words "[...] people lack many things: jobs, shelter, food, health care and drinkable water. Today, being cut off from basic telecommunications services is a hardship almost as acute as these other deprivations, and may indeed reduce the chances of finding remedies to them" (UN Secretary General, Kofi Annan, in a keynote addressed to the International Telecommunication Union, Oct. 9, 1999 in Mandviwalla et al., 2008, p.72). Both communities and municipalities recognized this problem and considered Wi-Fi technology to be a viable alternative to bring Internet connectivity in low-density, isolated, disadvantaged and rural areas, where laying cables would be too expensive (Wong & Clement, 2007). This could be seen as an answer to market failure (Lehr et al., 2006). Municipalities and communities thus wanted to engage in providing infrastructures in areas that are not interesting for the private sector or where there is not enough competition to guarantee a good level of service and in this way, help bridge the digital divide (Baker et al., 2009; Baker et al., 2010; Bar & Park, 2006; Christensen, 2006; Dingwall, 2006; Gillett, 2006; Heer et al., 2010a; Infante et al., 2007; Kolko, 2006; Mandviwalla et al., 2008; Middleton et al., 2006; Middleton, 2007; Middleton et al., 2008; Van Audenhove et al., 2007).

However, the problem regarded not only people living in rural areas but also people living in cities who could not afford current prices applied by the private sector (Chesley, 2009) and people with disabilities (Baker et al., 2009). Baker et al. (2009) advocate that a proper

design of MWNs offers increased access to information and services for people with disabilities and thus helps address also the so-called "disability divide" (p.47).

Aiming at fostering digital inclusion led especially municipalities to think in larger terms than it might have been fruitful. The goal became providing ***primary Internet access*** to people's houses and not simply covering public spaces anymore (Bar & Park, 2006; Middleton, 2007). In this way, municipalities entered in direct competition with the private sector, which started lobbying against municipalities stepping in the telecommunication market, a fact that finally led to the discontinuation of many projects (Chesley, 2009; Forlano, 2008a; Jassem, 2010).

Whether public Wi-Fi networks ***really manage to bridge the digital divide*** and foster digital inclusion remains an open issue. Fuentes-Bautista & Inagaki (2006) argue that public Wi-Fi networks tend to further enhance disparity by improving connectivity mainly in popular areas of a city like the center, commercial districts or tourist attractions while leaving behind underserved areas and less wealthy neighborhoods. Furthermore, it is often not enough to simply provide connectivity to disadvantaged areas, but educational programs and low-cost devices are needed to ensure that people take advantage of these new technologies (Tapia & Ortiz, 2008b).

2.4.2 Goals Specific to CWNs

There are some goals that are more specific to communities. One is ***challenging private ISPs*** by increasing the availability of broadband access and lowering its cost, but also by improving "democratic ownership over public goods" (Wong & Clement, 2007, p.277). CWNs aim at providing Wi-Fi connectivity based on a decentralized, bottom-up approach created by users for users without aiming at financial profit as telecommunication operators do. Another goal for Wi-Fi communities is ***technical experimentation*** (M. Oliver et al., 2010; Sandvig, 2004). People involved in communities are often technical enthusiasts who like to play and experiment with technologies and set up their own pioneer systems that meet the specific needs of local communities. Communities provide them ways to meet and exchange ideas with likeminded people who together might push technology forward. In this way, communities also aim at ***improving social relations*** and creating community feelings among members and the local community they serve (Wong & Clement, 2007) and foster social cohesion (Hampton et al., 2010; Lambert et al., 2014).

2.4.3 Goals Specific to MWNs

The implementation of public Wi-Fi networks is part of cities' strategies to become ***"digital" or "smart" cities.*** The widespread availability of Wi-Fi connectivity allows municipalities to foster growth, efficiency, productivity and competitiveness (Yovanof &

Hazapis, 2009; Lambert et al., 2014). Most arguments in favor of public Wi-Fi deployment used by municipalities and addressed in existing research aim at improving one or more ***e-government relationships*** between municipalities and stakeholders such as citizens (G2C), other municipalities/governments (G2G), visitors (G2V), businesses (G2B), non-profit organizations (G2N) and employees (G2E) (Kalbaska et al., 2016; Kalbaska et al., 2017). The following section, thus, makes an effort to explain how the various goals brought up by municipalities can be considered as part of an overall e-government strategy that aims at taking advantage of ICTs to improve services, create better relationships and, in general, improve quality of life for residents, tourists, employees and business people (Shaffer, 2007). By addressing different e-government relationships, the deployment of public Wi-Fi services is expected to contribute to cities' efforts toward becoming "smart" and digitally-oriented.

2.4.3.1 Improving G2C Relationship – Better Serving Citizens

Fostering ***digital inclusion*** has already been described as one of the major motivation of municipalities (but also of communities) to implement their own Wi-Fi networks (see section 2.4.1). This goal mainly addresses the G2C relationship. Improving access to broadband connectivity for all fosters social inclusion and consequently directly impacts on citizens' welfare and positively influences the relationship between municipalities and citizens.

Another aspect capable of improving services to citizens is linked to the policy debate whether broadband Internet access should be considered as a ***public good/utility*** (debate already discussed in section 2.3.3) and as such provided by municipalities on the same basis as water or electricity (McChesney & Podesta, 2006; Middleton et al., 2006; Middleton, 2007; Powell, 2008a; Shaffer, 2007; Tapia et al., 2009; Wong & Clement, 2007). The former CIO of the City of Oulu went as far as defining open wireless networks as a civil right (Ylipulli et al., 2014). Many municipalities considered the provision of public Wi-Fi networks as a "natural extension of their on-going activities" (Bar & Park, 2006, p.111) and wanted to provide it to their communities at reasonable prices or even free of charge (Van Audenhove et al., 2007). Hence, the idea of public good reflected the desire for free Internet for everyone everywhere (Clark, 2002; M. Estevez, 2006; Middleton et al., 2006; Middleton, 2007) and links back to the previously described goal of digital inclusion.

Another goal of MWN's addressed mainly to citizens is ***civic participation***. Through the implementation of MWNs, cities expect to positively influence public participation in government activities (Chesley, 2009) and civic debates (Bar & Park, 2006) by empowering citizens and allowing them to "organiz[e], debat[e] political issues, and acquir[e] information via the Internet" (Mandviwalla et al., 2008, p.75). In this way,

MWNs would allow to increase civic engagement both online and offline (Middleton et al., 2006; Middleton et al., 2008; Powell & Meinrath, 2008) and contribute to "higher overall levels of democratic and social engagement" (Hampton et al., 2010, p.701).

Furthermore, cities expect MWNs to ***increase public safety*** (Chesley, 2009; Tapia & Ortiz, 2008b; Tapia et al., 2011) by offering citizens a channel through which they can report issues related to public safety such as natural disasters, terrorism, incidents, traffic or health issues. As such, MWNs facilitate the sharing of information and help improving communication between citizens and city employees.

The entrance of municipalities in the telecommunication market might also help ***stimulating competition*** in the broadband market (Infante et al., 2007), which might eventually result in improved services and cheaper prices for end-users (Middleton et al., 2006; Middleton et al., 2008).

2.4.3.2 Improving G2B Relationship – Fostering Economic Development

With the deployment of public Wi-Fi networks, cities also want to foster ***economic development*** and thus support local businesses and contribute to the creation of an attractive market environment (Ballon et al., 2009; Dingwall, 2006; Gillett, 2006; Heer et al., 2010a; Lambert et al., 2014; Middleton et al., 2006; Tapia & Ortiz, 2008b; Tapia et al., 2011). It is expected that public Wi-Fi attracts businesses or conventions (Bar & Galperin, 2004; Bar & Galperin, 2005) but also commercial travelers and tourists (Middleton, 2007) to cities and city areas where Wi-Fi infrastructures are deployed. Therefore, MWNs are expected to attract new investments and jobs that can spur economic growth (Van Audenhove et al., 2007). Being able to offer free Wi-Fi connectivity might be a critical advantage for smaller businesses such a coffee shops, hairdressers or shops. In a study by Forlano (Forlano, 2008a), respondents confirmed that if they had the choice between two similar coffee shops, 75% would choose the one that offers Wi-Fi access. Only 5% of the respondents stated that the availability of Wi-Fi was not a factor influencing their decision (Forlano, 2008a). Public Wi-Fi should also help lower the costs of Internet provision for less wealthy people and small businesses so that they can use and invest the gained profit in other activities or commodities (Forlano, 2008b). Altogether, MWNs allow increasing the value of a city's territory (Infante et al., 2007). Public Wi-Fi networks thus have the potential to enhance attractiveness, competitiveness and productivity of a city and its businesses (Ojala et al., 2008) and as a result it can ***encourage local innovation*** for example in the form of improved municipal services or applications to be used on the Wi-Fi network (Ballon et al., 2009; Fuentes-Bautista & Inagaki, 2005; Heer et al., 2010a; Infante et al., 2007; Middleton et al., 2006; Middleton et al., 2008).

2.4.3.3 Improving G2E Relationship – Wi-Fi for Employees and City Operations

Deploying their own Wi-Fi networks allows municipalities to provide functional Internet connectivity not only to city staff working in offices but also to employees like policemen or public maintenance staff who regularly work in city's outdoor areas (Ballon et al., 2009; Bar & Park, 2006), away from headquarters. Widespread Wi-Fi connectivity allows them to have access to the Internet and the city' Intranets and simplifies the exchange and collection of information (e.g. parking meter reading, traffic monitoring, security surveillance, etc.) (Heer et al., 2010a). In other words, a well performing public Wi-Fi network helps city employees to efficiently deliver city services and thus supports the supply of city operations (Fuentes-Bautista & Inagaki, 2005; Gillett, 2006; Heer et al., 2010a; Infante et al., 2007; Middleton et al., 2006; Middleton et al., 2008; Van Audenhove et al., 2007). Self-provisioned Internet connectivity also allows cities to make savings in telecommunication expense as they do not have to rely on private ISPs (Ballon et al., 2009; Bar & Park, 2006; Infante et al., 2007).

2.4.3.4 Improving G2V – Promoting Tourism

As international roaming costs still make the use of cellular 3G/4G Internet connectivity very expensive for end users globally, visitors and tourists are a particularly interesting target group for MWNs. For them, the utility of a public Wi-Fi network is even bigger than it might be for locals, as they do not have a lot of alternatives to get connected to the Internet at reasonable prices. Furthermore, for tourists and visitors, accessing the Internet is particularly relevant as it allows them to access information on the place they visit, identify tourist attractions, look up events or opening hours, get directions on up-to-date maps, find retail shops, book a car, read hotel/restaurant/museum reviews or stay in contact with family and friends back home (M. Estevez, 2006; Heer et al., 2010a). Thus, "wireless access is fast becoming the indispensable tool of the leisure or business visitors" (M. Estevez, 2006, p.1). Providing cheap if not free broadband connectivity to visitors allows a municipality to make their stay as simple and pleasant as possible, providing, in this way, a good hospitality level (M. Estevez, 2006). This again helps make a city attractive to visitors. As a result, public Wi-Fi networks can be a useful tool to ***promote and support tourism*** (Ballon et al., 2009; Lambert et al., 2014; Ojala et al., 2008; Tapia & Ortiz, 2008b; Van Audenhove et al., 2007).

Also within the city itself Wi-Fi areas can be used to ***attract people to attractions*** or special places of interest (Forlano, 2008a; Hampton & Gupta, 2008) and even to provide information on them through the punctual use of landing pages of Wi-Fi networks (Picco-Schwendener et al., forthcoming). The Wi-Fi network can therefore be used to provide additional services to visitors (Infante et al., 2007). This is fundamental also for ***conventions/conferences***. Having infrastructures that provide good and cheap Wi-Fi

Internet access to attendees and organizers makes convention centers more attractive to potential organizers. As a consequence, being able to attract large conventions means attracting a large number of visitors to a city (E. Fraser, 2009; Mandviwalla et al., 2008).

A functional public Wi-Fi network makes it possible to use traveling and waiting time in a productive way (Doyle, 2011), transforming public spaces also into productive spaces.

2.4.3.5 Gap between rationales and what happened

As it is often the case with e-government projects there has been a gap between the previously presented rationales and what actually happened, a so-called design-reality gap (Heeks, 2001; Heeks, 2002). Many of the rationales have in fact never been realized like for example the exchange and collection of information on parking meter reading, traffic monitoring, security and surveillance. The following overview shows which rationales have been realized to a larger or smaller extent:

To a large extent	In part	To a small extent
Digital inclusion, Internet as public good, economic development, Internet for public administration staff, promotion and support of tourism, attracting people to tourism attractions	Challenging private ISPs, improve social relations, encourage local innovation	Remote collection and exchange of information, civic participation, increase public safety, stimulating competition in broadband market (just in form of getting cities as clients)

Table 3 - Degree to which rationales have been realized as of today

2.5 The Swiss Market of Public Large-Scale Wi-Fi Networks

Switzerland is a particularly interesting market for public large-scale Wi-Fi networks for several reasons: first of all mobile data consumption in Switzerland is still expensive if compared to other countries and especially roaming rates are very high, for both foreigners coming to Switzerland and Swiss people going abroad. Providing free Internet connectivity might thus be an important aspect for attracting business and leisure tourists. Furthermore Switzerland is a very dynamic market with a federal system which grants big autonomies to regions (so-called cantons) and cities. This again, facilitates the development of public large-scale Wi-Fi networks.

The first public large-scale Wi-Fi networks in Switzerland emerged around the year 2005/6 but the vast majority of them appeared only after the turn of the new decade. In the last years, more and more municipalities, communities, ISPs and 3rd-party companies

decided to implement Wi-Fi networks in Switzerland's public spaces in order to provide free or cheap connectivity to citizens, visitors and teleworkers. However, in Switzerland public Wi-Fi access is not something you can take for granted yet. Various cities engaged in MWN initiatives but some explicitly decided against public Wi-Fi. For example, Bern, Switzerland's capital in 2015 decided against setting up a city-wide Wi-Fi infrastructure because it was considered too expensive. Neither in Basel nor Zürich there is a MWN, mainly because of the opponents' fear regarding radiation exposure (P. Kramer, 2015). Another example is Winterthur, where in 2012 the city council decided that public Wi-Fi access was not to be part of the "Service Public" (Winterthur beerdigt WLAN-Projekt, 2012).

The following sections focus on existing initiatives of public large-scale networks in Switzerland and try to organize and explain them with the help of the model of public large-scale Wi-Fi introduced in section 2.2, which is an extension of Heer et al.'s (2010a) framework of Organization of Large-Scale Wi-Fi Networks. In this way, this section wants to validate the attributes of the model with the help of Swiss cases of public large-scale Wi-Fi networks.

2.5.1 Framing Swiss Public Large-Scale Wi-Fi Networks

In order to provide a detailed overview and classification of existing public large-scale Wi-Fi networks in Switzerland, a framework based on the "interplay of the entities that build and maintain the wireless infrastructure as well as the back-end" proposed by Heer et al., (2010a) is used as basis and extended to match and represent the complexity of relationships between the various actors involved in the deployment of Wi-Fi networks in Switzerland. Heer et al.'s model takes into consideration various players that can be involved in the deployment of public large-scale Wi-Fi networks and their interplay. It distinguishes between ***provider-driven, municipality-driven and user-driven networks*** and any combination of them (figure 6).

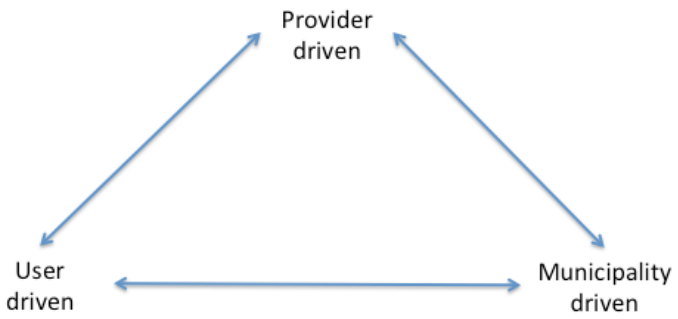


Figure 6 - Organization of Large-Scale Wi-Fi Networks (Heer et al., 2010a)

Provider-driven Wi-Fi networks are those initiated and operated by commercial ISPs. Their services might be available to single users or to municipalities. A famous example of a provider-driven public Wi-Fi network is Wireless Philadelphia, which was initiated, financed, deployed and operated by the ISP Earthlink (Breitbart et al., 2007). ***User-driven networks*** are the basis of Wi-Fi communities where private individuals share their home Internet access with the community. Each member is responsible and takes care of its own AP. The advantages of this option are its cheap deployment and low operation costs. The only costs the community has to bear are those of authentication and service infrastructure. ***Municipality-driven*** networks are networks planned, commissioned and run by a city administration with the idea of providing Internet access to city employees, citizens, businesses and tourists in some areas of a city.

Heer et al.'s framework covers the three main driving forces/actors for the deployment of public large-scale Wi-Fi networks presented already in section 2.2. However, the term "provider- driven" does not seem to be sufficiently accurate to represent all types of commercial actors/forces involved in Switzerland's existing public Wi-Fi initiatives. It is thus necessary to introduce a fourth driving force, called ***3rd-party-driven.*** This allows distinguishing between those commercial entities whose main goal/mission is the provision of broadband services like ISPs (provider-driven) and all other non-public entities (3rd-party-driven). This last group is called 3rd-party-driven as providing Wi-Fi services is not part of their core business but might simply support it. A 3rd-party can be a public transportation company, a retail-store, restaurant, hotel, airport or the local tourism company promoting the territory. 3rd-party entities provide Wi-Fi connectivity as a way to attract customers and incentivize them to consume goods related to their main activity. They are typically commercial entities but not always: also a non-profit association like for example Freifunk can be considered as a 3rd-party.

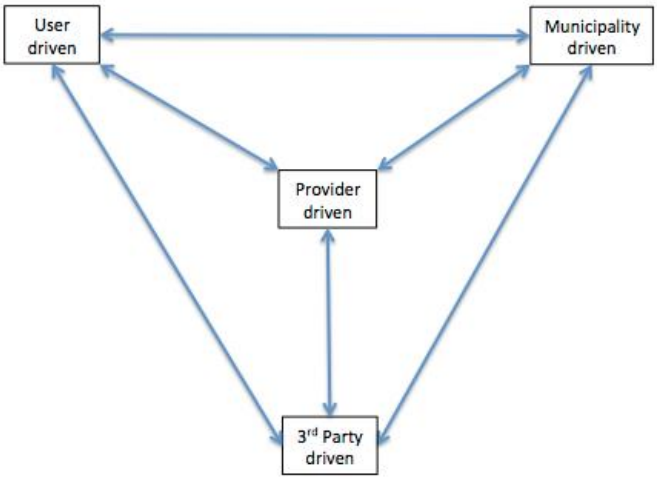
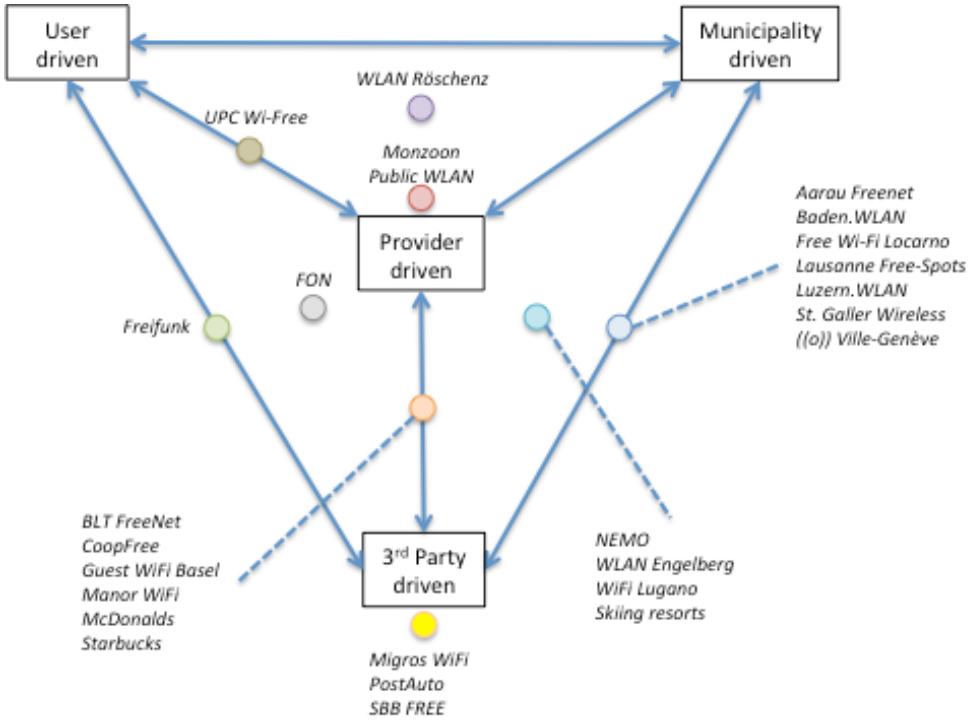


Figure 7 – Extended Framework of Organization of Public Large-Scale Wi-Fi Networks

In many public Wi-Fi initiatives, two or more driving forces are involved. These initiatives thus become an ***interplay between different driving forces***. MWNs for example are typically a combination of municipality-driven and provider-driven forces as they outsource the deployment and operation of the network to a provider. Furthermore, 3rd-party actors like a tourism organization are frequently involved. Heer et al. (2010a) even hypothesizes "architecting City-Wide ubiquitous Wi-Fi access" (p.589) by combining user- and municipality-driven models. They use the term "collaborative municipal Wi-Fi" for a MWN in which "users contribute to the network infrastructure or local services" (Heer et al., 2010a, p.592). Another example is Fon, one of the largest Wi-Fi communities, which is a combination of user-, provider- and 3rd-party-driven solution where users operate the single APs by sharing their Internet connectivity (provided by an ISP) while a 3rd-party company behind it "manages and controls all Wi-Fi related aspects of the network (i.e. user management, access control, and billing)" (Heer et al., 2010a, p.590-591). The adapted framework, including also "3rd-party-driven" networks is shown in figure 7.

This framework does not take into account how a public Wi-Fi network is funded, how it is technically implemented and whether it provides its services for free or against payment.

Several Internet searches have been done on public WLAN and Wi-Fi in Switzerland, (mainly using the search engine Google) and updated in July 2017 in order to identify public large-scale Wi-Fi networks in Switzerland. A more systematic search has been done to identify initiatives where a municipality is involved, by specifically looking for public Wi-Fi initiatives of all political and economic capitals of Switzerland's 26 cantons. Information on the identified public large-scale initiatives has then mainly been gathered from the networks' promoter and/or provider websites and online newspaper articles reporting on the provided services. In some cases, the promoters have been contacted by phone in order to get further explanations. The provided overview does not want to be a comprehensive list of all public large-scale Wi-Fi networks but it rather gives an insight into the most important and largest ones. Figure 8 shows how the different Swiss initiatives can be mapped on the previously illustrated model.



→ Circles are colored the same way as the rows in table 4

Figure 8 – Position of Swiss Public Large-Scale Wi-Fi Networks on the Extended Model of Organization of Public Large-Scale Wi-Fi Networks in Switzerland – Situation Feb. 2018

2.5.2 Mainly Provider-Driven Wi-Fi Networks

Swisscom, Switzerland's leading Telecommunication Company, implemented an extensive network of public Wi-Fi APs (Swisscom, 2018). Its network is called "*Swisscom Public WLAN*" and comprehends more than 5'000 hotspots in the whole country. It is available for free for most Swisscom clients and against a fee also to other users. The main rationale behind its implementation is allowing offloading mobile data from Swisscom's 3G/4G/LTE cellphone network, which registers continuously growing traffic. In fact, where available, customers can use Swisscom's Wi-Fi network instead of its mobile data network.

Another important telecommunication player in the provisioning of public Wi-Fi connectivity is the WISP ***Monzoon*** (Monzoon Networks AG). This Swiss telecommunication company was one of the first operators of public wireless Internet access in Switzerland and currently operates Wi-Fi networks at 920 locations across the whole country (Monzoon Networks AG, 2018). It has its own Wi-Fi network called

"*MONZOON",* which is implemented mainly in shops owned by the company such as the mobile phone retailer Mobilezone but also in restaurants, hotels, airports, and exhibition centers. This shows that Monzoon and in part also Swisscom need to rely also on partnerships with other 3rd-party entities to implement their services in commercially relevant locations. By doing so their public Wi-Fi networks are not purely provider-driven anymore but they are in part also 3rd-party-driven. Monzoon sells its services to both individual users who can buy metered or flat time-limited access or monthly subscriptions to access all "MONZOON" hotspots, and to 3rd-party companies such as, for example, McDonalds, for which they deploy Wi-Fi networks with an own SSID. At the same time these 3rd-party networks complement and extend the "MONZOON" network (Monzoon: Gestrauchelter Blitzstarter, 2003; Monzoon Networks AG, 2018).

2.5.3 Purely 3rd-Party-Driven Wi-Fi Networks

There are three public large-scale networks that can be considered as purely 3rd-party-driven. They are operated by companies whose core business is not related to telecommunication services but which are still registered as telecommunications service provider (TSP)[8] at the OFCOM (Federal Office of Communications OFCOM, n.d.). These companies are not considered as provider-driven, since the main rationale behind their involvement in a Wi-Fi initiative is providing customers of their core business with improved additional services and being able to manage the network, its authentication and user data by themselves without having to rely on another ISP. The three companies are SBB, the Swiss Federal Railway Company[9], PostAuto AG, the leading bus company in Switzerland's public transport network[10], and Migros, Switzerland's largest retail company and supermarket chain[11].

Since 2012, ***PostAuto*** equipped 1'700 post buses to provide free Wi-Fi connectivity to the passengers and as such it has been the 1st public transport company in Switzerland to offer a free Wi-Fi network on public transport vehicles. The company implemented the "*PostAuto*" Wi-Fi network because it is convinced that "Internet access in public transport meets with the ever-increasing needs of customers" (PostAuto, 2018). Wi-Fi access can shorten the felt travelling time and improve the travel experience of passengers (Huber & Suhner, 2013; PostAuto, 2018).

Between September and November 2013, ***SBB*** equipped Switzerland's 80 most frequented railway stations with Wi-Fi connectivity. Its Wi-Fi network, "*SBB FREE*",

[8] Elsewhere in this dissertation we refer to TSPs as ISPs

[9] Swiss Federal Railway Company SBB – www.sbb.ch/en.

[10] PostAuto AG – www.postauto.ch/en.

[11] Migros – www.migros.ch.

allows travelers to connect to the Internet for free for 60 minutes. A registration with a mobile phone number and a SMS code is necessary to access the Wi-Fi network. With its free Wi-Fi network, SBB wants to provide users access to up-to-date news and useful information about the station (e.g. shop opening hours or special offers). In return for the free service, SBB gathers usage data and creates usage and movement profiles in order to optimize the flow of people in stations (Steiger, 2013). At the end of 2015 they already had 950'000 registered users (Barandun, 2013; SBB, 2018a; SBB, 2018b); SBB plans to test Wi-Fi provision on international trains but does currently not want to introduce Wi-Fi on on trains travelling within Switzerland only (SBB: Züge fürs Ausland sollen mit WLAN ausgerüstet werden, 2016; Fueter, 2016).

Migros is the first retail company in Switzerland that offers a comprehensive free Wi-Fi network ("*MIGROS WiFi*") to its clients. The company started equipping all its retail stores, supermarkets and restaurants with Wi-Fi in September 2014. Once registered with a mobile phone number, users get automatically connected as soon as a Migros Wi-Fi network is in range. The reasons behind building Wi-Fi networks are: overcoming the partially bad cell phone reception in stores, and fostering the use and improving the usage experience of the Migros mobile application (Migros-corp-com, 2014). According to spokeswoman Martina Bosshard, Migros wants that its clients can compare prices and leave comments on Migipedia (Diggelmann, 2014a)

2.5.4 3rd-Party-Driven Wi-Fi Networks with Outsourced Providers

In the previous section, all those 3rd-parties acting as TSP have been described. However, this is the less common option. Generally, 3rd-party companies partner with existing ISPs in order to provide Wi-Fi connectivity to customers. This is the case for all the following 3rd-party entities. ***BLT AG***[12]***,*** the Baselland Transportation company, for example, has been offering a Wi-Fi network on its trams since 2012 ("*BLT FreeNet"*) in collaboration with Swisscom (BLT Baselland Transport AG, 2018; Müller, 2012), while ***Coop***[13], one of Switzerland's largest retail and wholesale company has partnered with Swisscom to offer free Wi-Fi connectivity in its stores (Coop, n.d.). ***Basel Tourism*** in collaboration with the local company for energy, water and telecom, which acts as ISP, provides a wireless network in the city of Basel covering the main tourist attractions. Its Wi-Fi network "*Guest WiFi Basel*", however, is available only to hotel guests (they receive a code from the hotel), as it is financed through the local tourist tax, a possibility also suggested by (Evenepoel et al., 2012). The network has been created in response to the decision of the canton Basel Stadt not to invest in a city-wide Wi-Fi network for financial reasons. Basel

[12] BLT AG – http://www.blt.ch/en.html.

[13] Coop Group – http://www.coop.ch/en/about-us/company.html.

Tourism argues that a city Wi-Fi network is an important promotion tool as it allows guests to actively use social media and upload pictures of the city. Furthermore, it wants to give tourists the possibility to have access to information and maps (Gratis-WLAN in Basel – aber nur für Touristen, 2017; Neu gibts für Hotelgäste in Basel ein Gratis-WLAN, 2017; Basel Tourismus, 2018; Feller, 2016). Other very popular examples are the Wi-Fi networks of McDonalds – "*McDo Free WiFi*" (Adelsgruber, 2009), Starbucks – "*STARBUCKS*" (Starbucks Corporation, 2016) and the Swiss retail store Manor[14].

The only difference of these 3rd-party- and provider-driven networks when compared to exclusively provider-driven Wi-Fi networks is that they do not act as ISPs themselves but outsource this task to a partner company. They are similar to municipality- and provider-driven networks, but instead of being promoted by a municipality they are promoted by a 3rd-party company.

2.5.5 Municipality- and 3rd-Party-Driven Networks

Most MWNs in Switzerland are 3rd-party-driven networks. A city, village or canton partners with the local electricity, water and/or energy company, which acts as TSP (similarly to for example SBB, which is registered as TSP at the OFCOM). Collaborating with the local electricity, water and Energy Company makes sense as these companies generally manage and operate already existing city infrastructures such as street and traffic lights, which can serve as basis upon which to install APs for the Wi-Fi network.

Luzern was the first city in Switzerland to implement a Wi-Fi network in some areas already in 2006. To do so, it partnered with EWL (Energy Water Luzern), the local Electricity and Water Company. The Wi-Fi network is currently undergoing a complete revision with the replacement of existing APs and an extension from 85 to 140 APs by summer 2017 (WLAN für alle macht die Stadt zu Luzern 2.0, 2015; ewl energie wasser Luzern, 2018; Luzern Tourismus AG, n.d.; Vogel, 2016). Luzern aims at becoming "the best public Wi-Fi network in Switzerland" (WLAN für alle macht die Stadt zu Luzern 2.0, 2015, translated from German by A. Picco-Schwendener) by using only newest Gigabit Wi-Fi Technology. This is one step to prepare the city for smart-city applications: head of Marketing at EWL Samuel Schnyder explained to 20Minuten that "in the future parking spaces can communicate the network whether they are free or not, and waste bins when they are full" (WLAN für alle macht die Stadt zu Luzern 2.0, 2015, translated from German by A. Picco-Schwendener). Since 2006, 15'000 users have registered to the "*Luzern.WLAN*" network, 30% of which are tourists (WLAN für alle macht die Stadt zu Luzern 2.0, 2015).

[14] Manor Retail Store – https://www.manor.ch.

Another popular example is the "*Baden.WLAN*" in ***Baden (Kabelloses Gratis-Internet für Baden, 2008; Regionalwerke Baden, n.d.; Stadt Baden, 2018)***. It has been active since April 2008 and consists of 30 APs. It was originally launched as a marketing instrument. However, thanks to the fact that the municipality makes the platform available also to third parties (e.g. city administration, city library, cantonal hospital, casino), the project is about to pay off financially (Adrian Fuchs, head of department Elektrizitätsversorgung at EWL in P. Kramer, 2015). "Yearly 20'000 new users register. Each day there are more than 500 connections to our free network, which are more than 15'000 per month. We are very satisfied by the usage figures" (Adrian Fuchs in P. Kramer, 2015, translated from German by A. Picco-Schwendener).

The "*St. Galler Wireless*" network is promoted by the city of ***St. Gallen*** and operated by the St. Galler Stadtwerke (St. Galler Stadtwerke, 2018). It is in place since 2012 and its main rationale is twofold: reducing radiation exposure for mobile phone users and residents in the city and thus motivating ISPs (mainly Swisscom, Sunrise and Orange) to invest in a low-radiation network, and offering an additional service to citizens, tourists, students and business people. The St. Galler Stadtwerke gathers data only for statistical reasons. From an initial test phase, both a free and a paying option were available. However, usage showed that people were not willing to pay for such a service, and hence, the paying version was abandoned. In May 2014, there were 35'000 connections per day (Gratis-WLAN in St. Gallen wird dauerhaft weitergeführt, 2014; Neue Mediengesellschaft Ulm mbH, 2012).

Other similar MWNs are those promoted by the city of ***Geneva*** – *"((o)) Ville-Genève*" (Geneva.info, 2017; Ville de Genève, 2016; Ville de Genève, 2017a; Ville de Genève, 2017b), ***Lausanne*** – "*Free-Spots Lausanne*" (Citycable, n.d.; Lausanne Tourisme, n.d.; Ville de Lausanne, n.d.) and ***Locarno*** "*FreeWiFi Locarno*" (Locarno amplia il WiFi gratuito, 2014; Città di Locarno, 2014).

The "Aarau Freenet" of the city of ***Aarau***, is promoted through a community of interest composed of commercial entities, the local transportation company, and the municipality and operated by the local energy company IBAarau AG. The network aims at promoting the attractiveness of the city and supporting the commercialization of local businesses. The network is financed through the advertisement of local businesses on the network's landing page while IBAarau covers the infrastructure costs. The network is composed of 30-40 APs that cover the city center. Usage is free, but movement profiles are registered and archived in order to measure visitor flows and use them for marketing reasons (Aarau Info, n.d.; Kuster, 2014; Rohner, 2015; Von Matt, 2016).

2.5.6 Municipality- and 3rd-Party-Driven Networks with Outsourced Providers

Similar to "Aarau Freenet", the "WiFi Lugano", "WLAN Engelberg" and "NEMO" are the result of collaborations between a municipality and various 3rd-party entities, institutions and companies. In addition, they partner with an external ISP for the provision of Internet services. The "*WiFi Lugano*" network is jointly promoted by the city of ***Lugano***, the Lugano Industrial Enterprises (AIL SA), Lugano Casino and Lugano Tourism. In this case, AIL is not acting as a TSP and the provider side is outsourced to another external, private company. The consortium aims at offering free wireless Internet access to citizens, business and leisure visitors to allow them to "do all those things which they would normally do in their office or at home: checking e-mail, looking up their company's intranet or taking advantage of the numerous services offered by the Web" (Lugano Tourism, 2016). Lugano was among the first cities in Switzerland to implement a MWN in some areas in April 2008 and since then it has continuously been improving and extending the network to cover new areas and ameliorate the network's performance. In September 2016, it counted 61 APs (AIL, 2018; Città di Lugano, 2016; Reclari, 2014).

Similarly, also ***Engelberg***, a popular tourist and skiing region in the center of Switzerland, collaborates with the local tourism company (Engelberg-Titlis Tourism AG) and a local cable Internet provider (Tele Alpine AG) to promote their village-wide free Wi-Fi network "*WLAN Engelberg*" (Engelberg-Titlis Tourismus AG, 2018). In April 2017, a pilot phase, during which 20 APs were installed covering nearly the whole public space of the village, ended. According to the village of Engelberg, for Switzerland's tourism it is fundamental to invest in such kind of initiatives, as decisions such as not to follow the EU in abolishing roaming rates are very bad for the country's image. Technical manager of Tele Alpine Philippe von Holzen summarizes users' need for Internet access as follows: "for many, permanent Internet availability is nowadays even more important than running water in their hotel rooms" (Unterschütz, 2017, translated from German by A. Picco-Schwendener). Users want to be able to access and post images on social media all the time and immediately. In May 2017, data of the pilot phase have been analyzed and evaluated. Depending on the results it will be decided (Unterschütz, 2017, translated from German by A. Picco-Schwendener)

whether to continue the service. Up to now strong seasonal differences could be noted, but generally the service has been used extensively (Unterschütz, 2017).

The canton of ***Neuchâtel*** launched an innovative Wi-Fi project with the goal of offering one centralized, reliable, stable and secure system of Wi-Fi access in the public space of the canton by pooling resources and broadcasting infrastructures of different partners. "NEMO" (***NE***uchâtel ***Mo***bile) is, in fact, a public-private partnership, in which partners from the public sector – canton of Neuchâtel, city of Neuchâtel, city of La-Chaux-de-

Fonds – and the private sector – Vidéo 2000 SA, Viteos SA and Arcantel SA – collaborate in developing an infrastructure that allows offering Wi-Fi services to citizens, tourists, students, business travelers and teleworkers in some well-selected areas of the region. The partnership allows reducing investment and operating costs for all involved partners. The initial setup of NEMO required about 135'000 CHF, while its annual operation amounts to about the same cost. The city of Neuchâtel estimates that costs would have been four times higher for a similar installation entirely at its own expense (Monnat, 2016). The shared infrastructure also offers the possibility to other municipalities and companies in the area to join the project and integrate their already existing Wi-Fi networks into the larger NEMO network, or set-up additional antennas and connect to NEMO, allowing in this way the constant expansion of the free Wi-Fi network. An information website (NEMO, 2018) available in four languages provides useful information on the location of APs, the legal framework and the available services. According to Laurent Kurth, State Councillor in charge of Finance and Health, "NEMO presents the vision of a dynamic canton, open to the world and new information technologies" (Monnat, 2016, translated from German by A. Picco-Schwendener). The Wi-Fi network is in fact, part of the canton's strategy towards the creation of more and more smart cities.

Many ***Swiss Skiing resorts*** implemented Wi-Fi networks especially at valley and mountain stations of ski lifts and cable cars and in restaurants (Engadin St. Moritz, n.d.; St. Moritz Tourismus, 2017). "Last year [2016] in anticipation of the ski world championship, additional hot-spots have been installed in order to provide access also in the village of St. Moritz, offer which was very much appreciated by tourists and with a return of image thanks to the publication of photos of the tourist destination on social media" said Roberto Rivola, spokesman of Engadin St. Moritz Tourism (Radiotelevisione Svizzera (RSI), 2017, translated from German by A. Picco-Schwendener). Similar initiatives are proposed by Laax (Diggelmann, 2013), Saas Fee (Gratis-WLAN im Skigebiet von Saas-Fee, 2015; Saastal Marketing AG, n.d.), Davos (Davos Klosters, n.d.) etc., while waiting for the implementation of a cantonal project, in which different locations in Graubünden are interested (Radiotelevisione Svizzera (RSI), 2017). Even though not much detail can be found on the collaborative structure of these networks, it is expected that these Wi-Fi initiatives mainly use a mix of 3rd-party (e.g. tourism board), public entity (village, region, canton) and provider-driven solutions.

2.5.7 Municipality- and User-Driven Networks with Outsourced Providers

Public Wi-Fi networks that are driven by municipalities and private citizens together are not yet very popular. The "WLAN Röschenz" is an example in Switzerland. It is a mix of municipality-, user-, and provider-driven network or a so-called ***Municipal Community Wireless Network***. Röschenz is a small village of about 1'800 inhabitants, situated in the

canton of Basel Land in the very north of Switzerland. It notoriously has very bad mobile data coverage, which makes it very difficult for people to navigate the Web through 3G/4G networks. To overcome this problem, in November 2015, the village council decided to implement a village Wi-Fi network in collaboration with EBL Telecom and the inhabitants. EBL Telecom has a high density of broadband Internet clients in the village and collaborates with UPC/Cablecom, another broadband provider. The providers support their clients in sharing part of their broadband access in order to create a shared MWN. The managing director of EBL Telecom explains that "the many already existing routers in the village, allow to make the signal available on a reserved bandwidth to surrounding areas" (Hofer, 2015, translated from German by A. Picco-Schwendener). With the installation of ten additional routers in buildings near to the village square, EBL Telecom wants to close large coverage gaps. According to mayor Remo Oser, with this network Röschenz's municipality wants to contribute to the image of a young village, able to increase attractiveness through the implementation of new communication options (Hofer, 2015). In order to use the Wi-Fi network, no registration is necessary, the user only needs to agree to the terms of use (Gemeinde Röschenz, 2018; Hofer, 2015). The costs for this municipal community network amount to about 25'000 CHF.

2.5.8 User-Driven Wi-Fi Networks

The particularity of user-driven networks is that they are not rolled out in a systematic and planned way. They follow a more or less community-driven approach where users share part of their home Internet connection with other people in the community, creating a broadly distributed Wi-Fi network. User-driven wireless initiatives have different levels of user involvement: in so-called hybrid communities with a for-profit company at the basis (e.g. Fon and UPC Cablecom) user involvement is typically lower than in purer non-profit communities like Freifunk 3Ländereck. In Switzerland, there are three different collaboration types of user-driven Wi-Fi networks: a) user- and provider-driven communities in the case the community is directly managed by an ISP (e.g. UPC Cablecom) – see section 2.5.8.1; b) a combination of user-, provider- and 3rd-party-driven forces in case the community is managed by a 3rd-party for-profit company (e.g. Fon) – see section 2.5.8.2 ; or c) user- and 3rd-party-driven Wi-Fi networks with two different types of 3rd-parties involved: a non-profit organization acting also as ISP and other commercial entities like restaurants or shops which agree to place an AP in their commercial spaces – see section 2.5.8.3.

2.5.8.1 User- and Provider-Driven Wi-Fi Networks

UPC-Cablecom, is one of Switzerland's leading telecommunication provider. With "*UPC Wi-Free*" the provider claims to have "the biggest WLAN network in Switzerland" (UPC,

2017), with over 500’000 home spots. Each UPC client having a modem can be part of the sharing community. UPC modems, like those of Fon, have two completely independent networks: a private one and a “Wi-Free” for sharing. The private network is always available at full speed as the company comes up for the additional bandwidth required for Wi-Fi sharing (dedicated to “UPC Wi-Free”). The clients who do not want to share their signal can deactivate it (opt-out option). After a pilot phase in St. Gallen, UPC Wi-Free has been deployed in the whole country from August 2014. UPC Cablecom’s main goal for building a public large-scale Wi-Fi network is attracting new clients (Kaat, 2015; UPC, 2017).

2.5.8.2 User-, 3rd-Party- and Provider-Driven Wi-Fi Networks

Fon is a Spanish company that aims at creating the “world’s largest Wi-Fi network, comprised of people sharing their WiFi” (Fon, 2018b). It claims to have 20’000’000 hotspots around the world. While it had a strong community component when it started its activity back in 2005, it now focuses on partnerships with ISPs in many countries. These ISPs include Fon’s software in their routers so that their clients become part of the Fon community and can share their Internet connectivity with others and at the same time profit from free Internet access all around the world. In the earlier years, individuals could become part of the Fon community by buying and installing a “Fonera” router; nowadays, the company suggests getting access through a telco partner: “[c]heck if Fon has a telco partner in your country and sign up for a broadband with them to experience the benefits of being part of the Fon WiFi Community” (Fon, 2018b). For those who are not part of the community, Fon sells hourly or daily Wi-Fi access passes. Initially, when Fon addressed its services directly to the end-user, there was no direct involvement of ISPs and the Wi-Fi network was only user- and 3rd-party-driven. There has thus been an evolution of the organizational model over time.

In Switzerland, since February 2017 Fon has been partnering with an ISP based in the French-speaking part called “Netplus” (Fon Wireless Ltd., 2018; net+, 2018). The jointly promoted Wi-Fi network is called “*net+Fon*”. However, as it is only a minor local provid er, Fon is not widely available in Switzerland and nowadays only very few Fon-spots can be found as shown in figure 9.

More information on the initial development of Fon can be found in Middleton & Bryne (2011).

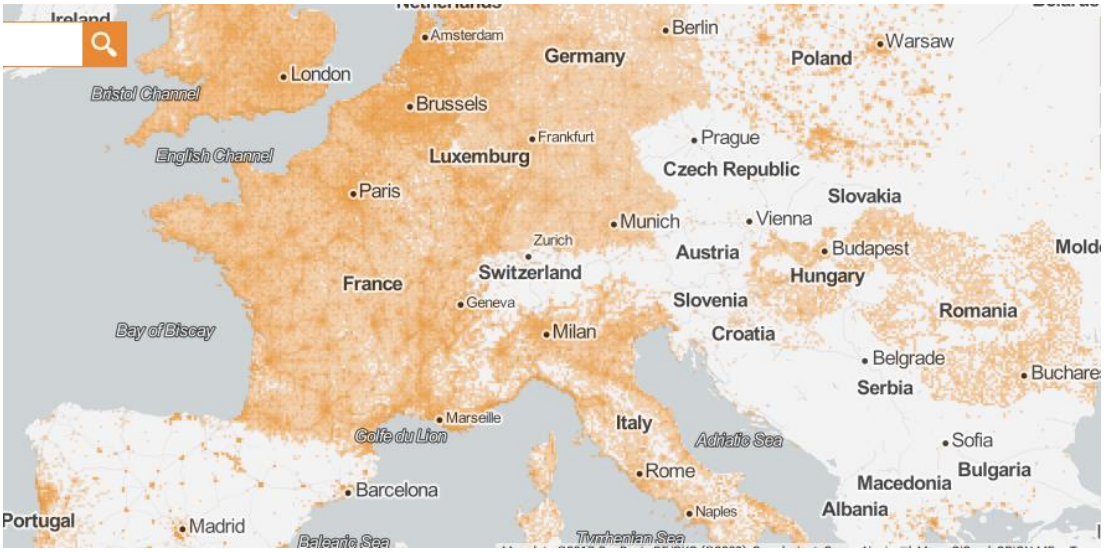


Figure 9 – Distribution of Fon-Spots (Fon, 2018a)

2.5.8.3 User- and 3rd-Party-Driven Wi-Fi Networks

Freifunk 3Ländereck (Freifunk Dreiländereck, n.d.) is part of the Freifunk movement, which was born as a grassroot movement of people setting up mesh-networks and thus sharing Internet connectivity in Germany. It promotes free and open Wi-Fi networks. Freifunk 3Ländereck is a German association acting as ISP for all its users but rolling out its services in the whole "3-Ländereck" (3 country triangle), namely in the region between Germany, France and Switzerland. In Switzerland, Freifunk is available in Basel. There, they started implementing hotspots in the city center after the municipality's decision of not investing in a city-wide MWN because of the expected high implementation and maintenance costs (Neu gibts für Hotelgäste in Basel ein Gratis-WLAN, 2017). Freifunk aims at equipping the whole region with high quality Wi-Fi signal. In order to extend its network, Freifunk has to rely on individuals, shop and bar/restaurant owners to install and operate a Freifunk router and thus to share their broadband Internet connectivity. The various Freifunk routers then connect among each others creating a mesh-network. The association is also looking for collaboration with the city's authorities, as they own many buildings in strategic places. For now, no registration is necessary to connect to the Freifunk network (Freifunk Dreiländereck, n.d.; Hufschmid, 2015).

2.5.9 Overview on Main Public Large-Scale Wi-Fi Networks in Switzerland

The following table summarizes what has been discussed section 2.5. It lists and classifies all the above-mentioned Wi-Fi initiatives according to the various driving forces involved. For each initiative it lists the identifying name (SSID), the type of driving forces involved, the main promoter and its core business area, the date when it was launched, and the network size, which generally consists of the number of APs composing the network. Finally, it also describes the main goals of the network.

Name (SSID)	Type	Main Promoter – Core Business	Since	Size	Goals
MONZOON	P	Monzoon – Telco/WISP		920 Wi-Fi networks	Selling Wi-Fi connectivity with the idea of making "nomadic workers mobile"
Public WLAN	P	Swisscom – Telco	n/a	5'000 hotspots in CH	Offloading of mobile data
MIGROS WIFI	3P	Migros –Retail	2014 Sep.	All stores & restaurants in CH	Overcoming bad cellphone reception; improve usage of own App
PostAuto	3P	PostAuto AG – Public Transport	2012 Apr.	1'700 post buses	Improving image and travel experience; shortening felt travelling time
SBB FREE	3P	SBB – Public Transport	2013 Sep.	80 most frequented railways stations	Providing access to up-to date news and information about train station;
BLT FreeNet	3P-P	BLT – Public Transport	2012 Feb.	All Tango & Be4/8 Schindler trams (route 10, 11, 17)	Providing Internet access to suburban passengers who have longer journey times
CoopFree	3P-P	Coop – Retail	n/a	Most stores in CH	n/a
Guest WiFi Basel	3P-P	Basel Tourism	2017 Jan.	20 APs (by end of 2017); near tourist attractions	Promoting the city through uploading photos on social networks; provide tourists access to information & maps
Manor WiFi	3P-P	Manor – Retail	2011 Jun.	All restaurants & manor food in CH	n/a
McDo Free WiFi	3P-P	McDonalds – Restaurant	n/a	Most branches in CH	Offering additional service to customers
STARBUCKS	3P-P	Starbucks – Restaurant	n/a	Most branches in CH	Offering additional service; making visit more agreeable
Aarau Freenet	M-3P	Aarau – City	2013	Ca. 40 APs in center	Promoting attractiveness of city and supporting local businesses
Baden.WLAN	M-3P	Baden – City	2008 Apr	30 APs in center	Using it as marketing instrument
FreeWiFiLocarno	M-3P	Locarno – City	2011	City center	Providing service for locals & tourists
Lausanne Freespot	M-3P	Lausanne – City	n/a	9 APs in city	n/a

Luzern.WLAN	M-3P	Luzern – City	2006 Sep.	140 APs in center	Preparing city for smart-city applications (metering / waste mng.)
St. Galler Wireless	M-3P	St. Gallen – City	2012 Aug.	n/a	Reducing radiation exposure for mobile phone users and residents → motivate ISPs to invest in a low-radiation network
((o)) Ville-Geneve	M-3P	Geneva – City	2013	635 APs in 78 sites	Democratization of Internet access
NEMO	M-3P-P	***Public:*** Neuchâtel – Canton; Neuchâtel & La Chaux-de-Fonds – City ***Private:*** Vidéo 2000 – ISP; Arcantel – IT provider; Viteos – Energy	2016 Feb.	113 sites (19.2.2016); public places and administrative buildings of Neuchâtel, La Chaux-de-Fonds or Val-de-Travers.	Offering a free, centralized Wi-Fi service in public spaces of the region to citizens, visitors, students and teleworkers; promoting vision of a dynamic canton, open to the world and new information technologies
WLAN Engelberg	M-3P-P	20 APs covering public space	n/a	20 APs covering public space	Promoting location through sharing photos on social media; high roaming rates & importance of Internet access for guests
WiFi Lugano	M-3P-P	Lugano – City	2008 Apr.	61 APs in center, airport, stadium, park	Providing service to locals, tourists and businesses
WLAN Röschenz	M-U-P	Röschenz – village	2015 Nov.	Citizen's hotspots & 10 additional APs in public space	Overcoming bad 3G/4G coverage; increasing attractiveness of location
Freifunk	U-3P	Freifunk 3Ländereck non-profit org. acting as ISP	2015 Mar.	Basel City-Center	Building free, open Wi-Fi networks
Wi-Free	U-P	UPC / Cablecom – Telco	2014 Jan.	500'000 home spots in Switzerland	Attracting new customers
net+Fon	U-3P-P	Fon / Telco	2005	20 mio. worldwide	Allowing users to share their home Internet connection through Wi-Fi

CB = core business; M = Municipality; P = Provider; U = User; 3P = 3rd-Party

Table 4 – Swiss Public Large-Scale Wi-Fi Networks (last updated in Jan., 2018)

2.6 The Two Public Wi-Fi Networks Chosen for This Study

In order to get a better understanding of the social dimensions of public large-scale Wi-Fi networks, two different types of networks available in Switzerland have been chosen: 1) a combination of user-, 3rd-party- and provider-driven network, also called hybrid CWN – the case of the Fon community network, and 2) a municipality- and 3rd-party-driven MWN with outsourced provider – the case of the "WiFi Lugano" network.

The ***Fon community network*** has been chosen as hybrid CWN because at the time of the study (2010–2012) it was the only hybrid community active in Switzerland. The Wi-Free network by UPC/Cablecom has become active only later and certainly contains less community aspects than Fon did at that time. The Freifunk movement on the other hand is a so-called "pure" CWN and was not yet very popular in Switzerland.

Understanding motivations for joining and participating in CWNs has been recognized as a key research issue. Previous studies analyzed motivations in pure CWNs but not much research has been conducted on hybrid CWNs. For this reason, the focus of this study is understanding motivations and concerns of people for joining and actively participating in the Fon community and identifying possible differences between pure and hybrid CWNs.

The study on the Fon community network has been conducted within the Wi-Com project (Picco-Schwendener, 2011), supported by the Swiss National Science Foundation, under grant number 100014-127006. It is important to acknowledge that the Fon of the study period has changed and is different from today's Fon which is much less community oriented.

The "***WiFi Lugano network***" has been chosen as a representative of a Swiss MWN. The city of Lugano was among the first cities in Switzerland (together with Luzern and Baden) to implement a wireless network in some of its areas. As the author's university (Università della Svizzera italiana) is located in Lugano, its municipality has been asked in November 2012 to collaborate in a usage study on the city's wireless network. Both the city and its partner AIL[15] immediately showed interest in supporting the proposed usage study. They provided the author with technical log-data on the network's use and agreed to publish a mobile survey on the landing page of the Wi-Fi network immediately after the login process.

While the first part of the study (based on the Fon CWN) focused on understanding what ***motivates users to share*** part of their home Internet connectivity with others, the second part (based on the "WiFi Lugano" MWN) investigated ***motivations to actively use*** a MWN

[15] AIL – www.ail.ch.

or in other words, aimed at understanding user needs by identifying current usage practices.

3 Community Wireless Networks (CWNs)

"I alone cannot change the world, but I can cast a stone across the waters to create many ripples."

(Mother Teresa)

This chapter presents the research conducted on motivations in hybrid CMNs. It starts by describing what CWNs are, how they emerged and evolved over time and what different approaches pure and hybrid CWNs followed. It then provides a detailed overview of various motivation theories relevant to the context of CWNs and then introduces existing literature on motivations in pure and hybrid CWNs. The provided literature review allows identifying research gaps, defining research questions and explaining the contributions of the study. In the final sections, the outcomes are presented in form of two publications that are part of this cumulative dissertation.

3.1 Background

3.1.1 What Are Community Wireless Networks?

CWNs have, on the one hand, a technical connotation, which has already been described in detail in section 2.3.1 and on the other hand, they include the notion of "***community***", which can be described as a combination of social relationships (Burt, 1992; Cho, 2008; Granovetter, 1977) supported by common ideas/views reflecting a shared identity or interest (Fernback & Thompson, 1995). Tönnies (1955) defines community (Gemeinschaft) simply as 'unity of will' as opposed to society (Gesellschaft). Following these definitions there can be many different types of communities like geographic communities, virtual communities, communities of circumstance or communities of interest (Cantoni et al., 2009; H. Fraser, 2005; Tardini & Cantoni, 2005; Tardini & Cantoni, 2009).

The first to combine the concepts of technology and community were ***Community Networks (CNs)*** that can be considered as precursors of CWNs. They are "technological and social hybrids […] that link people as well as machines" (Cho, 2008, p.6). In fact, CNs have first been created by social groups that wanted to improve communication among members (Szabó et al., 2008) usually following a bottom-up, self-organizing approach without central authority (Bina & Giaglis, 2005). They shared the ideals of promoting universal broadband access and the use of ICTs to "promote local economy and social development, civic participation and community learning" (Longford, 2005, p.3). These ***initial CWNs*** can thus be defined as "loosely-knit communities of wireless enthusiasts

who cooperate to set up and operate a wireless communications infrastructure" (Bina & Giaglis, 2006a, p.618) by providing knowledge, expertise, equipment and time (Bina & Giaglis, 2006a). Simply said CWNs are "a broadband system built by the people for the people" (Negroponte, 2002; Sandvig, 2004, p.580), in which members share their home broadband connection with others through Wi-Fi (Damsgaard et al., 2006; Evenepoel et al., 2012). In this way, they create a widely distributed Wi-Fi network (Heer et al., 2010a). Users and/or community members are thus both "provider and consumer of wireless service" (Damsgaard et al., 2006, p.106). Beyond their non-profit character, CWNs differ from commercial ISPs in that they do not provide any customer care nor service level agreements and do not systematically plan the development of the network (M. Oliver et al., 2010).

The role of the single individuals participating in these communities is thus more central for their success than the technology itself (Medosch, 2006). Hence, the greatest challenge for these communities is "not technical (e.g. building the wireless network) but social: engaging the community, sustaining volunteers and donors, attracting a wide range of users and adopting a sustainable business model" (Abdelaal et al., 2009, p.1).

3.1.2 From Technology to Community Centered Groups

Community based Wi-Fi networks have emerged as an alternative to commercial public Wi-Fi provisioning (Bina & Giaglis, 2006a), thanks to flat-rate Internet connections and cheap Wi-Fi equipment (Schmidt & Townsend, 2003), and the fact that bandwidth seems something natural to share as it always presents some excess capacity (Benkler, 2002; Bina & Giaglis, 2006a). Initially, however, they were mainly built by technological professionals and enthusiasts experimenting and playing with technologies (Abdelaal et al., 2009; Bina & Giaglis, 2006a; Schmidt & Townsend, 2003). They primarily had technical goals and generally failed to address social and policy goals and were therefore not able to really challenge the dominant position of commercial Internet providers (Powell, 2008b; Sandvig, 2004). These first groups tended to be "loosely-organized, decentralized, and somewhat anarchic in their approach" (Powell & Shade, 2006, p.386). Many of these initial projects can be considered as an evolution of amateur radio, packet radio and open source software (Lawrence et al., 2007). It has to be noted that wireless communities, despite their non-profit character, still need to rely on commercial ISPs to provide Internet connectivity to the community network (Readhead & Trill, 2003).

Slowly, however, the focus of these communities shifted from wireless technology itself to using technology as a means for bringing people together (Cho, 2008). In these ***2nd generation wireless communities***, the community aspect started playing a more important role than the "wireless" part (Cho, 2008). These newer communities maintained the grassroots, non-profit character of first wireless communities but now aimed at

implementing free public access to the Internet within cities (Cho, 2008) and "developed a discourse and practice that contextualized Wi-Fi as communication infrastructure built by and for citizens" (Powell, 2008b, p.1073). These communities thus started addressing societal goals like community creation, redefining local culture and communications and making them more democratic (Abdelaal et al., 2009; Powell & Shade, 2006; Powell, 2008b). Powell (2008b) emphasizes the importance of these communities to "create and distribute discourses and practices that mobilize not just geek-publics but community-publics too" (p.1084). Hence, CWNs have to broaden their vision from purely technical discourses to discourses that are relevant for a vaster audience to attract people who are interested and involve in addressing real societal problems to the community.

At first, participants simply left their home APs open, allowing anyone within range to benefit from their home broadband connectivity (Bar & Galperin, 2005; Schmidt & Townsend, 2003). Soon, however, more systematic Wi-Fi community efforts emerged addressing the needs of local communities all over the world and consequently strengthening them (Forlano, 2008a; Middleton & Crow, 2008; Powell & Shade, 2006; Powell, 2008b). Even though most wireless communities have similar ideologies – e.g. realizing free Internet access for anyone, everywhere and challenging the telecom industry –, they vary in size, activities, and the way they are implemented (Forlano, 2008a; Middleton, 2007). NYCWireless, for example, was available in New York's parks and public spaces while Freifunk grows with the help of antennas installed on rooftops and Île Sans Fil concentrates on the proliferation in cafés and retail stores in the city center of Montréal (Forlano, 2008a; Middleton, 2007).

Popular examples of these 2nd wave wireless communities, also called ***pure wireless communities*** are:

- ***Île Sans Fil*** – Île Sans Fil, today ZAP Montréal or ZAP Coop[16], is Canada's most successful CWN (Middleton & Crow, 2008). It is a non-profit group completely run by volunteers, who aim at providing free public Wi-Fi broadband access in public spaces and at fostering local community participation (Middleton & Crow, 2008; Powell & Shade, 2006). To do so they supply "software, hardware, and technical support to people and organizations who want to share their Internet signal" (Powell & Shade, 2006, p.391). Several authors studied ISF including (Crow et al., 2008; Middleton & Crow, 2008; Powell, 2008a; Powell, 2008b).
- ***Wireless Toronto*** – Similar to ISF, Wireless Toronto "is a not-for-profit community group dedicated to bringing no-fee wireless Internet access to public and publicly-accessible spaces in Toronto" (Wireless Toronto, n.d.). On its

[16] ZAP Coop – https://zap.coop

website, Wireless Toronto states: “our aim is to encourage the growth of wireless networking and to build community in interesting and innovative ways” (Wireless Toronto, n.d.). The following authors wrote about the case of Wireless Toronto: (Cho, 2008; Cho, 2006; Powell & Shade, 2006).

- ***NYCWireless*** – NYCWireless (NYC Wireless, n.d.) is a free public network in the metropolitan area of New York City. It aims at “providing free wireless service in public spaces, including parks, coffee shops, building lobbies, etc.” (Rao & Parikh, 2003a, p.481). Any real estate facility like for example Bryant Park in Manhattan can become partner of NYCWireless. NYCWireless then implements hotspot zones in the locations or buildings designated by the partner and consequently enlarges the availability of the CWN (Rao & Parikh, 2003a; Rao & Parikh, 2003b).
- ***Freifunk*** – Freifunk is a German “non-commercial initiative for free wireless networks” (Freifunk, 2017). It focuses on the development of open-source software enabling mesh networking (Middleton & Potter, 2008). Their vision is “the democratization of the media through free networks” (Freifunk, 2017). In the existing literature, among others, Middleton & Potter (2008), Behling (2010) and Hardes et al. (2017) have researched different aspects of the Freifunk initiative.
- ***Guifi*** – Guifi was a response to Spain’s low Internet penetration rates. It originated in Osona, a rural area in Catalonia (Spain) where it started as a self-organized community initiative. However, “it immediately got support from local municipalities in Osona, which financed nodes for the mesh network to provide broadband in areas where there was no commercial ISP coverage” (M. Oliver et al., 2010, p.457). Guifi has been defined as a “telecommunications network that links people” (Guifi.net, 2018). As such, it has a strong community part in which technical transparency and self-regulation are fundamental aspects (M. Oliver et al., 2010).

The development of these pure communities has often been limited by “commercial, technical, social and political barriers” (Shand et al., 2003). However, their main problem has been that they were not able to attract enough members to reach a critical mass: probably they did not offer enough incentives and were not able to reassure people enough about legal and security concerns.

3.1.3 Towards Hybrid CWNs

Hybrid communities follow a slightly different approach to develop community networks (Middleton et al., 2008). They are usually established and managed by a for-profit company supporting the community by providing hardware and software solutions for a secure sharing of the home Internet signal (e.g. authentication procedure, routers splitting

private and public signal, etc.) (Middleton et al., 2008). With the support of commercial companies, hybrid communities have managed to grow relatively quickly during the first decade of the 21st millennium. They have been able to attract several thousand members and capture the interest of other important commercial partners like BT in UK and Neuf in France. The fact that a company provides ready-to-use solutions, offers incentives and addresses users' concerns by providing security and authentication solutions favors trust in these networks and attracts many members. Hence, the presence of a supporting company within a wireless community might play an important role in influencing members' motivations and participation. It is thus important to distinguish between pure and hybrid communities in order to understand how each community type can best attract members and foster active participation. Typical examples of hybrid CWNs are Fon and Meraki:

Fon – see sections 2.5.8.2; 3.5.1.3 and 3.5.2.3

Meraki – Meraki does not directly operate networks, but "sells equipment to individuals and communities to allow them to create shared broadband infrastructures using a mesh network approach" (Middleton & Potter, 2008, p.7). Their goal is to enable communities to implement their own Wi-Fi networks (Middleton & Potter, 2008). "By simplifying powerful technology", they want to "free passionate people to focus on their mission and reach groups previously left in the darkness" (Cisco Systems, 2018).

3.2 Motivation Theories Relevant to the Community Context

Understanding motivations is part of understanding human behavior and means comprehending the reasons why people act and behave in a certain way (Elliot & Covington, 2001) or why they are moved to do something (Ryan & Deci, 2000). According to Ryan & Deci (2000), people can have different levels (from weak to strong) and also different types of motivation (orientation of motivation). This is also true for CWNs, which people might join to get free Wi-Fi Internet access in a certain area or to help provide affordable Internet to everyone, or again because of more personal interests such as learning about new technologies and exchanging knowledge with like-minded people. This shows that the "nature and focus" (Ryan & Deci, 2000, p.55) of motivation for joining and participating in a community can vary considerably.

Understanding the relation between human behavior, motivations and technology adoption has been a popular research issue in many disciplines like psychology, sociology, economics and information systems. This relation has been explored from various viewpoints and applied to many different domains/contexts and consequently many theoretical models have been developed to explain human behavior (Camponovo, 2011).

In order to understand what motivates people to join and actively participate in a hybrid CWN and thus provide Internet connectivity, different studies of user motivation in different types of virtual communities have been considered.

To provide an overview, the motivation theories that are most relevant to community participation, technology adoption and the context of hybrid CWNs have been identified and grouped into ***four main streams***: the first one regards the ***Self Determination Theory*** (SDT), which distinguishes between extrinsic and intrinsic motivations; the second category considers theories on ***intentional decision making in technology adoption***; the third stream focuses on theories related to ***pro-social behavior and volunteering***; and the last category groups ***various other theories*** relevant to the context, which do not fit in the previous three groups (e.g. idea of exchange, innovation diffusion theory, expectation-confirmation model). In the following four sub-chapters, the motivational theories used for this study, grouped into the above-mentioned four categories, are explained. An overview of all considered motivational theories can be found at the end of this section in table 5.

3.2.1 Self-Determination Theory (SDT)

The first stream consists of the SDT, a theory that explains motivation of people within a social context. Unlike other theories, it does not treat motivation as a unitary concept that can only differ in intensity (strong – weak) but distinguishes different types of motivations. "The most basic distinction is between ***intrinsic*** motivation, which refers to doing something because it is inherently interesting or enjoyable, and ***extrinsic*** motivation, which refers to doing something because it leads to a separable outcome" (Ryan & Deci, 2000, p.55). ***Intrinsically*** motivated people perform an activity because they have fun doing it, because it entails a challenge or because it satisfies some "basic human needs for autonomy, competence, and relatedness" and not because of some external pressures or rewards (Ryan & Deci, 2000, p.54). On the other hand, ***extrinsically*** motivated people do something because they expect either some tangible (money), social (approval and status) or psychological rewards (self-esteem, pride, avoid guilt or anxiety) in return.

It is possible that people are driven by more than one motivation type and there are studies suggesting that intrinsic motivation can be negatively influenced by extrinsic motivation resulting in a crowding-out effect (Gagné & Deci, 2005).

3.2.2 Intentional Decision Making in Technology Adoption

This second stream of motivational theories aims at explaining usage behavior related to information systems. It is very popular and thus many variants of the following

models/theories exist. Most of them have been developed for working contexts, however it has also been possible to apply them to non-working environments (King and He, 2007) and thus, they might be helpful in explaining motivations for joining and participating in a hybrid CWN.

The ***Expectancy-Valence Theory*** (Atkinson, 1964; Vroom, 1964) tries to explain why an individual would choose one behavior instead of another. Simply said, it suggests that a person is motivated to choose one behavior over others depending on the expected result of the behavior. It is thus about the process of choosing. According to the theory, individuals are motivated to perform an activity if they expect that their efforts will lead to a good performance (***expectancy***) and that this performance will then result in a desirable outcome (***instrumentality***) that is valuable enough to make the effort (***valence***).

The ***Theory of Reasoned Actions (TRA)*** by Fishbein & Ajzen (1975) wants to explain the relationship between attitudes and behaviors (e.g. communication, customer or community behavior) within human action. It allows predicting how individuals will behave based on their pre-existing attitudes and behavioral intentions. The theory suggests that the ***intention*** of an individual to behave in a certain way depends on two things: 1) on his/her ***attitude toward the behavior,*** namely his/her beliefs about the consequences of the behavior and evaluations of these consequences; and 2) on his/her ***subjective norm,*** namely his/her beliefs whether relevant referents think s/he should or should not perform the behavior and his/her desire to behave as others expect him/her to. Usually, the two variables are not weighted in the same way in predicting behavior, and depending on the individual and the situation they might have different impacts on behavioral intention.

Ajzen's (1991) ***Theory of Planned Behavior (TPB)*** is an extension of TRA. It proposes that behavioral intention does not only depend on individuals' attitudes toward the behavior and their subjective norms (as proposed by TRA), but also on ***perceived behavioral control,*** which is the individual's perceived ease or difficulty in performing the behavior. In fact, perceived behavioral control is a mix of self-efficacy (belief in own ability to succeed in performing the behavior) and controllability (external factors and the belief that they can influence the behavior). An increased behavioral control, thus, corresponds to a person's increased confidence in being able to perform a behavior successfully.

The previous three theories have been adapted by Davis (1989) to form the ***Technology Acceptance Model (TAM)***, which explains how users come to accept and use a certain technology. The model advocates that when users are confronted with a new technology, there are different factors influencing their decision about how and when to use it. In particular, the intention of using a technology (or technology adoption) is determined by 1) the technology's ***perceived usefulness*** – "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320)

and by 2) its ***perceived ease-of use*** – "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p.320).

The ***Unified Theory of Acceptance and Use of Technology (UTAUT)*** developed by Venkatesh et al. (2003) combines the previous theories proposing a unified view of information technology's user acceptance. It explains the intentions of users to use an information system and subsequent usage behaviors and proposes four key constructs that favor a user's intention to use a technology: 1) ***performance expectancy*** (perceived usefulness), 2) ***effort expectancy*** (ease of use), 3) ***social influence***, and 4) ***facilitating conditions***. Furthermore, Venkatesh et al. (2003) suggest that gender, age, experience and voluntariness moderate the impact of the four key constructs on usage intention and behavior.

Last but not least, Bandura (1977) proposes similar concepts as UTAUT in his ***Social Cognitive Theory (SCT)***. He suggests that individuals are more inclined to do a specific action if they believe in their capability to perform the action (***idea of self-efficacy***) and believe that it leads to a desired outcome (***outcome expectancy***). In other words, he argues that human behavior is caused by personal, behavioral and environmental influences (Bandura, 1986).

3.2.3 Prosocial Behavior & Volunteering

"***Prosocial behavior*** covers the broad range of actions intended to benefit one or more people other than oneself – behaviors such as helping, comforting, sharing, and cooperating" (Batson, 1998, p.463) or, simply said, it is a "voluntary behavior intended to benefit another" (Eisenberg et al., 1998, p.610). Batson (1998) suggests that there are different social motives that can origin prosocial behavior such as ***altruism***, ***principalism***, and ***collectivism*** but also self-interest (***egoism***).

Most research on prosocial behavior focuses on unplanned and spontaneous helping in unexpected situations while volunteering concentrates more on planned helping (Camponovo, 2011). Clary et al. (1998), for example, propose a set of motivations favoring volunteerism. Within the ***Volunteer Functions Inventory (VFI)***, they aggregate different volunteering theories and propose six functions suggesting that people volunteer because it allows them to 1) express their values ***(values)***, 2) gain knowledge ***(understanding)***, 3) comply with social expectations ***(social)***, 3) get utilitarian rewards – e.g. career-related benefits ***(career)***, 4) protect them against negative feelings about themselves – e.g. feeling guilty because being more advantaged than others ***(protective),*** and 5) enhance their ego ***(enhancement)***.

Members of a virtual community might not consider their participation as volunteering, however, motivations favoring volunteerism might still be useful to understand people's decisions to join and participate in a community.

3.2.4 Other Relevant Theories and Models

Innovation Diffusion Theory (Moore, 1999; Rogers, 2003): this theory describes patterns of how, why and at what rate an innovation is adopted among the members of a social system. According to Rogers (2003) "*[d]iffusion* is the process by which an innovation is communicated through certain channels over time among the members of a social system" (p.37). This definition already includes the four elements by which new ideas or technologies are spread: 1) ***the innovation itself*** or better some characteristics of an innovation such as relative advantage, compatibility, complexity or observability; 2) ***communication channels***, namely the means by which messages get from one individual to another – this is relevant because often people evaluate an innovation based on their evaluation of peers who have adopted the innovation; 3) ***time***, which is relevant for the innovation-diffusion process, innovativeness and the adoption rate of the innovation; and 4) ***a social system,*** which can be defined as "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers, 2003, p.39).

Furthermore, Rogers (2003) distinguishes between five ***adopter categories***, which classify members of a social system based on their innovativeness: innovators, early adopters, early majority, late majority, and laggards. While innovators and early adopter are more attracted by intrinsic motivations such as the enjoyment of trying out new things, laggards or late adopters are more skeptical and traditional and prefer proven solutions, which do not entail any risk.

Unlike the other proposed theories, the ***expectation-confirmation model*** by Oliver (1980) and Bhattacherjee (2001) focuses on the ***continuation of usage*** instead of the initial adoption of a system. This, too, is a critical factor for long-term sustainability of a system (e.g. a community). Oliver (1980) first created this model to explain purchase intentions based on satisfaction, which in turn depended on the confirmation of initial expectations against performance. Bhattacherjee (2001) then applied the model to information systems suggesting that the intention to continue using a technology is determined by 1) its ***perceived usefulness***, and 2) ***user satisfaction***, which on its turn depends on the confirmation of usage expectations and its perceived usefulness.

Collective Action Theory (Olson, 1971): both MWN and CWN incorporate the concept of collective action in which "[g]roups of individuals with common interests are expected to act on behalf of their common interests much as single individuals are often expected to act on behalf of their personal interests" (Olson, 1971, p.1). Olson thus proposes a number of negative and positive incentives for collective actions: sanctions, social

pressure or forced payments (e.g. taxes) are negative incentives, while social incentives in small groups such as friendship and gaining prestige positively influence collective action. Olson (1971) further assumes that these positive incentives may become less relevant, the larger a community becomes as in large communities it gets more difficult to build social ties among members.

Social Exchange theory (Blau, 1964): Economic exchange theories postulate that individuals behave based on ***self-interest*** (rewards should exceed costs) while social exchange theory includes also ***intangible benefits*** such as improved relationships or feelings like gratitude or trust.

Camponovo (2011) proposes a taxonomy in which the motivational concepts that emerged from the previously described theories are classified into psychological, social and utilitarian factors. He then uses this taxonomy to make a detailed overview of motivational factors in CWNs emerging from existing research.

Table 5 presents an overview of the various motivation theories presented in section 3.2, indicating the stream, the theory or model, authors and the main motivational factors each theory has identified.

Stream	Theory/Model	Author	Motivational factors
SDT	SDT	(Deci & Ryan, 1985)	Extrinsic vs. intrinsic
Intentional Decision Making in Technology Adoption	Expectancy-Valence Theory	(Atkinson, 1964; Vroom, 1964)	Expectancy, instrumentality, valence
	TRA	(Fishbein & Ajzen, 1975)	Attitude toward the behavior, subjective norm
	TPB	(Ajzen, 1991)	Perceived behavioral control
	TAM	(Davis, 1989)	Perceived usefulness, perceived ease-of use
	UTAUT	(Venkatesh et al., 2003)	Performance expectancy, effort expectancy, social influence, facilitating conditions
	SCT	(Bandura, 1977)	Self-efficacy, outcome expectancy
Prosocial Behavior & Volunteering	Mot. Underlying prosocial behavior	(Batson, 1998)	Altruism, principalism collectivism, self-interest
	VFI – Volunteering (planned helping)	(Clary et al., 1998; Snyder, 1993)	Six functions: values, understanding, social, career, protective, enhancement
Other relevant theories & models	Innovation Diffusion Theory	(Moore, 1999; Rogers, 2003)	Innovation itself, communication channels, time, a social system; early adopters vs. late adopters
	Expectation-Confirmation Model	(Bhattacherjee, 2001; R. L. Oliver, 1980)	Focus on continuation of usage: perceived usefulness & user satisfaction
	Collective Action Theory	(Olson, 1971)	Sanctions, social pressure or forced payments as negative incentives and social incentives (friendships, prestige) as positive incentives.
	Social Exchange Theory	(Blau, 1964)	Self-interest, intangible benefits

Table 5 – Overview of Motivational Theories Relevant for the Context of CWNs

3.3 Literature on Motivations in Pure and Hybrid CWNs

At this point it is important to mention that the following studies mainly refer to motivations for joining CWNs and thus to providing and sharing Internet connectivity rather than using it.

3.3.1 Research Agenda Based on a Literature Review

Until now there have been various studies focusing on motivations in wireless communities, however, most of them researched pure, self-organized communities and not on hybrid ones.

A good starting point for analyzing motivations is a research agenda proposed by Bina & Giaglis (2005). They did a systematic literature review on 40 publications to identify "emerging research issues in the area of community-based WLANs" (Bina & Giaglis,

2005, p.9) and found three main critical research areas: 1) ***technology*** (security, network management & performance), 2) ***business/economic*** (sustainable business models, impact on telco industry, policy and regulation), and 3) ***social/individual*** (importance of motivation and participation). They stress that individuals and their motivations play an important role in CWNs. In fact, according to them the main research question in the domain of CWNs "***refers to the assessment of the role of individuals – visitors and members alike – in the formation, growth and survivability of wireless communities***" (Bina & Giaglis, 2005, p.12). This means understanding motivations that drive participation and contribution, evaluating costs of participation and ensuring that benefits exceed them, and studying factors for communities' long-term sustainability.

Of the 40 publications that Bina & Giaglis (2005) reviewed, ***eight*** consider motivations. The ***first four*** simply stress the value of understanding motivations and developing incentives able to attract and maintain members. They use theoretical arguments such as "range limitations, self-organized nature and network externalities" to show that reaching a critical mass of active members is fundamental for the growth and survivability of CWNs (Camponovo et al., 2013, p.115). Below the findings of these early four publications are briefly illustrated.

1) ***Camponovo et al.*** (2003) analyzed business models of different types of WLAN service providers in Switzerland through case studies and summarized their findings in a WISP classification framework where they distinguished different business approaches: a) Private WLANs (e.g. CHUV hospital), b) Community WISPs (e.g. Myotis community), c) Hotspot WISPs (e.g. Zürich Airport) and d) Wide Area WISPs (e.g. leading network operators such as Swisscom, Sunrise, Monzoon, Netair). For community WISPs the study evidenced that "the major concerns are attracting new members and fostering their involvement" (p.39).

2) Also ***Rao & Parikh*** (2003a; 2003b) examined strategies for providing wireless broadband access. They analyzed 1) a traditional WISP (e.g. Boingo), 2) a software-driven initiative (e.g. Sputnik), and 3) a community-based network (e.g. NYC Wireless) and highlighted technical and social challenges for wireless broadband networks.

3) ***McDonald*** (2002) conducted a literature review on "Computer-Supported Cooperative Work" (p.2) and similarly to Rao & Parikh (2003a) revealed social and technical issues. He highlights that "important initial questions about the group include: who participates, what is their motivations, does participation grow or shrink, how does the group communicate, and how does the collaboration evolve overtime" (McDonald, 2002, p.4).

4) ***Readhead & Trill*** (2003) focused their study on ad-hoc networks, where different devices were connected together, for example through Wi-Fi, to create small

networks. They investigated whether users really took advantage of this possibility, why they did so and how they used these networks. They identified three factors having a positive impact on ad-hoc networks: 1) ***motivation*** – "users must want to communicate with each other and/or have a reason to co-operate" (Readhead & Trill, 2003, p.74); 2) technical feasibility; and 3) cost efficiency. According to them the most obvious reason to co-operate is to gain access to connectivity.

The following two articles in the research agenda of Bina & Giaglis (2005) already propose a ***first selection of motivations*** like cooperative spirit, gain prestige in the community, promote free communication and challenge telecom firms.

5) ***Schmidt & Townsend*** (2003) promote "free" wireless networks so that "homes, offices, and public spaces will increasingly be expected to provide hassle-free wireless bandwidth" (Schmidt & Townsend, 2003). They propose different incentives for individuals to participate in grassroots movements that deploy free and open wireless hotspots in cities: 1) a sense of mutual ***cooperation*** – e.g. setting up a free hotspot, hoping that others will do the same and having access to Internet connectivity when away from home; 2) ***prestige*** for those operating a node; and 3) ***challenging commercial ISPs***. Furthermore, they mention ***security*** as a main concern.

6) ***Auray et al.*** (2003) analyzed CWNs from a historical, technical, regulatory and business point of view and further focused on learning dynamics in these communities. Based on semi-structured interviews with wireless community leaders in Europe, they evidenced three main motivations to be part of a CWN: 1) willingness to break free from commercial ISP; 2) spirit of sharing between community members; and 3) learning benefits.

The last two papers in Bina and Giagli's (2005) research agenda addressing motivation, evidence ***similarities with other collective structures*** – cooperatives and commons – to show two potential ***conflicts of interests between single members and the community*** itself: 1) pushing members to contribute instead of free-riding (Sandvig, 2004); and 2) limiting them to a fair usage (Damsgaard et al., 2006) avoiding that some users use too much of the collective good, which can lead to overuse and a collapse.

7) ***Sandvig*** (2004) focused on similarities with cooperatives. He analyzed three cases of ***cooperative action***, each one focusing on a different areas of wireless Internet service: network discovery (a mechanism to identify APs), development (authentication), and provision (infrastructure / network transport) in order to "assess their role in the development of a Wi-Fi system" (Sandvig, 2004, p.584). The three cases were: 1) ***Mapping and "Warchalking"*** (***discovery***) – activity of

finding and marking Wi-Fi accesses[17] 2) ***NoCatAuth (development)*** an open-source portal software, which aimed at creating a global and centralized authentication framework for free networks in order to reduce security risks entailed in sharing; and 3) the ***Consume co-op[18] (provision)***, whose general mission could be defined as "cooperatively build a new, second Internet without the financing or expertise of the telecommunications companies of the first Internet" (Sandvig, 2004, p.594), and which mainly promoted the exchange of technical knowledge and a sense of being part of a community. Hence the Consume co-op was a sort of "social club for technical elites" (Sandvig, 2004, p.595), which aimed at building elite expertise. The real challenge was thus how to exploit their knowledge and passion for society's needs.

8) Damsgaard et al. (Damsgaard et al., 2006) applied the concept of Wireless Commons to Wi-Fi communities and wanted to understand how CWNs could create common good by sharing broadband connectivity. According to them the "***tragedy of the commons***" constitutes as a major problem in achieving this goal because the interest of single individuals often does not match the interests of the community as a whole. In Wi-Fi communities, for example, if some people use too much of the common good this might lead to the overall collapse of the network. ***Fair usage*** of the network by its users is thus of the utmost importance.

3.3.2 A first Theoretical Model Explaining Motivation in Pure CWNs and Two Empirical Tests

All papers proposed in Bina & Giaglis's (2005) research agenda are mainly conceptual, lack empirical evidence and none of them exclusively deals with motivations. Furthermore, in those papers proposing motivations, there is a lack of consistency in motivation theories. To address these shortcomings, Bina & Giaglis (2006a) develop a

[17] "Warchalking" stands for "drawing symbols in public places to advertise open wireless Internet networks" (Sevtsuk, 2008). Matt Jones started the activity of "Warchalking" in London in 2002. He painted a symbol on buildings with chalk to indicate where he found open Wi-Fi APs and then posted the locations on his personal Website (Sandvig, 2004).

[18] The ***Consume project*** was founded in London, UK, in 1999 as a ''collaborative strategy for the self-provision of broadband telecommunications infrastructure'' (Sandvig, 2004). It all started off with discussions between wireless enthusiasts. Consume refused any financial support from members and only accepted contributions in form of expertise or equipment as it always considered the Internet as something open that should rather be "consumed" / internalized than purchased. Even though it was founded in the UK, it did not know boundaries and mainly lived on the Internet itself in form of discussions on mailing lists. As such, it was one of the least organized cooperatives, being principally an information hub with mailing lists and a web site. By listing a node on the website, users got information on nodes nearby and were encouraged to contact their owners in order to interconnect the nodes (Sandvig, 2004).

first theoretical model explaining participation in pure CWNs and subsequently test the model in Greece (Nov 2006) and Australia (Jan-Feb 2007).

3.3.2.1 1st Theoretical Model (Bina & Giaglis, 2006a)

After having assessed that one of the main research questions related to CWNs is understanding ***"[w]hy […] people voluntarily participate and put up effort in community- based WLANs***" (p.619) Bina & Giaglis (2006a, p.619) propose a 1st theoretical model for understanding motivations in pure CWNs. They base their model mainly on Deci & Ryan's (1985) SDT, claiming that an "individual decides to participate in a wireless community because of intrinsic as well as extrinsic motives" (Bina & Giaglis, 2006a, p.618). The model further applies a cost-benefit perspective opposing motivations to the perceived effort to join and participate. This means that if the benefits resulting from participation are stronger than the effort to do so, a person is motivated to participate. The model consists of three main constructs: 1) ***motivation***, 2) ***effort,*** and 3) ***participation***, where motivation and effort influence participation.

The model distinguishes three types of ***motivations***: ***intrinsic*** (participating because of interest/enjoyment, need for competence, autonomy and relatedness), ***obligation-based*** (enforce one's identity, sharing common beliefs, reciprocity) and ***extrinsic***, which in turn is divided into external (explicit reward or external pressure), introjected (self-esteem and ego-involvement), identified (personal need, human capital, career prospect), and integrated (altruistic).

Effort is the "voluntary contribution of […] resources" (Bina & Giaglis, 2006a, p.622) and can be of very diverse nature (e.g. network equipment, time, knowledge and expertise). ***Participation*** can be translated into ***infrastructure*** participation (everything related to the set-up of an AP and to providing access to it), service participation (providing Internet connectivity as well as contents and services), community participation (level of engagement in the community such as participating in forums or meetings or supporting other members).

The different functions of the model emerged from interviews with community members and an analysis of community websites. The model was then pre-tested with three university professors and twelve respondents with the help of a questionnaire. With their inputs, it was possible to refine the model.

In order to empirically test the model, a survey instrument was developed based on existing literature, interviews with members of the Athens Wireless Metropolitan Network and pre-tests with experts. The questionnaire was then distributed to pure CWNs in Greece (Nov. 2005) and in Australia (Jan-Feb 2006) with the goal of understanding "motivations and drivers, which lead people to join in these 21st century community assets" (Lawrence

et al., 2007, p.173).

3.3.2.2 Empirical Test in Greece (Bina & Giaglis, 2006b)

E-mail invitations were sent to all wireless communities in Greece asking them to post the invitation on their web sites and discussion forums in order to understand their motivations to share and thus provide Internet connectivity. In addition, the survey was promoted to members of the Greek research and business community who were interested in wireless communities.

It was possible to collect 160 usable responses, out of which 106 were from members of a CWN. Respondents were mainly young & educated men interested in technological innovations. With the help of cluster analysis researchers grouped respondents into Wi-Fi ***Idealists*** (strongly motivated by ideology), ***Dispassionates*** (those with below-average motivation), ***Materialists*** (motivated by extrinsic rewards), and the group of the ***Privileged*** (highly motivated by intrinsic, extrinsic and obligation-based motives).

Results from collected data confirmed the theoretical model and suggested that individuals often initially joined the community to explicitly benefit from it, however, over time they developed more intrinsically-driven behaviors.

3.3.2.3 Empirical Test in Australia (Lawrence et al., 2007)

Between January and February 2007, CWN members found on Australian websites were asked to fill in the same survey that had previously been submitted to Greek CWNs. It was possible to gather 107 usable responses, 30 from members of CWNs and 77 from non-members. For the analysis only the answers of the 30 community members were taken into account. As in Greece, the typical respondent was a young, well-educated male interested in new technologies. Respondents confirmed the importance of the notion of collective action (Olson, 1971) in participating in CWNs.

3.3.3 Three Canadian CWNs: Understanding Users and Their Motivations for Participation

3.3.3.1 Concerns Sharing Private Wi-Fi Signals (Wong & Clement, 2007)

Wong & Clement (2007) did not focus on motivations but on ***barriers and concerns*** of people when sharing their own home broadband Internet connection with others. They claim that people might not be willing to "risk a reduction in their bandwidth or service slowdowns as a result of sharing" (Wong & Clement, 2007, p.276). Furthermore, they advocate that people may be deterred by high "switching costs" (e.g. psychological,

physical or economic cost of buying new equipment or making a new broadband contract). Last but not least, they stress the importance of considering aspects of trust towards other members of the community. In order to understand the concerns of people in leaving open their private home Wi-Fi hotspots to share their Wi-Fi signal with others, the authors collected qualitative and quantitative data in two phases: in October and November 2005, they did radio surveys of Wi-Fi signals in two urban neighborhoods in Toronto in order to "assess the intensity and forms of wireless use in residential neighbourhoods" (Wong & Clement, 2007, p.279) and between November 2005 and May 2006, they submitted two questionnaires to wireless users and conducted in-depth interviews with some respondents. Respondents were asked to rank their concerns about using wired and wireless Internet. It emerged that ***security and reliability*** were the most cited ones, followed by ***privacy, range, complexity, and health***. Respondents mentioned to prefer if people first asked them before using their connectivity but they did not seem to have any problem in using other people's left-open hotspots (even without asking first). This suggests that respondents were generally "comfortable with sharing signals, just not their own" (Wong & Clement, 2007, p.284). Respondents justified this behavior by considering their own use as harmless. Hence, the results of the study suggest that people do not seem to trust strangers and are afraid of opening up their private connection because their speed/bandwidth might be reduced or because of security and privacy concerns.

3.3.3.2 Geek Public vs. Community Public (Île sans Fil)

Powell (2008b) studied the Canadian CWNs Île sans Fil over several years and identified two different types of publics: the so-called "***geeks***" who are "interested in developing wireless technologies that not only connect to the [I]nternet but also create local networks that can be used as forms of community media" (Powell, 2008b, p.1074) and the "non-geek" or ***community public*** which is "not necessarily interested in using technology as a means of creating social links" (Powell, 2008b, p.1076). The first, are technologically passionate people who experiment with wireless technologies with the broader goal of serving the community public, while the latter are individuals who mainly want to get access to free Internet connectivity. However, the tendency of such communities to mainly attract a geek public might limit its capability to be really beneficial for a broad community public. It is thus fundamental that publics expand and become broader for wireless communities to growth. According to Powell (2008b) it is fundamental that "Wi-Fi publics […] create and distribute discourses and practices that mobilize not just geek-publics but community-publics, too" (p.1084).

3.3.3.3 Short-Term (Personal) vs. Long-Term (Public) Interests (Wireless Toronto)

Cho (2008) distinguishes between ***short-term*** (personal interest) motivations and ***long-term*** (public interest) motivations. Short-term motivations include having fun, learning, skill sharing, social networking and getting free Wi-Fi access. Long-term motivations encompass more public interest motivations such as bridging the digital divide and media democracy. Cho (2008) conducted an ***ethnographic case study*** on the Wireless Toronto CWN in order to understand ***who*** participated in the community, ***why*** and in ***what*** sense this CWN was a community. The study was based on theoretical frameworks of social capital, community networks, community informatics and constructivist vision of technology. Cho (2008) found that "Bandwidth. Beer. Fun. Free." best describe "the group of self-professed geeks known as Wireless Toronto" (Cho, 2008, p.1), meaning that they are mainly socially motivated. The study suggests that CWNs are "***social and civic networks*** of individuals whose short-term social implications are practical (i.e. local community participation) and long-term implications, symbolic-ideological" (Cho, 2008, p.1). It thus confirms findings from Shade and Powell (2006) on the Île Sans Fil CWN suggesting that people participate for a variety of reasons.

3.3.4 Other Empirical Studies on Motivations in Pure CWNs

Efstathiou et al. (2006) proposed a protocol – Peer-to-Peer (P2P) Wireless Confederation protocol – that encourages cooperation in CWNs based on ***reciprocity (reciprocity scheme)***. It suggests that a person participates in a CWN and shares his/her broadband connectivity in order to be able to connect to other hotspots when on the go and so to profit from the same that s/he contributes. According to the reciprocity scheme members should have a consumption (data volume someone uses over other APs) – contribution (data volume user puts at disposal of others) ratio of near to 1:1. In this way, participation in CWNs should be stimulated and more APs should become available.

Abdelaal et al. (2009) developed a conceptual framework describing the importance of ***social capital*** in the process of formation of a CWN. It considers various collective actions and cooperative activities, which contribute to the development of CWNs. Such actions could be "***donating money and hardware, volunteering manpower and technical skills, developing open source software for the network, and sharing wireless nodes with peers***" (Abdelaal et al., 2009, p.1).

The authors used a survey instrument to collect data from CWN activists and test the proposed framework. The survey was distributed to activists during their annual event (International Summit for Community Wireless Networks) in Washington, DC in 2008 in order to address different types of roles (project managers, volunteers, donors, etc.). They used a short version of the World Bank instrument on social capital, adapted some questions and added some more on other aspects of community contributions such as

money and hardware donations, sharing APs with peers, providing technical support and developing software. These types of contributions have been identified through a detailed literature review, experience from working for a CWN project (Omaha Wireless), and discussions with CWNs' leaders. They were able to collect 41 responses representing 28 CWNs worldwide.

Results showed that CWNs were built and operated with the contribution of members (time, money, skills, computers). Facing ***social challenges*** such as "engaging the community, sustaining volunteers and donors, attracting a wide range of users and adopting a sustainable business model" (Abdelaal et al., 2009, p.1) seems to be critical for the development of CWNs and much more relevant than technical challenges (building networks). Abdelaal et al. (2009) thus confirm the ***importance of social aspects and the role of individuals*** in the creation and growth of CWNs as Bina & Giaglis had already proposed in their research agenda.

Schaffer (2011) analyzed ***motivations of mesh networks'*** representatives with the help of resource mobilization theory[19]. She wanted to understand what motivates people to "steal" Wi-Fi signals and what motivates them to share their own wireless signals. To do so, she conducted qualitative in-depth telephone interviews (60-90 min) with representatives of 12 different grassroots, community mesh networks in the U.S. between July 2008 and January 2009. The primary motivational factors that emerged from the interviews were: 1) ***digital inclusion*** as the main incentive to develop a mesh community; 2) ***technology & network design*** (ease of use, experimentation, geek-fun); 3) ***ideology*** (Internet access should be considered as a public utility and as such be free); 4) ***volunteer support*** (most initiatives rely on a core group of tech-savvy volunteers); 5) ***relationships with ISPs*** (they are important to guarantee a legally correct sharing of Internet connectivity); 6) ***technological innovation*** (opportunity to meet and discuss with like-minded peers); and 7) ***marketing*** (promote themselves through word of mouth and other techniques). To summarize, one can say that people who share Wi-Fi signals are "driven by ***ideology*** as much as ***pragmatism***" (Shaffer, 2011, p.71).

3.3.5 Empirical Studies of Motivations in Hybrid CWNs

The following studies concentrate on motivations in hybrid community models, namely on communities that are supported by a company, while the previously presented research studies focus on self-organized communities, so-called pure communities.

[19] "***Resource mobilization theory*** assumes that a social movement will fail to produce change without adequate resources. Alliances between grassroots actors and institutionalized factions such as political parties and government agencies are also necessary" (Shaffer, 2011, p.72).

Biczok et al. (2009) evidences that user participation plays an important role also in hybrid CWNs such as Fon and that it is fundamental to create ***valuable incentive systems***. They analyzed economic interactions in global wireless community networks (i.e. Fon) between users, ISPs and community providers (mediators) in order to show "under what circumstances players benefit from joining the user-provided networking framework" (Biczók et al., 2009, p.6). To do so, they used a ***game-theory approach*** based on the Stackelberg (leader-follower) game[20]. They conclude that the success of communities like Fon depends on "properly designed incentive mechanisms which facilitate both the participation of users and the cooperation of ISPs" (Biczók et al., 2009, p.1).

As part of her PhD dissertation, Shaffer (2010) surveyed 43 members from both pure and hybrid CWNs and identified various motivations and concerns. She investigated how respondents learned about their CWN, what motivated them to join and what their level of involvement was. She found that motivations for sharing bandwidth with other people range from ***altruistic*** to ***selfish*** (personal gratification). Motivations may include the willingness to expand broadband access, learning, saving money, having access to Internet connectivity when on the go, and challenging traditional telecom operators. These motivations were evaluated against possible ***concerns*** like reliability, signal strength, speed and security of information. Participants contributed with money, time and knowledge to the community.

Gao et al. (2017) propose that users can join wireless communities in different roles, either as contributors, sharing their home Internet connectivity, as beneficiaries, benefitting from the community by accessing APs shared by others, and as hybrid contributors and beneficiaries who both contribute and benefit from the community. This distinction allows users to "make separate decision on contributing and benefiting" (Y. Gao et al., 2017, p.1) to/from CWNs. Similarly, Ma et al. (2017) analyzed user behaviors when choosing between different membership types (Bill, Linus, Alien as in the Fon community) as part of an economic analysis on user behaviors and the community network operator's pricing design. They defined interactions between network operators and users as a "two-layer Stackelberg model" (p.1856), in which the operator determines the pricing scheme in layer one and users choose their Wi-Fi sharing scheme in layer two. It emerged that a user with a "more popular home location, a smaller probability of travelling, or a smaller network access evaluation is more likely to choose to be a Bill" (p.1868) (a user who can earn money from sharing his/her AP with other users).

[20] In the ***Stackelberg leader-follower game***, a leader company, which generally acts first, competes on quantity with follower companies, which join the market later (Von Stackelberg, 2010)

3.3.6 Empirical Studies on Motivations Specific to the Fon Community

Becker et al. (2008) studied ***motivations of Fon's early adopters*** in Germany. In collaboration with Fon, they surveyed 268 German Fon users (Feb/Mar 2007) and then conducted three in-depth interviews with Foneros in Hamburg. The online survey was promoted through Fon community newsletters and user forums. The average respondent was male, around 30 years old and member of the Fon community since three months. As in the case of pure CWNs, early adopters of the Fon community were mainly technically motivated while financial rewards played a minor role. The community was thus propelled by technically engaged people who enjoyed experimenting with technologies and relied on the idea of reciprocity.

As part of a larger research project with the goal of understanding what motivates and dissuades individuals to/from voluntarily joining and actively participating in hybrid wireless communities (Wi-Com project), Camponovo & Picco-Schwendener (2010) developed in a first step a ***theoretical motivational model adapted to the hybrid community context***. The model was adapted from Bina & Giaglis' (2006a) theoretical model and postulates that people are motivated to join hybrid communities because of extrinsic motivations (tangible, social and psychological rewards) and intrinsic motivations (interest and enjoyment), and hindered by effort and security, legality and bandwidth concerns. In a second step, the model was refined with data gathered through a content analysis of Fon community forums (Camponovo & Picco-Schwendener, 2010) and through 30 semi-structured face-to-face interviews with Swiss Foneros (conducted between June and September 2010) (Camponovo & Picco-Schwendener, 2011). It resulted that members would join Fon for a variety of reasons but first of all for ***getting connectivity***. Moreover, the ***idea of sharing*** was mentioned by most respondents but seemed to be less strong. Furthermore, ***technical interest*** played an important role. On the other hand, ***social and intrinsic motivations seemed to be weak***. Members were aware of possible risks (security, abuse, legality) but felt reassured by the presence of a supporting company.

It is important to acknowledge that the Fon of these studies is different from the Fon of 2018 (for more information on how Fon evolved see section 2.5.8.2).

The results of the subsequent two steps of the Wi-Com project are part of this PhD dissertation. They are based on a quantitative online survey aiming at measuring and validating the results obtained in the first two steps. The results are described in detail in section 3.5.1.6 and 3.5.2.7.

The following two tables summarize the findings of the previously described studies on motivations in CWNs and highlight for each study the main motivational factors. Table 6 describes the findings of the eight papers addressing motivations in Bina & Giagli's (2006a) literature review while table 7 provides an overview on all other studies.

Camponovo (2011) more specifically addresses how the observations of the single studies match the general motivation theories.

Topic	*Author(s)*	*Type*	*Study focus*	*Motivational aspects*
Recognition of importance for CWNs to understand motivations	(McDonald, 2002)	Literature Review	Computer Supported Cooperative Work	Importance of social (motivation) and technical issues
	(Camponovo et al., 2003)	Case Study	Analysis of business models of different types of WLAN service providers in Switzerland	Importance of attracting new members and fostering their involvement
	(Rao & Parikh, 2003b)	Case Study	Description of 3 different business approaches: traditional (Boingo), sw-driven (Sputnik), community-based (NYC Wireless)	Importance of social and technical challenges
	(Readhead & Trill, 2003)	Conceptual	Ad-hoc networks	3 success factors: user motivation, technically possible, cost effective
1st list of motivations	(Schmidt & Townsend, 2003)	Conceptual	Incentives for individuals to participate in grassroots CWNs	Mutual cooperation, prestige, challenging commercial ISPs, security concerns
	(Auray et al., 2003)	Conceptual & Empirical	Analysis of CWNs from a historical, technical, regulatory and business point of view	Break free from commercial ISP; spirit of sharing, learning benefits
Similarities with other ***collective structures***	(Sandvig, 2004)	User Study	Analysis of 3 cases of cooperative actions: Warchalking (discovery), NoCatAuth (development), Consume co-op (provision)	Building elite expertise → understand how to use these skill for societal goals
	(Damsgaard et al., 2006)	Conceptual	Understanding how wireless commons create common good	Faire usage

Table 6 – Findings of 8 Papers Presenting Motivational Factors in Bina & Giagli's Literature Review

CWN type	*Author(s)*	*Type / Methodology*	*Community*	*Region*	*Period*	*Motivational aspects*
Pure	(Bina & Giaglis, 2005)	Literature Review: 8 papers mentioning motivations*				Understanding motivation = key research issue
	(Bina & Giaglis, 2006a)	Theoretical Model	---	---	---	Intrinsic, obligation-based, extrinsic motivations and effort influence participation in a CWN
	(Bina & Giaglis, 2006b)	Empirical (online survey, n=160, 106 members)	Greek CWNs	Greece	Nov. 2005	4 user types: idealist, dispassionate, materialists, privileged
	(Lawrence et al., 2007)	Empirical (online survey as in Bina & Giaglis, 2006b, n=107; study focus on 30 members)	Australian CWNs	Australia	Jan – Feb 2007	Confirmation of motivations in Bina & Giaglis' s theoretical model

	(Wong & Clement, 2007)	Empirical (radio surveys; short online survey, n= 58; long online surv., n=33; 9 semi-struct. interv.)	Wireless Nomad	Canada – Toronto	Oct 2005 – May 2006	Barriers & Concerns (security, reliability, privacy, range, complexity and health)
	(Powell, 2008b)	Empirical (participant observation, paper & online survey, n=370; 20 structured interviews)	Île sans Fil	Canada – Montreal	2004 – 2007	Geek vs. community public
	(Cho, 2008)	Empirical (participant observation, online survey, n=20; 8 in-depth interviews; analysis of organizational documents)	Wireless Toronto	Canada – Toronto	Sep 2005 – Apr 2006	Short-term (personal) vs. long-term (public) interests
	(Efstathiou et al., 2006)	Technical (Peer-to-Peer Wireless Confederation protocol)	---	---	---	Reciprocity (contribution – consumption ration of 1:1)
	(Abdelaal et al., 2009)	Empirical (survey distributed at International Summit for Community Wireless Networks, n=41)	Various	Worldwide	May 2008	Social capital (donating money/hw, volunteering manpower and technical skills, developing open source sw, sharing
	(Shaffer, 2011)	Empirical (in-depth telephone interviews with representatives of 12 mesh CWNs)	Wireless mesh CWNs	USA	Jul 2008 – Jan 2009	Ideology & pragmatism
hybrid	(Biczók et al., 2009)	Game-Theory Approach	Global CWNs (i.e. Fon)	---	---	Importance of a properly designed incentives
mixed	(Shaffer, 2010)	Empirical (surveyed 43 members of pure & hybrid CWNs)	Various CWNs	USA	Jun-Dec 2008	From altruistic to selfish, concerns
hybrid	(Becker et al., 2008)	Empirical (online survey addressed to early adopters of Fon, n=268)	Fon	Germany	Feb-Mar 2007	Mainly technical motivations
	(Camponovo & Picco-Schwendener, 2010; 2011)	Theoretical (model) & Empirical (content analysis of 1100 threads; 30 semi-structured interviews)	Fon	Switzerland / Worldwide	Jun-Sep 2010	Tangible rewards, idealism, technical interest; to a lesser extent social & intrinsic mot.
mixed	(Y. Gao et al., 2017)	Game-theory, simulations	Crowdsourced Wi-Fi community	---	---	Users can join CWN in different roles (contributors; beneficiaries; mix of both) and thus make distinct decision on contributing and benefitting
Hybrid	(Ma et al., 2017)	Interactions between network operators and users as a “two-layer Stackelberg model”	Fon-like community	---	---	Users with more popular home location, smaller probability of travelling, or smaller network access evaluation generally chooses a Bill membership model

Table 7 - Overview of Existing Literature on Motivations in CWNs

3.4 Research Gaps, Research Questions (RQ) and Contributions of this Study

3.4.1 Research Gaps

Existing literature mainly focuses on pure communities that are built and operated by members in a self-organized way. In addition to these generally non-commercial communities, enterprises have started to create "hybrid communities", where the company supports individuals sharing their Internet connectivity. The company usually provides technical support and incentives (e.g. free use of the network, revenue sharing) in exchange of being allowed to exploit the network (e.g. by selling access to non-members, advertising or partnerships). This distinction between pure and hybrid CWNs is important because it is expected that the presence of an underlying company would influence members' motivations on participation. Many pure communities struggle to reach a critical mass of members mainly because of "commercial, technical, social and political barriers" (Shand et al., 2003). On the other hand, hybrid communities (e.g. Fon) are able to grow much faster and attract large numbers of members. This suggests that hybrid communities are more successful in motivating members and overcoming their concerns. The underlying firm seems to be able to address members' concerns by providing proven technical solutions (centralized authentication, routers with two distinct signals, etc.) and interesting incentives. This study wants to provide further empirical evidence on motivations in hybrid CWNs. Furthermore, in addition to study motivations that favor users' decision to join a hybrid CWN, it wants to identify motivations that actually result in a higher level of active participation in the community. The reasons that motivate people to continue or stop participating in CWNs might indeed be different from those that pushed them to join. Therefore, this study adapts the motivational model created by Camponovo & Picco-Schwendener (2011) for hybrid CWNs in order to measure which motivations result in a higher degree of participation. By doing so, differently from previous studies, it does not analyze motivations and participation in isolation anymore, but examines their relationship. Table 8 shows the existing research gaps and how this study wants to address them.

Existing Literature	*Gap*	*Proposed solution*
Focus on pure CWNs	Few studies on hybrid CWNs	Analyzing the hybrid CWN Fon
Few empirical evidence	Need for more empirical data on motivations in hybrid CWNs to validate existing theoretical models	Collecting qualitative and quantitative data on motivation from members of the Fon community
Theoretical models for motivations in CWNs mainly based on SDT	Need for a broader theoretical basis for explaining motivation in CWNs	Creating a theoretical model explaining motivations in CWNs which complements SDT's intrinsic and extrinsic motivations with other relevant motivation theories
Motivation and participation are studied in isolation (motivations to join)	Relation between motivations and active participation has not been analyzed	Identifying motivations, which result in a higher level of active participation by analyzing the relation between motivations and participation

Table 8 – Research Gaps and Contributions of this Study (CWNs)

3.4.2 Research Questions

In order to address the research gaps previously described, the following research questions will guide this investigation:

RQ1: What motivates people to ***join*** a hybrid CWN and what hinders them from doing so?

RQ2: What motivates people to actively ***participate*** in a CWN and what hinders them from doing so?

> ***RQ2.1:*** What types of participation can be identified in hybrid CWNs?
>
> ***RQ2.2:*** Which motivations result in a higher level of participation?

3.4.3 Outcome Expectations

It is expected that members of hybrid CWNs join hybrid CWNs and participate in them for a different mix of motivations than in pure CNWs because of the presence of a supporting firm that provides technical solutions and fosters incentives (Shah, 2006). The use of rewards (getting free connectivity, revenue sharing, subsidized hardware) may reduce intrinsic motivations in favor of extrinsic motivations (Gagné & Deci, 2005) while the larger size, and often, worldwide extension of hybrid communities may lower the importance of social motivations, as it becomes more difficult to build social relations among members (Olson, 1971). It is also expected that technical motivations are weaker because the managing company generally provides already proven technical solutions that do not allow for much experimentation.

The theoretical model explaining the reasons to join and actively participate in hybrid CWNs should be based on a broader set of motivation theories, taking into account the

various theories identified and described in section 3.2. Bina & Giaglis' (2006a) theoretical model provides a good starting point but is mainly based on SDT. However, also other theories are expected to provide useful contributions to the context of hybrid CWNs. The following assumptions can thus be made:

1) ***SDT:*** while in pure CWNs intrinsic motivations seem to prevail, it is expected that reward mechanisms of companies at the basis of hybrid CWNs weaken intrinsic motivations and strengthen extrinsic ones.
2) ***Intentional Decision Making Theories*** (Expectancy-Valence-Theory; TRA, TPB, TAM, UTAUT, SCT) suggest that the following factors may be relevant in hybrid CWNs:
    a. *Perceived usefulness:* hybrid CWNs may be perceived as more useful than pure ones due to the fact that the company provides tangible rewards and access to a larger network.
    b. *Ease of use:* the company usually provides easy-to-use technical solutions.
    c. *Social influence:* the social involvement of people might be lower in hybrid communities than in pure ones because of their larger size.
    d. *Facilitating conditions:* the fact that a company provides support, centralized authentication and security solutions may favor adhesion to the community.
3) ***VFI:*** while the first three motivations mentioned by the theory (expressing values, gaining knowledge, social expectations) may be more relevant in pure communities, *utilitarian rewards* are expected to be dominant in hybrid ones.
4) ***Innovation Diffusion Theories:*** while pure communities mainly attract early adopters and technology passionate people, hybrid communities may attract also late adopters as the company offers mature technological and security solutions. Participation is expected to entail less risks for members.
5) ***Expectation-Confirmation-Model:*** the model highlights *perceived usefulness* as a key factor for guaranteeing members' active long-term participation.
6) ***Social Exchange Theory:*** people may join hybrid CWNs for pure self-interest. Therefore, rewards should exceed costs (buying a router, time spent setting up router).

Based on the examined literature, the author formulated the following six hypotheses explaining participation in hybrid CWNs:

- H1: Utilitarian motivation positively affects participation
- H2: Idealistic motivation positively affects participation

- H3: Social motivation positively affects participation
- H4: Intrinsic motivation positively affects participation
- H5: Concerns about sharing negatively affect participation
- H6: Effort expectancy negatively affects participation

Each hypothesis will be explained in detail in the two publications on CWNs that are part of this dissertation (chapter 3.5.1.5.1 and 3.5.2.5). There it is also possible to find an illustration of the theoretical model and the involved hypotheses.

It is expected that the mix of motivations may differ between the two Fon studies. While the first study focuses on motivations/barriers for joining the Fon community, study two analyses, which motivations actually result in higher active participation. In fact joining the community does not automatically mean putting effort into participating. Study two thus focuses on how people contribute to and participate in the community and which motivations favor different types of participations.

3.5 Outcomes (Collection of Articles)

This section includes the two publications presenting the study outcomes on motivations in the hybrid CWN Fon. The first article concentrates on motivations for joining the community while the second article uses structural equation modeling (SEM) to measure relationships between motivations and active participations and thus identifies motivations, which result in active community participation.

Some minor changes have been made to the originally published papers in order to fit the overall structure and writing style of the dissertation and make it coherent throughout the whole text. Examples are: the numbering of tables/figures, the use of upper case in titles, the correction of minor grammar mistakes, the use of American English style, the addition of page numbers to in-text quotes, and the moving of web links to footnotes. Furthermore, the appendixes of article one have been moved to the end of the dissertation, together with the other appendixes.

Inside the two publications, quoted text in italic (e.g. *"hello"*), represents excerpts from interview answers provided by Fon members.

3.5.1 Article 1: Motivations and Barriers of Participation in Community Wireless Networks: the Case of Fon

Title:	Motivations and Barriers of Participation in Community Wireless Networks: The Case of Fon
Authors:	Giovanni Camponovo, ***Anna Picco-Schwendener***, Lorenzo Cantoni
Publication:	Book chapter in Social and Economic Effects of Community Wireless Networks and Infrastructures (pp. 112-134), IGI Global, 2013

3.5.1.1 Abstract

Wireless communities are an interesting alternative to 3G networks to provide mobile Internet access. However, the key success factor for their sustainability is whether they are able to attract and retain a critical mass of contributing members. It is thus important to understand what motivates and dissuades people to join and participate. This [book] chapter analyzes motivations and concerns of members of Fon, the largest wireless community in the world, together with their contributions, usage and satisfaction. This study employs a mixed research method, combining qualitative exploratory interviews with a quantitative survey. Members are mainly motivated by a mix of utilitarian (getting

free connectivity) and idealistic motivations (reciprocity and altruism), whereas intrinsic and social motivations are less relevant.

3.5.1.2 Introduction

We live in an increasingly mobile and connected society. People traditionally accessed the Internet via fixed-line services. Now, with the diffusion of a new generation of mobile devices like smartphones and tablets, the need of having Internet access anytime and anywhere becomes stronger. This fostered a massive adoption of wireless technologies for connecting to the Internet, to the point that they overtook fixed broadband subscribers in 2008 (International Telecommunications Union, 2009).

3G networks offered by Mobile Network Operators are by far the most widely adopted solution. They are ubiquitous and reliable, but are slow and expensive. For its distinctive advantages, Wi-Fi is an interesting alternative despite its limitations. It has limited range, but is faster and cheaper. Moreover, it operates on unlicensed spectrum and hence allows many alternative business models (Rao & Parikh, 2003b). Network operators use it to complement 3G by offering pricey fast connections in crowded venues like airports and hotels. Individuals can group their private Wi-Fi access points into wireless communities providing free wireless connectivity to each other and the public at large. Other for-profit companies may try to blend commercial and community aspects into hybrid communities where the company supports members who share their own access points in exchange of being able to operate and cash in on the community network.

For these communities to be viable it is fundamental to attract a critical mass of members. As a result, it is important to understand why people join and actively contribute to them so as to design suitable incentives. Even though researchers have recognized this to be the most critical research issue on wireless communities (Bina & Giaglis, 2005), existing research mostly focused on pure non-commercial communities.

The purpose of this [book] chapter is to understand what drives people to join and actively participate in a hybrid wireless community. The distinction between pure and hybrid communities is important because the presence of a supporting firm can influence members' motivations and participation, ultimately determining the success of the community. Moreover, while most pure communities struggle achieving a critical mass (the largest one, NYC Wireless, only has 40'000 participants), hybrid communities appear to be more successful (the largest one, Fon, claims to have more than 4 million users). A possible reason is that the latter are better at motivating people by offering an attractive mix of incentives and support.

To attain this research purpose, a mixed method approach was employed. The Fon community has been chosen because it is the largest and most successful case of hybrid

wireless community. In a first phase, a qualitative content analysis of Fon community forums and 40 exploratory semi-structured interviews with Fon members were conducted. This [book] chapter complements these qualitative insights with a quantitative survey of 292 members about their participation, motivations and concerns with the Fon community.

3.5.1.3 The Fon Community

Fon (Fon Wireless Ltd.) is a for-profit company founded in 2005 by Martin Varsavsky. Its mission is to create "a Wi-Fi network built by the people" where "you share a little bandwidth with others and millions more share with you."

Fon initially provided a free software solution that could be used to convert Linksys routers into Fon hotspots, but then quickly started selling its own custom "Fonera" router to provide an easier way to create community hotspots. The idea was to generate revenues through the sale of routers and antennas, access fees from non-sharing members wanting to use the Fon network and advertising.

Fon received funding from important firms including Google and Skype. This allowed it to heavily promote its activity by distributing their routers at a low cost or even for free, thus seeding the community network and enabling its growth. However, with that course of action, "Fon has been losing large amounts of money since its inception" (Middleton & Potter, 2008, p.12).

Over time, Fon regularly adjusts its business model to adapt to evolving market conditions. In particular, it recently started to focus more on selling its routers as a source of revenue, relying less on promotions and more on building partnerships with telecom firms to further expand its network. The first collaboration started in 2007 with BT Group (UK), followed by SFR (France), ZON (Portugal), Comstar (Russia), Belgacom (Belgium) and others. These companies typically integrate Fon's software in their routers to allow customers to participate in the Fon community without having to buy an additional Fonera Router.

Fon has a broad target. Basically, everybody who has a broadband Internet connection at home can join the community and become a Fonero. There are three different types of membership. "Linus" members share their home connection through a Fonera (or a compatible model) for free and in turn can access other Fon Spots for free. "Bill" members are like Linus but also get 50% of the net revenue (i.e. after subtracting fees and taxes) generated by passes bought at their spots. "Alien" members do not share their Internet connection and have to purchase passes to access Fon Spots. By segmenting members in this way, Fon may appeal to a variety of users: "Linus" for those who value community principles like free sharing, "Bill" for those who want to earn money or find fair that Fon shares revenues generated by their hotspot, "Alien" for those who do not want to share but want to occasionally use Fon Spots.

The core value proposition proposed by Fon is to get free connectivity to its community network and can be summarized by their slogan "share a little bandwidth and roam the world for free." In marketing its offering, Fon advertises above all its utilitarian aspects by promising "free access to over four millions Fon Spots worldwide", "speedy connection to all your devices" and the possibility to "make some money by selling access to non members." At the same time, Fon tries to address potential user concerns by promoting that it is "easy to join" (with plug-and-play hardware), "secure" (by providing one encrypted private signal just for its owner and another public signal for registered Fon members) and allowing users to limit the shared bandwidth. Whether these claims are actually maintained is a debatable issue that goes beyond the goal of this paper (see Middleton and Potter (2008) for a critical discussion of those aspects).

Fon also marginally promotes itself as "a community network built by the people", even though in reality it provides members very limited control on the community network. Essentially, they can only limit the bandwidth shared with other members, visualize who connects to their spots and exchange messages with other members through the community forum.

Otherwise, with the notable exception that the network infrastructure is provided by individual members, Fon basically operates like a regular ISP in that it controls the development of the technical solution and operates central network elements like the authentication and billing system. Fon also maintains a central database of hotspots that is used to provide an interactive map that members can use to find Fon Spots and downloading their locations to GPS or other mobile devices.

3.5.1.4 Background

Wireless communities emerged at the turn of the 21st century: while wireless carriers were struggling with deploying 3G cellular networks, a grassroots movement quietly began to deploy open hotspots and organize itself in wireless communities. They aggregate individuals offering free Wi-Fi Internet access to each other and the neighboring population. Fueled by cheap equipment and flat-rate Internet connections, wireless communities started to grow and become an interesting alternative to operator-centric networks for providing wireless broadband, especially in densely populated areas (Schmidt & Townsend, 2003).

Some traditional operators soon realized that Wi-Fi could complement their slower but ubiquitous 3G networks and a few start-ups tried to exploit the low entry barriers of Wi-Fi to enter the mobile industry (Camponovo et al., 2003).

This resulted in various approaches for deploying Wi-Fi: 1) an ***operator-centric*** approach where a firm builds the network and charges access to its users, 2) a ***pure community***

approach where individuals organically share their own access points with each other and the public for free, and 3) an ***hybrid*** approach blending both commercial and community aspects. In contrast to pure communities that are exclusively built and operated by its members, hybrid communities are built by members but operated by a firm. Members add their own access points to the community network in exchange of incentives like revenue sharing, subsidized equipment or free network access. In return, the firm is allowed to commercially operate the network, e.g. by selling equipment, connectivity or advertising.

Quickly researchers began to investigate this phenomenon. A literature review on wireless communities (Bina & Giaglis, 2005) examined 40 peer-reviewed papers published before 2004, drawing a research agenda with critical technological, economic and individual research challenges. Among the latter, they state that "the main research question refers to the assessment of the role of individuals […] in the formation, growth and survivability of wireless communities" and more specifically "what are the motivational incentives that drive participation and contribution to a wireless community" (p.12).

The literature review found eight papers addressing this question. The earliest four papers use theoretical arguments (range limitations, self-organized nature and network externalities) to support that reaching a critical mass of active members is vital for wireless communities' growth and sustainability. It is thus crucial to understand their motivations and design proper incentives to attract them and sustain their participation (Camponovo et al., 2003; McDonald, 2002; Rao & Parikh, 2003b; Readhead & Trill, 2003). Two papers (Auray et al., 2003; Schmidt & Townsend, 2003) describe a set of motives such as to create a spirit of cooperation, gain prestige in the community, break free from telecom firms and promote free communication. The two last papers study two potential conflicts of interests between individuals and the community: inducing members to contribute to the community instead of free riding (Sandvig, 2004) and limiting them to fair usage practices (Damsgaard et al., 2006). However, most of these studies are conceptual and provide little empirical evidence.

To address this limitation, Bina and Giaglis (2006a) developed a model proposing that members are driven by a mix of intrinsic motivations (enjoyment, competence, autonomy or relatedness), obligation-based motivations (reciprocity or other community values), extrinsic motivations (get free connectivity, develop skills, get appreciation by others, feel altruist or pursue ideological goals). On the other side, members are discouraged by the perceived cost and effort to join and participate in the community. This model has been tested with two online surveys submitted to members of wireless communities in Greece (Bina & Giaglis, 2006b) and Australia (Lawrence et al., 2007). They found that although different groups of members participate for different reasons, members generally tend to participate to communities more for intrinsic than extrinsic reasons.

Two studies on Wireless Toronto also analyze motivation and barriers. The first (Wong & Clement, 2007) suggests that people have "positive feelings about the benefits of sharing, especially when using others' signals, but serious reservations about making their own signals open" because they consider it difficult, lack trust in strangers, worry for security or their available bandwidth. However, sharing becomes more viable if these concerns are addressed and people get tangible benefits like cost reduction or increased reliability. The second study (Cho, 2008) suggests that personal motivations (having fun, learning technical skills, social networking, getting free Wi-Fi access) are complemented by public interest motivations like promoting inclusion in the information society, media democracy and civic activism.

Abdelaal et al. (2009) focuses on the various types of contributions from members (time, money, expertise, sharing, hardware, software) and shows the importance of social capital besides technical and economic benefits, proposing that communities "were built by technology developers […] to obtain expertise [but] have been redirected to achieve social objectives" (p.1).

Recently, a few authors tried to expand research on members' motivations and hindrance factors of hybrid communities. Biczók et al. (2009) proposes a theoretic game-theory model to illustrate motivations of the various stakeholders of a hybrid community: members, community operator and ISPs. Shaffer (2010) surveys members from both pure and hybrid Wi-Fi communities finding various motivations (expand broadband access, use technical skills and get connectivity, but not to save money or challenge ISPs) and concerns (signal reliability, speed, security and privacy). She also suggests differences between motivations of members of each type of community.

Finally, Camponovo and Picco-Schwendener (2010; 2011) conducted a qualitative study on motivations of members of the Fon community. Participation appears to be driven by tangible rewards (especially free nomadic connectivity, but also revenue sharing or cost-effective equipment), idealistic reasons (the appeal of altruistic and reciprocity values embedded in the concept of sharing and to promote free Internet) and technical interest, whereas social and intrinsic motivations tend to be weak. On the other hand, members are generally aware of potential risks like security, abuse and legality, but are only mildly concerned as the presence of a firm supporting the community plays a key role in reassuring them.

3.5.1.5 Methodology

The literature review above shows that existing research covers several aspects of motivations of wireless community members, but has some relevant shortcomings. Most notably, motivations in hybrid wireless communities have insofar been explored to a lesser extent and only through qualitative methods. As a result, this [book] chapter intends to

address this issue by presenting the results of a quantitative study conducted on members of the Fon community.

3.5.1.5.1 Research Model and Hypotheses

This study is the third part of a research project aiming at understanding motivations and barriers in hybrid wireless communities. Firstly, a theoretical model of motivations and barriers for participating in these communities was developed based on previous research. The model was then refined through a content analysis of 1100 threads of Fon community forums (Camponovo & Picco-Schwendener, 2010) and 30 semi-structured exploratory interviews with members of the Fon community (Camponovo & Picco-Schwendener, 2011). The resulting model is depicted in figure 10 and briefly justified thereafter.

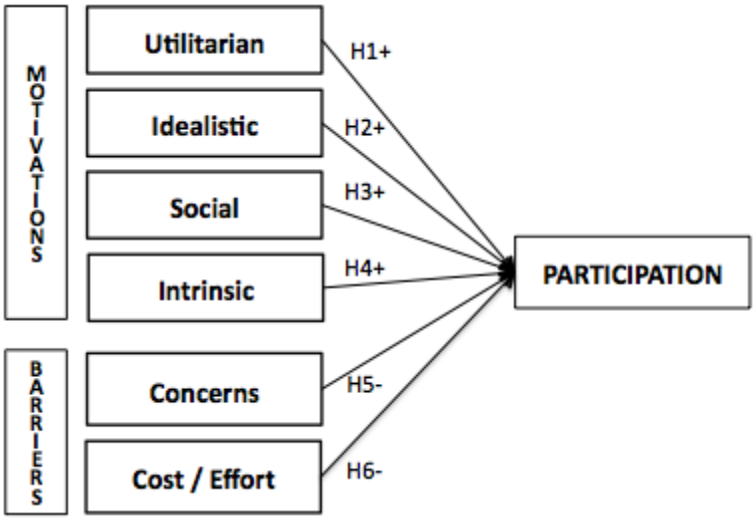


Figure 10 – Motivation and Barriers Affecting Participation in Hybrid Wireless Communities

This model is theoretically grounded on previous studies on wireless communities (especially Bina & Giaglis, 2006a; 2006b) and a set of motivation theories including Self Determination Theory (SDT) (Deci & Ryan, 1985), Volunteer Functions Inventory (VFI) (Clary et al., 1998) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). As a result, the following six hypotheses are proposed:

1. ***Utilitarian motivation positively affects participation:*** as explained by SDT (extrinsic motivation), UTAUT (performance expectancy) and VFI (instrumental function), a behavior can be motivated by the expectation to get something of value in return. In pure communities, this motivation appears to be weak. However, in a hybrid community utilitarian motivation is expected to be important, especially free network access, and maybe also revenue sharing, as their network is bigger and thus more valuable.

2. ***Idealistic motivation positively affects participation:*** SDT (identification) and VFI (enhancement and values) suggest that people are also motivated by psychological rewards like enhancing self-esteem or attaining fulfillment by pursuing idealistic goals. In pure wireless communities these motivations appear to be quite important; in hybrid communities idealistic motivations like endorsing values of sharing, reciprocity or promoting free wireless connectivity are expected to be present, even though they may be limited if the sponsoring firm is perceived more as a business.
3. ***Social motivation positively affects participation:*** as suggested by SDT (relatedness), VFI (social function) and UTAUT (social influence), people can also be driven by social motives like feeling part of a group or gaining approval by others. In pure communities, these motivations are important. In hybrid communities, we expect them to be weaker due to the firm-supported resource-oriented nature of the community (Camponovo, 2011) and their larger size (Olson, 1971).
4. ***Intrinsic motivation positively affects participation:*** SDT (intrinsic motivation) explains that people can be motivated by the enjoyment obtained by performing an interesting task for itself. While this is one of the most important motivations in pure wireless communities, in hybrid communities it may be mitigated by the use of extrinsic rewards, which can have a negative effect on intrinsic motivation (Gagné & Deci, 2005).
5. ***Concerns negatively affect participation:*** as explained in the literature review, people may be reluctant to participate in a wireless community due to a variety of concerns like security, bandwidth consumption and legal concerns. In a hybrid community these concerns are expected to be mitigated by the presence of a supporting firm.
6. ***Effort negatively affects participation:*** as suggested by UTAUT (effort expectancy), people are keener to do an activity if they think it requires low effort. While in pure communities, effort is a significant barrier, in a hybrid community this is expected to be less important as the underlying firm makes it easy to join and participate though standardized hardware and support.

3.5.1.5.2 Instrument of Data Collection

To empirically test these hypotheses, a survey directed at members of the Fon community was developed. The survey (see appendix 2) contains questions about four main themes: 1) membership and experience, 2) participation and contribution to the community, 3) motivations and concerns, and 4) demographic data. To ensure validity, reliability and comparability of results, the questions have been developed based on earlier surveys (Bina, 2007; Shaffer, 2010) and tested measurement scales as shown in appendix 3.

The survey was principally addressed to Foneros in Switzerland. To contact them, Fon has agreed to send an invitation to fill in the web-survey as part of its April 2011 newsletter to all Swiss Foneros. In addition, the survey was advertised through the Fon Twitter channel and posted on the official Fon forum, where it stayed on top of all posts for two months. In that way, it was also possible to tap into Fon users from other European countries. This was useful to check for particularities in the sample and extend the generality of the results.

The survey was published on the project website[21] from April to October 2011. It was available in English and in the three Swiss official languages (German, French and Italian).

It obtained 292 complete and usable responses. A descriptive statistical analysis of these responses is presented in the following section. To enrich their interpretation, they will be complemented with the findings from the 40 semi-structured interviews conducted in the previous phase of the project.

3.5.1.6 Results

3.5.1.6.1 Sample Description

To provide a general understanding of what kind of people participated at the survey, the table below describes the most relevant aspects of the sample.

[21] Wi-Com project website – www.wi-com.org.

Question	Answer	Count	%	Question	Answer	Count	%
Gender	Men	258	88%	Education	Primary/secondary	25	9%
	Women	34	12%		Upper secondary	106	36%
					Tertiary	161	55%
Age	<18	2	1%	Membership type	Linus	130	45%
	18-24	22	8%		Bill	99	34%
	25-34	100	34%		Alien	9	3%
	35-50	121	41%		Ex Member	19	7%
	>50	47	16%		Not yet member	35	11%
Country	Switzerland	131	45%	Membership year	2006	91	31%
	Italy	60	21%		2007	58	20%
	France	32	11%		2008	41	14%
	Germany	23	8%		2009	35	12%
	UK	15	5%		2010	32	11%
	Other countries	31	10%		Not yet member	35	12%

Table 9 – Sample Description

The sample is mostly composed of male participants, which is expected as the perceived technological nature of Fon may discourage women from participating. Adults from 25 to 50 years are predictably the dominant age class (75%), but it is somewhat surprising that only 9% of respondents are younger than 25, whereas 16% are over 50. With regard to the country, almost half of respondents are Swiss (as expected, given that the survey was advertised mainly to them) and half from other countries. Since we checked that responses are not significantly different among the countries, the whole sample is used for the analyses below. It is also interesting that 45% respondents are Linus (without revenue sharing), whereas 34% are Bills and only 3% are Alien (passive member). Finally, by looking at the year of entry, it emerges that those joining in the early years are more numerous than in the following years. This is surprising considering that the growth of the number of members has accelerated through the years, but may partly be explained by the fact that Fon reduced promotional activities, especially in Switzerland, since 2007.

3.5.1.6.2 Motivations

From the survey emerged the following groups of motivations:

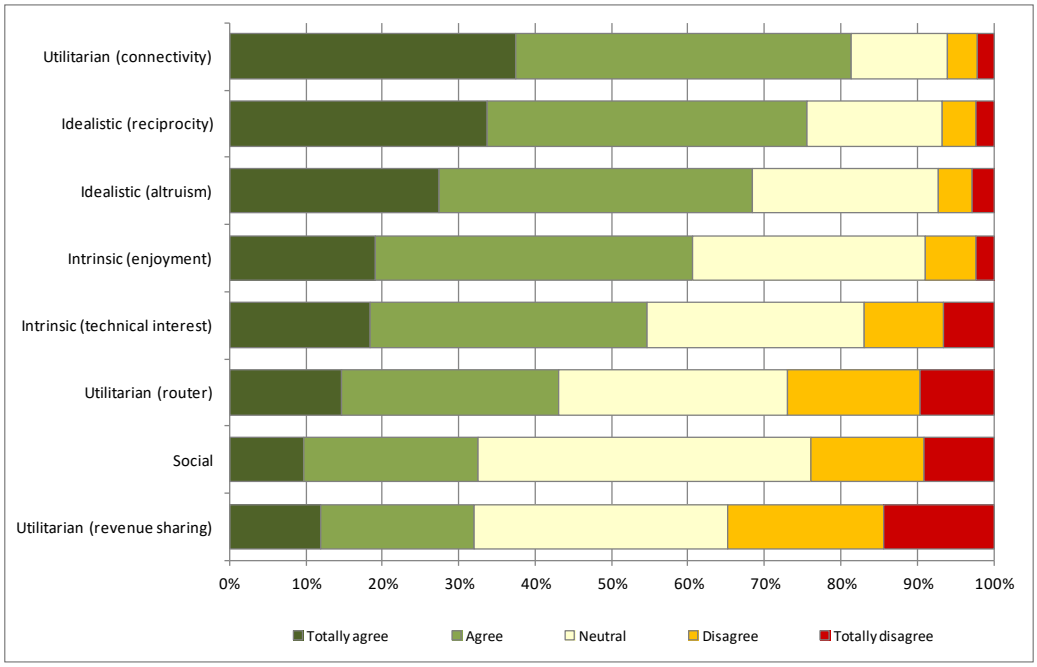


Figure 11 – Motivations of Fon Members

These results fit well into the motivational model described above. Coherently with Fon's business model, which combines business and community aspects, members are motivated by a mix of utilitarian and idealistic motivations like getting free connectivity and respecting community ideals of reciprocity and sharing. Members are also motivated, albeit to a lesser extent, by intrinsic motivations such as enjoyment and technical interest. However, social motivations, getting a cheap router and revenue sharing play a marginal role. In the following sections these results will be interpreted with the help of interviews with Fon members.

Utilitarian Motivations: Getting free Internet ***connectivity*** through the Fon network stands out as the strongest motivation, with 81% of respondents. This is in line with our previous interviews and consistent with Fon's marketing message emphasizing the benefit of getting "free access to over 4 million Fon Spots worldwide."

In the interviews, this emerged even more clearly as the main motive. Many members explained that *"what really made me participate is the fact that it allows me to use other Fon Spots worldwide and for free. Still today this is the key point."* Members value both the extension and the internationality of the community network. However, many contend that the network is not widespread enough and that it is difficult to find working Fon Spots when travelling. They would like Fon to support network expansion through partnerships (60% of respondents find them positive, only 8% find them negative), promotional activities or other means. Members want coverage in areas that are useful to them. For

many this implies having access in places like city centers, hotels or transportation stations. Others see Fon's value in offering connectivity in residential, industrial and rural areas that are neglected by commercial providers.

With the development of 3G and flat rates subscriptions, a lot of members now are less interested in Fon for national use and perceive it as being useful only abroad, where the expensive roaming fees of mobile network operators still make it worthwhile to make the effort to search for access points.

On the other hand, other utilitarian motivations like acquiring a cost-effective ***router or revenue sharing*** appear to be less important.

Only 43% of respondents are motivated by the possibility to get a cheap ***router***. In the interviews, some members pointed out that this was true in the beginning when Fon heavily promoted its routers, but is no longer the case as promotions decrease and other routers got cheaper. Our survey does indeed indicate that this motivation is weaker among members who joined in 2008 or after (39%) than those who joined before (44%)

As for ***revenue sharing***, 32% of members are motivated by it, whereas 35% disagree with it. This is further supported by the fact that more members choose to be Linus (45%) than Bill (34%), even though the latter has the same advantages and also get a share of revenues. Two possible explanations emerged from the interviews. Some members like the idea of revenue sharing, but do not think that they can earn much in their location: only 27% of respondents think that their Fonera reaches areas that are attractive for other Foneros. For others, getting a financial pay-off is in contrast with ideological motivations: for instance *"what I like less is the commercial aspect. I am a Linus type, like Linux, who offers it for free, but the mean thing is that most people still have to pay, because they are not members of Fon."*

Ideological Motivations: Ideological motivations also play a key role for Fon members: 76% of respondents are motivated by reciprocity and 68% consider altruism an important aspect of the community.

In this community, ***reciprocity*** (that is the mutual exchange of connectivity between members) is a key value. It is not surprising that it emerges as one of the most important motivations. For some members reciprocity has mainly a fairness connotation: they consider it right to share given that other Foneros do so. On the other side, other members consider reciprocity simply a means for getting connectivity, reinforcing their utilitarian motivations: they contribute to Fon because they expect the others to do the same *("I don't have a problem with sharing my connection, since in this way I can also use the connections of others").*

With regard to ***altruistic motivations***, various nuances emerged from the interviews and were confirmed by the survey: the idea of sharing *("I thought it is a nice idea to be able*

to share it with others"), of providing universal Internet access *("today you cannot live without Internet, how can you? I don't say that it has to be a universal right, but it should be easily accessible")*, of supporting an alternative to commercial operators (*"it is not really rebellious but it is a sort of declaration of war to the big mobile hot spots, so I wanted to participate and operate a free hotspot myself, so that people can connect")* and of better exploiting existing infrastructures *("I like it because anyway during the day I don't use my bandwidth, so why shouldn't other people use it, too?")*.

Intrinsic Motivations: Participants are also moderately motivated by intrinsic reasons. 61% of respondents perceive participating in the community as ***enjoyable and interesting*****.** A member expressed it nicely: *"for me Fon is cool, they offer me something that is interesting."* Furthermore, 55% of participants are attracted because of ***technical interest*****.** This can be explained by the high percentage of IT specialists among respondents: 56% work in the IT field and 25% are open source contributors. They are naturally curious to see how the community works technically and want to learn and apply their technical skills: *"I try to follow and try out, to a certain extent, all IT and social trends, so that as an IT manager I have a clue and feeling on what is going on."*

Social Motivations: Finally, it is worth noticing that members are not really attracted by social aspects (32%). This is surprising as it contrasts with the concept of a community. Many members did indeed express a "*lack of community feel*", especially when compared to other communities like open source. In the case of Fon, this might be explained by the fact that the community aspect mainly lies in sharing connectivity and not in interacting: *"a community without interacting, where you simply share something with others."* Only 20% state that they interact with other community members through one of the channels offered by the community (forum, messages between members, meetings etc.). In fact, Fon does not put a lot of effort in building social ties among members: forums are strongly moderated and the messaging system is only internal, meaning that members are only notified about messages when they log into their Fon account, resulting in low usage: *"I wrote to others, but I never received an answer."*

3.5.1.6.3 Barriers: Concerns, Cost and Effort

In addition to motivations, we also investigated several potential concerns for participating in Fon. Their importance is illustrated by the following graph:

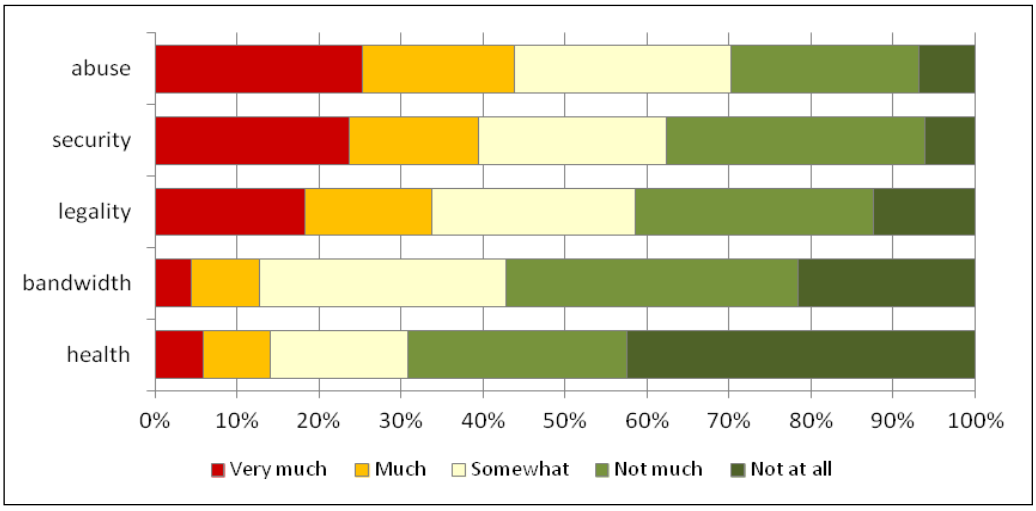


Figure 12 – Concerns of Fon Members

Members are quite aware of these potential risks, but are somewhat reassured by noticing that Fon actively tries to address these concerns by proposing some solutions.

Participants are mainly concerned by the possible ***abuse*** of their shared connection to make illegal or immoral activities (44% being much concerned). The fact that Fon is only open to registered members and claims on its website that *"if anyone tries to do anything illegal with your internet connection, we block them"* comforts many users, as confirmed by several members during the interviews (e.g. *"yes, clearly, it is an open network where you log in but you have to identify yourself. And then, I don't believe that someone is doing some bad things using this hotspot").*

Security and privacy issues are also quite salient (39%). Fon strongly claims to be *"safe and secure"*, emphasizing on his website that "la Fonera protects your connection with two secured WiFi signals" (an encrypted signal for the owner and a public one accessible to other Foneros). Although its actual security is a debatable topic (Middleton and Potter, 2008), this is enough for many Foneros (e.g. *"I have no doubt, I have read what they described on the Internet and I saw that one can be quite safe, knowing that the access is separate from the one which I have on the home PC*"). However, some doubt the security and prefer to implement additional security measures like *"always operating the Fonera in front of a firewall."*

Members are also concerned by the ***legality*** (34%) of sharing their Internet connection, especially with regard to contractual clauses imposed by their ISPs. Many members want Fon to solve this issue by reaching agreements with ISPs. The current partnership strategy of Fon in various countries is a step in the right direction. However, some members feel that *"ISPs don't have any interest in pursuing their customers"* or that the responsibility falls on Fon anyway: *"if it should ever become a problem in Switzerland, they should*

contact Fon and it is their business." It is worth noticing that Swiss respondents are less concerned by legality (27%) than respondents in others countries like France (69%) and Italy (34%) with stricter laws affecting Wi-Fi sharing.

On the other hand, ***bandwidth*** consumption seems to be of no significant concern to respondents (13%) as they can restrict the bandwidth dedicated to sharing and have large broadband connections that they only partially use. ***Health*** concerns are similarly unimportant (14%) even though they emerged a few times during the interviews showing a certain sensibility towards *"energy efficiency"* and *"radiations."*

Beyond these concerns also ***effort and cost*** are traditionally considered hindrance factors in the adoption of a technology solution. With regard to cost, during the interviews it became apparent that this is not a problem for most members. Fonera routers are quite cheap and connection costs would be paid regardless of Fon. With regard to effort, we measured several aspects tied to perceived ***ease of use*** as follows:

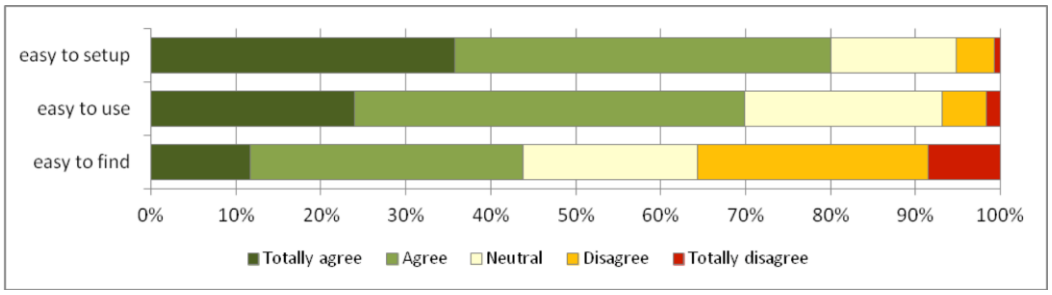


Figure 13 – Ease of Use of the Fon Network Solution

A large majority of respondents (80%) agrees that the initial ***setup*** of the Fonera is easy. The interviews confirmed that this can be achieved without any difficulties *("the solution is well implemented, it works, you don't have to be a specialist, you plug it in and log yourself on the webpage and then it works")*. A few interviewees, however, expressed some concerns with the reliability of the Fonera router.

Fon Spots are similarly considered ***easy to use*** by 70% of the respondents. The landing page and login procedure are generally found to be straightforward to use.

With regards to the ***ease of finding Fon Spots***, respondents have contrasting opinions: 44% of them find it relatively easy and 36% find it difficult to find and access other Fon Spots. From the interviews and survey comments, some recurring difficulties emerged in finding Fon Spots: their actual availability and diffusion *("I travel a lot, but unfortunately I ran into a Fon Spot that I could use, only twice")*, the lack of reliability of the map with misplaced or unreachable Fon Spots *("some disappointments, when you are sure you will find a connection and then when you arrive it does not work")* and signal strength *("Fon Spots are not very well placed. Most people place it so that they have good reception inside*

the flat but then it is mostly just enough to see it on the street but not for the other to use it properly"). A frequent comment is that *"there should really be easier ways to find out about Fon Spots around the world"* otherwise members would *"never use Fon Spots while travelling cause it is too troublesome to actually find them."*

3.5.1.6.4 Usage, Satisfaction and Future Intentions

The difficulty of finding Fon Spots also exerts an influence on their ***actual usage***. The reported number of Fon Spots accessed by respondents is quite low: in average respondents accessed 2 Fon Spots in the last 12 months, with 43% them not accessing any and only 6% accessing more than ten.

In our survey, we also asked respondents what they do when connected to a Fon Spot. The vast majority of members mainly check their ***e-mail*** (77%) or simply browse the ***web*** (75%)**.** Many look for specific ***local information*** (65%) such as *"getting tourist information on the region, organizing something for the evening or [finding] something to visit."* This suggests that free Wi-Fi networks may have valuable applications in the tourism sector. Fon is also used for phone calls via VoIP ***communication*** services like Skype (48%), using *"Wi-Fi in order to do phone calls at reasonable prices."* Yet, some members find the quality of such calls not always satisfactory. On the other hand, heavy bandwidth-consuming applications like audio/video streaming (24%) and file sharing (10%) are used less. Many members do not want to consume too much bandwidth keeping in mind that the community is based on respectful sharing and that Fon Spots are *"the wrong place for doing downloads."* In addition, Fon Spots seldom reach places that are comfortable for connecting, resulting in *"mostly short connections […] when I stay online for longer time then I usually look for a more comfortable place."*

The most common ***devices*** used to access Fon Spots are notebooks (81%) and smartphones (74%), followed by far by tablet PCs (20%) and gaming consoles (9%).

It is interesting to note that, inside their country, respondents use mainly 3G (57% use it at least some times per week), much more often than Wi-Fi (27%) to connect to the Internet. In contrast, abroad they tend to prefer Wi-Fi. This is explained by the diffusion of 3G subscriptions that allow flat-fee consumption of data nationally but charge expensive roaming costs abroad. This is in line with the above suggested interpretation that wireless communities may play an important role in the field of tourism and travelling by supplying people with cheap Internet connectivity abroad, while 3G will probably dominate the domestic use of mobile Internet access.

The survey also tried to measure the satisfaction of respondents. A large majority of members declared to be satisfied with their experience with Fon (70%) and even more would recommend it to their friends (77%). Such a high satisfaction likely results from the

fact that Foneros expectations about using Fon are mostly confirmed (57%). While many members admitted in the interviews that their expectations are not necessarily very high, given the low entry costs and community nature of Fon, this suggests that most Foneros are not fooled by Fon's marketing promises and mostly get what they expect.

Finally, respondents were asked about their future intentions. 81% of respondents state that they intend to remain an active member, at least for the next year, while 78% expect to actually use Fon in that period.

3.5.1.6.5 Types of Contributions

The following graph shows how members participate in various ways in the Fon community:

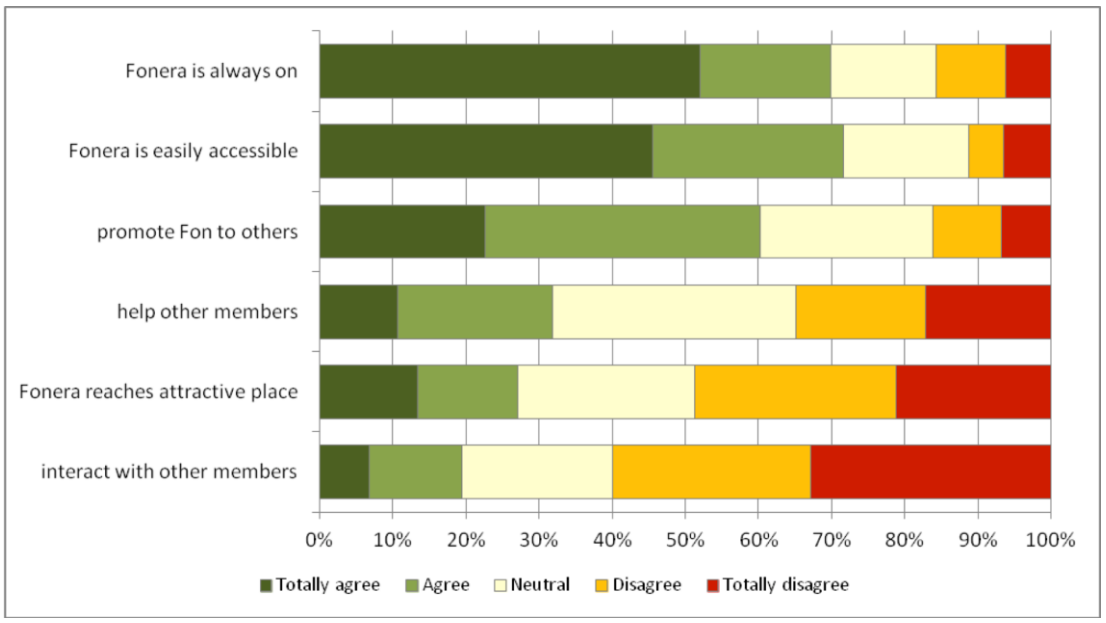


Figure 14 – Contributions of Fon Members to the Community

The main contribution of members is predictably sharing their Internet connection with other members. Approximately 70% of respondents claim to keep their Fonera ***active*** most of the time and believe that they installed it in a way that it is ***easily accessible*** by other Foneros. This is somewhat surprising as it contrasts with the reported difficulties of finding working Fon Spots. A possible explanation is that Fonera have limited range and their signal is strongly attenuated by walls *("It already had some reception problem inside our flat with 6 rooms. The router was in one room and at the other end of the flat I didn't have any reception").* During the interviews, we observed that some members simply put the Fonera near their phone lines, often not an ideal place. Yet, some really make an effort to

place their Fonera well, for instance *"a bit outside [so that] it really reaches far",* or reinforce the signal with external antennas. It is also worth noticing that about 30% of respondents claim to have more than one active hotspot.

Only 27% of respondents consider that their Fonera ***reaches attractive places*** for other Fon members. Most members live in residential areas that are not close enough to points of interests like bars, restaurants, stations or tourist attractions where "*it really could have a chance to be used.*"

This is also supported by data on the number of accesses to participants' Fon Spots, with an average of only 4 visitors in the last 12 months. Nearly 50% of them had no visitors at all, while only 6% had more than one visitor per month. The number of visits is coherent with the perceived attractiveness of their position: those declaring to live in unattractive places report less visits than those in more attractive ones.

Another way in which members contribute to the Fon community is by ***promoting or recommending*** Fon to friends and people they know. 60% of respondents state to promote Fon to potential new members and even more to recommend to their friends (77%). The interviews showed that they do it in various ways. Many members simply talk to their friends about it and try to convince them to join. Others use signs to advertise their Fon Spots like *"a shield with Login and Password in front of my house"* or *"a Fon sticker on my mailbox."* Some members even give friends extra Foneras and *"regularly ask and check whether they actually use it or at least forward it to someone else when they don't use it anymore."* This is interesting as it helps the community grow, resulting in benefits for both Fon and members. The former can sell additional routers, the latter can have access to more Fon Spots.

On the other hand, it may be quite surprising for a community that members do not engage much in "social" activities like ***helping other members*** (32%) and ***interacting*** with each other (20%). However, this is coherent with the observation that social motivations are weak and that most respondents do not exchange messages at all with other members (86% have received no messages from other members in the last 12 months).

3.5.1.7 Discussion and Recommendations

Given that connectivity is the most important motivation of Fon members, extending the community must be considered as the key success factor. Fon should therefore continuously put effort in attracting new members and thus enlarging the community at a worldwide level. To do so, it can employ various means.

Their current strategy of extending their network of ***partnerships with telecom*** operators in various countries seems to be an effective means to quickly enlarge their community. This strategy is positively regarded by a large majority of our respondents (60%), while

only a few find it negative (8%). However, many of our interviewees indicated that these deals are welcome only as long as they respect reciprocity. It is important that all Foneros can benefit from them by accessing the spots of the partner's customers and not only vice versa. Members would be upset if *"you participate and try to make everything work on your spot and then [partner's clients] can use your spot but you cannot use theirs. This I don't like."*

Members also suggest extending ***collaborations to commercial partners*** who own places where an internet connection would be prized. These include companies in the travel sector like transportation companies, airports, bus or train stations *("It's a pity that you cannot find Fon Spots in train stations, you always find Swisscom but never Fon, it's a pity because there you really need it")*. Restaurants, hotels and commercial centers are also seen as interesting venues. Members find that "*the concept of Fon would be better if it was more deployed in commercial centers, cafés and so on."* Another suggestion is to look for partnerships with ***municipal / public institutions*** to *"go much more into the public space."* In the last years, several cities created their own wireless networks for their citizen and tourists. Usually they are confined to the central areas of the city and to a few points of interests. As Fon's business model is currently based on private people sharing their Internet access, most access points are in residential areas, leaving attractive places in the center uncovered. In this sense, looking for collaborations with cities could increase Fon's attractiveness and make people more aware of the community.

Foneros also believe that elaborating commercial deals with ***Local distributors*** would be a good idea. This would make the Fonera routers more accessible to the large public and increase its visibility. In this way you don't need to know Fon beforehand, but you can find it as a possible alternative in the local shop when buying a router. Furthermore, not everybody likes to buy equipment online and paying expensive delivery costs. It seems that in some countries this is already possible and appreciated: *"In Japan I saw Fon Spots for sale in various shops. You don't have to order it in an online shop in Spain with 20 Euro delivery cost to Switzerland. This is certainly a big obstacle."*

Even partnerships with other ***companies developing routers*** might be interesting in order to *"be able to activate Fon on a standard router without necessarily having to buy a Fonera."*

Concerning the ***Fonera router***, most members are actually quite satisfied with it. They mostly consider it secure and easy to use. However they would like Fon to include a more powerful antenna or at least *"it should not be necessary to buy the external antenna extra."* They would like Fon to invest more in increasing the signal strength of their routers: this is fundamental to make the signal reach the streets and make it actually available to others. Some members also notice that an improvement in this sense should be possible, as other routers seem to have stronger signals and reach farther. Furthermore a better education of

members in how and where to best place the router inside the house and in how to install them may be useful to increase availability and reliability of Fonera Wi-Fi signals to other members.

Members also strongly expressed in both the survey and interviews that it is crucial to be able to ***easily find active Fon Spots***. Many of them indicated that there should really be easier ways to find Fon Spots around the world, otherwise members would never use them as it may be too troublesome to actually find them. They need effective means to locate them and want Fon to focus on *"improvement of search tools."* They consider that Fon maps are not reliable enough and expect that Fon engages more in *"checking whether the Spots really are where they are marked, whether they are usable and possibly providing a solution for evaluating each spot."* They would also like to be able to download such maps on mobile phones or GPS devices.

Several participants also suggested that Fon should ***facilitate interaction*** among community members and with the company. Members generally appreciate the availability of an official Forum that can be used to discuss with other members and get some support from them, but many members find that Fon should provide a more effective and timely support when they encounter problems. Another aspect that should be improved is Fon's internal ***messaging system***. As a community, it should be easy for members to get in touch with each other without having to log into their Fon-account regularly. As it is currently implemented, it seems to be nearly impossible to get in contact with other members through the messaging system, it is a *"communication system that does not really work."* It would be appreciated by community members to receive an e-mail whenever a Fon Message arrives and be able to easily answer it.

Finally, many members are interested in how Fon works from a technological point of view and would like to be able to play and experiment with the technology. Unfortunately the community does not leave much room for these kinds of experiments as most technical aspects are controlled by Fon itself. However it might be beneficial for the community to allow a higher involvement of the community (many members are active open source software contributors) in the evolution of the service and welcome technological contributions and inputs.

3.5.1.8 Research Limitations and Future Directions

This research focuses on one specific wireless community: Fon. Even though it is the largest one, with more than 4 million members worldwide, it might be interesting to look for other hybrid communities and repeat the study with their members in order to better understand if the results of this study can be generalized to all types of hybrid wireless communities.

It would also be interesting to compare motivations between pure and hybrid wireless communities. Existing literature provides some interesting studies on pure communities, suggesting that motivations are partly similar but differ in their importance. In particular, intrinsic and social motivations appear to be more important in pure communities, whereas utilitarian motivations seem to be stronger in hybrid ones. However, a direct comparison of these results is difficult as they refer to communities in different times, diverse cultural contexts and employ various methodologies. This makes it impossible to tell whether these differences are caused by the presence of a supporting firm or by other differences. It would therefore be interesting to conduct a new study, similar to this one, on pure communities.

Researchers can even go a step further and analyze if similar motivations and barriers apply to other types of online communities such as P2P networks, open source projects, communities of practice, social networks, user-generated content communities and other forms of web 2.0 collaborations.

3.5.1.9 Conclusion

This [book] chapter analyzed motivations and barriers influencing participation in a hybrid wireless community like Fon, based on the data collected from a quantitative analysis of 292 members and interpreted with the help of the qualitative insight collected through semi-structured interviews with 40 Foneros.

It appears that members of hybrid wireless communities are essentially motivated by a mix of utilitarian, idealistic and – to a lesser extent – intrinsic motivations.

The first and most important motivation is the ***utilitarian*** value of the community. In particular, members value the possibility to get Internet ***connectivity*** from other members at a worldwide level. Especially when being abroad, where 3G roaming prices are generally found excessive, wireless communities offer a much cheaper solution to get Internet connectivity. However other utilitarian motivations like getting cheap equipment and revenue sharing are quite weak.

A second important group of motivations is ***idealistic***. It includes ***reciprocity*** as well as ***altruism*****.** The first is a fundamental aspect of a resource-based community where members are supposed to contribute to and not only benefit from the community network. The latter is also important as members value the spirit of helping and sharing with others, allowing them to contribute to make Internet accessible to everyone. They also like the idea of supporting an alternative to traditional commercial operators. Finally, members appreciate the environmental gains (e.g. lower radiation and electricity savings) by better exploiting existing infrastructure through sharing.

Intrinsic motivations like technical interest and enjoyment are also present, albeit to a lesser degree, but are still stronger than ***social motivations***. While in other communities, social aspects play a fundamental role and represent the community spirit, here it is not the case: members do not really interact with each other. The community is consequently reduced to a reciprocal exchange of Internet connectivity.

Regarding ***concerns***, members are generally aware of the risk that someone may use their hotspot for illegal activities (abuse), that someone might be able to access and use their data (security) and that participating in the community might not comply with contractual clauses of their ISP (legal). However, most members feel sufficiently reassured by the various efforts done by Fon to deal with these issues.

This [book] chapter also analyzed member ***contributions*** to and ***usage*** of Fon. Members principally contribute by sharing their own connections, trying to keep their router on and making it easily accessible to others. They also try to help by promoting the community, but engage less in socializing, helping and interacting with other members. On the other hand, actual ***usage*** of the community is quite low. This is influenced by the difficulty of finding active Fon Spots and the increasing adoption of 3G with flat rate contracts. In spite of this, members are generally satisfied with their experience of participating in Fon and find that their expectations are mostly met.

The Appendixes “Survey” and “Survey Scales” have been moved to the section Appendixes at the end of this dissertation.

3.5.2 Article 2: Motivations and Barriers for Participation in a Hybrid Wireless Community: the Case of FON

Title:	Motivations and Barriers for Participation in a hybrid wireless community: the Case of FON
Authors:	Giovanni Camponovo, ***Anna Picco-Schwendener***, Lorenzo Cantoni
Publication:	International Journal of Technology Diffusion (IJTD), 5 (3), 22-38, 2014

3.5.2.1 Abstract

Wireless communities may be an intriguing alternative to 3G networks for offering mobile Internet, but their success depends on their ability to reach a critical mass of active members. The main issue is to understand what motivates and hinders people to join and participate in these communities to design suitable incentives to attract people and promote an active and enduring participation. This paper studies the factors that influence participation in Fon, the largest wireless community, based on a theoretical model based combining research on technology adoption, self determination theory and prosocial behavior. The model is then empirically tested employing a mixed methodology drawing on 30 interviews and a survey of 268 members. Two types of participations are found to be driven by different motivations: participation by sharing, mainly driven by idealistic motivation linked to community values and reciprocity, and social participation is driven by social and technical motives like interacting and learning with other community members. On the other hand, utilitarian motivations do not have a significant effect on participation, even though they are deemed important for attracting members.

Keywords: wireless communities, adoption, motivation, participation

3.5.2.2 Introduction

Our society is increasingly mobile and connected. Two trends contributed to this: the diffusion of mobile computing fosters a need for Internet access anytime anywhere (Ladd et al., 2010; Petrova & Huang, 2011), while social computing is making communities redefine our online experience (Parameswaran & Whinston, 2007).

The potential of combining these trends into wireless communities, where members share wireless Internet access, is therefore fascinating. Some envisioned a "napsterization" of wireless communications, disrupting the telecom industry and realizing the vision of a free wireless Internet anytime anywhere (Clark, 2002). This vision has been going for a decade and is somehow still associated with Wi-Fi despite its proximity restrictions (Cho, 2008)

and 3G networks have arguably better fulfilled the anytime anywhere, but not free, vision. Yet, Wi-Fi still is an intriguing option because it allows community-based models that are so successful in the web 2.0 era.

For wireless communities to be viable it is fundamental to attract a critical mass of members willing to share their Wi-Fi. This requires understanding why people may decide to join and actively contribute to such communities, and designing suitable incentives to attract and maintain their participation over time.

Existing research tackled this issue with regards to "pure" communities, built and operated by members in a self-organized way. In reality, "hybrid" communities, where a company supports individuals sharing their own Wi-Fi by operating central network elements and offering incentives, have been more successful in attracting members. While the largest pure community (NYC Wireless) has 40'000 members, the largest hybrid community (Fon) has more than 7 million (Fon, 2013). This distinction is crucial because the presence of a supporting firm may influence members' motivations, their participation and the success of the community.

The purpose of this paper is therefore to understand what drives or hinders people to join and actively participate in a hybrid wireless community. A mixed method approach is employed, based on qualitative interviews with 30 members and a quantitative analysis of a survey with 268 members of the Fon community. Fon is chosen because it is the largest hybrid wireless community in the world.

3.5.2.3 Study Context: Wireless Communities and the Fon Case

Wireless communities appeared around 2000. While mobile operators struggled deploying 3G networks, a grassroots movement quietly set up open Wi-Fi hotspots and formed wireless communities offering free Wi-Fi Internet access (Schmidt & Townsend, 2003). Fueled by cheap equipment and flat-fee Internet connections, they started to grow and become an option for offering wireless broadband in densely populated areas.

Other actors began to offer Wi-Fi Intenet access with various business models including ***pure communities*** (entirely built and operated by members in a self-organized way), ***hybrid communities*** (where a business firm supports members by operating central network elements and offering and incentives in exchange of exploiting the community network), ***commercial providers*** (which deploy hotspots, manage them and charge users for access) and ***government-based municipal networks*** (Lehr & McKnight, 2003; Rao & Parikh, 2003b).

Fon stands out as the largest wireless community, with more than seven million members worldwide. It is a for-profit company founded in 2005. Its mission is to create "a Wi-Fi network built by the people" where "you share a little bandwidth with others and millions

more share with you." The initial idea was to offer a firmware for turning standard routers into Fon hotspots, but the firm quickly began to sell its own preconfigured routers, named 'Fonera', as a way to get revenue besides access fees from non-sharing members and advertising. Fon received funding from firms like Google and used it to offer low cost routers, seeding the community network and enabling its growth. With this model "Fon has been losing large amounts of money" (Middleton & Potter, 2008, p.12). Over time, the business model evolved by focusing on selling routers at higher prices and relying on partnerships with telecom operators (like BT Group, SFR, ZON, Comstar etc.) to expand its network.

Fon offers to its members, called 'Foneros', three types of memberships to target different users: "Linus" share their home connection for free and can freely access other Fon spots, "Bill" are alike but also get 50% of the net revenue generated by their spots, "Alien" do not share connectivity and must pay a fee to get access.

Fon's offering emphasizes its utilitarian aspects by promising "free access to over four millions Fon spots worldwide", "speedy connection to all your devices" (like notebooks, smartphones, tablets and other wireless devices) and the possibility to "make some money." At the same time, Fon tries to address potential concerns by claiming it is "easy" (with plug-and-play hardware), "secure" (by providing separate encrypted signals for its owner and registered Fon members) and allowing bandwidth limits. Whether these claims are maintained is not an issue covered by this article (cf. Middleton et al. (2008) for more information on these topics).

Fon also promotes itself as "a community network built by the people", even though it provides members limited control on the community. They can only limit the shared bandwidth, visualize who connects to their spots and exchange messages with other members. Except that network infrastructure is provided by individual members, Fon basically operates like an ISP in that it controls the technical solution and operates central network elements. Fon also maintains a central database of hotspots to provide an interactive map of Fon spots.

3.5.2.4 Literature Review

3.5.2.4.1 Motivation Theories

Three research streams are relevant for understanding adoption and participation in wireless communities.

The first emphasizes intentional decision making. The ***expectancy-valence theory*** (Atkinson, 1964; Vroom, 1964) first proposes that people are motivated to do something if they expect that their efforts will lead to some valuable outcomes. The ***Theory of***

Reasoned Action (Fishbein & Ajzen, 1975) further suggests that behavior depends not only on "beliefs about the behavior's consequences and [their] evaluations" but also on "beliefs that relevant referents think he should or should not perform the behavior." The ***Theory of Planned Behavior*** (Ajzen, 1991) adds "the perceived ease or difficulty of performing the behavior" (p.188). These theories were adapted to explain technology acceptance and usage by the ***Technology Acceptance Model*** (Davis, 1989), suggesting that they are driven by perceived usefulness and ease of use. ***Innovation Diffusion Theory*** (Rogers, 2003) identifies five innovation properties that favor its diffusion (relative advantage, compatibility, complexity, trialability, observability) and different adopter types (from early adopters to laggards). Finally, the ***Unified Theory of Acceptance and Use of Technology*** (Venkatesh et al., 2003) integrates those aspects by proposing four determinants of behavioral intention (performance expectancy, effort expectancy, social influence, facilitating conditions). Although developed for working contexts, these models were also successfully applied to non-working contexts as well as communities (see King & He, 2006).

The second stream is represented by the **S*elf Determination Theory*** (Deci & Ryan, 1985), which distinguishes various types of motivation ranging from intrinsic motivation (doing something for its inherent satisfaction) to extrinsic motivation (to get some separable outcome). The latter is further differentiated between external (to get some reward), introjected (it enhances self-esteem), identified (it is considered personally important) or integrated (assimilated with one's values) motivation.

The third stream focuses on prosocial behaviors like helping, comforting, sharing and volunteering (Batson, 1998), which are a key component of communities. The ***Functional Approach to Volunteers Motivations*** (Clary et al., 1998; Snyder, 1993) explains that people enact such behaviors because it serves functions like gaining knowledge, express one's values, comply with social expectations, get utilitarian rewards, enhance one's ego or protect against negative feelings about oneself.

3.5.2.4.2 Motivations in Wireless Communities

A literature review on wireless communities confirms that "the main research question refers to the assessment of the role of individuals […] in the formation, growth and survivability of wireless communities" (Bina & Giaglis, 2005, p.12). The need to understand member motivations is raised by several authors (Camponovo et al., 2003; McDonald, 2002; Rao & Parikh, 2003a; Readhead & Trill, 2003) and specific motivations have been proposed like create cooperative spirit, gain prestige in the community, promote free communication and challenge telecom firms (Auray et al., 2003; Schmidt & Townsend, 2003). Potential conflicts of interests between members and the community are also analyzed: inducing members to contribute instead of free riding (Sandvig, 2004)

and limiting them to a fair usage (Damsgaard et al., 2006). However, these papers address the question abstractly, with little empirical evidence.

The first empirical studies of wireless community members in Greece (Bina & Giaglis, 2006b) and Australia (Lawrence et al., 2007) suggest that participation is driven by a mix of ***intrinsic motivations*** (enjoyment, competence, autonomy, relatedness), ***obligation-based motivations*** (reciprocity, community values) and ***extrinsic motivations*** (explicit rewards, external pressure, self-esteem, connectivity needs, human capital, altruism), but hindered by ***perceived effort*** to join and participate. Different groups of members are driven by distinct mixes of intrinsic, idealistic and extrinsic motivations, with the first two being higher.

Focusing on Wireless Toronto, Wong and Clement (2007) find that people have "positive feelings about the benefits of sharing […] but serious reservations about making their own signals open" because they believe it is difficult, distrust strangers, worry for security or bandwidth. On the other hand, sharing is more likely if these concerns are addressed and members perceive benefits like cost reductions or enhanced reliability. Cho (2008) reports a mix of motivations based on *personal interest* (fun, technical skills, social networking, free Wi-Fi access) and *public interest* (Information Society inclusion, media democracy, civic activism).

Abdelaal et al. (2009) concentrates on member participation, highlighting that members contribute in other ways besides sharing (i.e. with their time, money, expertise, hardware or software) and suggests the importance of building social capital in addition to technical and economic benefits.

Only recently a few authors started to focus on hybrid communities. Biczók et al. (2009) build a game-theory model describing the motivations of members, community operators and ISPs. Shaffer (2010) conducts a survey of members of pure and hybrid communities, finding various motivations (expand broadband access, use technical skills, get connectivity) and concerns (reliability, speed, security, privacy). She also suggests differences between members of pure and hybrid communities. Finally, Camponovo and Picco-Schwendener (2010; 2011) analyzed forum posts and conducted interviews with Swiss Fon members finding that they are motivated by tangible rewards (free connectivity), idealism (altruism, reciprocity, promotion of free Internet) and technical interest, while social and intrinsic motivations are weaker. Members are aware of possible risks (security, abuse and legality) but are mildly concerned as they feel reassured by the supporting firm.

3.5.2.5 Research Model and Hypotheses

To guide this research, a theoretical model explaining why individuals may participate in a hybrid wireless community is developed. The model is based on existing literature, especially on the motivation and barriers model developed by Bina and Giaglis (2006a) as well as the considerations on participation of Abdelaal (Abdelaal et al., 2009), and was adapted to the context of hybrid wireless communities through exploratory analyses of forum posts and interviews with members of the Fon community (Camponovo & Picco-Schwendener, 2010; 2011). These studies confirmed the relevance of the proposed motivations and clarified their meaning in the context of hybrid wireless communities. The resulting model, illustrated in Figure 15, proposes that participation in hybrid wireless communities is driven by utilitarian, idealistic, social and intrinsic motivations, but is hindered by concerns and perceived effort. The underlying hypotheses are briefly justified thereafter.

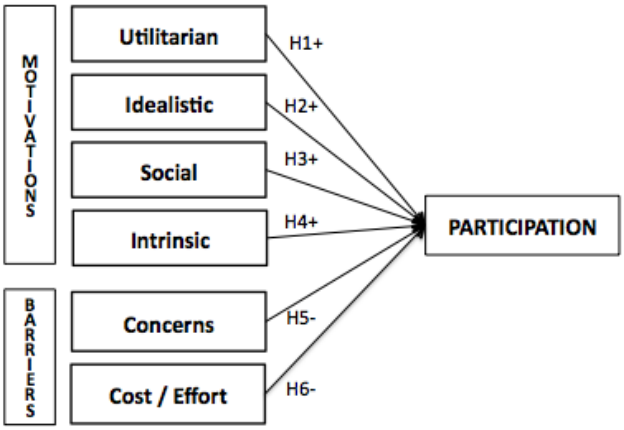


Figure 15 – Theoretical Model

H1: utilitarian motivation positively affects participation This hypothesis is supported by all three theory streams described before: Technology acceptance research supports that technology adoption is driven by its perceived usefulness; Self Determination Theory explains that people can be extrinsically motivated to do an activity to attain some separate outcome; even volunteerism research confirms that such activities may also have an instrumental function. Research on pure wireless communities offers mixed support. Some studies find utilitarian motivations to be lower than intrinsic and idealistic motivations, while others find getting connectivity a major motivation. In hybrid communities, utilitarian motivations like free connectivity are expected to be a key motivation to join the community as the network is larger and thus more valuable.

H2: idealistic motivation positively affects participation. Self Determination Theory explains that people may also be motivated by psychological rewards like enhancing self-esteem by engaging in idealistic actions that express personal values. Research on volunteerism confirms that prosocial activities may be motivated by their enhancement and values function (develop psychologically, feel better about oneself, humanitarianism). In pure wireless communities, idealistic motivations like altruism, reciprocity and promotion of Wi-Fi are consistently found to be important. In hybrid ones, idealistic motivations are also expected, though the presence of a supporting company may reduce them as it may be perceived as worse suited to achieve idealistic goals. Still, studies on Fon suggest that idealistic motivations are almost as important as utilitarian benefits.

H3: social motivation positively affects participation. The importance of social motivation is explained by Olson (1971): "people are sometimes motivated by a desire to win prestige, respect, friendship and other social or psychological objectives" (p.60). Technology acceptance research recognizes that social motivations play a role in the diffusion and adoption of an innovation. Self Determination Theory proposes that people may act to satisfy a relatedness need, establish a sense of mutual respect and reliance with others. Research on volunteerism states that prosocial activities often satisfy a social function. In pure wireless communities, social motivation is a third motivation behind intrinsic and idealistic reasons. In hybrid communities, it is assumed that social motivation plays a similar or weaker role because of the firm-supported resource-oriented nature of the community (and because their larger size makes social ties between members less relevant).

H4: intrinsic motivation positively affects participation. As shown by Self Determination Theory people can be intrinsically motivated by performing an interesting or enjoyable task for the activity itself, rather than for obtaining some separable outcome. Intrinsic motivation also stems from a need of feeling competent by succeeding at challenging tasks. In pure wireless communities, technical interest and the chance to improve technical skills are a key form of motivation. In hybrid communities, this factor is expected to play a somewhat reduced role due to the fact that the technology is more mature and controlled by the supporting firm.

H5: concerns about sharing negatively affect participation. Research on pure wireless communities found that people may be reluctant to share their connections due to concerns like security, privacy, reduced bandwidth and distrust for strangers. In hybrid communities, these concerns are expected to be reduced by the presence of a supporting company proposing solutions to tackle these issues and reassuring members.

H6: perceived effort negatively affects participation. Technology acceptance research considers effort as the other main adoption determinant besides usefulness and social influence. In pure wireless communities, the perceived difficulty and effort required to

join and participate appears to be a significant barrier. In hybrid communities, members expect that the underlying firm makes it easy to join and participate through a standardized and mature technical solution, but they also tend to be more demanding.

3.5.2.6 Methodology

3.5.2.6.1 Instrument Development

Survey questions were developed based on already validated measurement scales, adjusted to the hybrid community context by adjusting their wording and verified through a pre-test with ten respondents to ensure the questions were clear and interpreted as intended. Table 10 lists the questions and the references where the questions were taken from. The items are measured using five-point Likert scales measuring the level of agreement formulated as follows: 1) totally disagree, 2) agree, 3) neither agree nor disagree, 4) agree, 5 totally disagree. Moreover, the questions were presented following a random order to reduce response biases.

Construct	Item	Wording	References
Participation	PA1	My Fonera is always on and connected to the Internet	Social capital contributions (Abdelaal et al., 2009)
	PA2	My Fonera is installed in a way that it is easily accessible by other members	
	PA3	I interact with other community members (Fon messages, forums, meetings)	
	PA4	I volunteer my skills to help members or improve the Fon offering	
Utilitarian Motivation	UT1	Participating in Fon is useful to get free Internet access when not at home	Intrinsic Motivation Inventory: value usefulness (Ryan, 1982)
	UT2	Participating in Fon enables me to get free Wi-Fi access worldwide	
Idealistic Motivation	ID1	I can use other people's access points, so I desire to give back	Reciprocity (Bina, 2007)
	ID2	I know other Foneros share their access with me, so it's fair to share my connection too	
	ID3	When I contribute to the Fon community, I expect others to do the same	
Social Motivation	SO1	I would like a chance to interact with other Foneros more often	Intrinsic Motivations Inventory: relatedness (Ryan, 1982)
	SO2	I feel close to the other members involved in the Fon community	
	SO3	I feel like I can trust other people in the Fon community	
Intrinsic Motivation	IM1	Participating in Fon allows me to learn or apply technical skills	

	IM2	I am interested in Fon from a technical viewpoint (to see how it works)	Basic Psychological Needs: competence (Bina, 2007)
Concerns	CO1	Security or privacy (viruses, hackers, access to personal data etc.)	Concerns (Wong, 2007)
	CO2	Abuse (illegal or immoral activities)	
	CO3	Legality (of sharing my Internet connection	
Effort	EF1	The Fonera is easy to setup	UTAUT: effort expectancy (Venkatesh et al., 2003)
	EF2	Fon spots are easy to use	

Table 10 – Model Constructs and Measurement Scales

3.5.2.6.2 Sample and Data Collection

To contact Fon members, Fon agreed to promote the survey in its April 2011 newsletter to all Swiss Foneros. In addition, the survey was advertised through the Fon Twitter channel and posted on the official Fon forum, where it stayed on top for two months. In that way, it was possible to collect data from members of other European countries, allowing to check for particularities in the sample and to extend generalizability.

The survey was published on the project website[22] from April to October 2011. It was available in English, German, French and Italian. 388 responses were obtained, among which 91 were incomplete and 29 were not from Fon members, resulting in 268 usable responses. The sample is mainly composed of men (93%) aged 25-49 (73%), which is fitting with previous surveys on wireless communities. About half respondents is Swiss (47%), which is expected as that the survey was advertised mainly to them, while the other half comes mainly from Italy (16%), France (12%), Germany (7%), UK (6%) and other European countries. During the analyses no significant differences emerged between Swiss and other members.

3.5.2.6.3 Data Analysis

A Structural Equations Modeling technique was employed for data analysis. This method has the advantage of simultaneously evaluating the measurement model (validity and reliability of constructs) and the structural model of relations between them. The software employed was LISREL version 8.8 for Windows.

Data analysis followed a two-stage approach as suggested by Gefen et al. (2000). Firstly, the measurement model is tested using confirmatory factor analysis to evaluate the validity

[22] Wi-Com project website – www.wi-com.org

of constructs and indicators. Then, the structural model is tested to assess the relationship between constructs and the overall fit of the model.

Convergent validity was assessed through a confirmative factor analysis. Based on its results, which suggested the existence of two different participation constructs, we decided to split participation in two separate constructs. This decision is theoretically justified by the findings of Abdelaal et al. (2009), which differentiates between various types of participation in a wireless community. The first is "social participation", where members are socially involved in the community by interacting and helping each other to improve the community and its services. The second is "participation by sharing", where members actively share their Internet connection with the community, making an effort to keep their routers always on and placing them to reach the public space. The results of the factor analysis with the two separate participation constructs are shown in Table 11. All item loadings are significant (t-value>1.96) and above the 0.50 threshold (Kline & Santor, 1999) and all reliability statistics are above the recommended 0.70 level (Gefen et al., 2000), except effort, which is close.

Construct	Items	Reliability	Loadings	Mean	St.Dev.
Participation (sharing)	PA1	α = 0.81	0.78	4.10	1.22
	PA2		0.88	4.10	1.12
Participation (social)	PA3	α = 0.74	0.73	2.30	1.25
	PA4		0.80	2.92	1.24
Utilitarian motivation	UT1	α = 0.78	0.83	4.12	0.95
	UT2		0.72	4.10	0.91
Idealistic motivation	ID1	α = 0.78	0.77	4.09	0.87
	ID2		0.82	4.18	0.91
	ID3		0.62	4.16	0.88
Social motivation	SO1	α = 0.78	0.79	3.16	1.33
	SO2		0.78	2.87	1.08
	SO3		0.64	3.35	0.88
Intrinsic motivation	IM1	α = 0.73	0.83	3.32	1.14
	IM2		0.72	3.62	1.10
Effort	EF1	α = 0.65	0.84	4.15	0.83
	EF2		0.58	3.86	0.90
Concerns	CO1	α = 0.84	0.8	3.22	1.31
	CO2		0.89	3.37	1.30
	CO3		0.71	2.99	1.30

Table 11 – Convergent Validity Measures

Discriminant validity is also assessed by examining that the correlations of factors supposed to measure distinct constructs are not excessively high, that is not above the 0.85

level recommended by Kline (1999). Table 12 shows that none of the values exceeds this limit.

Variable	1	2	3	4	5	6	7	8
1 PartSHA	**0.83**							
2 PartSOC	0.26	**0.77**						
3 Intrinsic	-0.07	0.56	**0.78**					
4 Social	0.16	0.70	0.60	**0.74**				
5 Utilitarian	0.31	0.03	0.12	0.14	**0.80**			
6 Idealistic	0.42	0.14	0.21	0.24	0.82	**0.74**		
7 Effort	0.30	0.24	0.18	0.12	0.46	0.53	**0.72**	
8 Concern	-0.02	-0.07	0.12	-0.01	0.01	-0.01	-0.09	**0.81**

Table 12 – Correlations Among Factors and Average Variance Extracted (Diagonal)

3.5.2.6.4 Hypotheses Testing

After establishing the validity of the measurement model, the structural model was examined. From the results emerged that two different types of participation exist and are associated with different motivations.

Social participation is driven by social motivation (H3), intrinsic motivation (H4) and low effort (H6). On the other hand utilitarian motivation (H1), idealistic motivation (H2) and concerns (H5) do not impact it significantly. Model fit indexes (ChiSquare=118.82 with 98 df, 0.07 p-value, NFI=0.95; IFI=0.99; CFI=0.99; GFI=0.95; AGFI=0.92; RMR=0.045, RMSEA=0.028) meet recommended levels showing a good model fit (Gefen et al., 2000). The model explains 58% of the variance of social participation.

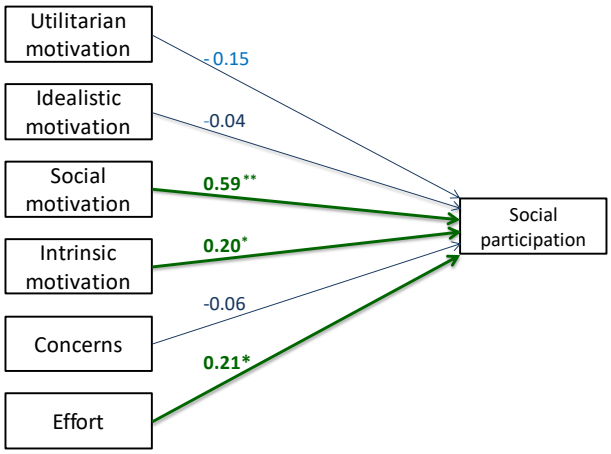


Figure 16 – Structural Model, Social Participation (* significant at p<0.05; ** significant at p<0.01)

Participation by sharing is driven by idealistic motivation (H2) and low effort (H6), while intrinsic motivation (H4) impacts it negatively. Utilitarian motivation (H1), social motivation (H3) and concerns (H5) do not have a significant impact. Model fit indexes (ChiSquare=111.73 with 98df, 0.16 p-value, NFI=0.95; IFI=0.99; CFI=0.99; GFI=0.95; AGFI=0.93; RMR=0.041, RMSEA=0.023) meet recommended levels showing a good model fit (Gefen et al., 2000). The model explains 26% of the variance of participation by sharing.

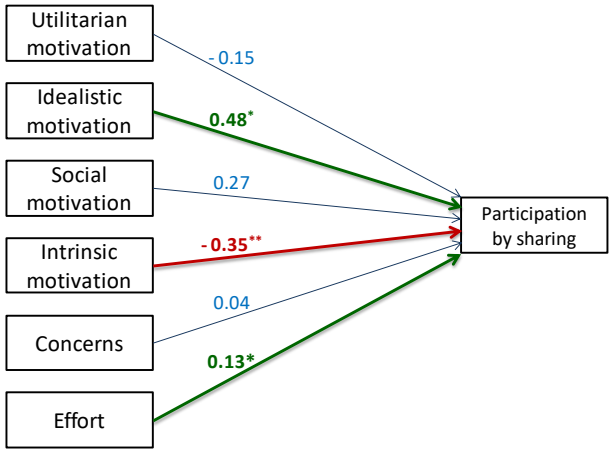


Figure 17 – Structural Model, Participation by Sharing (* significant at p<0.05; ** significant at p<0.001)

The result of each hypothesis applied to the two models is summarized in Table 13.

Hypothesis	PartSOC	PartSHA
H1: **utilitarian** motivation positively affects participation	Rejected	Rejected
H2: **idealistic** motivation positively affects participation	Rejected	**Supported**
H3: **social** motivation positively affects participation	**Supported**	Rejected
H4: **intrinsic** motivation positively affects participation	**Supported**	Rejected
H5: **concerns** about sharing negatively affect participation	Rejected	Rejected
H6: **effort** negatively affects participation	**Supported**	**Supported**

Table 13 – Results of Hypotheses Testing of this Study

3.5.2.7 Discussion

Our results suggest two different types of participation in hybrid wireless communities, driven by different motivations: participation through social involvement and participation by sharing connectivity. This is congruent with the intuition of Abdelaal et al. (2009) that members can contribute not only by sharing, but also by taking time and expertise to help other members. To better highlight the characteristics and differences of each type of participation, both are represented by an archetypal persona integrating findings of previous interviews (imaginary names are used) with Fon members (Camponovo & Picco-Schwendener, 2010; 2011).

3.5.2.7.1 Social Participation

Marc manages an IT company and is passionate about technology in general. He read about Fon on an IT blog and liked the idea of participating in a community and experiencing new ways of using technology. As an early adopter, he ordered several Fonera routers and installed them at home, in his office and in other places. He experiments with the hardware and firmware to understand how it works, to develop additional features and to see how they are used by end users. He actively follows Fon forums, often providing advice to help people with technical problems or suggesting new ways of using the community, promotes the community on his blog and discusses issues with friends and colleagues.

Social motivation (***Hypothesis 3***) is expectedly the most important factor explaining social participation. Socially motivated members are highly involved in community aspects like interacting with other members or contributing to forums and blogs. However, social motivation and social participation in Fon are quite low (with averages of 3.13 and 2.61). This is much lower than in studies about pure communities (Bina & Giaglis, 2006b; Lawrence et al., 2007). Possible explanations are that the resource-oriented nature of the community promotes sharing above social aspects (Camponovo, 2011) and that its larger size makes social ties between members less relevant (Olson, 1971). Many members stated *that "it is not really to know other people, it's for the sharing"* and that *"we are a bit part of it because we share our connection […] but I don't have a feeling of belonging to a community."* Members seldom care to actually know or meet each other, except maybe at a very local level: a member told us that in the beginning, a few meetings among members of a city or neighborhood were organized, but now members mostly interact through the forum. Even then, it is *"not for following the life of the community, but rather for solving technical problems or discussing technical questions."*

Furthermore intrinsic motivation (***Hypothesis 4***) and low effort (***Hypothesis 6***) positively influence social participation. Members interested in the community from a technical viewpoint get naturally involved in exchanging know-how with peers, discussing technical

aspects on forums and volunteering skills to help other members solve problems. Some members also participate in other technically-oriented communities, such as open source software communities, and are even more driven by curiosity and learning motives. A member told us that he joined *"very much for curiosity, I like to experiment new technical concepts and see how they perform and are used in real conditions."* Of course, the easier it is to participate in forums and to exchange knowledge through well-established channels, the more prone people are to actually do it.

On the other side, utilitarian and idealistic motivations as well as legal and security concerns (***Hypotheses 1, 2, 5***) do not affect social participation. To get the benefits of belonging to the community, such as free connectivity, or help the community achieve its mission of providing free connectivity to others it is not necessary to interact with other members. As well, while legal and security concerns are sometimes debated through the forums, they are more discussing for the inherent satisfaction of debating them (therefore an intrinsic motivation) while members generally feel reassured by the presence of a supporting firm that operates the network and is presumed to take care of those aspects.

3.5.2.7.2 Participation by Sharing

Peter lives in the center of a city near popular bars. He joined the community attracted by the idea of getting free Internet access all around the world while sharing his own signal. Motivated by the idea of reciprocal exchange, he puts effort in providing good signal quality and installs his Fonera router near his balcony window with an additional antenna to strengthen the signal and make it reach nearby streets and bars. He likes technology but more to use than to experiment with: Fon's solution is appreciated as it is simple and quick to set up. He is aware of possible risks such as security and privacy but trusts that Fon provides good solutions to prevent them.

Idealistic motivation (***Hypothesis 2*****)** is the most important aspect explaining participation by sharing. It also is the strongest motivation overall (with an average of 4.14 on a 1-5 scale). This is expected, as wireless communities are built on the concepts of sharing and reciprocity, and members who care about that naturally put effort in sharing their connectivity to contribute to the community. For some members, sharing may be just a secondary aspect they gladly accept*: "my main motivation [was for own use] yes, then the idea that someone passing by my house, can have the possibility to connect to the Internet, never disturbed me."* Others appreciate the idea of sharing per se *("I just found it a great idea, not to use the own broadband connection only for oneself but to be able to share it with other people")* and support it by always keeping their Fonera on, placing it so that *"it can spread at a maximum outside"* and by offering enough bandwidth to visitors. Some members associate it with other idealistic motivations such as promoting free access *("having an Internet connection is fundamental nowadays […] if it was free of charge, it*

would be even better") or better using resources *("I thought it was stupid that in buildings there are 36 ADSL [Asymmetric Digital Subscriber Line], when with Wi-Fi one can get organized")*. Many members consider reciprocity a key value: *"It is the goal, to know that it is not one-way, that's the principle of exchange at this level."* Through the fact that each member both gives and takes, he feels in a way related to the other members and thus part of the community.

Sharing is also positively influenced by low effort (***Hypothesis 6***): members considering participation in the community easy are more prone to actively share their signal as it does not request them a lot of effort. Many members noted that actively sharing one's signal does not entail any extra cost *("it costs nothing, you would have to pay the Internet connection anyway")* or other nuisances *("I use my Internet connection less than 100%, so if someone else can benefit from it, then I like that").*

Surprisingly, intrinsic motivation (***Hypothesis 4***) has a negative effect on sharing. Technical motivations are lower than in studies about pure wireless communities. A possible reason is that pure communities are composed of more technically oriented early adopters (Rogers, 2003), while hybrid communities have more pragmatic late adopters. As put by one member *"at the beginning I had the enthusiasm of curiosity […] then with time the interest decreases."* In addition, Fon more and more controls the technical solution and thereby increasingly limits experimentation and thus technical interest.

Against our expectations, utilitarian motivation (***Hypothesis 1***) does not affect sharing, even though it is the second highest motivation (average of 4.11) for joining the community. An explanation is that active participation is not needed to benefit from the community's free network access: Fon only checks that a member's router is on when he wants to connect to another Fon spot, but does not check it at other times or if the signal is truly accessible to others. Thus active participation does not provide additional benefits. Moreover, members do not use the community network frequently (with an average of 2 accesses in the last 12 months) due to the difficulty of finding accessible spots (e.g. limited Wi-Fi range, offline routers) and the fast proliferation of 3G/4G networks with flat rate subscriptions. The motivation of free Internet access seems to be relevant mainly abroad, where other wireless technologies still cost too much. As a result it becomes difficult to create the necessary critical mass for the community to be attractive.

Finally, social motivation (***Hypothesis 3***) and also legal and security concerns (***Hypothesis 5***) do not affect sharing. Sharing does not require social involvement (one simply activates his router) and the presence of a firm reassures members that these concerns are addressed appropriately (Abu-Shanab & Ghaleb, 2012) e.g. by broadcasting separate public and private signals, requiring registration for all users, keeping logs etc.

3.5.2.7.3 Theoretical Implications

So far, research has only analyzed motivations or participation in isolation (without studying their relationship) and only in pure wireless communities. This study contributes to theory by extending research to hybrid wireless communities and by examining the relationship between motivations and participation.

In contrast with pure wireless communities, this study found a different mix of motivations where idealistic (average 4.14) and utilitarian (4.11) are higher than intrinsic (3.47) and social (3.12) motivations. Pure community members are motivated more by intrinsic, idealistic and social than by utilitarian motivations. However, since these studies were conducted in different years and cultural contexts, it is not clear whether the difference stems from different community types (pure vs. hybrid), cultural differences or different maturity stages (pure communities came earlier and attracted technically-interested early adopters, while hybrid communities attracted practically-oriented late adopters).

With regard to the relationship between motivation and participation, two types of participations with different motivations have been found. Participation by sharing is more ideologically driven, whereas social participation is driven by social and intrinsic motivations. Ease of use facilitates both types of participation. This may open new views on participation in virtual communities, where until now participation was mostly regarded as one single indivisible concept.

3.5.2.7.4 Practical Implications

One of the most interesting findings is that although utilitarian motivation is high and plays a crucial role in attracting members, it does not result in higher levels of participation. Maybe it is because active participation is not required to get community benefits. This may be addressed with incentives making benefits depend on participation. Then again, incentives like free connectivity and revenue sharing may simply not be attractive enough nowadays. Members rarely use the community network as finding accessible Fon spots is not easy. In many areas, Fon has not a critical mass of users to allow ubiquitous usage. Members have to actively look for a Fon spot: this often implies moving to residential areas instead of being able to connect where they already are. There are also range limitations: many routers do not reach the public space and members often have to stand on the street instead of being able to connect in comfortable places like parks or bars. Moreover, the improved quality and nearly ubiquitous availability of 3G networks with affordable rates makes Wi-Fi networks less attractive. In addition, low usage also makes revenue sharing less enticing, except maybe in attractive places like city centers or tourist attractions. It would thus be dangerous to rely on utilitarian incentives only.

On the other hand, idealistic motivation like reciprocity plays a fundamental role in inducing members to actively share their Internet connection. It is crucial for communities like Fon to keep this in mind, especially when defining partnerships with other operators. Those partnerships are mostly judged positively by Fon members as they help expand the network, but only if reciprocal access rights are ensured: if operator's customers can access Fon spots, Foneros should be able to access their spots as well. Otherwise, Fon members will feel disadvantaged and may cease to contribute. A similar problem may stem from the low usage of the network, which may also negatively affect idealistic motivation. If members cannot find and access other Fon spots, they may feel they contribute more than they get, reducing their motivation to contribute.

Social participation also plays a key role in creating community spirit among members. It is mainly driven by social aspects and intrinsic technical interest. Fon is weak in both aspects as there is limited interaction among members – Fon messages and forums are hardly used – and technical aspects are controlled by Fon, leaving little room for experimentation by members. Accordingly, it may be beneficial to improve communication tools and allow higher user involvement in the evolution of the community.

Ease of use plays a positive role in both forms of participation. Fon's hardware and authentication system is perceived as easy to use. However, members often complain that it is not easy to find working Fon spots (e.g. due to offline routers, limited signal or misplacement on the maps). Improvement of search tools, signal strength of Fonera routers and better education of members in how to install them may be useful.

Participation in hybrid wireless communities seems to be more passive than in pure communities. In fact, most members are actively involved only at the very beginning when they set up their router, decide where to place it and whether to enhance the signal with an antenna. After this, the router mainly runs by itself. Social participation in general is low and usage of other Fon Spots is minimal. While members may not mind continuing sharing, as it does not require them any other active effort, this does not promote their involvement and makes them more passive. As a result, their participation may not be sustained over time limiting the potential expansion and long-term sustainability of the community.

3.5.2.8 Conclusions

This paper analyzed motivations and barriers influencing participation in hybrid wireless communities, based on a survey of 268 members of the Fon community. This enhances knowledge of member motivations and participation in wireless communities by extending research to hybrid wireless communities and by examining the relationship between motivations and participation.

In contrast with pure wireless communities, where intrinsic, idealistic and social motivations play a key role, utilitarian motivations are important together with idealistic motivations. Participation in hybrid wireless communities is also different: members are less actively involved, especially with regards to social participation. Most users put effort in the community when they join, but just let the router run by itself afterwards. Moreover, other Fon spots are not frequently used, which may reduce both the perception of utilitarian benefits and idealistic motivation, eventually further reducing their participation as time passes.

With regards to participation, this study identified two distinct forms of contributions by members: social participation by interacting with and helping other community members and participation through sharing connectivity. Each type is driven by different motivations: social participation is driven by social motivation, technical interest and ease of use, whereas active sharing is driven by idealistic motivations (such as reciprocity and altruism) and ease of use. Surprisingly, utilitarian motivations do not have a significant impact, even though they are high and play a crucial role in attracting members when deciding to join the community. Also, security and legality concerns are insignificant, as members seem to be reassured by the supporting firm.

These findings entail a number of practical implications. Firstly, it may be dangerous to only rely on utilitarian incentives: they may allow the community to attract members, but may not be enough to sustain their participation especially if other technologies develop to provide appealing alternatives to satisfy the same needs. It is also important that typical community values like reciprocity are respected, especially when designing incentives and negotiating partnerships. Furthermore, it may be beneficial to nurture social and intrinsic motivation by improving communication tools, fostering a sense of community and promoting member experimentation and involvement. Finally, it is important to continue ensuring ease of use and improving ease of finding accessible spots by enhancing search tools and improving signal strength of routers.

4 Municipal Wireless Networks (MWNs)

"An intelligent city lays its foundation on a digital-city infrastructure which connects a local community and drives growth, efficiency, productivity and competitiveness"

(Yovanof & Hazapis, 2009)

After having discussed CWNs and people's motivations for joining them in chapter 3, this chapter focuses on MWNs. It first introduces the concept of MWNs (4.1.1), describes the initial enthusiasm of cities in implementing public Wi-Fi networks (4.1.2) and the quickly following drawbacks linked to technical, sustainability, and policy related problems (4.1.3). It then introduces a new, re-dimensioned and more targeted and user-oriented vision of MWNs based on understanding users, user needs and usage practices (4.1.4). An extensive literature review on Wi-Fi usage is proposed subsequently, which allows determining how different network types/contexts and different study perspectives contribute to a better understanding of users and usage practices (4.2). Afterwards, the research gaps and the dissertation's contributions are introduced (4.3). Finally, research results are presented in form of two publications on usage of the MWN "WiFi Lugano", one from an eTourism (4.4.1) and one from an eGovernment (4.4.2) perspective.

4.1 Background

4.1.1 What are Municipal Wireless Networks?

The term "Municipal Wireless Networks" has two connotations: a technical one (technology used to create wireless networks), which has been described in detail in section 2.3.1, and a more governance-related one, referring to the role of "municipalities." Typically, in this context, "***municipal***" means that a municipality or local government is in some way involved in the development of a wireless network (Heer et al., 2010a; Ojala et al., 2011; Van Audenhove et al., 2007). This involvement may vary, going from the municipality simply promoting a Wi-Fi network or allowing using existing city infrastructures for its deployment, over to providing financial contributions, up to building and maintaining the entire Wi-Fi infrastructure and related services itself (Heer et al., 2010a; Jain et al., 2007). The ***main purpose*** of MWNs is to provide access to broadband Internet connectivity in public spaces of a city like parks, squares, community centers and government offices (Middleton & Crow, 2008) and thus, to pursue a public interest (Middleton, 2007). MWNs in fact lay the basis for the development of additional ***local services*** favoring municipal applications (e.g. guide to free parking spaces; environmental

or traffic information), governmental applications (e.g. e-voting and e-participation) or tourism-related applications (e.g. electronic tourist guides) (Heer et al., 2010a).

There are different abbreviations and other terms used for Municipal Wireless Networks like “muniwireless”, “muni Wi-Fi”, “MWN” (Middleton, 2007) or “wireless city networks” (Ojala et al., 2011). This dissertation uses the abbreviation “MWN.”

4.1.2 Emergence of First MWNs

While at the beginning of the 21st century in the U.S. and Canada, many municipalities started planning and deploying large-scale wireless projects, often with the aim of covering entire cities and bringing broadband Internet connectivity not only to public areas but also to homes and offices (primary Internet access) (Middleton, 2007), European cities had a more cautious and step-by-step approach to public Wi-Fi development (Van Audenhove et al., 2007). In the U.S., both mobile and wired broadband networks have been less well developed and performing than in Europe, and networks used for public administration and eGovernment services have often been outdated (Shin & Tucci, 2009; Tapia & Ortiz, 2008a; Van Audenhove et al., 2007). There was thus a substantial digital divide between those having access to broadband Internet connectivity and those being cut off. Hence, municipalities tried to overcome these problems by deploying large-scale wireless projects. Even though the initial euphoria pushed many cities to invest in such projects (nearly 400 by December 2007: (Infante et al., 2007; Tapia et al., 2011), cities quickly had to face reality and deal with various ***problems and disappointments***.

4.1.3 Problems Faced by First MWNs

Early municipal Wi-Fi initiatives had, in general, ***too ambitious goals***. In order to properly address the digital divide, they aimed at covering entire cities, outdoors and indoors, in public spaces but also in private homes. However, ***technology*** did not maintain what it promised (M. Estevez, 2006; Fuentes-Bautista & Inagaki, 2005). Covering entire cities resulted to be much ***more complex and onerous*** than initially expected (Middleton, 2007). For example many initiatives “badly overestimated WLAN’s range and coverage in city centers with many tall buildings” (Ojala et al., 2011, p.119). In fact, Wi-Fi has been developed to cover small areas like a café or square and not to cover entire cities (Kolko, 2006). Furthermore, Wi-Fi signals do not travel well through walls, and this made it particularly difficult to bring Wi-Fi connectivity also inside buildings (M. Estevez, 2006; Forlano, 2008a; E. Fraser, 2009; LaVallee, 2008) and “property rights prevented municipalities from installing the required number of access points inside private buildings” (E. Fraser, 2009, p.170). Covering entire cities, as, for example, San Francisco resulted to be too onerous and complicate (Chesley, 2009; E. Fraser, 2009). Hence, the

first Wi-Fi initiatives had to recognize that Wi-Fi was not the ideal technology to provide primary, last mile, network access in homes (Middleton et al., 2008).

Another problem was that by providing broadband Internet services also to homes, municipalities became direct ***competitors to telecommunication operators***, which started lobbying against municipalities entering the telecommunication market and providing high-speed access as a public good (Christensen, 2006; Dingwall, 2006; E. Fraser, 2009). In many American states, lobbying activities were successful and led to new policies hindering municipalities from providing primary Internet access (Chesley, 2009; Dingwall, 2006; Forlano, 2008b; Hudson, 2010; Hudson, 2010).

Furthermore, many American cities had ***difficulties in identifying sustainable business and ownership models*** and did not succeed in creating functioning private-public partnerships (Christensen, 2006; M. Estevez, 2006; Hudson, 2010). Municipalities did not do a good job in designing and planning wireless projects both from a business and from a social point of view (Chesley, 2009). As a result, even large cities' Wi-Fi initiatives had to be abandoned shortly after their initial deployment (Chesley, 2009; Forlano, 2008a; E. Fraser, 2009; Hudson, 2010; Jassem, 2010; Ojala et al., 2011). Public Wi-Fi networks were indeed ***used much less than expected*** (Chesley, 2009; Jesdanun, 2007; Middleton, 2007; Troulos & Maglaris, 2011) and did not seem to be "widely useful" for citizens (Middleton et al., 2006, p.18). Technical problems often disincentivized their use (Chesley, 2009) and better solutions were available to connect to the Internet when on the go (e.g. ubiquitous 3G/4G mobile networks) especially for those users who could afford to pay for it (Middleton et al., 2008). In fact, connectivity of MWNs often was not ubiquitous and had low bandwidth while complicate and time consuming authentication procedures further disincentivized their use. As such, municipal initiatives often ***failed to meet the needs and expectations*** of their users (Forlano, 2008a; Ylipulli et al., 2014). It slowly became clear that it is fundamental to ***understand and analyze the needs*** of potential users and to identify desired outcomes before implementing Wi-Fi networks (Hudson, 2010; Jain et al., 2007; Meinrath, 2005; Middleton et al., 2008; Ojala et al., 2011) and to "rigorously ***measure the societal impact*** of a [M]unicipal [W]ireless [N]etwork, once the network has been deployed" (Ojala et al., 2011, p.120). There is no universal "right" model for implementing a MWN. Each municipality has to identify how and where within a city it might be useful to provide Wi-Fi Internet connectivity and for whom and for what they might be useful (Chesley, 2009). Each city has to define its unique advantages, needs and cultural contexts before launching MWN initiatives (Forlano, 2008b).

4.1.4 A New Vision of MWNs

As a result of the various problems mentioned above, several municipal Wi-Fi projects had to be abandoned shortly after they were started. Popular examples are Philadelphia, San Francisco or Chicago (Chesley, 2009; Forlano, 2008a; E. Fraser, 2009; Jassem, 2010; Ojala et al., 2011).

While American MWNs struggled, European cities followed a ***more cautious and structured approach*** to MWN deployment (Van Audenhove et al., 2007). Their main goal was not bridging the digital divide – Europe generally had good broadband penetration rates – but stimulating economic development (Ojala et al., 2011). This allowed municipalities to ***think in smaller terms*** without the ambition of covering entire cities (M. Estevez, 2006; Van Audenhove et al., 2007). Instead, municipalities focused on identifying city areas where Wi-Fi Internet access was expected to be most useful to potential users and implemented single hotspots or hot zones (Forlano, 2008b; Ojala et al., 2011; Van Audenhove et al., 2007). A good example is the Finnish city of Oulu, which for its panOULU MWN "adopted a less ambitious approach, providing coverage in those public places and service points where it is deemed useful" (Ojala et al., 2011, p.126). European cities, thus, had a more ***user-oriented approach*** towards Wi-Fi networks and often had specific goals in mind beforehand (Van Audenhove et al., 2007). Their focus was on identifying meaningful sites rather than offering anytime, anywhere connectivity (Forlano, 2008b). This re-dimensioned approach to public Wi-Fi implementation actually suits the technical specifications of Wi-Fi technology much better and is less expensive (Chesley, 2009). In general, the idea was to start small by implementing Wi-Fi zones in some carefully selected areas of the city and expand them at a future time (LaVallee, 2008; Troulos & Maglaris, 2011). Cities thus provides mainly ***secondary access*** to the Internet, offering connectivity as an additional city service to those people who live the public space and move in between home and office (Middleton, 2007). This approach allowed cities to create more realistic expectations and better address the actual needs of users (Ojala et al., 2011). However, to successfully achieve this, it is necessary that user needs are identified and analyzed.

4.1.5 Importance of Understanding Usage

Much research has been done in the past to understand Wi-Fi technology and network types, business models, policy and regulatory aspects of MWNs, especially on those developed in the U.S. and Canada (Forlano, 2008b; Middleton et al., 2006). However, only few studies addressed MWNs' social dimensions and put the user and his/her needs at the center of attention. The first Wi-Fi initiatives simply took for granted that public Wi-Fi access was something people wanted and would use (Middleton, 2007). Hence, at the latest with the advent of the newer, re-dimensioned approach to MWNs (especially in Europe),

municipalities recognized the ***importance of planning networks, understanding demand*** (Hudson, 2010; Infante et al., 2007), ***defining goals beforehand, and addressing specific user needs*** (Hudson, 2010; Jain et al., 2007; Meinrath, 2005; Middleton et al., 2008; Ojala et al., 2011; Ylipulli et al., 2014). Only in this way, they would be able to identify potential user groups, key applications, relevant usage contexts and meaningful places where to build Wi-Fi zones and, thus, make sure that the networks will be useful for different user groups and in different contexts and situations (Doyle, 2011; Forlano, 2008a). When developing MWNs the focus should be on ***preparing users*** instead of purely technical networks (Tapia & Ortiz, 2008b). Initial MWN initiatives did not take into account that "requirement for user needs" should always have "precedence over technical possibility" (Blackman et al., 2007, p.207) and hence, should be user and not technology driven.

In fact, ***people*** play an important role in smart cities and, consequently, in the development of MWNs. Understanding how citizens "experience these technologies as part of their everyday lives" (Ylipulli et al., 2014, p.147) is fundamental as they often "make choices to adopt or neglect technologies based on their own needs and previous experience with similar technologies" (Ylipulli et al., 2014, p.156). For this reason, it is important to gain a deeper understanding of "who would be using mobile services, what they might want to use them for and how much they might want to use them" (Blackman et al., 2007, p.208) but also "what types of devices are needed to access the networks" and whether they are "the devices that users want to carry around with them on a daily basis" (Middleton, 2007, p.2). Lehr (2012) and Forlano (2008b) highlight the ***importance of measuring usage*** and collecting more granular data on the people using a MWN and on the activities they undertake when using it and tracing data in time and space. The panOULU initiative, for example, was among the few municipal Wi-Fi initiatives that recognized the importance of collecting usage data from the very beginning and openly reported on the usage of their network in order to show the impact it had on the city and to justify municipal investment (Ojala et al., 2011). To do so in a successful way, both ***technical and social usage data*** are necessary and need to be combined (Lehr, 2012) to delineate accurate and realistic ***usage and user profiles*** (Blackman et al., 2007). In existing literature (see section 4.2), many researchers have already attempted to understand how Wi-Fi networks in public or semi-public spaces are used for a multitude of reasons, from different points of view and perspectives and with different data collection strategies and methodologies. However, especially ***uses and usage practices of MWNs*** have remained relatively unexplored.

4.2 Literature on Wi-Fi Usage

After having recognized the importance of understanding usage, a systematic literature review has been conducted on existing research regarding Wi-Fi usage. The ***studies that have been included*** in the literature review all share the general goal of understanding how a particular Wi-Fi network is used (user behavior). For some studies this has been the

main and only goal, while others have taken a step further by, for example, trying to understand how usage evolves over time, who the users are, how they interact and move, how Wi-Fi use is related to people's real-life routines, and how Wi-Fi networks are used in different environments. Some studies simply describe usage in general terms while others try to identify ***different usage practices/profiles***. The studies included in the literature review have analyzed usage from different study ***perspectives*** (network, user, observer) and with different ***types and sizes of datasets***. They have been conducted in cities and regions all over the world even though American studies clearly dominate this research field with nearly 2/3 of all studies.

Even though this dissertation focuses on usage of public large-scale Wi-Fi networks, this literature review includes usage studies of ***Wi-Fi networks in public or semi-public spaces*** but also on research regarding usage of networks located in ***similar spaces*** such as university ***campuses or conferences***. It is expected that usage in these contexts can contribute to the understanding of Wi-Fi behavior in public and semi-public spaces. On the other hand, studies focusing on Wi-Fi usage in ***private or corporate*** settings (Balazinska & Castro, 2003) ***have not been included*** as their contexts are expected to generate different user behaviors.

Only studies that at least in part focus on ***user behavior*** and user characteristics have been considered as this dissertation is particularly interested in the social aspects of Wi-Fi usage and not in the mere technical ones. Therefore, Wi-Fi usage studies focusing mainly on ***network behavior*** aspects have not been included in the literature review. Examples are:

- the evaluation of network architecture and performance (e.g.(Aguayo et al., 2004; Bicket et al., 2005; Castignani et al., 2013; Robinson et al., 2008; Solarski et al., 2006; Zhou et al., 2017; Zola & Barcelo-Arroyo, 2011);
- the analysis of AP data (Jones & Liu, 2007);
- the modeling of network mobility patterns (Kim & Kotz, 2005; Kim & Kotz, 2007; Prentow et al., 2015; Ruiz-Ruiz et al., 2014);
- the modeling and characterization of network traffic (Ghosh et al., 2011; Massa, 2015; Na & Rappaport, 2004)
- understanding routing protocols and inter-node throughputs (Bicket et al., 2005)

A total of 35 Wi-Fi usage studies have been considered as relevant for understanding Wi-Fi usage in public and semi-public spaces.

The main ***goals*** of this literature review are:

1) to provide an overview of existing studies on Wi-Fi usage in public and semi-public spaces and on usage practices emerging from them;

2) to understand how Wi-Fi usage studies in different contexts and on different network types contribute to the overall understanding of Wi-Fi usage in public spaces;
3) to determine different study perspectives and understand how each perspective contributes to the understanding of Wi-Fi usage behavior;
4) to identify some key aspects influencing the use of Wi-Fi networks in public spaces.

This section first provides an overview of the different ***motivations and reasons*** why Wi-Fi usage has been studied in various disciplines and what Wi-Fi usage data has been used for (4.2.1). Section 4.2.2 introduces ***different contexts*** relevant to the understanding of Wi-Fi usage in public spaces (e.g. university campuses, conferences) and a ***categorization of the various network types*** identified in existing Wi-Fi usage literature (e.g. large-scale networks – free or pay-for; small-scale networks – coffeehouse networks or several single Wi-Fi areas in a city). Furthermore, a series of ***variables*** used to describe Wi-Fi usage (e.g. user behavior, user characteristics, application mix, devices and user profiles/usage practices) are introduced (4.2.3) and three different ***study perspectives*** used to explore Wi-Fi usage in existing literature are presented (4.2.4). Section 4.2.5 then provides a detailed ***overview of existing studies on Wi-Fi usage*** in public and semi-public spaces and on the various Wi-Fi usages and practices that emerge from them. The following section (4.2.6) highlights ***recurrent usage practices*** and shows how the findings of each study context, Wi-Fi network type and study perspective contribute to the overall picture of Wi-Fi usage. Finally, three main ***aspects influencing Wi-Fi usage*** in public and semi-public spaces are identified and described (4.2.7).

4.2.1 What for and Why Is Wi-Fi Usage Studied

Wi-Fi usage has been studied within different research fields and for a multitude of purposes. Often understanding the usage of a Wi-Fi network is part of a larger study goal and understanding user behavior and user characteristics is a way to achieve this goal. The more technically oriented studies mainly have aimed at understanding how ***network performance, design, deployment and management*** can be improved and optimized (e.g. Brik et al., 2008; Kotz & Essien, 2002; Lee et al., 2005; Redondi et al., 2016; Tang & Baker, 2002) to better balance traffic load (Zhang et al., 2017) and bandwidth allocation (Zola & Barcelo-Arroyo, 2011; Zola & Barcelo-Arroyo, 2013), design network topologies based on user mobility (Ojala et al., 2005) and mobility models (Balazinska & Castro, 2003; Hsu & Helmy, 2005) and develop better management techniques and capacity planning (Hsu & Helmy, 2005). Accurate usage data can assist content delivery (Zhang et al., 2017) and the development of application software for wireless networks (González

Rodríguez, 2010; Kotz & Essien, 2002), and might even contribute to improve the networks energy efficiency (Zhang et al., 2017).

Other studies have focused on understanding the ***relation between space and Wi-Fi usage***. Calabrese et al. (2010) explored what Wi-Fi usage can give insights about the use of spaces while Ruiz et al. (2014) studied whether Wi-Fi use could be helpful in better informing facility planning in large building complexes such as hospitals. Sevetsuk et al. (2005; 2009) and Redondini (2016) tried to ***infer the spatial/temporal distribution of people*** (how many people are in which area at which time) from data on their Wi-Fi usage. With the help of this information they then made approximations on where most people were located during events or inside shopping malls in order to provide location-based services in a targeted way. Doyle (2011) even went as far as considering Wi-Fi usage a "source of inspiration for ***designing urban places*** of gathering in the 21st century" (p.ii), attributing a role in urban planning to Wi-Fi usage and even in the "formation of social networks, opinions and democracy" (Hampton & Gupta, 2008, p.834).

Other studies are more interested in the ***social implications*** of Wi-Fi usage. Some investigated the role and influence of Wi-Fi on urban and sub-urban public spaces and on their inhabitants, while others examined how Wi-Fi usage influences social interactions of clients of Wi-Fi-equipped coffeehouses. Forlano (2008a; 2010), for example, studied the users of city Wi-Fi networks to "allow cities to design networks, applications and services that could be tailored to the user's needs" (Forlano, 2008a, p12 of article).

4.2.2 Classification of Existing Studies on Wi-Fi Usage in Public Spaces

Because of the large number of relevant Wi-Fi usage studies and their heterogeneity, it was necessary to find a way of grouping them into coherent categories. The ***context*** in which Wi-Fi usage is explored and the ***type of Wi-Fi network*** under study have been identified as useful variables to classify the studies.

With regard to ***contexts***, studies focusing on Wi-Fi networks in ***public and semi-public spaces*** are certainly the most relevant ones. However, also studies in similar contexts such as ***campuses*** and ***conference facilities*** have been taken into consideration as they share certain characteristics with public Wi-Fi networks. Wi-Fi networks in these contexts face similar challenges and hence contribute to a better understanding of Wi-Fi usage in public and semi-public spaces (Vural et al., 2013).

Tang & Barker (2000) suggest that "similar environments may exhibit similar behavior and trends" (p. 1). In fact, Wi-Fi networks that cover larger university campuses might show similar usage patterns as a small-scale city Wi-Fi network. Similarly to cities, they provide Wi-Fi connectivity in different milieus like residences, recreational areas, or studying/working spaces (Henderson et al., 2008), both indoors and outdoors.

Furthermore, they have a heterogeneous user base. Usage of conference Wi-Fi networks, on the other hand, can give interesting inputs on how Wi-Fi networks are used during special events. This can be relevant for cities, too, since in public spaces different kind of events are regularly taking place.

Figure 18 shows the three different contexts that have been considered for this literature review, with the number of publications for each context.

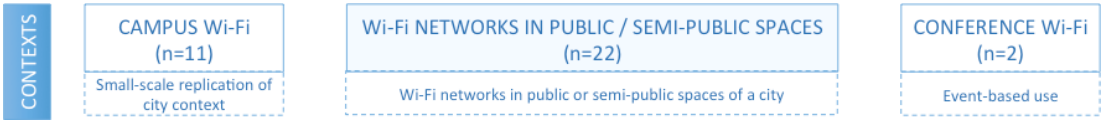


Figure 18 – Classification Scheme of Studies on Public Wi-Fi Usage (n=35) – Three Contexts

Wi-Fi networks in public or semi-public environments can be further divided into ***four different network types***, each one with characteristics that might result in different usage practices. ***Large-scale networks*** generally extend over vast areas or are available in different locations of a city or nation. They consist of several APs implemented or managed by a single entity (e.g. municipality or WISP). While in section 2.5, the author distinguishes between municipality-, provider-, 3rd-party- and user-driven Wi-Fi networks, for existing Wi-Fi usage studies the difference between free and pay-for networks seems to be more relevant. This is why in this chapter public large-scale Wi-Fi networks are further divided into ***free*** and ***pay-for*** networks. Most free networks are municipality- or community- driven, but there are also private entities (e.g. WISP) that might decide to offer free services. On the other hand, most pay-for services are provider-driven, thus offered by ISPs or WISPs against payment or only to customers that have already subscribed to other packages of the same provider. ***Small-scale networks*** are networks that consist of one or few APs and that are available only in small areas. Such so-called hotspots can, for example, be found in cafés, restaurants, airports, parks or squares. Each hotspot is generally managed by different entities (e.g. 3rd parties such as a coffeehouse or shop owners but also municipalities or communities). Some studies have focused on ***coffee shop hotspots only*** while others have analyzed usage of ***various Wi-Fi areas within a single city, region or country*** or even throughout different cities/countries.

In some cases, studies could not be assigned with 100% precision to one group or another, as they showed aspects of more groups. In those cases, the studies were assigned to the group to which they showed most similarities. For example, the study on the ZAP Québec Wi-Fi network can be considered both a study on a large-scale network (access and authentication are managed centrally by ZAP Québec) or a study analyzing many single hotspots in a city (ZAP Québec aggregates already existing hotspots that are deployed and individually managed by different entities like cafés, shops, etc.). As the focus of the study

was more on the use of single hotspots than on the community network as a whole, it was assigned to the studies on various small-scale Wi-Fi networks.

Figure 19 shows how the four network types complement the classification scheme of existing studies on public Wi-Fi usage.

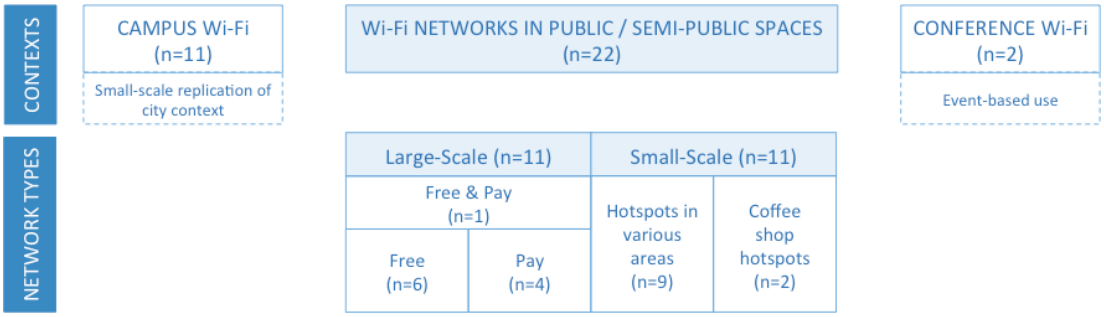


Figure 19 – Classification Scheme of Studies on Public Wi-Fi Usage (n=35) – Four Network Types added

4.2.3 Variables Used to Describe Wi-Fi usage

In addition to context and network type, the following ***five variables*** have been used to describe the outcomes of the analyzed usage studies: 1) ***user behavior (UB)***: when, how long, how often, how much, with whom (alone – together), which APs, why, for what type of activities, and mobility patterns (M); 2) ***user characteristics (U)*** like demographics and socio-economic variables; 3) ***application mix (AM)*** indicating what kind of applications and contents users access when connected to a Wi-Fi network; 4) ***types of devices (D)*** used to connect to the Wi-Fi networks; and 5) ***user profiles and/or usage practices (UP)*** where available.

4.2.4 Different Study Perspectives

Wi-Fi usage has been studied from different perspectives using different types of methodologies. It is expected that different study perspectives contribute in different ways to the understanding of Wi-Fi usage. This section describes the ***three types of study perspectives*** used in existing literature for analyzing Wi-Fi usage and shows how each perspective contributes to the comprehension of Wi-Fi usage in a public space. Understanding the various study perspectives and their contributions to the larger picture of Wi-Fi usage is fundamental to be able to choose the right study perspective and methodologies for each study context and study goal.

Studies focusing on the so-called "***network perspective***" analyze user behavior and network usage with the help of technical data generated when the network is used. This kind of data can provide very accurate information on the technical use of Wi-Fi networks.

There are different tracing methods to collect such technical data. While ***syslog*** and ***SNMP*** (Simple Network Management Protocol[23]) create traces that allow analyzing network traffic/flows, user authentications/associations and user mobility, ***sniffers*** (software programs installed to monitor traffic) like ***tcpdump*** provide information on what users are doing on the network (e.g. what kind of application layer protocols they use) (Henderson et al., 2008; Kotz & Essien, 2005; Zola & Barcelo-Arroyo, 2011). By using these methods it is possible to define precisely how many users used the network: when, how often and for how long, what type and how much traffic users have generated from which APs. This information helps identify popular and often-used Wi-Fi points/locations (APs), user mobility patterns (how much users move around when connected to the Wi-Fi network), the amount of traffic generated on the whole network or by single users, and the number of active network users. To a certain extent, it is also possible to learn what users do when connected to the network even though this is generally limited to information on the application layer protocol (e.g. DNS, Telnet, FTP, etc.) and does not provide any insight on the browsing content. Information on the browsing history is generally not available because of privacy reasons. The MAC address of a device used to connect to the Wi-Fi network allows inferring some device properties and sometimes precisely identifying the type of device. The ***advantage*** of the network perspective is that it provides objective and accurate data on how the network is used from a technical point of view and that it allows researchers to easily collect large amount of usage data. However, unless the user has given some personal information during the registration process, the network perspective is not able to provide data on the user him/herself, and not even on the environment, context and situation in which the usage takes place. It is possible to identify usage practices and user profiles based on the used AM, UB, and network traffic but it is difficult to assign a socially relevant meaning to them without additional information on the users, the usage context and situation.

The "***user perspective***" analyzes network usage from the point of view of the user. The user provides data on how s/he uses the network through ***surveys***, ***interviews*** or ***diaries***. This data is certainly more subjective as users are not always able or willing to provide accurate data on their usage behavior. However, it is a good approximation. The great advantage is that researchers can collect richer and more varied data especially on the ***user*** him/herself (demographics and socio-economic information), on his/her ***motivation*** to use the Wi-Fi network (why) and on what s/he does when connected. Unlike in the network perspective, thanks to the user perspective it is possible to gather information on the application content (e.g. news, tourist information, etc.) and scope (work-, leisure-, communication-related), and not only on the type of application protocol. Even though the

[23] SNMP is an Internet Standard protocol for collecting information on devices of an IP network like APs, routers, servers, modems, etc.) and is widely used for network monitoring.

amount of data collected is generally lower, the researcher has the possibility to question the user on exactly those aspects s/he is interested in and thus, complement mere usage data with data on the user, the context and the situation in which the usage occurs. Usage profiles generally result to be more meaningful as they can be explained and interpreted with the help of additional user and social variables. Studies focusing on the user perspective are thus better in contextualizing usage and consider also social aspects of Wi-Fi usage.

Studies using the "***observer perspective***" analyze information resulting from observing people using a Wi-Fi network in specific environments. This perspective is particularly useful to understand non-technical user behaviors such as social interactions of Wi-Fi users, external user characteristics or information on the geographical and social environment. Observations generally allow collecting data only during relatively short usage periods (especially if compared to technical network tracing, where very long collections are possible). This might lead to erroneous conclusions, as the identification of typical usage periods is not always easy (De Freitas, n.d.). With the proliferation of smaller mobile devices, it might also be more difficult to identify Wi-Fi users within a Wi-Fi area. While it is plausible to assume that a person with a laptop sitting within the range of a Wi-Fi area actually used the Wi-Fi network, this is not automatically true for smartphone users. They might use their 3G/4G data or do activities that do not require Internet connectivity. This makes it very difficult to visually capture only those people who are actually using the Wi-Fi network in question (De Freitas, n.d.). To compensate this, the observer perspective is generally used in combination with the user perspective.

Table 14 provides an overview of the three study perspectives and of how each perspective contributes to a better understanding of Wi-Fi usage.

	Network Perspective	User Perspective	Observer Perspective
Data type	Technical data generated and stored when the network is used (e.g. IP/MAC address, time/duration, generated traffic, authent. data); objective data	Data actively provided by the user on how s/he uses the network; subjective data	Data based on observing a person using the network; subjective data
Data collection methods	SNMP polls, syslogs, tcpdump	Online, paper surveys, interviews, diaries	Field observations
Contribution of each perspective to:			
User Behavior (UB)	When, how often, how long, how much, where, mobility (M)	Why, what for, with whom, where	How, with whom, where, situational info
User (U)	None or limited to registration/authentic. info	Demographics & socio-economic info	In part demographics; external characteristics
Application Mix (AM)	Info on AM based on Application Layer Protocols (e.g. web sessions, SMTP, FTP)	Application content & type (e.g. news, tourist infos, social media)	Generally, none without being invasive
Device (D)	Info from MAC address	Device type	Device type
User Profiles / Usage Practices (UP)	UP created based on AM & UB, device type, pre-defined customer group	UP created based on why/what for, where, demographics and socio-economics variables; or if UP created based on technical variables (eg. AM & UB), demographics and socio-economics variables are used to interpret/assign meaning to the profiles	

Table 14 – Overview of Study Perspectives and their Contribution to Understanding Wi-Fi Usage

In Figure 20, the classification scheme of existing studies on public Wi-Fi usage is further extended to include the study perspectives used for each network context and type in existing literature.

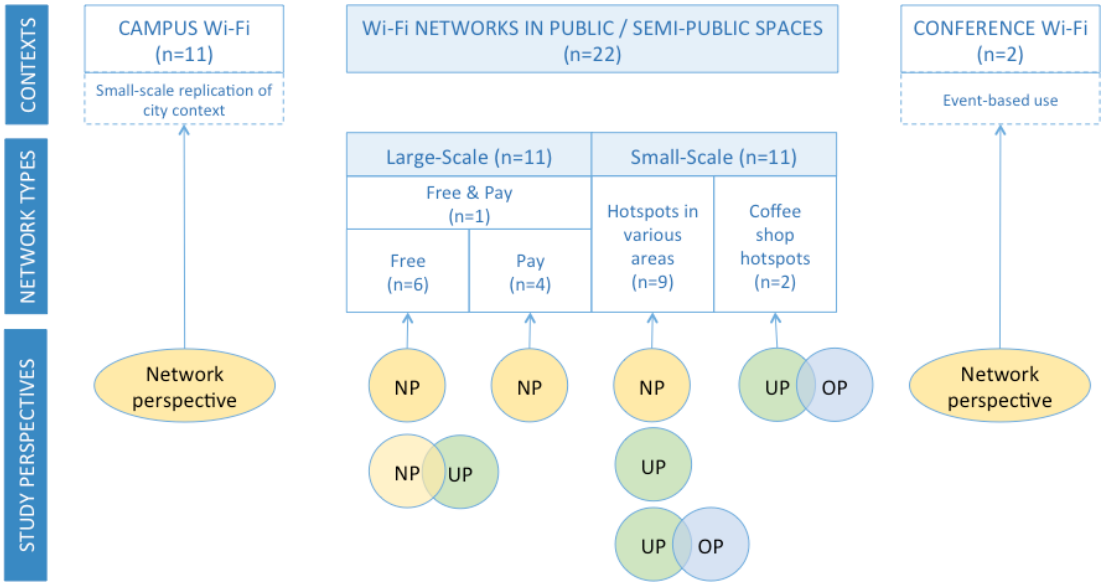


Figure 20 – Classification Scheme of Studies on Public Wi-Fi Usage (n=35) – Study Perspectives added

4.2.5 Wi-Fi Usage in Existing Literature

Table 14 provides a structured overview on the 35 Wi-Fi usage studies selected for this literature review. They are ordered according to the classification scheme of public Wi-Fi studies presented in the previous sections (figure 20), specifically according to study context (campus, conference, public/semi-public) and Wi-Fi network type (large-/small-scale; free, pay-for, hotspots in various areas, coffee shop hotspots). Within each group the single studies are mentioned in a chronological order based on the time of data collection.

For each study the following attributes are mentioned: network, network characteristics, country of data collection, authors, study period and length, study coverage (for technical studies: APs, unique users, buildings; for user- and observer perspective studies: number of interview/survey answers and observations), study perspective (network, user, observer), study focus and main Wi-Fi usage findings.

At this point it is important to note that context of Wi-Fi usage drastically changed over the years between the first public Wi-Fi projects in the early to mid-2000s and today. Today we live in a different technological era in which every one owns smartphones and uses them on a regular basis to connect with friends and family through social media. It is important to keep this changed context in mind, as in some cases past research may not provide particularly useful insights to explain current behaviors.

Network(s)	Network Characteristics	Country	Authors	Study Period	Study coverage: APs / Users	Persp.	Focus	Main findings
CAMPUS WLANs								
Stanford College	Depart. WLAN – registration	USA	(Tang & Baker, 2000)	1999 (Sep-Dec) 12 weeks	12 / 74 / 1 build.	Network	Usage descript. **User classes**	**AM:** web-surfing, chat; **M:** low 11 user classes (e.g. talky, web-surfer)
Georgia Tech	Campus WLAN – non-residential	USA	(Hutchins & Zegura, 2002)	2001 (Jan-June) 6 months	109 / 444 / 18 build.	Network	Usage descript.	**UB:** diurnal; **M:** medium
Dartmouth College	Campus WLAN – indoor and outdoor; also residential	USA	(Kotz & Essien, 2002; 2005)	2001 (Fall term) 11 weeks	476 / 1'706 / 161 build.	Network	Usage descript.	**AM:** web-surfing, backup, file-sharing; **UB:** short sessions; Fri/Sat less; high residential traffic; **M:** low
			(Henderson et al., 2008)	2003 /2004 17 weeks	566 / 7'134 / 190 build.	Network	Evolution of usage	Increased usage and traffic: **AM:** P2P, streaming, (VoIP), less web; **UB:** different devices; **M:** low but slightly increased
Saskatchewan University	Campus WLAN – non-residential	Canada	(Schwab & Bunt, 2004)	2003 (Jan) 1 week	18 / 136 / several build.	Network	Usage descript.	**M:** low; **L:** importance of focusing on popular/used locations
University of North Carolina	Campus WLAN	USA	(Chinchilla et al., 2004)	2003 (Feb – Apr) 11 weeks	222 / 7'681 / 79 build.	Network	Association and mobility patterns	Prediction of next AP association **UB:** short sessions; **AM:** few URLs created 70% of traffic
MIT	Campus WLAN; also residential	USA	(Sevtsuk & Ratti, 2005; Sevtsuk et al., 2009)	2005 real time visual.	2'659 / n.a.	Network	Usage – space patterns	**UB-Space:** Main Campus: diurnal use; dormitories: late evening use
4 U.S. universities	4 Campus WLAN	USA	(Hsu & Helmy, 2005)	2001 – 2005 (4 different traces)	1'300 / 12'000	Network	Individual vs. group behavior	**Ind. UB:** short sessions, long offline time; heavy & light users; **M:** low **Group UB:** low encounter rate
Technical University of Catalonia (UPC)	3 Campus WLAN (1 build. each)	Spain	(Zola & Barcelo-Arroyo, 2011)	2009 (Mar – May) 3 months	12-13 / 1'417 – 5'917	Network	Usage descript.	**UB:** Similar usage in the 3 buildings; infrequent use; used less on we; popular vs. less used APs **M:** low
	BRGF Library WLAN	Spain	(Zola & Barcelo-Arroyo, 2013)		12 / 5'917			
Politecnico Milano	Campus WLAN	Italy	(Redondi et al., 2016)	2015 (Nov-Dec) 3 weeks	28 / 27'538 / 1 build.	Network	Infer real-life UB from Wi-Fi use	**UB:** diurnal; Wi-Fi use reflects users' day-to-day behavior
CONFERENCE Wi-Fi networks								
Computer Netw. Conf (San Diego)	Conference hotspot	USA	(Balachandran et al., 2002)	2001 (Aug) 2.5 days	4 / 195	Network	Usage descript.	**UB:** active during conf. sessions; short sessions; **M:** when expected **AM:** web-surfing; **NT:** not correlated to number of users

IETF conference (Seoul)	Conference hotspot	South Corea	(Lee et al., 2005)	2004 (Feb/Mar) 5 days	32 / 1'293	Network	Usage descript. & co-located 802.11a/b netw.	**UB:** active during conf. sessions; short sessions; **M:** medium **NT:** more 11a than 11b traffic
PUBLIC WI-FI networks (Wi-Fi network in the public / semi-public space)								
LARGE-SCALE Wi-Fi networks								
5 public large-scale & 3 campus WMNs	Large-scale WMN: free, pay-for & campus	USA	(Vural et al., 2013)	--	--	Network	Survey of papers on large-scale urban-area WMNs	**UB:** few users generate most traffic; more inbound traffic than outbound; traffic varies within each day/week; **AM:** more and more P2P, streaming, VoIP; **M:** there are different mobility classes; **AP:** load depends on location; **UP:** recurrent usage practices emerge
FREE Large-Scale Wi-Fi networks (mainly municipality- and community-driven networks that cover larger and multiple areas)								
PanOULU	MWN – open, free, unrestricted	Finland	(Ojala et al., 2005)	2004/5 (Jan–Feb) 14 months	250 / 4'115	Network	Network usage; **User groups**	**UB:** university & visitor accounts - diurnal usage; city accounts -evening usage; short sessions; few users generate most online minutes **M**: low; **AM**: e-mail; **UP:** heavy vs. visiting users
			(Ojala et al., 2008)	2008 (Jan – Aug) 8 months	800 / 25'939			
			(Ylipulli et al., 2014)	2010 – 2012 (Jun-May) 24 months	1'440 / 37'167; 1'022 surveys; 48 diaries; 16 interv.	Network & User	Adoption of panOULU	**UB:** laptop (less mobile; longer online time) vs. mobile device users & young vs. older adults; **Adopt.**: high among students
Fred-eZone	MWN – hotspots, free; limited bandwidth & some ports blocked	Canada	(Powell, 2008a)	2008 (Mar)	211 online surveys	User	Understanding role of Wi-Fi as public utility by comparing users of Fred-eZone & Île sans Fil	**UB:** most used at downtown coffee shop, public library, coffee shop in suburban mall, university computer lab, truck stop on highway; **U:** 50% visitors (professionals, students, truckers); used "rarely"; **AM**: e-mail and web surfing; very few VoIP & audio/video content
Google Mountain View	MWN mesh – free, registration	USA	(Afanasyev et al., 2008; 2010)	2008 (spring) 4 weeks	500 / 31'284	Network	Network usage; **User groups**	**3 UP:** modem, laptop or smartphone users with different UB, M and AM
Futur3	Urban mesh – free, authentic.	Italy	(Vincenzi et al., 2010)	2009 (Oct) 3 days	n.a.	Network	Event-based use, social interact.	**UB**: short connections, **M**: low; **U:** residents, students, tourists; **Inter-actions:** short chat conversations
COMMERCIAL / PAY-FOR Large-Scale Wi-Fi networks (mainly provider-driven networks that cover larger and multiple areas)								
Metricom Packet Radio Network	Urban non Wi-Fi Mesh	USA	(Tang & Baker, 2002)	1998 (Feb-Mar) 7 weeks	14'053 / 24'773	Network	Network usage	**UB:** Diurnal/evening use; higher use during weekdays; **M:** moderate
WISP	Nationwide hotspot	Australia	(Divgi & Chlebus, 2007; 2013)	2004/5 (Oct-Mar) 5 months	n.a.	Network	Network usage; Differ. to non-commercial WNs	**UB:** night-time; uniform over all weekdays; occasional use; few users generate most traffic; used 2/3 of purchased time

Verizon HotSpot	Urban hotspot - only for clients	USA	(Blinn et al., 2005)	2004 (Nov-Dec) 5 weeks	312 / 1'682	Network	Network usage	**UB:** not used a lot; diurnal usage; less during week-ends; **M:** low;
MadMesh	Urban Mesh - indoor, resident.	USA	(Brik et al., 2008)	2007 (Nov-Dec) 2 weeks	250 / n.a.	Network	Network usage & performance	**UB:** late evening & night usage
SMALL-SCALE Wi-Fi networks								
VARIOUS small-scale Wi-Fi networks (various Wi-Fi areas that are available only in small areas such as parks, cafés, squares, etc.)								
Austin's public Hotspots	Urban hotspots – 85 public venues	USA	(Fuentes-Bautista & Inagaki, 2005)	2004 (Jul-Sep)	151 surveys	User	Understanding users	**U:** Young, well educated, affluent, heavy Internet users; **AM:** E-mail & news; **Activities:** work & homework
Île Sans Fil	Urban hotspot – free, registration	Canada	(Powell, 2008b)	2004 – 2007	2004: 56 paper survey responses 2006: 370 online survey responses; 20 struct. interv.	User	Wi-Fi Publics: geeks vs. community public	**U:** 25-34; higher education, worked in education, media, and telecomm., geeks; use hotspots to get out of home or office; **AM**: mainly information seeking & e-mail but also some audio/video downloading, contribution to blogs, podcasts
			(Powell & Shade, 2006)	2005 (Apr)	ca. 33 paper surveys distributed at 9 hotspots	User Network	Understanding users	**UB:** most used in early afternoon, midweek in downtown cafés; **U:** youthful users (18-30 years); technical-elite, male; freelance workers & students; **AM**: E-mail, information seeking, instant messaging
Cafés, parks, etc.	Urban hotspots – public spaces	USA, Canada, Hungary	(Forlano, 2008a; 2010)	2006/7 (Oct – Apr)	1'362 survey responses & 29 interv.	User	Understanding users: how, who, where, why	**Activities:** work & leisure, get out of office/home, retrieve info, socialize; creation of "third places"; Wi-Fi attracting people to places
Parks, squares, markets	Urban hotspots – 7 public spaces	USA, Canada	(Hampton et al., 2010)	2007 (May – Sep)	151 visits; 227 interv. 1'310 observed users	User; Observer	Impact of Wi-Fi on urban public spaces, users and inhabitants	**U**: young, single, well-educated males; **UB:** 1-2h; 1-2x per week; **Activities:** communication (e-mail, instant mess., VoIP); part. in public sphere (news & polit. info); Wi-Fi attracting people to places
Helsinki	Urban hotspots - open & free	Finland	(González Rodríguez, 2010)	2009 (Jun– Sep) 50 hours	n.a. / 651	Network	Network usage	**AM:** web-applications; **UB:** different de-vices; short & long sessions; → usage depends on location
ZAP Québec	Urban hotspot – free, registration	Canada	(Doyle, 2011)	2009/10 (Aug-Jan)	209 / 50'000 63 online surveys	User	Network usage; **User profiles**	**UB**: afternoon/evening, laptop, alone; **Activities**: recreational & work, access information, stay in contact; travel planning; **3 UP:** Local Relaxers, Urban Mobiles, Suburban Parents

Public places	Urban (2) & Sub-urban hotspots (4) – free	Australia	(Lambert et al., 2014)	2013 (Feb)	x observations & x interv.	User; Observer	Popularity; environment; usage (how, why); **Usage types**	**User:** traveler, student, out-of-office worker; **UB:** laptops, tablets, smartphones; **3 usage types:** supportive, productive, entertaining/social
Urban Wi-Fi networks	Urban hotspots – residential & non	China	(Zhang et al., 2017)	2015 (Mar – Apr) 1 month	8 mio / 6.4 mio per day	Network	Network usage & deployment; **AP classification**	**UB:** usage during commuting times & weekdays; short or long sessions; **AP:** business, public, residential APs
COFFEE SHOP Wi-Fi networks								
4 cafés in 2 cities	Urban semi-public hotspots –free & pay	USA	(Hampton & Gupta, 2008)	2003/4(Dec-Mar)	120 h observ. 20 interv.	User; Observer	Social interact.; **Usage practices**	**True mobile**: Wi-Fi for work related activities; **Placemaker**: Wi-Fi to look for social interactions
Starbucks coffee shops	Sub-urban semi-public hotspots	USA	(Elledge & Kwon, 2016)	2015 (Feb – Mar)	63 visits to 20 cafés; 132 h observ. 20 interv.	User; Observer	Role of Wi-Fi in sub-urban, semi-public spaces; **Visitor profiles**	**5 coffeehouse visitor profiles:** Motivated User; Motivated Non-User; Passive Visitor; Spectator; Obnoxious Overuser

black font = network perspective; blue font = user/observer perspective; red font = presence of user profiles/ usage practices

AM – Application Mix; L – Location; M – Mobility; NT – Network Traffic; U – Users; UB – User Behavior; UP – User profile / Usage Practice

Table 15 – Classification of Existing Studies on Public Wi-Fi Usage

4.2.5.1 User Behavior on Campus WLANs

Most colleges and universities nowadays have medium- to large-scale Wi-Fi networks to provide wireless Internet access to students and staff. Similarly to city Wi-Fi networks, campus WLANs are often deployed over different buildings, outdoor spaces and recreational areas and have a multitude of different users. Hence, especially large-scale campus networks have similar characteristics and deployment challenges to Wi-Fi networks in urban areas (Vural et al., 2013). Furthermore, campus networks usually offer ideal study conditions, as network data is easily available (Hsu & Helmy, 2005; Tang & Baker, 2000), while for other types of Wi-Fi networks, it is often more challenging as a researcher to get access to network data traces. For this reason, many early studies on Wi-Fi usage have been conducted on campus WLANs. Even though all studies on campus WLANs exclusively analyze usage with the help of technical data that is generated and stored when the network is used (network perspective), they provide a good starting point for understanding how Wi-Fi networks can be analyzed and what findings can be expected.

Eleven studies analyzing Wi-Fi usage behavior on university campuses have been considered in this literature review. Most of them have been conducted on U.S. campuses – especially the early ones – and used a combination of three technical tracing methods to collect Wi-Fi usage data: syslog, SNMP and tcpdumb. The duration of data collection varied from one week up to 6 months and the coverage ranged from 12 to 2'659 APs, from 74 to 27'538 unique users and from 1 to 190 buildings.

The ***earliest studies*** (Henderson et al., 2008; Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005; Schwab & Bunt, 2004; Tang & Baker, 2000), all conducted in the U.S. and Canada between 1999 and 2005, have simply ***described*** "how mobile users take advantage of a Wi-Fi network" (Balachandran et al., 2002, p. 196). The study on the Stanford college campus WLAN (Tang & Baker, 2000) was among the first to analyze Wi-Fi usage of campus WLANs and served as model for all following Wi-Fi usage studies on campuses. However, while the study on the Stanford campus WLAN was limited to only one department, later campus WLAN studies explored much larger areas (Henderson et al., 2008) with many different environments. Such environments could be public spaces like libraries, lounges, coffee shops or conference rooms (Henderson et al., 2008; Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005; Schwab & Bunt, 2004; Tang & Baker, 2000), spaces dedicated to academic or administrative activities like classrooms, offices and labs (Henderson et al., 2008; Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005; Schwab & Bunt, 2004), residential areas with dormitories (Henderson et al., 2008; Kotz & Essien, 2002; Kotz & Essien, 2005), and recreational areas with sport infrastructures (Henderson et al., 2008; Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005; Schwab & Bunt, 2004).

From these early studies, it emerged that Wi-Fi usage of campus WLANs is mainly ***diurnal*** (Hutchins & Zegura, 2002; Redondi et al., 2016) and more intense during ***weekdays*** than on weekends (Friday & Saturday). This finding is in line with the normal life-routine on a university campus where students and staff might rest or even leave during weekends. Wi-Fi traffic tends to increase again on Sunday when students start preparing for the next week (Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005). Users generally connect for ***short sessions*** (Chinchilla et al., 2004; Hsu & Helmy, 2005; Kotz & Essien, 2002; Kotz & Essien, 2005; Redondi et al., 2016) and a small number of users generates most network traffic (Henderson et al., 2008; Kotz & Essien, 2002; Kotz & Essien, 2005). Most users do ***not move*** around when connected to the WLAN and limit their network activity to some relevant campus areas like those located near large lecture halls (Hutchins & Zegura, 2002; Kotz & Essien, 2005; Tang & Baker, 2000). However, there are few very mobile users (Tang & Baker, 2000). ***Web surfing*** accounts for the largest amount of traffic generated on the network (Henderson et al., 2008; Kotz & Essien, 2002; Kotz & Essien, 2005; Tang & Baker, 2000), but also session-oriented (e.g. telnet[24]) and chat activities (Tang & Baker, 2000) as well as network backups and file sharing contributed considerably to the generated traffic (Kotz & Essien, 2002; Kotz & Essien, 2005).

While most studies have been conducted in the Wi-Fi network's early implementation stage (Hutchins & Zegura, 2002; Kotz & Essien, 2002; Kotz & Essien, 2005; Schwab & Bunt, 2004), Henderson et al., (2008) focused on the ***evolution*** of Wi-Fi usage by re-examining the usage of Dartmouth College's Wi-Fi network after it had matured. Compared to the findings of the first study conducted after the initial deployment of the network, ***network usage and traffic increased*** considerably. New and more diverse devices were used to connect to the network and new applications such as P2P and streaming multimedia were used increasingly, while web traffic decreased significantly. The massive increase of streaming media (192%) might be explained by their frequent use for teaching (e.g. language courses). Both streaming media and P2P were mainly used internally between on-campus hosts. The proportion of heavy users remained the same and users still showed very low mobility.

Three subsequent studies on American campuses (Chinchilla et al., 2004; Hsu & Helmy, 2005; Sevtsuk & Ratti, 2005; Sevtsuk et al., 2009) – based on data collected between 2003 and 2005 – had more specific goals and were particularly interested in some specific aspects of Wi-Fi behavior. Chinchilla et al. (2004) studied ***association and mobility patterns*** of Wi-Fi users on the University of North Carolina campus and were able to predict with a good probability (86%) the next AP with which a user would associate (Chinchilla et al., 2004). Sevtsuk et al. (2009) focused on the ***use of space and on how***

[24] Telnet indicates remote login to hosts.

Wi-Fi networks impact on it to understand daily working and living patterns of MIT (Massachusetts Institute of Technology) students and staff. They combined network traces with geospatial data of all buildings, rooms and their uses to produce visualization maps of Wi-Fi usage in different locations. In this way, they were able to estimate the number of people located in the different buildings/rooms at a certain moment. They found that the main campus with the classrooms was most populated between 10am and 5pm while dormitories in the West campus showed the strongest network activity in the late evening hours (Sevtsuk & Ratti, 2005; Sevtsuk et al., 2009). This type of analysis might be interesting also for cities to understand Wi-Fi usage space-time patterns. Last but not least, Hsu & Helmy (2005) analyzed already existing traces from four different U.S. university campuses to get a better understanding of ***individual and group usage behavior***. With regard to individual user behavior, the authors found that users of the four campuses shared several usage patterns, which were in line with the findings of the earlier studies: users connected for short time periods, showed low mobility visiting only few APs and had long offline times. Group user behavior was based on metrics for encounter and friendship, which showed that during a month most users encountered less than 6% of the whole network population.

The ***two most recent studies*** have been conducted in Europe – two at the Technical Universtiy of Catalonia (Zola & Barcelo-Arroyo, 2011; Zola & Barcelo-Arroyo, 2013) and one at the Politecnico di Milano (Italy) (Redondi et al., 2016). The WLANs under study were limited to single buildings hosting lecturing rooms, offices, corridors and libraries. They showed similar Wi-Fi behaviors as those found in previous studies on WLANs of U.S. campuses: users did not connect frequently, used the network more during the week than on weekends, and did not move much when connected. In these European WLANs, some APs were also popular and had a lot of traffic while others were mostly idle. Furthermore, Redondini & Fitzgerald (2016) did a temporal and spatial characterization of Wi-Fi traffic at the Politecnico di Milano. They found that students who were in a room when there was no class generally connected to the network once and then stayed connected over a longer time, while those attending a lesson in the same room connected more often but for shorter sessions. Furthermore, from observing the Wi-Fi behavior of architecture and engineering students during lectures, they could infer that engineering students attended classes less often but with more attention than architecture students.

To summarize, a typical campus WLAN user connects during the day in buildings dedicated to teaching, studying and working and in the evening in residential buildings. S/he connects more often during weekdays and less during weekends. Wi-Fi usage thus follows the typical daily-life schedule of a student and a university collaborator. Users generally have short sessions and tend to always connect to the same few APs without moving around much when connected to the Wi-Fi network. This results in a few popular

APs generating most network traffic. The most used applications are web-surfing followed by session, chat, streaming or backup activities, P2P and VoIP. A few heavy users generate most traffic. Only the study on the Stanford College Wi-Fi network identified user classes. The 11 different user classes are based on users' application mixes and network behavior (e.g. "web-surfers", "talkies", "late-night") (Tang & Baker, 2000).

4.2.5.2 User Behavior on Conference Wi-Fi Networks

This section presents two studies that analyzed Wi-Fi usage at a computer networking conference (ACM SIGCOMM) in San Diego (U.S.) in August 2001 (Balachandran et al., 2002), and at the 59th IETF standard conference in Seoul (South Corea) in February/March 2004 (Lee et al., 2005). Similar to the studies on campus WLANs, they used a mix of technical tracing methods like syslog, SNMP and tcpdump, and thus, entirely focused on technical data generated when the network is used (network perspective). At the conference in San Diego, researchers traced four APs covering a large auditorium and the lobby and 195 users during the two and a half conference days. The second study analyzed a larger setting with 32 APs covering multiple conference rooms, lobbies and other mixed areas and 1'293 clients during 5 days. Furthermore, Lee et al. (2005) compared co-located 802.11a/b networks (dual-mode APs).

The particularity of these networks is that they are placed in a context where a lot of people move frequently and go from one session room to another based on a conference schedule. This is why findings about conference networks might be relevant for an urban context, especially in case of ***events*** taking place in public areas and attracting a large amount of people (e.g. exhibition areas, concerts, festivals, etc.).

Results on conference Wi-Fi usage, suggest that ***user arrival and traffic patterns strongly depend on the conference's session schedule***. Users, in fact, were most active during conference sessions and least during coffee and lunch breaks (Balachandran et al., 2002; Lee et al., 2005), and they moved when expected, namely at the beginning and at the end of a session (Balachandran et al., 2002; Lee et al., 2005). Similar to campus WLAN users, they connected for short sessions (less than 10 minutes) (Balachandran et al., 2002; Lee et al., 2005) and used the network mainly for web browsing activities (Balachandran et al., 2002). Traffic load was distributed unevenly across APs and did not correlate to the number of users connected to a specific AP (Balachandran et al., 2002). Where 11a and 11b networks co-existed, there was 3.3 times more 11a traffic per client than 11b.

4.2.5.3 User Behavior on Wi-Fi Networks in Public and Semi-Public Spaces

A total of 22 studies exploring Wi-Fi usage of networks in public or semi-public spaces have been identified and subdivided into four different network types. As shown in the

classification scheme of public Wi-Fi usage (figure 20), it is possible to distinguish between large- and small-scale networks, between free and pay-for and between studies that focus on various small-scale networks and studies that focus on cafés Wi-Fi networks only.

While studies on campus and conference WLANs base their analysis exclusively on technical data generated and stored when the network is used (network perspective), studies on public Wi-Fi networks also rely on more qualitative data gathered directly from the user through ***surveys, interviews and observations***. Many studies on public Wi-Fi networks are thus more interested in the networks' ***social implications and contextualization*** than in understanding usage solely from a technical point of view. Hence, they put the ***user at the center*** of their observation and not the network. Therefore, the research focus of these studies shifts from a mere technical perspective to a social one where usage is considered within its context.

The fact that collecting network data from public Wi-Fi networks is generally more challenging than collecting data from campus or conference networks might have contributed to this shift. Within universities researchers generally have easy access to traces and can to a certain extent even contribute to the definition of variables they want to store for future analysis during the planning phase of the WLAN. With traces of Wi-Fi networks in public spaces, researchers often have to rely on data that has not been gathered for research purposes (Tang & Baker, 2002) and have to make the best out of what is available.

4.2.5.3.1 User Behavior on Free Public Large-Scale Wi-Fi Networks

Typical Wi-Fi networks in this category are MWNs but also commercial Wi-Fi networks that offer their services for free. Six studies analyzing four different Wi-Fi networks fall under this category. Three studies have been conducted on the PanOULU MWN in Finland, one on Canada's Fred-eZone, one on the Google Mountain View MWN in Californina (U.S) and one on the Futur 3 network providing free Wi-Fi in three cities in Trentino (Italy). All studies except two analyzed usage from a network perspective using purely technical data. Only the last study on PanOULU combined technical data with user-provided information and Powell (2008a) studied users of the Fred-eZone network with the help of data collected through a survey and observations.

The Finnish PanOULU network[25] is one of the largest MWNs in the world providing open, free and unrestricted Wi-Fi Internet access to the general public. It covers the university campus, public city premises and outdoor areas in the city center. Since the very

[25] Finnish PanOULU Wi-Fi network – http://www.panoulu.net.

beginning of the project in 2003, the promoters have recognized the importance of collecting and analyzing usage data in order to improve the network and provide services that are useful for the users (Ojala et al., 2005). Between 2004 and 2012 three major usage studies have been conducted, allowing for a constant improvement of the network. ***The first one*** (Ojala et al., 2005) took place between January 2004 and February 2005 over a period of 14 months. Results showed that different user groups had different daily and weekly usage patterns: while university and visitor accounts normally connected during office hours, city accounts used the network more in the evenings. In general, users were not very mobile.

The ***second study*** (Ojala et al., 2008) that took place between January and August 2008 revealed that usage had been growing constantly and even doubled after the removal of network authentication in June 2005. Even though the vast majority still connected with PCs/laptops, at the time of the study, a good 20% of clients used ***Wi-Fi equipped phones or tablets***. Similar to campus networks, there were few "heavy" users utilizing the network at least every other day and generating most of the total online minutes. Interestingly, more than half of the people were "visiting" users, using the network during a maximum of one week. This allows inferring an increased importance of the network for visitors. The typical user connected for short sessions in order to check e-mails.

The ***third usage study*** (Ylipulli et al., 2014), which took place over a period of two years between June 2010 and May 2012 concentrated on the ***appropriation process*** of two public infrastructures in Oulu: the panOULU MWN and large interactive displays providing information services. While the previous two studies only used technical log data, this time researchers used a ***mixed-method including also user data*** collected through a questionnaire and an ethnographic study. It emerged from the ***log file*** that laptop users were less mobile and had much longer online times than mobile device users, who generally connected more frequently but for shorter sessions. As in the previous study, "visiting" users were the largest user group (57.7%). To complement this technical data, local high school students and students of the university of Oulu were asked to fill in a ***survey***. Results showed that adoption and support of panOULU was high among students. Furthermore, in order to understand how citizens of Oulu used ICTs in their everyday life, young adults were asked to fill in a ***dairy*** with different tasks and were then invited to semi-structured group interviews while elderly adults (recruited from a computer course for aging citizens) were invited to ***semi-structured life-story interviews*** on their past and current ICT experiences. For young adults panOULU was an integral part of their daily lives while elderly adults liked the idea of free and open access to the Internet for their home computers but did not really consider using it in public places. Researchers agree that panOULU provides significant intrinsic value to both people living in and visiting Oulu and thus "enhances attractiveness, competitiveness and productivity" of the city (Ojala et al., 2008, p.2).

Powell (2008a) had more socially-oriented motivations to study users and usage of the ***Fred e-Zone Wi-Fi network***, one of the first municipally-owned free Wi-Fi networks in Canada (developed between 2003 and 2007 in the city of Fredericton). As part of a vaster study aiming at understanding the role of Wi-Fi as a public utility, she conducted surveys with users of the Fred-eZone network as well as with users of the community network Île sans Fil in Montréal. The Fred-eZone network was initially completely open but in response to spamming problems, some ports were blocked and bandwidth was limited. In March 2008, she conducted an online survey addressed to the users of Fred-eZone and collected 211 responses. It emerged that the network was mostly used in a downtown coffee shop, in the public library, in a coffee shop in the suburban mall, in a university computer lab, and at the truck stop on the highway. More than half of the respondents were professionals, university and high school students and truckers visiting Fredericton. Visitors thus seemed to benefit more often from the network than local residents. E-mail and web-surfing were the most common applications on the network, while only very few users utilized VoIP and audio/video contents. Most users connected to the network only very rarely, which confirms that the network is used mainly for occasional usage complementary to other ways of accessing the Internet. While the main reason for Fred-eZone users was to access free Internet, users of ISF used the network as a motivation to get out of their home and office into the public space. ISF users employed a broader application mix than users of the Fred-eZone, using the network also to contribute to blogs, podcasts and websites and download and view audio/video.

Afanasyev et al., (2008; 2010) studied usage of the ***Google Wi-Fi network in Mountain View*** (CA), which covered an area of about 31 km^2 with 72'000 inhabitants. All APs had been installed outdoors but signal coverage could be extended to indoor areas with the help of Wi-Fi modems or bridges. Users were aggregated into three groups based on the device used to connect to the network: modem or fix-location users (e.g. residents or businesses), laptop, and smartphone users. ***Modem users*** tended to be static and always connected, employing a lot of network capacity and using the Wi-Fi network as a substitute for DSL or cable modem services. ***Laptop users*** employed the network mostly in commercial and public areas and showed medium mobility. Both laptop and modem users generated P2P traffic. ***Smartphone users*** were by far the most numerous group and generally used the network while ***commuting***. They only connected a few times and used mainly web and TCP applications, some streaming media and VoIP.

The third network under study in this category is the ***Futur3 wireless mesh network***, which provides free Wi-Fi Internet access in three cities in Trentino – Italy (Trento, Rovereto, Riva del Garda). Vincenzi et al. (2010) studied network use during a special scenario: the Blogfest Event in Riva del Garda (Oct 2^{nd} – 4^{th}, 2009). During the three-day event, users connected on average five times for short sessions. In addition to free Wi-Fi, Futur3 provided users with an interaction application. While using this application, most

users did not move and generally had short chat conversations. Younger users generated most chat traffic. Overall, it emerged that network usage was often highly dependent on the APs' position and the overall situation (normal life vs. special event).

4.2.5.3.2 User Behavior on Pay-for Public Large-Scale Wi-Fi Networks

Four studies analyzing Wi-Fi usage of provider-driven or commercial networks covering larger and/or multiple city areas have been identified. There are three American studies focusing on urban contexts (Blinn et al., 2005; Brik et al., 2008; Tang & Baker, 2000; Tang & Baker, 2002) and an Australian study exploring a nation-wide Wi-Fi network (Divgi & Chlebus, 2007; Divgi & Chlebus, 2013). The services of the non-Wi-Fi Metricom Ricochet Packet Radio mesh network (Tang & Baker, 2002), the Australian Wi-Fi hotspot network (Divgi & Chlebus, 2007; Divgi & Chlebus, 2013) and the MadMesh network (Brik et al., 2008) were offered to paying subscribers, whereas the Verizon Wi-Fi hotspot network in Manhattan (Blinn et al., 2005) was only available to Verizon Online DSL and dial-up customers to provide them with the possibility to connect to the Internet also outside their homes. While MadMesh was mainly used by customers to get Internet access in ***homes*** or ***indoors*** (student dormitories, university buildings, cafeterias and residences), the Verizon Wi-Fi hotspot clearly aimed at a non-residential use. The other two commercial networks (Tang & Baker, 2002) could be potentially available in both residential and public spaces.

As for usage studies on campus and conference Wi-Fi networks, only technical data collected with the help of one or more tracing method like sylog, tcpdumb, SNMP was employed and thus, all considered studies on Wi-Fi usage of pay-for public large-scale Wi-Fi network exclusively focused on the network perspective.

The four studies produced partially contradicting results especially on when users utilize commercial Wi-Fi networks. The reason for this might be found in some environmental characteristics of the networks. In fact, it looks like the networks available in places which are linked to day-time activities, and are thus most populated during the day, have strong diurnal usage patterns and are used more during weekdays than on weekends (Blinn et al., 2005; Tang & Baker, 2002). On the other hand, the networks that are used in more residential contexts like homes, hotels or campus residences show stronger activities at night or in the late evening (Brik et al., 2008; Divgi & Chlebus, 2007; Divgi & Chlebus, 2013) and have more uniform usage over all weekdays.

For other aspects, commercial Wi-Fi networks show similar usage behaviors to free networks: people connect more for occasional use than for everyday activities as they only connect rarely. In fact, only few potential users (e.g. those having a subscription) connect on a single day (Blinn et al., 2005; Divgi & Chlebus, 2007; Divgi & Chlebus, 2013; Tang & Baker, 2002). For example, on the Verizon Wi-Fi network out of 26'925 devices

associating to any of the network's APs, only 1'682 actually logged-in successfully during the study period (Blinn et al., 2005). Similar to campus Wi-Fi networks, clients generally connect to few APs, which are located close together (Tang & Baker, 2002) and few heavy users generate most network traffic (Divgi & Chlebus, 2007; Divgi & Chlebus, 2013). Furthermore, the use of APs is uneven, some are used a lot and others less, both in terms of users connecting and traffic generated (Blinn et al., 2005).

4.2.5.3.3 Recurrent Usage Practices of Public Large-Scale Wireless Mesh Networks (WMNs)

Vural (2013) provides a good summary of the usage practices that emerged from the above-mentioned studies on large-scale urban WMNs. He conducted a review of already existing usage studies on both free (Afanasyev et al., 2008; Afanasyev et al., 2010) and pay-for (Brik et al., 2008; Tang & Baker, 2002) large-scale city and campus Wi-Fi mesh networks (Chinchilla et al., 2004; Henderson et al., 2008; Kotz & Essien, 2002; Kotz & Essien, 2005) in order to define guidelines for the deployment of future city Wi-Fi mesh networks and to provide "researchers with a categorization of the research issues commonly encountered in city-wide WMNs" (Vural et al., 2013, p.225). He emphasizes the following frequently occurring network usage behaviors: most traffic is created by a small number of users; inbound traffic is generally higher than outbound; traffic volumes vary within each day/week; and different mobility classes exist. P2P, multimedia streaming and VoIP make up for an always-larger part of generated traffic. VoIP is in fact expected to become a major application on Wi-Fi networks as it allows to do free telephone calls in direct competition to existing cellular networks (Efstathiou et al., 2006; Middleton, 2007; Middleton & Potter, 2008). Vural (2013) also identified ***recurrent usage patterns/classification types*** within most reviewed studies. These are 1) ***temporal or time-based usage patterns*** with hourly, daily and weekly network usage trends with regard to traffic volume and number of clients (e.g. week-ends generally show stronger activities); 2) ***user classes*** depending on session lengths (e.g. short & light session vs. long and heavy sessions) and the user's geographic position (e.g. residential, commercial, and transportation area); and 3) ***device classes*** with different application mixes, session lengths, transmission rates and connection times. The following three user and device categories have been identified: ***local residents and businesses*** that use the Wi-Fi networks as substitutes to DSL or cable modem; ***laptop users*** showing mobility and workload patterns typical in public Wi-Fi hotspots; and more mobile ***smartphone users,*** who use Wi-Fi networks mainly during commuting times. Another pattern regards ***user privacy***: most studies analyzed aggregated data without any individual or client information.

4.2.5.3.4 User Behavior on Various Public Small-Scale Wi-Fi Areas

Seven Wi-Fi usage studies have considered various Wi-Fi areas or single hotspots available in small areas such as parks, cafés, markets or squares. Rather than studying Wi-Fi networks as a whole, they analyze the use of single hotspots or Wi-Fi areas. These small-scale networks are provided by different entities such as private people, communities, municipalities or commercial entities like cafés, restaurants or shops. The study on the ZAP Québec Wi-Fi network (Doyle, 2011) and those on Île sans Fil (Powell & Shade, 2006; Powell, 2008b) have been included in this category even though at first sight the networks under study look more like large-scale networks. Even though access and authentication are managed centrally, both ZAP Québec[26] and Île sans Fil (today, ZAP Coop - https://zap.coop) actually aggregate single and already existing hotspots, which are deployed by different entities (e.g. bars, shops, etc.). Furthermore, in his study on ZAP Québec, Doyle (2011) focuses on the use of single hotspots more than on that of the community network as a whole. Two studies analyzed networks located in multiple countries (Forlano, 2008a; Forlano, 2010), whereas the others on networks in single countries like Finland (González Rodríguez, 2010), Australia (Lambert et al., 2014), China (Zhang et al., 2017), the U.S. (Fuentes-Bautista & Inagaki, 2005) and Canada (Doyle, 2011). The analyzed networks are thus placed in very different cultural contexts but still show similar usage behaviors. Of the seven studies, two investigated Wi-Fi usage from a network perspective (González Rodríguez, 2010; Zhang et al., 2017) while the others from a user or a combination of user and observer perspective (Doyle, 2011; Forlano, 2008a; Forlano, 2010; Fuentes-Bautista & Inagaki, 2005; Hampton et al., 2010; Lambert et al., 2014).

All studies described usage behavior, characterized users and usage environments, and identified usage reasons and types of content and activities. To do so, they conducted online surveys, open-ended interviews and observations in various cities such as Austin (Fuentes-Bautista & Inagaki, 2005), New York, Budapest (Forlano, 2008a; Forlano, 2010), Montreal (Forlano, 2008a; Forlano, 2010; Powell & Shade, 2006; Powell, 2008b), Philadelphia and Toronto (Hampton et al., 2010), at six sites in Victoria (Australia) (Lambert et al., 2014) and at various hotspots in Québec. Two studies used different approaches: Gonzalez went warwalking[27] in Helsinki to identify and trace free Wi-Fi networks while (Zhang et al., 2017) used a utility software platform, which allows users to select the best available Wi-Fi network, to collect "location and ownership information

[26] ZAP Québec Wi-Fi network – www.zapquebec.org.

[27] Warwalking means walking around an area to look for free Wi-Fi networks using a portable computer and a packet sniffing software.

of reported wireless APs[28], as well as the connection records between Wi-Fi users and those APs" (p.43).

Findings showed that Wi-Fi ***users*** in urban public spaces tended to be quite similar: they were young, single, well-educated, affluent and mainly male (Doyle, 2011; Fuentes-Bautista & Inagaki, 2005; Hampton et al., 2010; Powell & Shade, 2006; Powell, 2008b). Fuentes-Bautista et al. (2005) described them as "experienced and heavy Internet users that go online from diverse platforms, and are fully engaged in the age of mobile communications" (p.22). They own and use a large variety of devices to connect to Wi-Fi networks including laptops, tablets and smartphones (Doyle, 2011; Forlano, 2008a; Forlano, 2010; Fuentes-Bautista & Inagaki, 2005; Lambert et al., 2014). They use public Wi-Fi networks for both ***work and leisure related activities*** and appreciate the flexibility that these networks offer to get work or homework done outside the office or the school in more pleasant settings like a park or a café. Furthermore they value being able to retrieve information when on the go, and familiarizing with people (Doyle, 2011; Forlano, 2008a; Forlano, 2010; Fuentes-Bautista & Inagaki, 2005; Powell, 2008b). Lambert et al. (2014) distinguished between three different usage forms: ***supportive*** – to look for a place to stay or collaborate and communicating with friends and family, ***productive*** – to get study or work tasks done, and ***entertaining and social*** to, for example, pass some time browsing the web and socializing with friends over the Internet. The authors thus underline the importance of public Wi-Fi for ***travelers, visitors, students and out-of-office professionals*** (Lambert et al., 2014; Powell & Shade, 2006; Powell, 2008b). Most people use their Wi-Fi connections to communicate with peers that are not physically present either via e-mail, instant messaging or VoIP (Fuentes-Bautista & Inagaki, 2005; Hampton et al., 2010). Another popular activity is participating in the public sphere by accessing online news or political information (Fuentes-Bautista & Inagaki, 2005; Hampton et al., 2010). However, ***travel planning*** seemed to still occur mainly at home or office (Doyle, 2011). Web-based applications generated most traffic while real-time audio/video only made up a small proportion of the overall traffic (González Rodríguez, 2010). Nearly 80% of the users were alone when using the wireless networks, while the others were mostly together with non-parental companions such as friends or co-workers (Doyle, 2011; Hampton et al., 2010). Users visited the same site or hotspot one or more times per week and some even more times per day (Doyle, 2011; Hampton et al., 2010). They tended to regularly use their favorite hotspot mainly because of its "ambiance", or proximity to home (Doyle, 2011) and either stayed connected for very short sessions (less than 5 min) or for quite long ones (more than 1 hour) (Hampton et al., 2010, Gonzalez, 2010, Zhang et al.,

[28] "To ensure secure access to the shared WiFi networks, the users are willing to report their connections to Tencent (one of the largest Internet companies in China) and have the traffic monitored" (Zhang et al., 2017).

2017). Some networks were mainly used during weekdays (Zhang et al., 2017) while others showed no relevant difference between workdays and weekends (Doyle, 2011). Popular hotspots were mostly located in downtown areas or cafés (Powell & Shade, 2006).

Doyle (2011) also identified different usage practices/user profiles. He distinguishes between "Local Relaxers", "Urban Mobiles", and "Suburban Parents." ***Local Relaxers*** use hotspots for leisure-related activities and usually reach them on foot. ***Urban Mobiles*** use hotspots for both work- and leisure-related activities. They are mainly single or in couple living workers or students without children, they live in urban neighborhoods and use public transports to move. They use Wi-Fi at hotspots but also at home and go to hotspots mainly because of the ambiance. They stay there between one and four hours. In this group, men and women are nearly equally represented. ***Suburban Parents*** live in more suburban areas, mostly travel by car, live with a partner and have children. They often use a hotspot to do work-related activities while waiting for their children having activities nearby.

Beyond understanding how and why people use Wi-Fi services, Lambert et al. (2014) identified ***factors that influence the popularity of public Wi-Fi services***. Their observations showed that sub-urban sites were generally less successful than centrally located and popular places with heavy flows of people. This confirms the findings of Doyle (2011) who discovered that most popular hotspots are located in places where people come together. Successful Wi-Fi services are robust and cover large and usable areas while less successful sites either lack open and comfortable places to sit down and socialize, a user-centric orientation with no access restriction and bandwidth limits, or are located in utilitarian places where people just go to get some duties done (e.g. shopping).

4.2.5.3.5 User Behavior on Coffeehouse Wi-Fi Hotspots (Small-Scale, Public)

Two Wi-Fi usage studies focused on how Wi-Fi is used in American coffeehouses, which had installed their own Wi-Fi networks. Both studies mainly employed ethnographic methods and analyzed usage behavior by combining a user and observer perspective. They observed coffeehouse customers using mobile devices and complemented their observations with customer interviews. Both studies were interested in the role of Wi-Fi use in semi-public spaces and chose coffeehouses as a typical example of such a space. While Hampton & Gupta (2008) were more interested in the urban context – they observed four cafés in two American cities, Elledge & Kwon (2016) focused on ***sub-urban*** areas – they observed 20 Starbuck coffeehouses located in the suburbs of an U.S. metropolis. Additionally, both studies investigated how Wi-Fi use in semi-public spaces influenced social interactions. To do so they took notes on how visitors used their mobile devices, how they interacted with each other and the staff and how they behaved in general (Elledge & Kwon, 2016; Hampton & Gupta, 2008).

As a result of their analysis both research teams developed a set of ***coffeehouse visitor profiles*** based on visitors' Wi-Fi usage behavior. Hampton & Gupta (2008) distinguished between "true mobiles" and "placemakers." ***True mobiles*** mainly engage in work related activities (studying, paid work, etc.). For them the café is a mere space of productivity. They tend not to interact with other people in the café and use their laptop as "protecting shield" to avoid interactions. They only engage in online communication (e-mail, instant messaging) with people they know. ***Placemakers***, on the other hand, use their mobile devices more as a pretext to get engaged in real-life interactions. Similar to the "true mobiles", they check their e-mails, surf the web and use instant messaging, but online activities are never their primary focus. Most "placemakers" are daily customers while the "true mobiles" visit cafés between one and two times a week. Both user types generally spend more than 30 minutes in the café with one third of all Wi-Fi users staying for more than four to five hours.

Elledge & Kwon (2016) identified five non-mutually exclusive ***coffeehouse visitor categories***: 1) the ***motivated user***, who is driven by "productivity" and wants to get some work done using a mobile device and Wi-Fi; 2) the ***motivated non-user***, who goes to the coffee shop for a specific purpose (e.g. meeting a friend, drinking a coffee, reading the newspaper, etc.) but does not use his/her mobile device; 3) the ***passive visitor***, who shuts him/herself off from any interaction with other people present in the café, often using digital or non-digital devices (e.g. phone, laptop, news-paper) as protective shields, s/he could be either a user or non-user of Wi-Fi; 4) the ***spectator/bystander***, who simply observes its surrounding and other visitors while for example waiting for a friend and usually does not use mobile devices; and 5) the ***obnoxious overuser***, who tends to be a disrespectful user, behaving as if s/he was at home (e.g. conducting a videoconference speaking loudly). Researchers concluded that most visitors considered Wi-Fi as an inherent element of their coffeehouse experience.

4.2.6 Contribution of Different Network Contexts/Types and Study Perspectives to the Overall Understanding of Wi-Fi Usage

Table 16 summarizes the main findings resulting from the analyzed Wi-Fi usage studies by combining three information dimensions: 1) network context/type, 2) study perspective, and 3) variables used to describe Wi-Fi usage. Two different colors are used to distinguish findings from network perspective studies (black) and those from user and observer perspective studies (blue). In this way, the table provides a good visual overview of what kind of usage findings emerged from which network type/context and which study perspective.

In conclusion, it can be said that a number of recurrent Wi-Fi usage patterns emerged from the studies on campus, conference and public Wi-Fi networks and on different network types in public spaces.

Users generally connect during daytime but in some cases, especially in residential Wi-Fi networks, also in the evening and at nighttime. Most networks, especially campus networks, are used more during weekdays than on weekends. Wi-Fi usage seems to follow the typical daily and weekly life schedules of users, which results in different user groups showing different daily and weekly usage patterns. Most users connect for short sessions and have long offline times and those having longer sessions are idle for most of the time. There are both frequent and occasional users. A few heavy users generate most traffic through a few popular APs. In fact, users tend to always connect to the same few APs without moving around much when connected to the Wi-Fi network. The most used application is web-surfing followed by session, communication or backup activities, P2P, VoIP, audio and video streaming. Users engage in different types of activities: ***productive activities*** such as writing e-mail or reading information for work or study related tasks; ***supportive activities*** such as looking for information, reading online news and political information; and ***entertaining/social activities*** such as communicating with peers, listening to music or simply browsing the web. Users own and use a large variety of devices to connect to Wi-Fi networks. In early studies, laptops were mainly used but in more recent studies smaller and easy-to-use mobile devices such as smartphones or tablets are employed increasingly. A typical Wi-Fi user is a young, educated, affluent, single, and technology-affine male. However, not all users behave in the same way, and this is why different usage practices emerge based on the connection time, the device types used to connect, the environment or location of connection, user characteristics, and employed application mixes.

	CAMPUS	CONFER.	PUBLIC LARGE-SCALE		PUBLIC SMALL-SCALE	
			FREE	PAY-FOR	VARIOUS HOTSPOTS	CAFÉS
UB						
When	Diurnal (main build.), evening/night (residences); wd	During conf. sessions	Diurnal; smartphone users during commuting times; different daily/weekly usage patterns for different user groups	Diurnal or night; wd or wd & we	Diurnal, commuting times; wd & we or wd only	
How Long	Short sessions; long off-line times	Short sessions; longer sessions are idle for most time	Short sessions;		Short (< 5 min) or long sessions (>1h)	
How Often			Rarely	Occasional use	In avg. once to several times a week; frequent vs. occasional use	
How Much	Few users generate most traffic		Few heavy users generate most traffic; high adoption rate	Few users generate most traffic		
With whom					Alone	
APs	Few popular APs with a lot of traffic	Users evenly distributed; traffic not	Most used hotspots downtown coffee shop, public library, coffee shop in suburban mall, university computer lab, truck stop on highway	Uneven use of APs	Most users have favorite hotspots	
Why/What for					**Leisure**- (chatting, listening to music) & **work-related** (e-mail looking for info); **Travel planning; Productive act.**: (home-) work; **Entertaining/social act.**: com. with peers, web-browsing, music; **Supportive act.**: looking for info; **Participation in public sphere** (news & political info)	
Mobility	Low / Moderate	Session beg/end	Low; modem & laptop users less than mobile device users			
USER (typical)	Students, staff		Visitors (professionals, students, truckers)		Young, educated, affluent, heavy Internet user, single, males	

USER Profiles (with different behaviors)	1 with 11 user classes based on users' AM and network UB		Locals, students, tourists; Heavy vs. Visiting; Modem, laptop, smartphone users; Locals vs. Visitors Younger vs. Older;		Travelers, students, out-of-office workers; Local Relaxers, Urban Mobiles; Suburban parents	True-mobiles vs. Place-makers; Motivated User, Motivated Non-User, Passive Visitor, Spectator, Overuser
AM	Mainly web-surfing but also session- & chat activities, backups, P2P, VoIP, streaming	Web browsing	Web browsing, streaming, VoIP, P2P, e-mail; audio/video content		Web brow., streaming, e-mail, instant mess., looking for info, listening to music, VoIP, reading online news and political information	
DEVICE			Mainly laptop but more and more phones & tablets; modem (home)		Large variety of devices	

Blue Font Indicates User/Observer Perspective while Black Font Stands for Network Perspective

WD – Weekdays; WE – Week-ends;

Table 16 – Summary of Main Findings by Combining Three Information Dimensions: 1) Network Context/Type, 2) Study Perspective and 3) Variables used to Describe Wi-Fi Usage

Overall, Wi-Fi usage is quite similar across the different analyzed network types (e.g. free, pay-for, large- and small-scale) and contexts (campus, public space, conference facilities). In fact, usage behavior seems to depend more on the situation in which a Wi-Fi network is used, on the people who use it and on their real-life behaviors. Wi-Fi usage during an event, for example, is different than during normal life, as well as Wi-Fi usage in public spaces is different from usage in residences/homes. Similarly, Balazinska & Castro (2003) claim that "differences [in Wi-Fi usage] appear not so much among public, academic, or corporate networks but among networks that cover usage at the work place, at home, or during a specific event".

It is thus more revealing to have a closer look at the different ***study perspectives*** employed to examine Wi-Fi usage. Each perspective contributes in different ways to the overall understanding of Wi-Fi usage. By focusing only on the network perspective, hence, employing purely technical data, it is for example not possible to gather information on the user him/herself, on his/her motivation to connect to a Wi-Fi network and on the environment, location and situation in which the user connects to the network. However, these are fundamental pieces of information in order to interpret mere technical usage data and assign a social meaning and interpretation to it. From table 16 it nicely emerges that studies focusing on the user and observer perspective complement and enrich information on technical network data with more qualitative information. Especially if a researcher is interested in the social dimension of Wi-Fi usage it is important to combine technical network data with personal information provided by the user and/or observer.

The network perspective is dominant in studies on campus, conference and public large-scale Wi-Fi networks. Only one study on the Finnish panOULU MWN complemented technical network data with information gathered from users through surveys and interviews (Ylipulli et al., 2014). On the other hand, studies focusing on small-scale networks tend to focus more on the user and/or observer perspective. This might be due to their more social and less technical study focus, and to the fact that getting access to technical network data of single small hotspots is more difficult.

Another aspect that influences the results is the ***overall study goal and focus*** of each paper. Studies focusing more on social aspects like the role and impact of Wi-Fi on urban and sub-urban public spaces and their inhabitants, or Wi-Fi users' social interactions tend to have a more qualitative or ethnographic approach, studying data provided by the user or observer. On the other hand, studies primary focusing on network evaluation and improvement are generally more oriented towards the analysis of technical data and analyze usage from the network perspective.

4.2.7 Aspects Influencing Wi-Fi Usage

Wi-Fi user behavior cannot be analyzed in isolation as it is always embedded into a context. They depend on various external factors such as the environment, the location, the context or situation in which it is used and on personal, social and socio-economic factors, which are more intrinsic to a person such as demographics, lifestyles or attitudes towards technologies (Hsu & Helmy, 2005; Vincenzi et al., 2010). In order to understand the value of Wi-Fi networks for its users, it is thus fundamental to understand the environment and the context in which networks are placed and used and their users (Hsu & Helmy, 2005; Middleton, 2007). Only by taking these aspects into consideration it is possible to evaluate whether the provided services really meet the needs of the users (e.g. is connectivity available where the users require it? does it support the applications users want to use? etc.).

Below three important aspects that impact Wi-Fi usage and that emerged from the literature review on Wi-Fi usage are briefly described.

4.2.7.1 Importance of location:

The analyzed studies on Wi-Fi usage highlight in particular the ***importance of the location and the environment*** in which APs or hotspots are deployed. While early MWNs aimed at covering entire cities and providing nearly ubiquitous Internet coverage in whole city areas, this does not seem to be crucial for the success of a Wi-Fi network in public or semi-public spaces. In fact, existing research shows that the popularity of APs strongly depends on their location (Vural et al., 2013). It is thus much more important to ***identify the right locations*** where to deploy APs and guarantee a high-quality service in these places, instead of covering also the space in between these locations (González Rodríguez, 2010; Schwab & Bunt, 2004; Vincenzi et al., 2010). Most users tend to connect ***always from the same APs*** without moving around much when connected (Blinn et al., 2005; Doyle, 2011; Schwab & Bunt, 2004). Lambert et al. (2014) highlight the importance of "exploring the factors that make a particular Wi-Fi service 'work' in a particular public space" (p.45.7). To do so, Lambert et al. (2014) and Hampton et al. (2010), investigated popular and less popular Wi-Fi areas in the U.S., Canada and Australia and identified various ***location-related factors influencing the popularity of a hotspot*** such as the reputation of a place, its population density, its urban design (availability of shade, chairs, kiosks, places to sit, etc.), its local culture and its atmosphere/ambience (e.g. people like places with a lot of relaxing and happy-looking people). The "design of a space, its material attributes and location, the existence of other amenities and attractions, and a proximate demand for free Wi-Fi" (Lambert et al., 2014, p.45.13) are therefore all factors influencing the popularity of a Wi-Fi site.

The availability of Wi-Fi can also have a positive effect on the location itself and ***improve its attractiveness***. Hampton et al. (2010) and Forlano (2008b; 2010) recognized the importance of Wi-Fi in attracting people to places. Forlano (2008b; 2010) called these places "***third places***" as they complement office and home. According to the researchers people visit a place more often after it offers Wi-Fi. "Third places" are appreciated by users as they offer the possibility to leave the office or home and conduct some work- or leisure-related activities in a more casual and pleasant environment (Forlano, 2008b; Forlano, 2010). This characteristic gives cities the possibility to use the availability of Wi-Fi connectivity to promote specific locations in the city. However, to do so, locations have to be carefully chosen, taking in consideration the qualities of places where people preferably use Wi-Fi (Doyle, 2011).

The location of a Wi-Fi spot also influences which device people use to connect. In spaces where people can sit down and spend some time (e.g. a coffeehouse or a bench in a park), they tend to connect more often with laptops while smaller mobile devices are used more frequently in commuting spaces (Doyle, 2011).

4.2.7.2 Importance of overall-scenario:

Location, however, is only one of the aspects that influence Wi-Fi behavior. Another important factor is the "***overall-scenario***" in which usage occurs (e.g. normal life vs. special event; alone vs. together with others; living in a place vs. being on holiday) (Vincenzi et al., 2010). In fact, ***Wi-Fi usage often reflects users' real-life behaviors***, as people tend to integrate new technologies in their daily lives and use them according to their personality, lifestyle, socio-economic status, values, needs, beliefs and social relationships but also based on previous experiences with similar technologies (Hsu & Helmy, 2005; Ylipulli et al., 2014). This emerges, for example, when observing Wi-Fi usage on university campuses where it clearly follows the daily routines of users. Buildings hosting classrooms show strong diurnal Wi-Fi activity while residences and dormitories strong evening or night activities (Sevtsuk & Ratti, 2005; Sevtsuk et al., 2009). Similarly, at conferences Wi-Fi usage strongly depends on the conference schedule. During coffee and lunch breaks Wi-Fi activity decreases and increases again when sessions start (Balachandran et al., 2002; Lee et al., 2005). Redondini & Fitzgerlad (2016) have shown that students attending a lecture have different Wi-Fi behaviors than students studying or simply spending time in the same room without lecture. The first connect frequently for short sessions while the latter generally connect once and then stay online for a longer time. Based on how many people are connected to a specific AP of a Wi-Fi network, it is thus possible to make approximations on how many people are located in a specific area at a specific moment (Sevtsuk & Ratti, 2005; Sevtsuk et al., 2009). This information might be helpful to understand the flow of people during events or within larger shopping malls or even within a city. It allows inferring and eventually predicting

people crowding in certain areas at certain times. Therefore, it is possible to learn something about user's real-life behaviors from simply observing their Wi-Fi behavior (Redondi et al., 2016).

Another example of how the overall scenario influences Wi-Fi usage is the ***relevance that Wi-Fi networks have on tourism*** as opposed to normal life situations. Visitors have different needs than locals also with regard to Wi-Fi connectivity. Wi-Fi proves to be particularly useful for situations in which users are away from home, as it allows people to access information and stay in contact with others when on the go and to use traveling and waiting time in a productive way (Doyle, 2011). Even though travel planning seems to still occur mainly at home or office, some people start using also hotspots to do so and the majority of users would use Wi-Fi on public transport to get travel information (Doyle, 2011). Lambert et al. (2014) mention that travelers mainly engage in "supportive" Wi-Fi usage forms such as looking for a place to stay, get some work done and communicate with friends and family but also in "entertaining use", for example, using Wi-Fi to simply pass their time browsing the web and socializing over the Internet. The importance of Wi-Fi for visitors emerges from various studies such as for example those on the panOULU MWN, where a majority of users are so-called "visiting" users and use the network for maximum one week (Ojala et al., 2008; Ylipulli et al., 2014). Researchers agree that panOULU provides significant intrinsic value to both people living in and visiting Oulu and thus, "enhances attractiveness, competitiveness and productivity" of the city (Ojala et al., 2008).

4.2.7.3 Importance of user:

This section focuses on the importance of ***users as social people***. People integrate Wi-Fi usage in their real-life routines in various ways. It is expected that different user groups show different Wi-Fi behaviors. In order to design Wi-Fi networks that address users' real needs and that are useful to different user groups it is thus important to understand who the users are and what usage practices they engage in. Identifying user profiles or usage practices might be an efficient way to draft/gain a structured overview of the heterogeneity of users and their respective needs and implement them into requirements for a Wi-Fi network.

Studies focusing on mere technical network data are able to define usage profiles based on users' network behavior but not on user intrinsic characteristics. They do not consider users as social beings who live embedded in a social context. This is why studies, which also include user-provided or observer data are able to identify richer and more complete profiles. By distinguishing between "Local Relaxers", "Urban Mobiles", and "Suburban Parents", Doyle (2011), for example, proposes a very nice example of nearly self-explaining user profiles. The names of these profiles clearly show that detailed

demographic and socio-economic variables have been taken into consideration. Not only do they explain Wi-Fi behaviors, they also describe the way in which users have embedded Wi-Fi usage in their daily routines and lifestyles. Needless to say, such kind of profiles are much more helpful in characterizing Wi-Fi practices and thus infer Wi-Fi needs of each single user category. From the previous literature review it emerges that various studies have attempted to identify Wi-Fi user profile or usage practices distinguishing for example between locals, students and visitors (Lambert et al., 2014) or "supportive", "productive" or "entertaining/social" usage forms (Lambert et al., 2014).

In conclusion, it can be said that in order to build successful public Wi-Fi networks it is important to contextualize Wi-Fi usage behavior and identify different usage practices that are able to represent different contexts, life-situations and users. A Wi-Fi network is, in fact, not only a means of transmitting data, but it is also able to have implications on its users and the environment it is placed in.

4.3 Research Gap, Research Questions (RQ) and Contribution of This Study

4.3.1 Research Gap and Contribution of This Study

From the above presented literature review different research gaps emerge, which this dissertation wants to address. First of all, MWNs have been studied from various points of view (business model, policy, etc.) but not much attention has been dedicated to their ***social dimension***. Even though the importance of understanding users and usage has been widely recognized, not much research has been conducted on ***Wi-Fi usage of MWNs***. Only one study on the American Google Mountain View (Afanasyev et al., 2010) and three studies on the Finnish panOULU MWN (Ojala et al., 2005; Ojala et al., 2008; Ylipulli et al., 2014) analyzed usage of MWNs. While the first three studies analyzed usage only from a network perspective using mere technical network data, the last study on panOULU (Ylipulli et al., 2014) complemented network data with information collected from users through surveys, interviews and diaries in order to understand the adoption of the open and free Wi-Fi service. However, in the study, the different data sets, namely network traces and data provided by users, have been analyzed only independently. Hence, until now, only few studies on Wi-Fi usage and especially on MWN usage have defined user profiles and/or usage practices based on both technical network data and user-provided information. Furthermore, no study has been based on merged data sets in which user information on a specific session is combined with data on that session.

Furthermore, up to date Wi-Fi usage has not been contextualized to specific everyday life situations. Even though various studies have acknowledged the relevance of public Wi-Fi

for tourism and for increased participation in the public sphere, none has focused on the role of Wi-Fi for eTourism or eGovernment.

To address these gaps, this dissertation studied the usage of the "WiFi Lugano" MWN in Switzerland. The study collected both technical log data and user-provided information on a session (collected through a mobile survey at the moment of connection to the Wi-Fi network) and matched the two data sets to analyze technical and user-provided data together. This allowed identifying usage practices based, on the one hand, on the "reason for being in Lugano" and, on the other hand, on the activities that users declared to do on the "WiFi Lugano." Usage practices have then been interpreted with the help of other available technical, demographic or socio-economic variables. Last but not least, the usage of the "WiFi Lugano" network has been contextualized within the eTourism and eGovernment domain to show how public Wi-Fi can be relevant for them. Table 17 shows the existing research gaps and how this study wants to address them.

Existing Literature	***Gap***	***Proposed solution***
MWNs have been studied from various points of view (technical, business/ownership models, policy)	Only few studies addressed the social dimension of MWNs	Studying users and how they use MWNs (usage practices) by focusing on the role of individuals (social dimension)
There are only few usage studies on MWNs (4 on 2 MWNs)	Need for more data on how MWNs are used to deploy services that satisfy the real needs of users	Understanding usage of the Swiss MWN "Wi-Fi Lugano"
Wi-Fi usage is either studied from a network or user/observer perspective	Only one study complemented technical network data with user/observer perspective data but none matched session data with information on the same session provided by the user	Combining network and user-provided data by matching network data with data provided by users through a mobile survey at the moment of connection to the network
Limited amount of user perspective data	Amount of collected survey responses has generally been much lower than the amount of technical network data	Collecting a large number of survey answers by placing a short mobile survey on the entry page of the Wi-Fi network
Importance of identifying usage practices	Only few studies defined usage practices based on both user and network perspective data	Defining Wi-Fi usage practices based on the "reason for being in Lugano" and based on activities users declared to do on the "WiFi Lugano" network
Importance of contextualizing usage	Usage is generally not contextualized	Contextualizing the results within eTourism and eGovernment (usage situations)

Table 17 – Research Gap and Contribution of this Study (MWNs)

4.3.2 Research Questions

In order to address the previously described research gaps the following research questions have been formulated:

RQ3: Who are the users of a MWN? What for, why, when, with whom, where, and with what devices do they use the MWN?

RQ4: Are there usage differences between leisure tourists, business travelers and residents?

RQ5: Can users/usage be grouped into meaningful clusters?

4.4 Outcomes (Collection of Articles)

This section contains the two publications with the results of the research studies carried out to understand users and usage practices of the "WiFi Lugano" MWN. The first article distinguishes between leisure-, business- and non-tourists and thus highlights the importance of public Wi-Fi networks especially for the tourism field, while the second study used cluster analysis to identify meaningful groups of users and usage practices and contextualized the results within the e-government context.

Also in this case, some minor changes have been made to the originally published papers in order to fit the overall structure and writing style of the dissertation and make it coherent throughout the whole text. Examples are: the numbering of tables/figures, the use of upper case in titles, the correction of minor grammar mistakes, the use of American English style, the addition of page numbers to in-text quotes, and the moving of web links to footnotes.

4.4.1 Article 3: Tourists and Municipal Wi-Fi Networks (MWN): The Case of Lugano (Switzerland)

Title:	Tourists and Municipal Wi-Fi Networks (MWN): The Case of Lugano
Authors:	***Anna Picco-Schwendener***, Lorenzo Cantoni
Publication:	Information and communication technologies in tourism 2015 (pp. 565-578), Springer, Cham, 2015.

4.4.1.1 Abstract

Being always connected is among the new needs of tourists, who are using more and more smartphones for that goal. Still, data roaming costs are a major obstacle to that end. If hotel Wi-Fi connections are offering part of the solution, municipal Wi-Fi networks are the most interesting offer for connectivity on the go, a connectivity offered both to own citizens and tourists. The touristic city of Lugano (Switzerland) has been offering an open Wi-Fi network since 2008. In the paper usage data, assessed via log files as well as via a survey automatically displayed to connecting users, are presented and discussed, providing a vivid profile of users (personas), and of their usage-patterns; they also offer insights about the difference between citizens and tourists when it comes to their usage of the Wi-Fi network.

Key Words: Wi-Fi connectivity, mobile tourism, municipal wireless networks (MWN).

4.4.1.2 Introduction

Today we live in an increasingly mobile and connected world. Mobile devices such as smartphones and tablets are omnipresent and they need connectivity to fully exploit their potential. In Switzerland smartphone penetration rate reached 54% in 2013 with 64% using it to access the Internet on a daily basis (Google & Ipsos MediaCT, 2013).

More and more travelers expect to be able to connect to the Internet not only at home or in the office, but also when on the go and in public places, asking for connectivity everywhere and at any time. This has favored a massive adoption of wireless technologies. 3G/4G networks are certainly the most widely adopted solutions. They are ubiquitous and reliable but (sometimes) slow and expensive, especially when used abroad, due to data-roaming costs. Wi-Fi technology offers an interesting alternative, as it is usually faster and cheaper for the end user, even though it covers only limited range (Gass & Diot, 2010).

Offices and commercial businesses, like shopping malls and restaurants, started to take advantage of this technology to provide Internet access to employees and customers. However, in public areas like streets and parks Wi-Fi access remains scarce. In order to fill this gap and to reach people and businesses that have remained unreached, many municipalities developed Municipal Wireless Networks (MWNs).

Tourists were not the primary audience of MWNs when they first emerged. Nevertheless, they certainly have strong motivations to use them. Most tourists nowadays are equipped with mobile devices, which they carry around when exploring a city. Foreigners rely on the availability of wireless networks whenever possible, as they do not want to pay high roaming costs. MWNs allow tourists to access information on the place they are visiting and to connect with friends and families.

The goal of this paper is to present the case of the MWN "Wi-Fi Lugano." Lugano is a popular tourist destination in Switzerland and among the first cities to implement a MWN in the country. This study aims at understanding *who* are the people accessing "WiFi Lugano", *what* they use it for (thus being able to infer *why* they get connected), *where* they preferably connect, and *when* they use the network. By doing so, the article wants to define some usage patterns and *personas* for leisure tourists, business travelers, and non-tourists (residents and commuters).

4.4.1.3 Literature Review

4.4.1.3.1 Municipal Wireless Networks (MWNs)

In the first years of the new millennium, a number of cities around the globe planned or implemented Municipal Wireless Networks in order to offer broadband Internet access to employees, citizens and visitors (Middleton, 2007). Their goals ranged from fostering

digital inclusion (Bar & Park, 2006; Farkas et al., 2009; Tapia & Ortiz, 2008b), to strengthening local economy (M. Estevez, 2006) by enhancing attractiveness and competitiveness (Ojala et al., 2008). To achieve these ambitious goals, municipalities started to provide primary Internet access (main access to broadband connectivity) (Middleton, 2007). Access to broadband Internet was meant to become a public service: "the electricity of the 21st century" (Middleton et al., 2006, p.9), to which everyone should have had access (M. Estevez, 2006; Middleton et al., 2006). Wi-Fi seemed to be the perfect technology to achieve this, thanks to its "low barriers to entry" (Gillett, 2006, p.583). It has relatively low installation costs – "streets do not have to be dug up" (Gillett, 2006, p.592), uses unlicensed spectrums, performs well, and is easy to use (Bar & Galperin, 2004; Middleton et al., 2008).

Yet, the initial euphoria about municipal Wi-Fi quickly evidenced problems and disappointments. First, the implementation of ubiquitous MWNs was more complex and onerous than expected especially for providing connectivity not only outside but also inside buildings (E. Fraser, 2009). Second, as primary access providers, cities became direct competitors to Internet Service Providers (ISPs), which started lobbying to prohibit or strongly limit municipal broadband. Furthermore, most initiatives were not able to identify a suitable and sustainable business model to guarantee service over time (Christensen, 2006; M. Estevez, 2006; Hudson, 2010). Finally, in many cases, it was simply taken for granted that public Wi-Fi access is something citizens really need, while the service was not used as much as expected (Chesley, 2009; E. Fraser, 2009; Hudson, 2010). These barriers led to several municipal Wi-Fi initiatives (e.g. Philadelphia, San Francisco or Chicago) to be abandoned after only two or three years (Chesley, 2009; E. Fraser, 2009; Jassem, 2010).

On the other hand there is no doubt that MWNs can be useful to people who require connectivity (Middleton, 2007), and municipalities and scholars are advocating for new ways of taking advantage of this service. Cities started thinking about MWN in smaller terms (Chesley, 2009). Especially in Europe, where market players are preferred to governments to develop wireless networks, more limited solutions of MWNs emerged. Chesley (2009) provides the example of the Prague MWN, and notes that the service is not a substitute for existing broadband access but just a service to provide information about essential city services. Hudson (2010) argues that municipalities should aim at providing broadband access in limited, well-selected outdoors public areas, such as public parks, squares, or community centers. This allows to contain the costs as only small areas have to be covered (Chesley, 2009) and to better match the technical characteristics of Wi-Fi (by covering outdoor areas). Thus, successful public Wi-Fi should be limited in scope and scale (E. Fraser, 2009).

As a consequence, priorities of MWN changed. Whereas offering secondary access (e.g. access when on the go) to tourists, business travelers and citizens was a minor goal of first

MWNs, it became a major purpose for cities offering Wi-Fi broadband in public places (M. Estevez, 2006; Middleton et al., 2008).

4.4.1.3.2 MWNs and Tourism

Tourism and Travel industry are expected to benefit largely from wireless technologies. These markets consist of highly mobile consumers, who want to be able to communicate with everyone, anywhere, and anytime (Buhalis & Pistidda, 2009). Always-on connectivity offers opportunities for interactivity at the destination and allows retrieving personalized, contextualized, and location-based services (Buhalis & Law, 2008). Three-quarters of smartphone owners use LBS Zickuhr (2012). According to a study of Google, "92% of smartphone users look for local information on their phone and 85% take action as a result, such as making a purchase or contacting a business" (Google & Ipsos MediaCT, 2013, p.2). Thus, the tourism industry should be very interested in these behaviors, and MWNs, are not only relevant for tourists but also for the local economy.

Visitors demand access to travel information: they want to be able to look up maps, get directions, find shops, and read restaurant reviews (M. Estevez, 2006). Wireless technologies, together with mobile devices, allow tourists to feel close to home (White & White, 2007). The new vision of MWNs is able to perfectly meet the needs of people who are on the move but still want to be connected. MWNs offer interesting and affordable solutions especially for foreigners, as roaming fees for 3G/4G are still quite expensive. The importance of Wi-Fi access for travelers is also shown by the significance of free Wi-Fi services in hotels and restaurants. Internet access in hotels is nowadays expected by "the new tourist" and is not just a diversification tool (Pirnar et al., 2010). Bulchand-Gidumal et al. (2011) showed that offering free Wi-Fi helps hotels to improve their rankings by up to 8%. Of all amenities, free Wi-Fi has the highest significance level for client satisfaction, and is important to both business and leisure travelers. Also for venues like restaurants, offering Wi-Fi is important to attract customers (Molloy, 2011).

4.4.1.3.3 Users' Needs

For municipalities, it is fundamental to understand the needs of MWNs' users, be they locals or tourists. Pirnar et al. (2010) highlight the importance of understanding profiles and demand patterns for the so-called "new tourist." Understanding consumer and demand dimensions together with technological innovation has been identified as a key research issue for the tourism field (Buhalis & Law, 2008). The same is true for MWNs: Middleton (2007) points out the importance of understanding who the people using a wireless network are, and how, where and what they use it for, as "good public infrastructure [should] meet[] the needs of its users" (Middleton, 2007, p.9). Careful analysis on what users expect from a city Wi-Fi network, where they expect to use it, what they expect to

do with it, and what kind of devices they use, might highlight important information on how to implement MWNs (Middleton, 2007).

However, there still are not many studies focusing on the users' perspectives of city Wi-Fi. Afanasyev (2010) studied the usage of the Mountain View Google Wi-Fi Network and analyzed the temporal activity of clients, traffic demand, and mobility of users as they roamed through the city. His study was entirely based on network statistics (28 days in spring 2008), and did not include any type of client information. A similar study characterized user behavior of a public Wi-Fi area at a conference in San Diego to understand wireless user behavior and wireless network performance (Balachandran et al., 2002).

The paper at hand addresses exactly this research gap by analyzing both log-data and user information provided by users of a Swiss MWN ("Wi-Fi Lugano"). In this way, usage patterns will be highlighted and personas (descriptions of the user in a scenario (Nielsen, 2004) for leisure tourists, business travelers and non-tourists will be defined. This will allow to better understand which user requirements should be taken into account when creating new MWNs and how existing ones might be improved.

4.4.1.4 Study Context – "Wi-Fi Lugano"

For this study, the MWN of Lugano called "Wi-Fi Lugano" has been chosen. Lugano is the 9th largest city of Switzerland and the largest city in Ticino, Switzerland's Italian speaking region. Lugano was among the first cities in Switzerland to implement public Wi-Fi access back in 2008. The case of Lugano is particularly interesting as the city is a very popular tourist destination for both leisure and business tourists, from within and outside Switzerland. Lugano is in very close proximity to Italy and thus many Italian commuters regularly work in Lugano. Its relatively mild climate favors usage of outdoor Wi-Fi connectivity. "Wi-Fi Lugano" has been available to the public since April 2008 in the center of Lugano, and soon after it was implemented also inside the stadium Cornaredo, and at Lugano-Agno airport. The project has been promoted by the city of Lugano together with AIL, Lugano Casinò, and Lugano Tourism. The city's goal is to offer citizens, business travelers and leisure tourists free access to the Internet in some selected areas of the city (AIL, 2018). To access the network it is necessary to subscribe by providing a phone number. People can connect for free for 30 minutes but can reconnect as often as they want. Currently, there are 36 access points (AP) installed in the city; by April 2015 additional 15 APs should be installed in order to extend the reach of the network.

4.4.1.5 Methodology

The goal of the study is to answer two research questions:

- ***RQ1***[29]: *who* are the users of the MWN "Wi-Fi Lugano"? To do *what* and *why* do they use public Wi-Fi connectivity? *When*, *where*, *how* and *with what devices* do they use it?
- ***RQ2***[30]: are there differences in the usage between leisure tourists, business travelers, and residents?

With the help of AIL, data from two different sources were collected: 1) anonymized log-data providing information about each user-session, and 2) information provided by users through a short mobile questionnaire. Log-data is registered every time a user connects successfully to the "Wi-Fi Lugano" network. It provides information on when, how long, where (IP address of AP), device id (MAC address), amount of data transmitted in and out and the country code of the registered phone number. This data only provides information on single sessions (not on single users) and it allows describing usage only from a technical point of view.

To collect user data, a very short questionnaire has been developed and put on the splash page of "Wi-Fi Lugano." When a user has logged-in successfully, he/she is asked to provide information about him/herself and his/her current network usage. They have been asked questions about the type of device they were using, what they were going to do online, their position in the city, information about their stay, whether they have a Swiss data contract and demographics. For all questions, multiple-choice answers were proposed. At the end, those who wished could leave a comment.

In order to address a vast audience, the survey was available in the three official Swiss languages, German, Italian, and French and in English. Filling in the survey was not mandatory. The questionnaire has been active since April 2013.

For the current study the amount of data has been limited to three months in order to allow the matching of log-data and survey data, which cannot be done completely in automatic. The period from June until August 2013 has been chosen, as these summer months are the most important ones for the local tourism sector.

Matching each submitted survey with its corresponding session-log is important mainly for two reasons: 1) in order to use the phone country code to infer the user's country of origin, and 2) in order to be able to eliminate duplicate survey answers from the same device (and thus user). In order to do the matching, it was necessary to use the survey start-

[29] RQ1 of article 3 corresponds to RQ3 of this dissertation.

[30] RQ2 of article 3 corresponds to RQ4 of this dissertation.

date/time and the session start-date/time. It was not possible to use a unique identifier such as the MAC address, as this information was not recorded by the online survey system. The matching was based on survey and session start-date/time, and it was necessary to check all matched records manually.

During the selected three months, a total of 28’354 sessions were registered. From those it was necessary to eliminate failed connection attempts (301) and records that did neither have a MAC address nor a country code (108), resulting in a total of 27’945 valid records. During the same period, 3’796 surveys have been completed. Of those, 3’464 (-332 records) have been successfully matched to their corresponding log-entry. As some respondents answered more than once, only the first survey answered by each device (MAC address) has been kept for further analysis (-1’525 duplicate surveys). The MAC address was used because it was the best possible way to identify a single user. However it cannot be excluded that a user connected to “Wi-Fi Lugano” using multiple devices, or that a single device had been used by more than one user. In total, 1’939 survey entries were considered valid.

In the analysis, users have been grouped into the three categories business-, leisure- and non-tourists (residents and commuters) by using their reason for being in Lugano.

4.4.1.6 Results and Discussion

4.4.1.6.1 Network Usage Based on All Sessions

During the three summer months 4’820 single devices (single MAC addresses) have made a total of 27’945 connections to the “Wi-Fi Lugano” network. Of those, 2’340 devices (48.6%) connected more than once, meaning that returning users account for nearly half of all connections. Most returning users (92.7%) connect always in the same place. Based on the AP’s IP addresses four usage areas can be distinguished: 1) center/airport, 2) stadium, 3) exhibition center and 4) Lugano casino. The center/airport area is by far the most used one with 68.9% of connections. Being it the largest and most important area of “Wi-Fi Lugano”, this is no surprise. In the selected period, on average one device connected 5.8 times to the network with few devices connecting very frequently. 36 devices (0.8%) connected more than 100 times with one reaching even 791 connections.

On average, 302.8 connections per day can be recorded, with peaks going up to 753 connections on a single day, on a Saturday during a tattoo fair at Exhibition Centre. The peak is mainly due to the connections at the Exhibition Center (386 connections) while on an average Saturday there are only 28.6 connections from the area. Also connections from the city-center area slightly increased due to this event (298 vs. 210.3 on an average Saturday).

4.4.1.6.2 Who Are the Users Connecting to "Wi-Fi Lugano"?

In this section, the study gives an overview of who the people connecting to "Wi-Fi Lugano" are. This includes understanding where they are from, for what reason they are in Lugano, what kind of devices they use, in which area of the city and when they use the network, whether they are alone or with others, whether they have a Swiss data contract, and evidencing differences in gender and age.

During the three summer months, 1'939 valid and matchable surveys were collected. This means that 40.2% of the connected devices have answered the survey.

Gender		**Swiss Data Contract**	
Male	66.8%	Yes	37.4%
Female	33.2%	No	62.6%
Device Used		**Alone / With Others**	
Smartphone	73.4%	Alone	44.3%
Laptop / Notebook	12.8%	Together with others	55.7%
Tablet	12.3%		
Other (e.g. Console)	1.5%		

Table 18 – Gender, Devices Used, Swiss Data Contract, Alone/Together

Gender. Little more than 2/3 (66.8%) of the network users are male, whereas females only account for 1/3 (33.2%). This is not surprising as males are usually more passionate about technology than females, who might prefer easier solutions to connect to the Internet, like 3G. However, about the same number of males and females have a Swiss data contract (36.7% and 38.1% respectively).

Devices. A vast majority of respondents (73.4%) connects to "Wi-Fi Lugano" with a smartphone. This confirms the importance of smartphones for getting access to wireless networks and is in accordance with the 2012 Wireless Broadband Alliance (WBA) survey, which concluded that "smartphones have overtaken laptops in connecting to Wi-Fi hotspots" (Vos, 2012). Also in this study, only a few respondents used laptops (12.8%) or Tablets (12.3%) to connect to the network. Laptops and Tablets are slightly more used at the airport (22.5% and 22.8%, respectively). This is due to the fact that many business travelers connect from there and they are the ones that are more likely to use laptops. Furthermore, the airport is an indoor area where people have longer waiting times, also for starting up a laptop. Outdoor areas such as the Lido (recreational area with pool) and the city center, instead, favor the usage of small portable devices such as smartphones.

80.4% of users connecting in the Lido and 78.0% of those connecting in the center use smartphones.

Swiss 3G data contract. Only 37.4% of all respondents have a Swiss 3G data contract. This can be explained by the fact that about half of all network users are foreigners and thus not likely to have a Swiss data contract. In fact, of those having a Swiss 3G contract, 88.0% are Swiss, and 64.0% of those not having a Swiss 3G data contract are foreigners. This shows that public Wi-Fi access is an important alternative to 3G connectivity in order to connect to the Internet when on the go.

Alone/With Others. When connecting to "Wi-Fi Lugano", the majority of respondents (55.7%) is with other people, whereas 44.3% are alone. There are slight differences depending on the area where users connect. People connecting at the Lido (open pool area), for example, tend to be together more often (67.6%), and those connecting at the airport tend to me more often alone (34.4%). In fact, going to the Lido is a social activity, while most people connecting at the airport are business travelers and travel alone. Also, respondents coming from further away (other countries: 60.2%, and rest of Switzerland: 61.8%) are more often with others when using "Wi-Fi Lugano."

Age groups. The typical user of Lugano's MWN is between 20 and 49 years old. Surprisingly, the youngsters (below 20) do not use the network very frequently. This might be because very young people do not yet own Wi-Fi enabled devices.

Where from. People from more than 40 countries connected to the network. It is not possible to define the exact number of countries as only the first two digits of the country code (e.g. +41) were available to the researchers and thus countries using three digits could not be distinguished. Users with a Swiss phone number account for more than half of all connections (54.9%) while 23.3% of connections are made by users with an Italian number. This is as expected as Italy is the closest country to Lugano and many Italian people regularly work in Lugano or come for short visits. This means that only 21.8% of users are from other countries than Switzerland or Italy. Of those Germany (4.8%), UK (3.4%), France (2.7%), and the Netherlands (1.5%) are the most represented. In order to know more about the provenience of Swiss people, respondents were asked to specify whether they are from Lugano, the region Ticino, or from the rest of Switzerland. In this case, 52.6% of respondents answered to be from somewhere within Switzerland: of those, 60.0% declared to be from Lugano, 19.8% from Ticino, and 20.2% from the rest of Switzerland.

City areas. Respondents have been asked where in the city they currently are. A vast majority of users connects from the city center and lake front (47.7%), followed by the airport (17.0%) and the Lido (18.2%). "Wi-Fi Lugano" is not used that much in the Stadium (4.6%), and from the Exhibition Center (4.2%). In fact, the Exhibition center has

high peaks when an exhibition or fair is taking place (e.g. August 31th – TiTatoo event) but during normal days has only few visits.

When. According to the analysis of all sessions, usage during the different weekdays is quite even. Slightly more people use the network during the second half of the week (Thursday to Sunday) with Saturday having the highest connection rate (17.3%). As for the hours of the day, we found that people coming from the rest of Switzerland have a connection peak between 6pm and 7pm (16.4%), and the same is true for business tourists and the airport area: in that hour two flights leave from airport Lugano with direction Zürich and Geneva.

Reason for being in Lugano. Respondents could choose among 8 different reasons for being in Lugano. Tourism (20.6%), regularly working in Lugano (18.3%), doing a day trip to Lugano (17.5%), and doing a business trip (10.3%) are the most selected ones. Other reasons are studying (8.3%), attending an event/festival (6.3%), and shopping or going for a walk (3.4%). "Other reasons" was mentioned 15.4% of the times, and might indicate people living in Lugano.

This study wants to distinguish between three user categories: 1) business tourists, 2) leisure tourists, and 3) non-tourists (residents and commuters). People who were in Lugano for a day trip, an event or festival, or for tourism are considered *leisure tourists* (44.4% of respondents), while those declaring to study, regularly work, shop or go for a walk and have other reasons to be in Lugano, are considered *non-tourists* (45.3% of respondents). Being a *business tourist* (10.3% of respondents) is a category by itself. Business tourists are less represented than the other two categories, probably due to the fact that business travelers have other means of accessing the Internet.

Usages. In order to understand people's motivations to connect to the wireless network of Lugano, users were asked to select all applications they intended to use, from a given list. It emerged that communication activities are by far the most used ones with 60.0% of respondents planning to use e-mail and 27.2% social media. The only exception is VoiceOverIP: they are only used by 7.4% of people. Tourist related activities such as looking for tourist information (20.1%), using maps/orientation (17.1%), and looking for free time activities (14.0%), even though performed less frequently, are still important usages of "Wi-Fi Lugano." These activities are expected to be performed more frequently by travelers than by residents. 21.9% of respondents use "Wi-Fi Lugano" for other browsing activities, which have not been defined in more detail. Most respondents (59.8%) planned to use only one application during their session, whereas all others indicated multiple activities.

User Comments. 5.7% of respondents left a comment at the end of the survey, many of them expressing positively about "Wi-Fi Lugano." Nevertheless, some issues were raised,

especially regarding signal quality and speed, extension of the network and the difficulty of accessing the network.

In the next section, users will be distinguished between business-, leisure-, and non-tourists. Differences in their usage of the Wi-Fi network will be highlighted, and a user profile for each category will be traced.

4.4.1.7 Business-, Leisure- and Non-Tourists

	Business Tourist (n=199)	**Leisure Tourist (n=861)**	**Non-Tourist (n=879)**
Gender	Male (80.9%)	2/3 Male; 1/3 Female	2/3 Male; 1/3 Female
Age	40-50 years	20-50 years	20-40 years
Alone: yes/no	Alone	Company	Both
Where from	Other Country (58.3%)	Other Country (60.9%)	Switzerland (68.3%)
CH 3G contr.	No	No	Yes/No
Usages	**+ E-mail (74.4%)** + Other Browsing (27.6%) - Tourist info. (13.6%) - Social Media (13.6%)	+ E-mail (62.4%) **+ Tourist info. (25.5%)** + Social Media (25.1%) - Other Browsing (17.2%)	+ E-mail (54.5%) **+ Social Media (32.4%)** + Other Browsing (25.1%) - Tourist info. (13.0%)
Devices	Smartphone (52.8%) **Laptop (26.6%)** Tablet (18.6%) Other (2.0%)	**Smartphone (77.2%)** Tablet (11.4%) Laptop (10.8%) Other (0.6%)	**Smartphone (74.3%)** Laptop (11.7%) Tablet (11.7%) Other (2.3%)
City area	**+ Airport (49.2%)** + City (21.6%) Lido & Stadium → no	**+ City (60.6%)** + Lido (15.6%) Exhib. & Stadium → no	**+ City (40.8%)** + Lido (23.4%) Exhib. → no
Weekday	Thu. / Fri.	Fri. / Sat. / Sun.	same for all days
Time	6pm (peak)	Afternoon (12am-19am)	Evening (18pm-11pm)
Data in	Medium / Heavy	Medium / Low	Medium / Low

Table 19 – Usage Profiles

Table 19 presents three distinct user profiles of Lugano's Wi-Fi network, where differences and similarities emerge. Interestingly, in some cases the business tourist is more similar to the non-tourist than to the leisure tourist. This emerges especially when looking at the activities they do when connected to "Wi-Fi Lugano." E-mail is the most important usage for all categories but it is most important for the business tourist. While looking for tourist information and using maps, result to be of major importance for the leisure tourist, it is less relevant for the business and non-tourist.

For other aspects, the business-tourist has clearly a different profile than the other two categories. Even though smartphones are the most used devices by all categories, for business tourists also laptops are of major importance. In fact, they use smartphones less and laptops more than the other two categories. Furthermore, business tourists' preferred area of connection is Lugano airport while the other two categories mostly connect from the city center. Leisure- and non-tourists also like to use the network at the Lido, while business tourists hardly ever connect from there. This is plausible as going to the Lido is a free-time activity and business travelers usually do not have time for such activities. Another aspect where business travelers stand out is the amount of traffic generated (incoming traffic). They tend to be medium (1-10MB) / heavy (>10MB) users while leisure- and non-tourists are medium / low (<1MB) users. Business tourists use the network more during the week, and mostly between 6pm and 7pm (when waiting for the plane at the airport), while leisure tourists are more active on weekends during the afternoon. Non-tourists have similar usage during all weekdays, and are slightly more active in the evening. Furthermore, business tourists tend to be older than leisure- and non-tourists. Business tourists are similar to leisure tourists only in two aspects: most of them are from abroad (while non-tourists mostly are from Switzerland) and neither of them tends to have a Swiss data contract.

The ***business tourist*** is a man, aged between 40 and 50 years, who comes from abroad, does not have a Swiss 3G data contract, and is alone when connecting to "Wi-Fi Lugano." He accesses "Wi-Fi Lugano" on Thursday or Friday between 6pm-7pm at the airport of Lugano. He either uses his smartphone or laptop to connect, and accesses the wireless network either to manage e-mails or for other browsing activities but not to access tourism-related information or social media. He generates medium to heavy traffic during his sessions.

The ***leisure tourist*** is usually male but might be female too, is aged between 20 and 50 years, and comes from abroad. He is typically together with friends or family when connecting to "Wi-Fi Lugano", and does not have a Swiss 3G data contract. He uses a smartphone to access the network as he does not carry around larger devices while visiting Lugano. He generally connects while walking around in the city or while relaxing at the Lido, mostly during weekends (Fri-Sun) and in the afternoon. He accesses the Internet in order to check e-mails, to look for tourist-related information or to use social networks. He does not generate much traffic (medium/low).

The ***Non-Tourist*** is usually male but can also be female. He is aged between 20 and 40, and thus younger than the business and leisure tourist. Unlike the other two tourist types, he is from Lugano. He preferably connects to "Wi-Fi Lugano" when going out for a drink in the evening either in the city center or at the Lido (which commutes to a bar/disco in the evening) during any day of the week. He uses his smartphone to connect. While

connected he checks e-mails, accesses social media platforms and does some other browsing. Generally, he does not generate much traffic (medium/low).

4.4.1.8 Conclusions

This study analyzed the usage of the MWN "Wi-Fi Lugano" by combining log-data and user information in order to understand who the users of the network are and how they use it. Users have been grouped into three different categories: business-, leisure- and non-tourists, each one having different characteristics and showing different Wi-Fi usage behavior. All three user profiles clearly evidence characteristics and usage behaviors linked to the reasons why they are in Lugano. The typical business tourists are male, in their 40ies, and tend to be alone when accessing "Wi-Fi Lugano." They are not interested in accessing tourist related information and they use e-mail extensively. They are the only ones using laptops, and get frequently connected from Lugano airport. Leisure- and non-tourists demonstrate very different behaviors: they tend to connect mostly during their free time and are more socially oriented. They are younger, and access the network mainly while walking around in the center or while relaxing at the Lido. Leisure tourists connect mostly in the afternoon of weekends and are interested also in accessing tourist information and using maps to orient themselves in the city.

The study shows that all business-, leisure- and non-tourists use "Wi-Fi Lugano", even though business travelers account for fewer connections. E-mail is the key application, suggesting that it is still playing a major role in online interpersonal communication, and that it is important for cities not to restrict access to webmail platforms. The city center is the place where most users connect indicating that this is probably the area on which to focus in order to improve network performance. The exhibition center is not used very much in general, but has high peaks during events, suggesting that it might be important to strengthen the network during these periods.

This paper has contributed to a better understanding of mobile practices of people visiting a city, and of differences/similarities between business-, leisure- and non-tourists. The role that a MWN can play in order to support their connection needs has been explored through the case of "Wi-Fi Lugano." Besides its contribution to the wider field of e- and m-Tourism research, it provides also an interesting contribution to the field of e-Government, offering to policy- and decision-makers data on which to take informed decisions about managing a MWN.

Future studies should extend the period to be analyzed, from a few summer months to a full year, so to explore the impact of seasonality on Wi-Fi accesses and usages. In addition, research should go beyond the descriptive statistic phase, exploring relevant correlations and usage patterns.

The limits of the study are that only behaviors of clients that successfully connected to "Wi-Fi Lugano" could be analyzed and thus potential users that were unable or choose not to connect are not represented. Further studies should then also integrate the voices of tourists/locals visiting the city, so to better understand the reasons of people using "Wi-Fi Lugano", as well as those of people not using it.

4.4.2 Article 4: Usage Practices and User Types of a Municipal Wi-Fi Network: The case of "WiFi Lugano"

Title:	Usage Practices and User Types of a Municipal Wi-Fi Network: The case of "WiFi Lugano"
Authors:	***Anna Picco-Schwendener***, H. Jost Reinhold, Lorenzo Cantoni
Publication:	In Proceedings of the 10th International Conference on Theory and Practice of Electronic Governance (pp. 292-301), ACM, 2017.

4.4.2.1 Abstract

In recent years, many cities around the globe implemented Municipal Wireless/Wi-Fi Networks (MWNs) as part of their strategies towards becoming "smart" cities. While initial initiatives had very ambitious goals and often struggled implementing them, later projects were more limited in scale and scope. It became clear that understanding how existing MWNs are used is crucial in order to develop networks that satisfy expectations and needs of local residents and visitors. This will help building networks that are useful for the population at large and thus actively used. This study contributes to a better understanding of how MWNs are used and who their users are: to do so it analyses both network and user-provided data of the "WiFi Lugano" network, a MWN of a medium-sized Swiss city. With the help of cluster analysis, it identifies five different usage practices: two business-oriented ones – "E-mailer" and "Mobile-worker", two tourism-oriented ones – "Tourism information seeker" and "Always-on traveler", and one reflecting the practices of locals – "Local social networker".

Categories and Subject Descriptors: Networks~Metropolitan area networks; *Networks~Wireless local area networks*; Human-centered computing~User studies; Applied computing~E-government

General Terms: Measurement, Performance, Human Factors.

Keywords: Public Wi-Fi access, Municipal Wireless Networks (MWNs), usage.

4.4.2.2 Introduction

Mobility and interconnectivity are fundamental aspects of today's modern society. Mobile devices such as smartphones and tablets characterize most people's everyday life and evolved to omnipresent companions. They allow people to interact, retrieve and share information, orient themselves, play, get access to working tools and much more. However, to be operative, these devices need connectivity. In fact, mobile devices are

more and more used to access the Internet. As of 2015, in Switzerland 85% of Internet users also use mobile Internet and more than 50% of the so-called digital natives (aged: 14-29) access the Internet from their smartphone rather than from a computer (Y&R Group Switzerland, 2015). Thus, for both citizens and travelers it becomes more and more important to access the Internet not only at home or in the office but also in public spaces when they are on the go. This points out the growing importance of everywhere and anytime connectivity. At the beginning of the 21st century, wireless technologies have been widely adopted in order to satisfy this need. The private sector (especially Internet service providers – ISPs) started implementing 3G/4G data networks and selling connectivity in a top-down approach. These networks offer nearly ubiquitous and continuous coverage but are still expensive especially if used abroad, due to high roaming costs.

Wi-Fi technology offers an interesting alternative: it is often cheaper if not free but only covers limited ranges. In recent years, many commercial businesses such as supermarkets, shopping malls, restaurants and hotels but also public transports, airports and conference centers have set up smaller or larger Wi-Fi networks in order to offer Internet access to visitors, clients, and employees. However, many public areas such as streets, squares and parks remain uncovered. In order to overcome this problem and to reach areas that otherwise are not covered by Wi-Fi connectivity, both municipalities and communities started implementing wireless networks. They created so called Municipal Wireless Networks (MWN), where the municipality provides broadband access, and Community Wireless Networks (CWN), where members share Internet connectivity either with (e.g. FON) or without (e.g. NYC Wireless) the support of a company (Camponovo et al., 2014). While commercial businesses have certainly more economical reasons (e.g. attracting clients; gathering user data; promoting the use of their own apps) to provide Wi-Fi access, municipalities and communities are rather motivated by altruistic and public interest motivations (Middleton et al., 2006).

As part of their strategies towards becoming “smart cities”, many cities came up with very ambitious projects to create wireless networks being able to provide broadband Internet access to citizens and visitors in the whole city. The main rationales for building these networks were favoring social inclusion and fostering economic development, innovation and civic engagement. However, it became quickly clear that the implementation and maintenance of such networks were much more onerous than expected (Middleton, 2007). Policies hindering municipal entrance in the telecom market, technical problems and difficulties in identifying suitable business models, led several municipalities to abandon their projects only few years later. Furthermore, in most cases it was taken for granted that offering cheap if not free Wi-Fi connectivity was something that people really wanted, but in fact, MWNs were used less than expected (Middleton, 2007). Later MWNs were therefore often more limited in scale and scope and more tailored to the specific needs of its users (e.g. which are meaningful sites? what is the network used for?). MWNs have

been studied from several viewpoints; nonetheless, a deep analysis of their users and usages is still needed (Forlano, 2008a): This study presents the case of the MWN "WiFi Lugano," By combining network data and user-provided information, it analyses how its users use the network – how much, from which areas, with what devices, when, what for, and whether they are in company or alone – and who these users are. It then clusters them based on the activities they declared to do on the network, by using the SPSS two-step clustering algorithm. This procedure allowed identifying five different usage practices: two business-oriented ones ("E-mailer" and "Mobile worker"), two tourism-oriented ones ("Tourism information seeker" and "Always-on traveler") and one reflecting the practices by locals ("Local social networker"). This distinction helps understanding how and in what contexts a MWN is actually used and thus inferring the needs of its users. This again can be helpful in order to improve existing services or to plan new ones, by adapting the offer to the specific needs and usages of different user groups.

This paper covers in particular three main eGovernment relationships, i.e. Government to Citizens (G2C), Government to Visitors (G2V), and Government to Businesses (G2B), because it explores how a MWN can be used by locals, by business players, and by visitors (Kalbaska et al., 2016).

The paper first provides an overview of the existing literature on MWNs and the importance of understanding usage. Then, it describes the context of the "WiFi Lugano" MWN and the methodology used to gather and analyze data. Afterwards, the results are presented and discussed, while the concluding section provides some suggestions on how MWNs could be improved to better fit the needs of its users.

4.4.2.3 Literature Review

4.4.2.3.1 MWNs as Part of "Smart Cities"

At the beginning of the new millennium, many municipalities around the globe started to consider implementing wireless networks in their cities. They wanted to provide affordable broadband Internet connection in the city to employees, citizens and travelers (Hampton et al., 2010; Middleton, 2007). In fact, the development of MWN fits well into the concept of "digital" or "smart" cities, which create "city-area infrastructures and applications aiming to cover local needs and support local community's everyday life" (Anthopoulos & Fitsilis, 2010, p.301) in order to "drive[] growth, efficiency, productivity and competitiveness" (Yovanof & Hazapis, 2009, p.445). Many MWNs pursue similar goals by "promoting civic engagement, social inclusion and economic development" (Tapia et al., 2009, p.371) with a long-term objective of empowering citizens to "participate more fully in the political process by organizing, debating political issues, and acquiring information via the Internet" (Mandviwalla et al., 2008, p.75). As such, MWNs

can be a tool for municipalities to implement electronic governance strategies for sustainable development (EGOV4SD) (E. Estevez & Janowski, 2013).

4.4.2.3.2 Why Municipalities should Provide Wi-Fi

Whether municipalities should enter the broadband market and offer wireless Internet access to citizens and travelers has been extensively discussed (Christensen, 2006; Dingwall, 2006; Gillett, 2006). Should broadband Internet become a public utility/good (Tapia et al., 2009) available to everybody like water or electricity (Tapia et al., 2011)? Should broadband networks be considered an essential part of public infrastructure like roads, and as such be provided by municipalities (Middleton, 2007)? On the other hand, would municipal entrance in the broadband market entail an unfair advantage over the private sector, and thus distort competition and eventually push out private companies (Chesley, 2009; Infante et al., 2007)? This discussion was of particular importance in the U.S., where at the beginning of the new millennium residential broadband diffusion seriously lagged behind other developed countries (Dingwall, 2006; Hudson, 2010; Shin & Tucci, 2009). Telecommunication providers were slow to respond to the need of "universal, high quality broadband service at affordable prices" (Tapia & Ortiz, 2008a, p.257). Thus, municipal entry could be seen as an answer to market failure, and might eventually increase competition in the broadband market (Infante et al., 2007), improve service in local telecommunications markets (Middleton et al., 2006), and push towards lower prices (Dingwall, 2006). In a single question: how much regulation is necessary for MWNs (Dingwall, 2006)? In fact, closing the digital divide (inequalities in ICT access) was among the main rationales of early MWNs, especially in the U.S. and Canada (Christensen, 2006; Dingwall, 2006; E. Fraser, 2009; Tapia et al., 2011). Kofi Annan, former UN Secretary General, went as far as declaring the cut off from basic telecommunication services as serious as lacking shelter, food, health care and drinkable water (Mandviwalla et al., 2008). Public administrations quickly understood the potential of unlicensed wireless technologies to favor digital inclusion and started experimenting with them (Gillett, 2006), trying to use Wi-Fi technology to solve the "last mile" problem (E. Fraser, 2009).

However, digital inclusion is just one of many objectives municipalities wanted to pursue with the implementation of MWNs. They expected that providing wireless Internet access in the city would promote economic development, strengthen local economy and make cities more attractive for businesses and thus attract investments, jobs, business visitors, tourists, and conventions (M. Estevez, 2006; Ojala et al., 2008; Tapia et al., 2011). Furthermore, cities wanted to stimulate and encourage innovation, which again could benefit the local economy(Middleton et al., 2008)(Middleton et al., 2008)(Middleton et al., 2008) (Fuentes-Bautista & Inagaki, 2005). Some hoped that MWNs would increase civic engagement both on- and off-line (Tapia et al., 2011), by, for example, fostering

online participation in civic debates. As such, MWN could even act as "bridge to transit from e-government to m-government, which provides information and services to both citizens and city employees with wireless devices" (Shin & Tucci, 2009, p.145). MWNs could also be a means of revitalization and repopulation of specific public areas, by making them more attractive to people thanks to the availability of public Wi-Fi access (Forlano, 2008a; Middleton et al., 2006; Tapia & Ortiz, 2008a). Last but not least, MWNs were expected to improve efficiency of local governments (Infante et al., 2007).

To address those ambitious goals, municipalities started to deploy Wi-Fi access throughout entire cities, providing both primary Internet access to homes (people's main access to broadband connectivity), and secondary Internet access "in between" home and office, including outdoor locations (Middleton, 2007).

Wi-Fi seemed to be the perfect technology thanks to its "low barrier to entry" (Gillett, 2006). It uses unlicensed spectrum, which is free of charge, has low deployment costs – "streets do not have to be dug up" (Gillett, 2006, p.592) and uses already existing city facilities such as street or traffic lights (Bar & Park, 2006). Furthermore, it performs well, and is easy to use (M. Estevez, 2006).

4.4.2.3.3 From Euphoria to Disappointment

However, the initial enthusiasm about municipal Wi-Fi quickly wore off because of problems and disappointments. First, technology did not maintain what it promised (M. Estevez, 2006; Fuentes-Bautista & Inagaki, 2005),(Fuentes-Bautista & Inagaki, 2005) and the implementation of ubiquitous MWNs was more complex and onerous than expected (Middleton, 2007). Overcoming architectural barriers to signals proved to be difficult especially for providing connectivity inside buildings (E. Fraser, 2009; LaVallee, 2008). As such, Wi-Fi technology is limited in its capacity to support primary network access. Second, by entering the broadband market and offering primary Internet access, municipalities became direct competitors to telecommunication firms, which started to successfully "lobbying state legislatures to prevent cities from providing high-speed access as a public good", (Christensen, 2006, p.684; Dingwall, 2006; E. Fraser, 2009). They argued that the Wi-Fi market is already very competitive and that municipal entry into the broadband market would probably reduce investments by providers and put at risk small ISPs (Christensen, 2006). Third, many cities struggled to identify suitable and sustainable business and ownership models, and failed to create private-public partnerships that worked (Christensen, 2006; M. Estevez, 2006; Hudson, 2010). According to Chesley (2009), until now municipal governments have generally done a bad job in planning wireless projects. Finally, also well-established MWNs have not been used as much as anticipated. Jesdanu (2007) in Middleton (2007) mentions that "many cities are finding their Wi-Fi projects […] drawing less interest than expected" (p.8). It was

simply taken for granted that public Wi-Fi access is something good, which citizens really need, but finally it proved not to be that useful for citizens (Middleton, 2007). These difficulties brought several well-known municipal wireless initiatives like those in Philadelphia, San Francisco or Chicago to be discontinued after only few years of operation (Chesley, 2009; E. Fraser, 2009).

4.4.2.3.4 Reframing the MWN Issue

Nevertheless, there is no doubt that MWNs are useful to people who need Internet access, especially for those on the go (Middleton, 2007). Municipalities started investigating new ways of taking advantage of this service. First of all, they had to lower their very demanding specifications and ambitions, and to start thinking in smaller terms (LaVallee, 2008). Covering entire cities was actually not a feasible solution and required high investments. Hudson (Hudson, 2010) suggests creating small Wi-Fi areas, in well-chosen public areas such as parks and squares. This solution better fits the technical specifications of Wi-Fi technology, and is much less onerous (Chesley, 2009).

Especially in Europe, where municipalities did not aim at becoming major broadband providers, smaller MWNs with more limited scope and scale emerged. An interesting example is the Prague MWN, which implemented public Wi-Fi access simply to provide information about city services, without competing with already existing high-speed access (Chesley, 2009). This shift towards offering more tailored secondary Internet access may lead to infrastructures that are "not ubiquitous but that focus on meaningful sites of everyday life rather than merely 'anytime, anywhere' connectivity" (Forlano, 2008a, p.12).

In this new approach, visitors and tourists became particularly attractive publics, and the promotion of tourism an important goal of MWNs (Mandviwalla et al., 2008; Tapia & Ortiz, 2008a). The tourism and travel industry is thus expected to substantially benefit from public Wi-Fi access in cities.

In fact, Wi-Fi access together with portable mobile devices are becoming fundamental tools for both business and leisure travelers in order to communicate, access travel information, use maps and find directions, look up opening hours of shops, and read or post reviews on hotels or restaurants (M. Estevez, 2006). Such technologies allow these highly mobile consumers to feel close to home (White & White, 2007).

They also offer affordable connectivity especially to foreigners who otherwise, still, would have to pay high roaming fees for 3G/4G connectivity. Providing good and possibly free Wi-Fi access in some areas of the city will thus favor the city's hospitality (M. Estevez, 2006).

4.4.2.3.5 Understanding Usage and Users of Public Wi-Fi Networks

To date much effort has been put into understanding business and ownership models, technical solutions and regulatory implications of MWNs, but not much research has been done to understand their social context and implications – how MWNs are used? By whom? What for? What do users expect from MWNs and what are users' needs (Forlano, 2008a; Middleton, 2007)(Middleton, 2007)? However, for municipalities, it is fundamental to understand the needs of MWN's users. Middleton (2007) and Blackman et al. (2007) highlight the importance of understanding who the users of a public Wi-Fi network are, how they use it, where, when, with what devices and what for, as "good public infrastructure [should] meet[] the needs of its users" (Middleton, 2007, p.9). Understanding potential users will allow the city to "design networks, applications and services that could be tailored to the user's needs" (Forlano, 2008a, p.12). So far, it often happened that the possibilities offered by new technologies prevailed over understanding the needs of potential users (Blackman et al., 2007). Careful analysis of user behavior on public wireless networks could allow defining usage patterns, and user profiles (Blackman et al., 2007), which could then be translated into demand patterns. Understanding Wi-Fi use in public settings such as parks, squares and other city areas is thus recognized as an important research issue (Forlano, 2008a).

Measuring network data alone (e.g. megabytes of traffic and IP addresses) is not enough to describe user behavior and user characteristics in a relevant and comprehensive way. In order to get good data and metrics for Internet usage both networking data and user-perspective data are necessary (Lehr, 2012).

However, so far public Internet use has not been explored much (Hampton et al., 2010). There are only few studies trying to understand usage of public wireless networks and even fewer that try to combine network and user-provided data. A previous research by this paper's authors has already studied the MWN of Lugano. It analyzed three months data (Jun-Aug 2013) and allowed to define – through descriptive statistics – three different typical user categories: "business-tourist", "leisure-tourist", and "non-tourist", each showing slightly different usage behaviors (Picco-Schwendener & Cantoni, 2015). Afanasyev et al. (2010) studied usage of the Mountain View Google Wi-Fi network. They analyzed traffic demand, usage across time and user movements through the city. This study was entirely based on network data (28 days in spring 2008), and did not provide any information about users. Two similar studies characterize user behavior of public Wi-Fi areas: 1) at a conference in San Diego (Balachandran et al., 2002); and 2) the Dartmouth College campus-wide wireless network (Kotz & Essien, 2002) to get information on wireless user behavior and wireless network performance.

In a study on the Finnish panOULU wireless network, Ojala et al. (2008) focused on characterizing the usage of a large MWN based on network statistics. The study showed

an interesting trend "in increasing usage of the network by Wi-Fi handsets, although a clear majority of the clients are still PCs furnished with Windows OS" (Ojala et al., 2008, p.2). 1.1% were heavy users, using the network at least every other day, while 52.0% were 'one-time' users, a type of usage that clearly stresses the importance of the network for visitors. The typical client logged-in for short sessions to check e-mail.

An exploratory study based on observations of seven public sites in four U.S. and Canadian cities and on surveys of wireless Internet users in those sites, highlights that Wi-Fi users are not very diverse and as such mainly: "young, single, well-educated and predominantly male" (Hampton et al., 2010, p.718). Another study, which gathered information on the use of Austin's MWN through a survey, defines its users as a "group of experienced and heavy Internet users that go online from diverse platforms and are fully engaged in the age of mobile communications", whose main activity was checking their e-mails (Fuentes-Bautista & Inagaki, 2005, p.22). Forlano (2008a) conducted a 40-question online survey on the usage of wireless networks in cafes, parks and other public spaces between Oct. 2006 and Apr. 2007 in New York, Montreal and Budapest in order to understand how users use those networks. Results suggest that people used the networks for both work and personal activities, mainly because they wanted to get out of home/office, because they wanted to look for information, or because they could not afford Internet access at home.

4.4.2.4 Study Context

Lugano is a medium-sized – 63'583 inhabitants (Swiss Federal Statistical Office, 2015) – Swiss city located in the south of the country. It is the largest city and economical capital of the Italian speaking Ticino region. Lugano was among the first cities to provide public, free wireless Internet access in some selected areas of the city, already in 2008. For a number of reasons linked to its territory, Lugano is a particularly interesting city for implementing a MWN: being a popular tourist destination and economic center, it attracts many visitors from both inside and outside the country, and due to its proximity to Italy many commuters reach Lugano on a daily basis for work. Thanks to its university, congress center and new cultural center LAC, the city also attracts foreign students as well as visitors attending events, fairs and conferences. Thus, many non-resident people regularly populate the city. Furthermore, its mild climate invites to spend time outside, and thus favors outdoor usage of wireless Internet especially near to the lake and in recreational areas.

The MWN "WiFi Lugano" was launched in April 2008 in the center of Lugano. Soon after, it was also available in the football stadium Cornaredo, and in the Lugano-Agno airport. As of today, it also covers Lugano's congress center, a public park (parco Ciani) and the city's swimming pool area (Lido). The project is promoted by the city of Lugano

together with Lugano Industrial Enterprises (AIL SA), Lugano Casino and Lugano Tourism. With this project, the municipality of Lugano aims at offering free wireless Internet access to its citizens, business and leisure visitors in order to allow them to "do all those things which they would normally do in their office or at home: checking e-mail, looking up their company's intranet or taking advantage of the numerous services offered by the Web" (Lugano Tourism, 2016). The project is part of the city's ambition to be a "value-added city", which offers a variety of services to today's knowledge workers (Lugano Tourism, 2016).

Access to the network is free. Due to regulatory rules (Regulation on the surveillance of postal and telecommunication traffic), it is necessary to register to the service with a phone number. After 30 minutes people are disconnected, but can reconnect again.

Figure 21 – Estimated Coverage by the "WiFi Lugano" Network Before and After the Upgrade in Summer 2016 (Courtesy AIL)

Currently, the "WiFi Lugano" network consists of 61 access points (AP). In the city's continuous effort to improve it, in the last few months 33 new AP have been installed (8 of them substituted the previous ones), which allowed to nearly double the covered area (see map: smaller area shows the coverage before summer 2016 and the larger area shows the current coverage) and to increase the network's performance. However, this study has been conducted before the extension of the coverage areas.

4.4.2.5 Methodology

This study aims at understanding who the users of the "WiFi Lugano" network are, what for and why they use public Wi-Fi and when, where and with what devices they get connected to it. Furthermore, it investigates whether users can be grouped into meaningful clusters.

Two different types of MWN usage data have been collected and then combined in order to get a more comprehensive view of usage and users: 1) technical, anonymized network

data about each user-session (log), and 2) data provided by MWN users through a mobile questionnaire. Each time a user successfully connects to the "WiFi Lugano" network, a log-entry is created providing information on when, for how long and from where (IP address of AP) the user is connected, on the ID of the connecting device (MAC address), the amount of data used, and the country code of the registered phone number.

To complement this purely technical data with more personal user information, a very short survey has been created. It was presented immediately after the login to the "WiFi Lugano" network. In this way, users were invited to provide information about themselves and their network usage (device used to connect, planned online activities, position in the city, information on their stay in Lugano, whether they have a Swiss data contract, whether they are alone or in company when connecting, demographics). Multiple-choice answers were provided for each question. At the end, users had the option to leave a comment. The survey was not mandatory, and users could skip it and immediately start navigating. With regard to research ethics, user data is collected in an anonymous way, stored in a temporary database, independent from the one storing log data and only used in an aggregated way.

The survey was available in the three official Swiss languages (German, Italian, French) and in English. The current study takes into account one full year of data (June 2013 – May 2014). During this period, the network has been inactive for 3 months (January 22 – April 22) due to technical problems. Thus, only nine months of actual data has been collected.

If compared with the previous exploratory research on the "WiFi Lugano network" (Picco-Schwendener & Cantoni, 2015), this paper extends the time-scope from a few months to a year, and makes use of clustering to map the types of users of the MWN under study, while in the previous study only descriptive statistics were adopted.

In a first step, each survey record has been matched to its corresponding session-log. This was important 1) to infer the user's country of origin from the phone number provided by the session log; 2) to eliminate duplicate survey answers made by the same device with the help of the MAC address recorded in the session log; and 3) to allow for some consistency checks on survey data (i.e.: to pair the declared zone of connection with the actual IP-address of the areas APs).

The matching of the two datasets had to be based on the survey start-date/time and the session date/time, as there was no other common unique identifier available (the survey system did not record the MAC address of the respondent's device; it is only available from the corresponding session log). As the two times did not always match precisely, the procedure could be only partially automated, and a manual check of the matched records was necessary.

During the studied period, there have been 73’594 valid sessions on the “WiFi Lugano” network, and 8’748 surveys have been completed. Of those, 8’104 (92.6%) could be successfully matched to their corresponding session log. In order to eliminate duplicate responses, only the first answer from each device (MAC address) has been kept, resulting in a total of 4’115 (50.8%) valid survey records. 40.0% of the connected devices answered the survey, resulting in a relatively high response rate. All subsequent analyses are based on those 4’115 sessions matched with the surveys, if not indicated otherwise.

In this study, we use the MAC address of a device to identify a single user. However, this does not exclude that multiple users could connect to the “WiFi Lugano” network with the same device, or that one user got connected with multiple devices.

As indicated above, information on the area of connection was provided by both the session log and the users. The two data are almost perfectly aligned (96.0%), indicating a very good reliability of data provided by respondents. The 4.0% of discrepancies might be due to limited knowledge of the city geography, or to a fast/superficial inputting of the survey.

In order to understand whether the users of the MWN can be aggregated into meaningful groups of users, non-hierarchical two-step clustering was performed, using SPSS. Cluster analysis classifies large amount of data into groups “without any preconceived notion of what clusters may arise” by creating groups of users who “in each cluster are similar in some ways to each other and dissimilar to those in other clusters” (Burns & Burns, 2008, p.553). Two-step-clustering was chosen because it works well with large data sets and because it can handle both continuous and categorical data in the same model. It is possible to either choose the desired number of clusters or let the algorithm decide based on preselected criteria.

In this study, clusters are created based on nine input variables, corresponding to the activities the user declared to do while online – e-mail, social media, tourist information, maps, free-time activities, VoIP, apps, other browsing, and others. The SPSS two-step clustering algorithm automatically identified 13 clusters based on Schwarz’s Bayesian Information Criterion (BIC). However, the automatic decision of the best number of clusters is purely based on this single evaluation measure and thus lacks any contextual knowledge. This poses the risk of overfitting the data sample. It is therefore up to the researcher to identify a meaningful number of clusters to explain data in its context. In this study, it has been decided to stop the clustering process at five clusters, as further splits would have created groups of users whose characteristics were hardly explainable. The resulting clusters have a good cluster quality of 0.5, and a ratio size of 2.08 between the largest and the smallest cluster.

4.4.2.6 Results & Discussion

4.4.2.6.1 Network Usage

In this section, it is described how the "WiFi Lugano" network is used by the people who connect to it. To do so both network and survey data is used. Between June 2013 and May 2014, 10'298 single devices connected to the "WiFi Lugano" network 73'594 times. Slightly less than half (49.6%) are returning devices, which connected more than once to the network. On average, one device connected 7.1 times and 2.1% of devices connected more than 50 times with one reaching up to 1'132 connections. The fact that about half of the devices connect only once shows a certain importance of the MWN for visitors, as in the panOULU case (Ojala et al., 2008).

On average, there are 250 connections per day, with peaks of up to 1'208. High peaks usually occur when an exhibition is taking place at the congress center. On average, 9.3 MB of data are downloaded per session (Median: 1.5 MB) and 10.5 MB uploaded (median: 0.5 MB). There are few heavy users using several gigabytes per session (max up: 27 GB / max down: 7.1 GB).

When (based on all sessions): The network is used most between spring and autumn with May (17.4%) and October (14.1%) being the most usage intensive months. This period corresponds to Lugano's main tourism season. Furthermore, the generally good weather favors outdoor Wi-Fi usage during the summer months. During May and October also several exhibitions and fairs take place, boosting Wi-Fi usage. The network is used slightly more between Friday and Sunday with a peak on Saturday (17.4%). This is reasonable as Lugano's center is certainly more populated during weekends. Furthermore, these are the most popular days for exhibitions. Most connections take place during the late afternoon between 4pm and 7pm, when people leave their offices, schools finish, and airplanes leave. Exhibitions such as TiTatoo, Arte Casa, or Tisana strongly influence network usage. As an example, during the 4-day Tisana event, there was an average of 1'060 connections per day. 813 of those took place at the Exhibition center area, which corresponds to 4.0% of the entire yearly network usage.

Where (based on 4'115 sessions): Most respondents connect to the Wi-Fi network in the City center (47.6%). This is certainly the largest and most popular area of Lugano's MWN. 18.1% use the network at the Airport, 17.3% at the Exhibition center, and 12.0% at the Lido (the city's swimming pool area). The network is used less at the Stadium (5.0%), where people probably are busy doing other activities (watching a match, talking to peers, etc.), or tend to use their own mobile data contracts.

Used for: The session log does not record what people are doing on the network. Survey respondents were asked what activities they planned to do in the current session. Even if

this cannot be considered a perfect indicator of what they eventually did once connected, it can be considered a close proxy to it, and for sure indicates the main intentions/drivers to get connected. Respondents could choose multiple answers among a list of nine activities: E-mail is definitely the most popular application of Lugano's MWN, with 61.6% of all respondents declaring to use it, followed by social media (27.4%). This is in line with previous studies on public Wi-Fi usage (Fuentes-Bautista & Inagaki, 2005; Ojala et al., 2008). Many respondents connect to the network for tourism-related activities, such as looking for tourist information (18.7%), using maps (16.0%), and looking for free time activities (14.4%). Only few respondents declare to use Voice over Internet Protocol (VoIP) telephony (7.5%). This is surprising, as VoIP has long been considered one of the most important applications for Wi-Fi, allowing doing free phone calls in the whole world (Middleton, 2007). This is not the case of the "WiFi Lugano" network. Users probably do not associate VoIP with public Wi-Fi as they might prefer doing phone calls in more private environments where they are less disturbed by noise or by the presence of other people, or they simply use the cell phone network. The majority of users doing VoIP plan to do only this activity (59.7%), while the remaining 40.3% plan to do multiple activities.

Devices: Smartphones (68.3%) are by far the most used devices on the "WiFi Lugano" network, followed by laptops (14.4%), and tablets (16.3%). This confirms the trend of smartphones overtaking laptop usage on MWNs (Vos, 2012). In indoor areas such as Exhibition Center and Airport, laptops and tablets are used more frequently to connect especially by business travelers and as mobile working stations. On the other side, in outdoor areas (Lido & City Center), usage is dominated by the smaller and more portable smartphones.

Alone or Together: There is no main difference between the number of people connecting to the network alone (46.0%) or in company (54.0%). However, there are major differences depending on the location where people connect: at the Airport, most respondents connect alone (72.0%), while in the City center (59.5%), Exhibition center (60.0%) and Lido (65.5%) together. This trend is confirmed by the fact that people being in Lugano for tourism tend to be more often together (65.4%), while business travelers tend to be alone.

4.4.2.6.2 Network Users

In this section, the main characteristics of network users are described. Results are based on user information provided through the mobile survey and the phone prefix from their session log.

The typical user of the "WiFi Lugano" network is male (68.6%), aged between 20 and 49 years (71.0%) and comes from within Switzerland (51.0%). However, it would be misleading to rely only on this description. In fact, people from more than 45 countries

connected to the “WiFi Lugano” network, in primis from Italy (26.1%), from Germany (3.6%) and UK (3.0%). It is no surprise that Italian users account for more than one fourth of all connections, due to Italy’s territorial proximity. 29.6% of users are from Lugano. 38.3% are in Lugano for tourism-related reasons (e.g. day trip, event/festival, tourism), 15.7% for business-related activities, while 46.0% are either locals, students or commuters.

87.3% of foreign users do not have a Swiss 3G/4G contract, while 60.9% of Swiss users have one. This again highlights the importance of a free Wi-Fi network for foreign people who else would have to pay high roaming fees to access the Internet. Laptop users tend to prefer Wi-Fi connectivity even though they have data contracts (laptop users having a Swiss data contract: 45.5%) as laptops are more difficult to connect to 3G/4G data networks.

We cannot say much about the general satisfaction of the users’ network experience. As the people were asked to fill in the survey before actually using the network, there was no sense in asking any questions about satisfaction. However, 4.8% of respondents left a comment, which in many cases described their general feeling about the network and its performance (they probably experienced “WiFi Lugano” before). 50.1% of the comments were positive, appreciating the availability of a functional, free, public wireless network in the city of Lugano, while 19.5% provided suggestions on how the network could be further improved. Users mainly suggested making access to the network easier (provide clear instructions on how to connect; make the registration process simpler), increasing the available bandwidth for better performance, and extending the network to areas of the city that were not covered (which eventually happened in summer 2016, as mentioned above). Furthermore, they recommend indicating the availability of a public Wi-Fi network more clearly in areas where it is accessible, so that people know where free public Wi-Fi is provided.

4.4.2.6.3 Five Profiles of Practices

The clusters have been created, based on the activities users declared to do on the “WiFi Lugano” network: using e-mail and social media, looking for tourist information, using maps, looking up free-time activities, VoIP, apps, other browsing, and others.

With two-step clustering, it was possible to identify five different clusters of usage practices for the Lugano MWN. They confirm the distinction between “business tourist”, “leisure tourists” and “non-tourists”, proposed by the previous study on the “WiFi Lugano” network (Picco-Schwendener & Cantoni, 2015). Two business-oriented profiles, two tourism-related profiles and a profile representing locals could be identified.

Despite their differences, the five clusters share some basic characteristics. 1) *E-Mail* is the key application, it is the only activity that members of all 5 clusters declare to do when connecting to "WiFi Lugano"; 2) *smartphones* are the most used devices in all clusters; 3) *City center* is the most used area from where users connect to the network in all clusters; 4) *males* are the majority of users in all clusters.

In the description of each cluster, the most relevant aspects will be highlighted, leaving away variables that do not add anything significant to its characterization. A summary of the characteristics of each cluster can be found in table 20.

	Business-oriented		Tourism-oriented		Locals
	E-mailer (28.1%)*	**Mobile worker** (13.5%)	**Tourism information seeker** (26.3%)	**Always-on traveler** (17.1%)	**Local social networker** (15.0%)
Main activities	Only e-mails**	E-mail and browsing	Tourist and free-time info; maps (less e-mail)	Everything, including VoIP	Social media (less e-mail)
Most used devices	Also laptop (less smartphone)	Also tablet (less smartphone)	Smartphone	Smartphone, but also others	Smartphone
Where	Airport; City center	Exhibition center; City center	City center	City center, but also other places	Everywhere, incl. Lido & Stadium
In Lugano for …	Business trip; day trip; work	Business trip; work in Lugano	Day trip; tourism, but also work in Lugano	Event; tourism; work in Lugano	Event; shopping, study, work in Lugano, other
From …	Everywhere	Switzerland and Lugano	Italy and Switzerland	Switzerland and Italy	Lugano and Italy
Gender	Male (69.4%)	Male (75.2%)	Male (66.0%)	Male (70.9%)	Highest female presence (37.2%)
Age	Oldest (42.1)	Older (41.0)	39.9	Younger (36.9)	Youngest (32.6)
Together?	Alone (55.8%)	Together (52.2%)	Together (61.2%)	Together (56.3%)	Together (59.1%)
Data up / down ***	Low data use (8.7MB/7.8MB)	Medium (9.4MB/10.8MB)	Medium (11.0MB/9.6MB)	Very high (16.0MB/12.2MB)	Medium (7.3MB/10.4MB)

Table 20 – Overview of Clusters' Main Characteristics

*In this row, percentages are among clusters; in all other rows, they are within clusters.

**Characterizing activities are outside of brackets, while those practiced less than average are in brackets.

***Average based on all sessions (37'327) of those devices that were matched successfully with the corresponding survey.

E-mailer: This is the largest (28.1%) and a very robust cluster: it was present in all cluster sets starting from the set of 13 clusters, proposed by SPSS, down to a set of two clusters. What characterizes this cluster is that its members declare to use only e-mail on Lugano's Wi-Fi network. These users use laptops more often (20.2%), and smartphones less (60.9%) than the members of other clusters. They use the network mainly in the City center (38.9%) and at the Airport (27.1%), while they are in Lugano primarily for business-related motivations (business trip 20.2%; regularly working in Lugano 21.7%), and tend to be alone (55.8%) when connecting to the network. They have a low use of data, and have the highest average age (42.1) of all clusters. Based on the comments they left (38), they seem to be quite satisfied with the network. 55.3% left positive comments about it, while only 7.9% provided suggestions on how to improve it. This might indicate that the "WiFi Lugano" network works well for those using it only for e-mails. Based on these characteristics, the users of this cluster can be described as very goal-oriented**:** they access the Wi-Fi network with the purpose of reading/writing e-mails. Their barrier to access Wi-Fi might be quite high; they connect just when they really have to. We can imagine that these are people with leading positions, who are at a good point in their career, and come, and go from their offices, where they have all facilities. It can be assumed that for activities not related to checking e-mails they tend to rely on their mobile phone. If they need some information, they can call their secretary and do not need to look it up on the Internet.

Mobile worker: With 13.5% of the whole sample, this is the smallest cluster. All members of this cluster connect to the Wi-Fi network to browse the Internet, while some (41.0%) also want to use e-mail. They use tablets more (20.9%), and smartphones less (62.2%) than members of other clusters. Nearly a quarter (23.2%) connects from the Exhibition center, but also from other network areas. As the E-mailers, they are in Lugano mainly for business-related reasons. Most of them are Swiss people, coming either from Lugano (30.8%) or from the rest of Switzerland (32.9%). This is in line with the fact that nearly half of them (44.6%) have a Swiss data contract (highest rate of all clusters). With 75.2%, this cluster has the highest male rate. Similar to the E-mailers, its users are slightly older people (average age: 41.0) and have a medium use of data. Many of them connect to the "WiFi Lugano" network during different fairs and events such as Arte Casa, Ti-Tatoo, Ticino Case Expo, and Challenge di spada. When compared to the E-mailers, the Mobile workers seem to have a lower barrier to access public Wi-Fi as they use it not only for e-mail but also for browsing the Internet. We can assume that they use "WiFi Lugano" to get Internet connectivity for their mobile working station for example when working at exhibitions. They use public Wi-Fi even though many of them have a Swiss data contract, probably because for working purpose, they tend to use tablets or laptops, which usually do not have 3G/4G connectivity. They use laptops less than the E-mailers, and tablets more, possibly because for fairs tablets are optimal presentation devices. Compared to the E-mailers, the users of this cluster are less positive about the network, only 29.6% left

positive comments, while 33.3% provided suggestions on how to improve it. This might be explained by the fact that they use "WiFi Lugano" in a context that is more sensitive to network problems. They rely on the provided connectivity to do their job, so they have higher expectations than those people who use it just for checking e-mails.

Tourism information seeker: With 26.3% of respondents belonging to this cluster, it is the second largest cluster. Users of this cluster connect to "WiFi Lugano" primarily for tourism-related reasons: they look up tourist information (45.2%) and free-time activities (29.2%) and they use maps or orientation tools (28.9%), all being activities that aim at facilitating their stay in Lugano. They use the network less for e-mails than the members of all other clusters (36.1%). A vast majority of them (70.1%) use their smartphone to connect to the network, which makes sense, as people visiting a city tend to rely more on small and portable devices, which they can carry always with them. They use the network mostly in the City center (47.9%), which is the most attractive area for tourists, and are in Lugano mainly for tourism-related reasons (37.6%), which is in line with the activities they perform on the network. However, 18.8% of these people regularly work in Lugano. They might be commuters, who are not very familiar with the city. Many of them come from Italy (30.3%) but also from other parts of Switzerland (27.9%) or other countries (20.1%), while still 21.7% come from Lugano. When connecting to the network most of them are in company (61.2%), more than the members of all other clusters. This is comprehensible as people usually spend time with other people when on holiday. Furthermore, they use a medium amount of data. To conclude, the members of this cluster use public Wi-Fi mainly to access information useful to their stay but not for other activities such as VoIP or social networks. They could thus be described as tourists who try to really be on holiday, using Internet only when necessary.

Always-on traveler: This cluster accounts for 17.0% of respondents. These users intend to do many different things on the "WiFi Lugano" network. It is the only cluster whose members perform all the available activities. 83.7% of its members plan to perform more than one activity once connected. Many of them use the Wi-Fi connection for communication activities such as e-mails (75.2%), social media (58.2%), and VoIP (44.2%), but they also use it to look up tourist information (34.5%) and free-time activities (34.8%), to use maps (46.2%), to browse the Internet (46.2%), and to use apps (36.8%). They are the only group that uses VoIP. Similarly to the information seeking tourists, also these users mainly rely on their smartphone (69.2%) to access Lugano's public Wi-Fi network and connect primarily from the City center (40.7%). 39.8% of them are in Lugano for tourism-related reasons (tourism: 17.5%; event/festival: 12.0%; day trip: 10.3%), while 20.1% regularly work in Lugano. They come from both within Switzerland and abroad and are slightly more often in company when connecting to the Wi-Fi network. Average age within this cluster is lower (36.9%) than within the "Tourism information seeker" cluster (41%) and its users have a very high usage of data. Thus, the users of this cluster

tend to be very technology affine, using Wi-Fi connections often and for many different activities and generating a large amount of traffic. They use “WiFi Lugano” because they like to be online, and possibly, because they might be less wealthy than the “Tourist information seekers”, thus having to rely more on Wi-Fi networks in order to get Internet access when on the go. Together with their techy nature, this might also explain why they use VoIP.

Local social networker: Only 15.0% of respondents belong to this group. All of them connect to “WiFi Lugano” to use social media while some also to use e-mail (37.3) or to browse the Internet (18.5%). To do so, nearly all of them use smartphones (83.3%). Beyond the City center (35.4%), they also connect in areas such as the Exhibition center (17.0%), the Lido (15.6%) and the Stadium (6.8%), all areas that might attract more locals than tourists. They indicated many different reasons for being in Lugano, first of all regularly working in the city (21.6%), other (16.9%, which most probably stands for “I am from here”: there was no such option), study (11.9%), and attending events/festivals in the center (10.9%). These reasons suggest that users tend to be locals rather than foreigners. This hypothesis is supported by the fact that most of them are from Lugano (29.7%) and from Italy (29.9%). Many of those Italians are probably commuters, regularly coming to Lugano, or students who live in Lugano but still keep their Italian phone number. Many members of this cluster connect to “WiFi Lugano” during events taking place at the Exhibition center (MusicNet; Palco ai Giovani), events mainly addressed to a young local audience.

The members of this group generally connect to the Wi-Fi network when together with others (59.1%), they have the highest female presence (37.2%), and their average age is 32.6: the youngest among all clusters. They generate rather low traffic especially in terms of upload, which suggests that they are not sharing large amount of data (e.g. photos or video) through social networks. Probably they use social networks more passively by consuming information rather than contributing their own. People of this cluster make a more leisure-oriented use of “WiFi Lugano”, they connect for fun, when they have a moment during their free-time activities such as relaxing at the Lido, attending an event in the Exhibition center, or rooming around in the center with their peers. They are few, because probably the other youngsters have data contracts and do not need to rely on free Wi-Fi while on the move.

4.4.2.7 Conclusions

This study has investigated usage practices and user types of a Swiss MWN in order to understand how such networks are used and by whom. Thanks to cluster analysis, which used the declared activities on the network as input variables, it was possible to identify five different usage practices. Two of them are business-oriented: “E-mailer” and “Mobile

worker", two are tourism-oriented: "Tourism information seeker" and "Always-on traveler", and one represents the locals: "Local social networker." These five usage practices show that the "WiFi Lugano" network is used by a large variety of people, with different characteristics, using the network for many different activities and within various contexts. This is different from previous studies in which users of public wireless networks were not characterized as very diverse (Hampton et al., 2010).

Based on the above clusters, it can be said that "WiFi Lugano" fulfills three main functions: as a 1) business-; 2) tourism-; and 3) social-inclusion enabler, each addressing one of the three eGovernment relationships 1) G2B; 2) G2V and 3) G2C.

It is business-enabling because it offers business travelers a simple and convenient way to check their e-mails in areas where they have time to open up their laptop (e.g.: Airport or City center). Furthermore it enables workers, who regularly work outside office or commute between different offices a way to get Internet access. For example, people working at exhibitions have to spend longer times, disconnected from their base-office. For them, being able to rely on a well performing Wi-Fi access is highly valuable as it allows them to access their working tools. Being connected, also when outside office, allows them to be fully operative and thus to create economical value.

The tourism-enabling function of the MWN consists in providing visitors with a means to access all kinds of useful information to make their stay as pleasant as possible (e.g. finding restaurants, looking up opening hours, finding events to attend, using maps for orientation, accessing information about monuments, etc.). Furthermore, it allows travelers to stay connected with their friends and family back home, so that they themselves can feel at home even though being far away. Thus, a city can increase its hospitality level by offering visitors public Wi-Fi access to the Internet.

The third function of the "WiFi Lugano" network is favoring social inclusion by offering public Wi-Fi connectivity to those who else would not be able to connect to the Internet in public spaces. These can for example be foreigners, who, due to high roaming rates do not want to use their data volume, or less affluent (young) people, who have a smartphone but no (or only limited) data contracts.

Being aware of those functions and knowing how a MWN is used and by whom, allows cities to take specific actions to improve their services to both citizens and visitors and to implement more and more smart and personalized solutions. Based on the results of this study the following suggestions can be formulated to help city planners take advantage of a MWN for their G2B, G2V and G2C relationships: 1) to provide different landing pages to different publics in order to promote the city and its services in a targeted way; 2) to guarantee a high quality of service; 3) to exploit the MWN to promote tourist attractions and vice versa; 4) to allow small businesses in the area to take advantage of the MWN; 5)

to extend the reach of the MWN to areas that are relevant for at least one of the five user groups. Each suggestion is explained below in more detail:

First, providing different landing pages to different publics is an interesting solution to address the specific needs of different target audiences. It is possible to identify Wi-Fi areas that are particularly relevant for one or the other public: areas with sightseeing attractions mainly attract tourists, while cities' business districts and exhibition centers are mainly frequented by business travelers, and leisure areas such as recreational areas or stadiums have a more local public. Technically distinguishing city areas can be achieved by assigning different IP addresses to each Wi-Fi AP. The more IP addresses are used in a network, the more detailed distinction in areas can be made. Through different landing pages, the city can provide tourism relevant information to the tourist traveler (e.g. hotels, restaurants, events, activities or background information on monuments and tourist sights in the area s/he is connecting from), and business relevant information to the business traveler (e.g. timetables of public transport, contacts for taxis, information on the business district or even information on an event that is taking place at the exhibition area). In areas where mainly local people connect, the landing page can be used to promote city activities, to foster civic participation and to inform the population about relevant political or cultural initiatives.

Second, it is fundamental that the quality of the service is good, which means that the network has to be easy to use (simple registration and login procedures, clear instructions) and has enough bandwidth so that a large number of people can connect and use the Internet at a good speed. Furthermore, network downtime should be close to zero. During exhibitions or events for which many people are expected, it is suggested to add antennas and allocate more bandwidth. A low quality service, cancels the positive effects of the presence of a MWN, and disappoints the created expectations.

Third, it is possible to take advantage of MWNs to promote interesting locations and sightseeing attractions within the city and attract people to them. To do so, Wi-Fi areas could for example be marked on the city map and once a person connects to the MWN in a specific area, the landing page could provide relevant information on that specific location. Marking the MWN on the city map is also a way to promote the MWN with tourists. In fact, it is fundamental to promote the network to different publics and through different channels to make users aware of the network (e.g. by indicating Wi-Fi areas with panels, promoting it online, etc.).

Fourth, having a well-established Wi-Fi network in the city center might help reducing the number of Wi-Fi networks. It allows micro-players (e.g. small restaurants, bars, shops) to take advantage of the already existing MWN, instead of setting up one themselves for their clients. This is a particularly user-friendly solution as it allows a user to stay connected to the same network instead of having to choose a different one in each restaurant or shop.

Again, however, if this is to happen, the quality of the municipal Wi-Fi service needs to be high (good speed, enough bandwidth, no downtime).

Fifth, thanks to the five emerged usage profiles, Lugano's municipality now has empirical data, based on which it can explore and identify further areas, where to offer public Wi-Fi access to specific publics (e.g. other public parks, tourist attractions, recreational areas, schools etc.). In this way, the municipality makes a step towards the fourth phase of eGovernment as suggested by (Janowski, 2015): that of "Policy-Driven Electronic Governance" (p.425), which supports policy and development in specific locations and sectors.

Another important aspect to consider by city-planers are the technical downsides of Wi-Fi overcrowding, an aspect that has not been contemplated in this paper but can be object for further studies.

If a city is able to implement some of these solutions, it will manage to address different needs and usage scenarios, which will have a positive effect on how the city is perceived by its citizens, tourists and business travelers. Providing public broadband access in the city becomes thus part of the city's effort to become a "smart" city.

It would be interesting to replicate the same study in other cities having a MWN, in order to have comparable data. Understanding how the presence of a Wi-Fi network in a city can enable e-government or m-government services could be a further research issue to address in future studies.

5 Conclusions

This concluding chapter first provides short summarizing answers to each of the five research questions followed by the study's overview table. It then shows how the results add to existing research and what social and practical implications they might have. Finally, it acknowledges limits and suggests possible future research directions.

5.1 Main Outcomes

This research focused on the social dimension of public large-scale Wi-Fi networks, paying particular attention to the people using them. Two types of public large-scale Wi-Fi networks have been studied: CWNs, where people share Internet connectivity with other members (the case of Fon), and MWNs, where a municipality provides wireless Internet access in a city (the case of "WiFi Lugano").

While for CWNs understanding what motivates and dissuades people from joining and actively participating in these communities has been identified as a key research issue, for MWNs understanding users and usage practices has been proved crucial. Below, the main research questions that guided this study are briefly answered.

5.1.1 RQ1: What Motivates People to ***Join*** a Hybrid CWN and What Hinders Them from Doing so?

From the analysis of 292 survey answers and 40 semi-structured interviews with members of the Fon CWN, it emerged that the main motivations for joining a hybrid wireless community like Fon are ***utilitarian*** (in particular getting free access to the Internet), ***idealistic*** (idea of ***reciprocity*** which implies both benefitting and contributing, and ***altruism***) and, to a lesser extent, ***intrinsic*** (technical interest and enjoyment). While social motivations are fundamental in pure communities, they only play a marginal role in hybrid CWNs, where people do not interact much. The community is thus essentially reduced to a reciprocal exchange of Internet connectivity. With regard to ***concerns***, Fon members are generally aware of potential risks (abuse, security, legal issues) but feel sufficiently reassured by the solutions adopted by Fon to address these issues.

5.1.2 RQ2: What Motivates People to Actively ***Participate*** in a CWN and What Hinders Them from Doing so?

By applying SEM to 268 survey answers of members of the Fon community, motivations and barriers influencing active participation in a hybrid CWN have been identified. This actually allowed putting motivations in relation with active participation. While RQ1 only

investigated motivations to join the community, RQ2 investigated which motivations actually result in higher active participation.

Two different types of member participation emerged from the study, indicating two different ways in which members can contribute to the community: on the one hand, ***social participation***, which consists in interacting with and helping other community members, and on the other hand, ***participation through sharing***, which means that members put effort into actively sharing their home Internet signal with others. Social participation is driven by social motivation, technical interest and ease of use, while participation through sharing is driven by idealistic motivations and ease of use. Astonishingly, ***utilitarian motivations*** do not have a significant impact on either participation type, even though they play an important role in attracting members to the community. As for joining CWNs, security and legality concerns are insignificant and do not impact on members' active participation, probably because people are reassured by Fon's technical solutions.

5.1.3 RQ3: Who Are the Users of a MWN? What for, Why, When, With Whom, Where, and With What Devices Do They Use the MWN?

In order to trace an accurate overall picture of who the users of the "WiFi Lugano" MWN are and how they use the network, this research combined user data provided through a mobile survey placed on the network's entry page with technical network data from the log-entries generated by the user who answered the survey. In this way, it was possible to combine technical network data and user-provided information on a specific network session. This allowed drawing a more accurate characterization of usage practices and users than relaying only on either network or user-provided data.

User behavior on the "WiFi Lugano" MWN

"WiFi Lugano" is mostly used between ***spring and autumn***, during Lugano's main tourism season with the highest peaks in May and October, probably because of several important fairs taking place during these months that might boost network usage. The network is used slightly more on weekends and most connections occur during late afternoon when people leave their offices. The ***city center*** is the largest and most popular Wi-Fi area followed by the airport, the exhibition center and the city's swimming pool area (lido) while the Wi-Fi at the stadium is used less. Usage at the exhibition center shows very high peaks during exhibitions, while during normal days it is quite low. ***E-mail*** is definitively the most used application followed by social media. This is in line with previous research (Fuentes-Bautista & Inagaki, 2005; Hampton et al., 2010; Ojala et al., 2005; Ojala et al., 2008; Powell & Shade, 2006; Powell, 2008a). While ***VoIP*** has long been considered a key application for public Wi-Fi networks (Middleton, 2007), users of Lugano's Wi-Fi network hardly do any VoIP calls. They might prefer calling in more private spaces with less noise and people. ***Tourism-related activities*** like looking for

tourist information, using maps or looking for free time activities constitute another important group of activities. Despite the large variety of applications, most respondents planned to use only one application during their session. ***Smartphones*** are by far the most used devices, especially in outdoor areas like the lido and the city center. In indoor areas (airport or exhibition center), business travelers sometimes use also laptops or tablets to connect to "WiFi Lugano" which act as their mobile working station.

People connecting from the airport tend to be mostly alone (business travelers) while those connecting in the city center, in the exhibition center and at the Lido are generally with others. Like on other public Wi-Fi networks, few heavy users generate most of the network traffic (Chinchilla et al., 2004; Divgi & Chlebus, 2007; Divgi & Chlebus, 2013; Ojala et al., 2005; Vural et al., 2013).

Typical user of the "WiFi Lugano" MWN

The typical user of the "WiFi Lugano" network is male, aged between 20 and 49 years and comes from within Switzerland. However, it would be misleading to throw all users in the same pot as people from more than 45 additional countries connected to the network, primarily from Italy (because of its geographical proximity to Lugano) but also from Germany and the UK. The typical user is in Lugano either for tourism (visiting Lugano) or business-related reasons (regularly working in Lugano or on a business trip). The majority of Swiss people connecting to the network is from Lugano, showing that "WiFi Lugano" is relevant also for locals. This is further supported by the fact that also people having a Swiss 3G/4G data contract use Lugano's Wi-Fi network, probably because completely unlimited data contracts are still an exception in Switzerland (Fueter, 2016; Odermatt & Brunner, 2014).

5.1.4 RQ4: Are There Usage Differences Between Leisure Tourists, Business Travelers and Residents?

The generic user profile resulting from RQ3 suggests that "WiFi" Lugano is relevant for both locals and visitors, who, however, might have different usage practices. As Lugano is both an important tourist destination and Ticino's economical capital, researchers decided to differentiate users of the "WiFi Lugano" MWN, distinguishing not only between locals and visitors but also between ***business tourists***, ***leisure tourists***, and ***non-tourists*** (residents and commuters). This was possible thanks to the variable "reason for being in Lugano" present in the mobile survey.

Typically, ***business tourists*** are male in their 40ies who come from abroad and are generally alone when accessing Lugano's MWN. They use the wireless network mainly to access their e-mail account or do other browsing activities and only rarely to look up tourist information or to use social media. They mostly connect from the airport and to a

lesser extent from the city center using smartphones but also laptops. ***Leisure tourists*** are generally male, aged between 20 and 50 and come from abroad. They use "WiFi Lugano" in the afternoon or weekend while strolling around the city center or while relaxing at the Lido together with friends or family. They nearly exclusively use their smartphones when connecting to the MWN and preferably access tourist information or perform socially oriented activities like writing/reading e-mails and being active on social media. ***Non-tourists*** are also generally male, come from Lugano and, with an average age between 20 and 40 they are younger than the users of the other two groups. They connect to "WiFi Lugano" during any weekday, generally when going out in the evening in the city center or at the Lido (in the evening, the place commutes to a bar/disco) either alone or together with others. Similar to leisure-tourists, they mostly use their smartphone to connect to the network and when connected, they check e-mails, use social media and do other browsing activities but are not much interested in tourism-related information.

All three user profiles clearly show characteristics and usage behaviors that reflect the real-life behaviors of people in these categories.

5.1.5 RQ5: Can Users/Usage Be Grouped Into Meaningful Clusters?

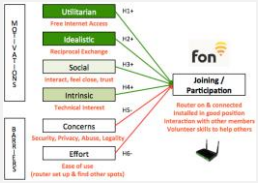
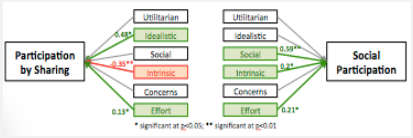
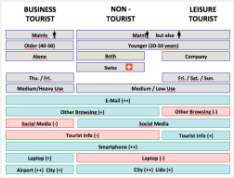
In order to identify meaningful usage clusters, the SPSS two-step clustering algorithm has been applied to the combined data set of technical network data and user-provided information on the use of "WiFi Lugano." Clusters have been created based on the activities users declared to do on the network (using e-mail-related applications and social media, looking for tourist information, using maps, looking free-time activities up, VoIP, apps, browsing, and others) and have then been interpreted with the help of all the other variables. This procedure allowed identifying five different usage practices: two business-oriented ones ("E-mailer" and "Mobile worker"), two tourism-oriented ones ("Tourism information seeker" and "Always-on traveler"), and one reflecting the practices of locals ("Local social networker").

Despite their differences, the five clusters have some common features: e-mail is the most used application, smartphones the most used devices, the city center the most popular Wi-Fi area, and the majority of users are male.

E-mailers connect to Lugano's Wi-Fi network only to read/write e-mails. They are goal-oriented and seem to be people with a leading position who come and go from their offices, where they have all job-related facilities. If they need information they probably rely on their mobile phones and call their secretary for help. They are quite satisfied with the network as they do not have very high requirements. With an average age of 42 years, this is the oldest cluster. ***Mobile workers*** use "WiFi Lugano" to connect to the Internet from their mobile working station especially when at exhibitions and preferably with their tablets. Beyond using e-mail, they do a lot of other browsing. ***Tourism information***

seekers connect to Lugano's MWN only when they need to look tourism- or free-time-related information up but not for other activities. To do so, they primarily use their smartphone. ***Always-on travelers***, on the other hand, are technology-affine people who like to connect to the Internet on a regular basis and use it for multiple purposes. In fact, they do many different activities when connected to "WiFi Lugano", including VoIP calls, probably to stay connected to the people back home and hence heavily use data. It is possible that they are less wealthy than tourism information seekers and thus need to relay more on public Wi-Fi connectivity. Last but not least, ***local social networkers*** represent the local populations and mainly engage in social media activities. They are young, dynamic, and connect when in company of others, all around the city and often during events taking place at the exhibition center.

The table below proposes again the study summary presented in the introductory chapter of this dissertation to illustrate what has been done to reach the above-described outcomes.

<table>
<tr><td></td><td colspan="4">Public Wi-Fi networks and the role of individuals using them (social component)</td></tr>
<tr><td></td><td colspan="2">CWN – Motivations – Case of Fon</td><td colspan="2">MWN – Usage practices – Case of “WiFi Lugano”</td></tr>
<tr><td>Theoretical Background</td><td colspan="2">Motivation theories relevant to CWN context (chap. 3.2)
Motivations in pure & hybrid CWNs (chap. 3.3)</td><td colspan="2">Usage studies on public and semi-public Wi-Fi networks
(chap 4.2)</td></tr>
<tr><td>Research Contribution</td><td colspan="2">Focus on hybrid CWNs
Extend and adapt existing theoretical model (chap. 3.4)</td><td colspan="2">Understand users and identify usage practices of MWNs (chap. 4.3)
Combine user-provided data with corresponding technical network data (chap. 4.3)</td></tr>
<tr><td>Research Questions</td><td>RQ1: What motivates people to JOIN a hybrid CWN and what hinders them from doing so?
(chap. 3.4.2)</td><td>RQ2: What motivates people to actively PARTICIPATE in a CWN and what hinders them from doing so?
(relationship between motivations and active participation) (chap. 3.4.2)</td><td colspan="2">RQ3: Who are the users of a MWN? What for, why, when, with whom, where, and with what devices do they use the MWN? (chap 4.3.2)
RQ4: Are there usage differences between leisure tourists, business travelers and residents? (chap 4.3.2)
RQ5: Can users/usage be grouped into meaningful clusters?
(chap 4.3.2)</td></tr>
<tr><td>Methodology</td><td>Mixed-method approach:
40 semi-structured interviews
Survey with 292 Fon members
→ Descriptive statistics (SPSS)
(chap. 3.5.1.5)</td><td>Quantitative Confirmatory Analysis:
Survey with 268 Fon members
→ Structural Equation Modeling
(chap. 3.5.2.6)</td><td colspan="2">Quantitative analysis of 2 combined data sets:
- technical log-data of the “WiFi Lugano” MWN
- user-provided data from a mobile survey placed on the landing page of “WiFi Lugano”
3 months data (Jun – Aug 2013):
27’945 sessions / 1’939 surveys
→ Descr. Stat. & User Groups (4.4.1.5)
1 year data (Jun 2013 – May 2014):
73’594 sessions / 4’115 surveys
→ Cluster Analysis (chap. 4.4.2.5)</td></tr>
<tr><td>Outcomes</td><td> 
(chap. 3.5.1 / 3.5.1.6)</td><td> 
(chap. 3.5.2 / 3.5.2.7)</td><td colspan="2"> 
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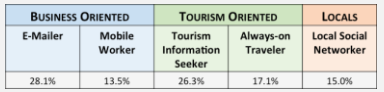
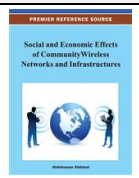
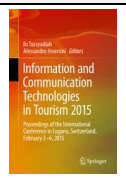
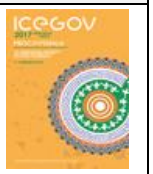
 
(chap. 4.4.2 / 4.4.2.6)</td></tr>
<tr><td>Publications</td><td>Motivations and Barriers of Participation in Community Wireless Networks: the Case of Fon
  </td><td>Motivations and barriers for participation in a hybrid wireless community: the case of FON
  </td><td>Tourists and Municipal Wi-Fi Networks (MWN) The case of Lugano (Switzerland)
  </td><td>Usage practices and user types of a municipal Wi-Fi network: The case of “WiFi Lugano” –
best paper award
  </td></tr>
</table>

Table 21 – Research Overview

5.2 Theoretical Implications

In the past, both CWNs and MWNs were studied from various points of view, in particular from a technical, a business and a policy one. However, only few studies focused on the people involved in and using these networks. An overall theoretical contribution of this study is thus, the inclusion of a social perspective that considers also CWN's and MWN's social dimensions and implications.

By analyzing the Swiss market of public large-scale Wi-Fi networks, it has been possible to ***extend the existing framework of organization of large-scale Wi-Fi networks*** proposed by Heer et al. (2010a) by including a fourth driving force: "3rd-parties." This allows distinguishing between those commercial entities whose main scope is providing broadband services like ISPs (provider-driven) and all other, generally non-public, entities (3rd-party-driven). It has thus been possible to map 24 Swiss public large-scale Wi-Fi initiatives on this extended framework (figure 8) to provide an overview of the different entities involved in the development of public large-scale networks and their interplay in Switzerland.

5.2.1 Theoretical Implications with Regard to CWNs

Past research on CWNs studied motivations mainly in ***pure*** wireless communities and the first theoretical models explaining motivations for joining these communities considered only a limited number of motivation theories (mainly SDT's intrinsic and extrinsic motivations). Furthermore, so far, motivations and participation have always been studied in isolation without analyzing their relationship. This allowed learning about members' motivations for joining a community without understanding, which motivations actually resulted in a higher level of active participation.

Therefore, this study contributes to existing theory by extending research to ***hybrid*** wireless communities, by creating a ***broader theoretical basis*** complementing SDT's intrinsic and extrinsic motivations with other relevant motivation theories and by analyzing the ***relationship*** between motivations and participation.

Until now ***participation*** has always been considered as one single inseparable concept. However, this study has identified two types of participation in hybrid communities showing that it is possible to contribute to the CWN in different ways: on the one hand, by putting effort into actively sharing the own home Internet signal (participation through sharing), and on the other hand, by being socially active in the community (social participation). In pure CWNs, both types of participation are strong, while in hybrid CWNs, members put their effort especially in sharing their signal but are less involved in social participation. When they initially join, they concentrate on setting their router up, but then they generally let it run by itself and do not engage much in community-related

activities such as interacting, helping, and exchanging knowledge. Participation in hybrid CWNs is thus ***more passive*** than in pure CWNs. The study also has showed major ***differences regarding motivations*** in pure and hybrid communities. While in pure CWNs intrinsic, idealistic and social motivations play a major role, in hybrid communities, utilitarian and idealistic motivations are more important.

The fact that Fon spots of other members are rarely used – often because of the difficulty in finding functional spots – might weaken both utilitarian and idealistic motivations and result in an even more passive participation as time passes.

Pure and hybrid CWNs also seem to attract ***different publics***: while pure communities attract early adopters interested in technology, hybrid communities entice a more practically-oriented and mature market segment.

5.2.2 Theoretical Implications with Regard to MWNs

In the existing literature on MWNs, there are only few studies focusing on users and their usage practices. However, understanding usage has been recognized as an important research issue, because beyond identifying good technical solutions and sustainable business models, and understanding policy issues, it is fundamental to know who might benefit from such public networks and how to efficiently address the needs of potential users in different contexts.

Even though there are not many usage studies on free large-scale MWNs, usage has been extensively studied in other types of public and semi-public Wi-Fi networks (e.g. campus or commercial Wi-Fi networks, single hotspot areas, etc.) The majority of existing studies either analyzed technical network data (log-data) or user-provided/observer data on Wi-Fi usage. Only very few studies employed both types of data but researchers always analyzed the different data sets independently. Up to now, no study combined user-provided data on a session with technical data generated from the same session.

Hence, this dissertation contributes to two scientific streams: 1) to theory on MWNs by focusing on MWNs' ***social dimensions*** and more precisely on the ***role of individuals*** using these networks (who the users are and how they use these networks), and 2) to existing literature on usage studies of public and semi-public Wi-Fi networks, by providing ***empirical evidence*** on usage of a Swiss, free, public, large-scale MWN ("Wi-Fi Lugano") and by ***combining two different types of data-sources*** (log-data and user-provided data) into one data set. This allows having a more complete picture of how a MWN is used as technical data is complemented with socio-economic variables, making it possible to interpret, ***contextualize*** and differentiate usage practices instead of considering usage just by itself, as it has been done so far. Thanks to the various usage practices that have emerged from this study, it has been possible to show the relevance and importance of

MWNs for ***eTourism*** and ***eGovernment***. Lugano's MWN is in fact able to positively influence three ***eGovernment relationships*** – G2B, G2V and G2C proposed by Kalbaska et al. (2016) – through its functions as ***business, tourism and social inclusion enabler***. It furthers businesses and generates economical value for the city by providing Internet connectivity to people who regularly work outside their office and by enabling them to be fully operative when on the go. It supports tourism by offering travelers a way to access useful information to enrich their stay and to stay in contact with family and friends back home. In this case, the presence of a functional MWN increases a city's hospitality level. Last but not least, a MWN favors social inclusion and digital equity by providing Internet access to those who would otherwise not be able to get connectivity in public spaces (e.g. foreigners who have to pay high roaming rates, younger and less affluent people, who have smartphones but no or only limited data contracts, and those who mainly use laptops or tablets without data cards).

At this point, it is also possible to include the two papers on "WiFi Lugano", used in this dissertation, into the classification scheme of existing studies on public Wi-Fi usage proposed in the literature review (table 15). Table 22 shows how the two studies can be integrated into the classification scheme.

Network (s)	Network Characteristics	Country	Authors	Study Period	Study size APs / Users	Persp.	Focus	Main findings
CAMPUS WLANs								
…..								
CONFERENCE Wi-Fi networks								
…..								
PUBLIC WI-FI networks (Wi-Fi network in the public / semi-public space)								
LARGE-SCALE Wi-Fi networks								
…..								
FREE large-scale Wi-Fi networks (mainly municipality- and community-driven networks that cover larger and multiple areas)								
Wi-Fi Lugano	MWN – free, registration	Switzer-land	Picco-Schwendener & Cantoni (2015)	2013 (Jun-Aug) 3 months	36 / 4'820 1'939 mob. surveys	**Combination of Network & User**	Network usage; User profiles	**Focus on Tourism- UP:** Business-, Leisure-, Non-Tourists; **U:** male, 20-49 years, from > 40 countries; **UB:** together with others; city center; wd & we; **AP**: e-mail, social media, tourism-related activities; **D:** mainly smartphone;
			Picco-Schwendener et al., (2017)	2013/14 (Jun-May) 1 year	36 / 10'298 4'115 mob. surveys		Network usage; Usage practices	**Focus on eGov** – **UP:** E-mailer, Mobile Worker, Tourism information seeker, Always-on traveler, Local social networker; **UB:** together; peak in May & Oct / Fri & Sat; late afternoon; during exhibitions; city-center but also airport, exhib. center, lido; **AM:** e-mail, social media, tourism-related activities, few VoIP; **D:** smartphones
COMMERCIAL / PAY-FOR large-scale Wi-Fi networks (mainly provider-driven networks that cover larger and multiple areas)								
…..								
SMALL-SCALE Wi-Fi networks								
VARIOUS small-scale Wi-Fi networks (various Wi-Fi areas that are available only in small areas such as parks, cafés, squares, etc.)								
…..								
COFFEE SHOP Wi-Fi networks								
…..								

Table 22 – "WiFi Lugano" Studies Inserted in the Classification Grid of Studies on Public Large-Scale Wi-Fi Networks Presented in Section 4.2.4

5.3 Social and Practical Implications

Wi-Fi networks are currently experiencing a revival especially thanks to their role in allowing to ***offload mobile data traffic*** from cellular networks, whose capacity is not able to keep up with the fast increase of generated data volumes (Ma et al., 2017).

Both the Fon and "WiFi Lugano" cases can be considered archetypical examples of a hybrid CWN and a MWN. Fon has certainly been the largest and most successful hybrid community, operating even at a worldwide level, while Lugano was among the first cities in Switzerland to implement a public Wi-Fi network and together with Luzern certainly was an example for other Swiss cities, which wanted to implement public Wi-Fi networks. It is thus possible to consider the two cases as archetypical examples in their category. This allows drawing some general policy recommendations from them, which might be valid also for other instances of CWNs and MWNs.

5.3.1 Social and Practical Implications with Regard to CWNs

As getting ***access to free Internet connectivity*** is the main motivation for people to join the Fon community, it is important that Fon and other hybrid communities put effort in extending their network. This is what Fon has done by building up partnerships with ISPs in various countries. Fon's technical solutions for Wi-Fi sharing is integrated in the routers of partnering ISPs, allowing their customers to share part of their Internet connection and thus automatically to become part of the Fon network. Fon has recognized that partnering with other ISPs is a much more effective means to quickly enlarge the network than addressing individual users. In fact, nowadays, Fon's strategy nearly exclusively relies on such collaborations and does not allow individuals to join the community independently anymore but only through a partner ISP. If a person's ISP is not partnering with Fon, the only way s/he has to benefit from the community network is to buy access passes. Fon's current strategy has thus changed significantly since the current studies have been conducted. With its changed strategy, Fon nearly completely ***excludes social participation*** and only focuses on participation by sharing.

Keeping in mind this evolution, Fon might also consider ***collaborating with other commercial partners*** for example from the travel or tourism sector in order to expand its network to relevant areas such as train stations, airports, hotels, restaurants or tourist attractions. ***Collaboration with municipalities*** might allow Fon to get more into the public space and to complement its mainly residential network of Fon spots with APs in more central urban areas.

One could however wonder whether utilitarian motivations (getting access to free Internet) today, in an era of cheaper or free mobile roaming (e.g. abolishment or EU roaming rates) would still be the strongest motivation to join a hybrid wireless community. Probably yes,

as cheap worldwide roaming is still an utopia and in any case such communities offer an alternative way to get connected to the Internet, and might also in the future be a valid backup solution.

Even though Fon claims to be the largest Wi-Fi community worldwide (Fon, 2018b), in most areas it does not have a critical mass of members to guarantee ubiquitous coverage. Thus, members have to ***actively look for Fon spots*** and often have to move (generally to more residential areas) to find a functional AP. Fon provides maps indicating the location of registered Fon spots. However, a registered Fon spot does not automatically correspond to a functional router. Often routers are not placed in a way that their signals reach the public space and sometimes they are even offline (even though this risk certainly has diminished since Fon's solution has been integrated in the router of members' ISPs and is not an additional device as the Fonera router was). Furthermore, using Fon often means standing on the street to capture a signal instead of comfortably sitting on the bench of a park or a bar. As a result, Fon members ***rarely use the community network*** (at least at the time in which the studies were conducted) making revenue sharing even less attractive. ***Improving the search tool*** of Fon spots might be an effective means to increase network usage. A user in an interview suggested for example to *"check whether the spots really are where they are marked, whether they are usable and possibly providing a solution for evaluating each spot."* Nowadays, Fon, in addition to its online maps, provides the App "Fon WiFi" (Fon, 2018c) for Android and Apple with maps showing the single Fon spots, but the app mainly aims at selling access passes and the maps contained are not more detailed than the maps on Fon's website. Furthermore, Fon should invest more in ***educating members*** on where to best put their routers so that their signals really reach the streets and eventually on how to boost the signal.

These improvement actions might contribute to an overall ***increase of ease of use*** of the community network, which in turn might lead to increased use and participation. Ease of use actually plays a positive role in both participation by sharing and social participation.

The fact that utilitarian motivations do not result in higher and more active participation might be because it is ***not necessary to participate or contribute actively in order to benefit*** from the community. In other words, once an account has been set up and a Fonera router installed and placed in a specific position, a member can access other Fon spots, even though his/her router does not perform well, is offline or does not allow the signal to reach the street. To address the issue of low active participation, hybrid CWNs might foster incentives which increase community benefits the more and better a member contributes to the community (e.g. by placing their router in a good position and/or by increasing their router's signal with the help of an additional antenna). A ***peer-review system***, where members can rate and comment on the quality of single Fon spots might be an easy-to-implement solution to increase members' effort in setting up a well-performing Fon spot. A ***ranking*** of the best spots in the area could show other members where it is worth to try

and look for a Fon spot. In this way, popular Fon spots could attract more users and are thus able to generate more revenue (if revenue is desired). Furthermore, ratings might challenge members to perform better and climb up their local rankings and hence, reach a good ***reputation***. In this way, also APs in less attractive areas might attract members and allow the sharing member to generate revenues.

Still, utilitarian motivations might not be strong enough to guarantee a member's active participation over a longer period of time without the ***addition of more typical community values*** such as reciprocity and social interaction. ***Reciprocity*** (if I put effort in sharing my signal I expect other members to do the same) is highly significant for members. Fon or other hybrid CWNs should keep this in mind especially when defining partnerships with other ISPs. Most members consider these partnerships as beneficial for the community as they allow increasing the network considerably but only if reciprocal access is guaranteed.

The study has shown that in hybrid CWNs not only participation through active sharing is important but also ***social participation***, which is mainly driven by social motivations and intrinsic technical interest. Fon has always been weak in both, and with its new strategy, it has completely shifted away from including more typical and socially oriented community aspects into its community. Fon never favored interaction among members but at least before the strategy change, they had an official Fon forum and a Fon messages tool, allowing members to contact each other. Nowadays, both tools do not exist anymore and anyway were not used much before they were abandoned. Furthermore, Fon does not leave much space for experimentation as it controls most technical aspects. Hence, for hybrid communities that want to keep a stronger community spirit, it might certainly be beneficial to ***foster interaction among members and with the company*** and ***favor more active involvement*** in the community and its evolution.

In conclusion, it can be said that with its evolution away from social participation and from more typical community characteristics, Fon certainly becomes less appealing to technically interested early adopters and ideologically motivated people who liked the idea of sharing Internet connectivity and thus challenging commercial ISPs. On the other hand, it is a straightforward and easy-to-use solution to get cheap and unlimited Internet access all around the world, and this certainly appeals to a more goal-oriented and mature public. Considering this, Fon is nowadays ***more service and less community-oriented***.

5.3.2 Social and Practical Implications with Regard to MWNs

Understanding who the users of a MWN are and how they use it made it possible to define different functions of a MWN (business, tourism and social inclusion enabler). Knowing these functions allows city planners to take ***specific actions*** to improve their G2B, G2V, and G2C relationships with the help of a MWN:

1) Providing ***different landing pages to different publics*** is an interesting solution to promote the city and its services in a targeted way and to address the specific needs of different audiences. With the help of dedicated landing pages, leisure tourists can immediately visualize tourism-related information on hotels, events or attractions while business travelers gain direct access to information on the city's business infrastructures and services, events and conferences or fairs taking place in the city. Locals might be addressed with a landing page promoting local activities and informing on political, cultural and societal initiatives or problems, thus, being able to foster civic participation.

2) High service quality is important to not disappoint user expectations. To guarantee a ***high service quality*** a MWN should ***be easy to use*** with simple registration and login procedures, have enough bandwidth to guarantee good speed to a larger number of connected people and have near-to-zero downtime. It is fundamental to pay specific attention to these issues as "achieving good usability in accessing the services is not straightforward" (Karvonen & Lindqvist, 2007, p.549). It is suggested to add further antennas and allocate more bandwidth during events with a high turnout especially at the exhibition center, which has very high usage peaks during events. Users in fact expect a certain standard of quality (Wong & Clement, 2007). A good quality service is also one of the best ways to promote the network and its APs through word-of-mouth promotion.

3) A successful MWN has to be ***promoted through different channels*** in a targeted way to raise the awareness of different publics. Wi-Fi areas should for example be indicated with panels and marked on city maps but can also be promoted online informing both tourists and citizens about the availability of a public Wi-Fi network. Hotels and tourist offices might also contribute to awareness raising by informing visitors about the availability of public Wi-Fi access and its functioning.

4) A MWN can be used to ***promote tourist attractions and attract visitors***, if a Wi-Fi area is set up near to an attraction. Wi-Fi is in fact an important factor in attracting people to a location (Forlano, 2008b; Forlano, 2010). A landing page with information on the tourist attraction can further improve the visitor's experience. Another way to favor the reciprocal promotion of public Wi-Fi access and tourist attractions is to indicate the city's Wi-Fi areas on a city map so that visitors can easily locate and reach them.

5) ***Making the city's MWN available also to small businesses*** located in one of the Wi-Fi areas allows reducing the number of Wi-Fi networks. Micro-players can take advantage of an already consolidated solution without having to set up their own Wi-Fi network. This solution is advantageous also for users, who can stay connected to one and the same network instead of having to continuously switch between different Wi-Fi networks while moving around the city. However, this presupposes a high service quality of the MWN with good speed, enough bandwidth and no downtime.

6) Last but not least, the city has now empirical data to identify areas where to ***extend the existing MWN*** such as, for example, parks, tourist attractions, recreational areas or schools. It is important that the area is relevant for at least one of the identified user groups and is easily accessible and possibly familiar to potential users. Focusing on specific, well-selected locations is in fact more fruitful than covering also spaces in between (Schwab & Bunt, 2004), as past research showed that users are not very mobile and tend to access the network mostly from the same APs/Wi-Fi areas (Blinn et al., 2005; Henderson et al., 2008; Hsu & Helmy, 2005; Kotz & Essien, 2002; Kotz & Essien, 2005; Ojala et al., 2005; Ojala et al., 2008; Schwab & Bunt, 2004; Tang & Baker, 2000; Zola & Barcelo-Arroyo, 2011; Zola & Barcelo-Arroyo, 2013). However, the areas where to provide public Wi-Fi access might be different from city to city depending on political, economic, cultural and societal factors.

By implementing some or all of the above-mentioned steps, a city can proactively take advantage of its MWN in order to achieve a "Policy-Driven Electronic Governance" (Janowski, 2015, p.425) favoring its policy, economic, cultural and societal development through the deployment, integration and active use of ICTs. Providing public Internet access in public spaces thus contributes to the city's endeavor of becoming increasingly "smart."

5.3.3 Some general policy recommendations:

The previously mentioned social and practical implications can be summarized in the following more general policy recommendations for both CWNs and MWNs:

- ***Network extension*** is of primary importance especially for CWNs as they rely on the concept of "critical mass", that is the more people share their home Internet connectivity with the community the more valuable the community actually becomes for all its members. As the study on Fon shows, to build a community of sharing members it fundamental to foster also community values (reciprocity, social interaction, involvement) besides purely utilitarian aspects.
- One way for communities and municipalities to extend the range of their public Wi-Fi networks is ***creating collaborations***. Such collaborations can for example be:
    - between ***communities and municipalities*** as municipalities usually cover more central urban spaces and communities more residential areas. From this point of view the two Wi-Fi network types would actually perfectly complement each other and allow creating a much larger network extensions making the networks more valuable for community members, citizens and travelers.

    - between a ***community and ISPs***, where the ISP includes the Wi-Fi sharing solution into their service offer. This allows amplifying the potential user base drastically as it automatically includes all customers of the ISP. This is in fact the way Fon has chosen to go for their future. They do not rely anymore on individual users but acquire users through collaborations with ISPs.
    - between ***communities/municipalities and local businesses***, so that not each single small business in the city has to build its own Wi-Fi network but that one common public large-scale Wi-Fi network can be used. This is preferable also from the point of view of the user who actually has to sign into only one network and can connect to the Internet using the same Wi-Fi network from different locations.
- Invest in a ***high quality service***, which is easy to use (simple registration procedures and login processes, clear instructions, single-sign on, etc.) and has enough bandwidth allocated in order to guarantee a good quality experience also when several people are consuming multimedia contents. Network downtime should be avoided as much as possible. To guarantee such a service regular maintenance is necessary. The availability of a public Wi-Fi network in a city usually has a positive effect on how the city is perceived and is generally highly appreciated by visitors and locals. However, bad experiences due to low quality services may cancel these positive effects and create disappointments. It is fundamental that this is avoided, else all the initial investments in the network become vain, people will not use the network anymore and thus it will not be possible to take advantage of beneficial effects and synergies the public Wi-Fi network offers.
- ***Use the public Wi-Fi network to promote the territory*** and vice versa. Public Wi-Fi networks can be used to promote for example tourist attractions by providing information about the attraction on the landing page and to attract visitors to an attraction. Eventually further services, favouring tourism could be provided like for example "shoot a selfie with Lugano's cactus and share it with your friends" or "take a picture of your favorit place in the city and share it on social networks".
- Be ***service oriented*** and try to make people's life easier by taking advantage of the public Wi-Fi network. Providing different landing pages to different publics (e.g. leisure travelers, business travelers, locals) is for example a way to provide users immediately those contents that are most relevant for them.

In the introduction the following two questions were raised: "***Why is it still so difficult to find connectivity?***" and "***Why is public Wi-Fi often so bad?***" Now, even though they were not part of the research questions of this dissertation, they are interesting questions. The results of this dissertation were not able to fully answer them. However, it is expected that

implementing some of the above suggested policy recommendations will contribute to more usable, user-friendly and better performing public Wi-Fi networks making access to Wi-Fi connectivity easier and more ubiquitous. This thesis further shows that a ***careful design and planning*** of Wi-Fi networks prior to their implementation with an analysis of potential users and their practices and needs, helps creating Wi-Fi networks more in line with user expectations and in places where they are actually needed. Creating public large-scale Wi-Fi networks composed of various disjoined and dislocated Wi-Fi areas/APs that however share the same SSID and authentication might be a reasonable solution. Furthermore it is important to consider that ***regular maintenance activities*** are just as important as initial design and planning of the network. These activities need to be planned and a budget has to be allocated to them. Else the performance and service quality of the network deteriorates over time. However, future research is needed to further investigate and fully answer these two important questions.

5.4 Limitations

Researchers were able to collect only a ***limited number of survey answers*** of active Swiss and foreign Fon members (especially considering the community's large size) because of the difficulty in identifying and contacting them. Fon agreed to promote the survey to Swiss Foneros in one of its newsletter and to advertise it through the Fon Twitter channel and its official forum to reach also foreign Foneros, but did not want to inform its members in a more targeted way (e.g. individual e-mails, newsletter to Fon members of other countries).

In the study's theoretical implications, the results of this study on hybrid CWNs have been compared to those of previous studies on pure CWNs. Still, a direct comparison of these results is not that easy as the studies have been conducted at different times, in different geographical areas and cultural backgrounds, and used different methodologies. Hence, it is ***difficult to say whether the differences really come from different community types*** (pure and hybrid) or if they are the result of cultural differences or different maturity stages (pure CWN have earlier origins and attracted more tech-savvy early adopters, while hybrid CWNs entice more practically-oriented late adopters).

The study on "WiFi Lugano" analyzed one-year data. However, ***data on three winter months*** (January 22 – April 22) ***are missing,*** as the network has been inactive because of technical problems. It was thus not possible to draw a complete picture of the impact of seasonality on usage.

The mobile survey, placed on the landing page of "WiFi Lugano", contained mainly ***multiple-choice questions***, because this was considered easier and faster for respondents to reply (which was a fundamental prerequisite that users even answered). However, in this way categories have already be given by the researchers and it was not possible to

identify new ones. The survey thus did not allow gathering information on more atypical usage practices.

It is expected that people who connect to a MWN, actually want to get access to connectivity as fast as possible and do not want to invest much time answering a survey. Even though it was clearly stated that the survey was not mandatory, some people did not understand it and complained about having to fill in a survey in the comments. This might have pushed some respondents to quickly fill in the survey, choosing random answers and thus negatively influencing ***data accuracy***.

Furthermore, placing the mobile survey on the landing page of "WiFi Lugano", allowed collecting ***data only from those users who were able to successfully connect*** to the network. Potential users, who were unable to, or chose not to connect, are thus not represented in this study.

As the mobile survey did not allow collecting the ***MAC address*** of the devices, from which the survey was answered, it was challenging matching the two data sets (survey-record with corresponding log-entry). The matching had to be based on the connection and survey-start time/date, which did not always match 100%. Hence, the matching process could not be fully automated, was time consuming and certainly less accurate than relying on the MAC address as unique identifier.

As at the time of study most APs of the "WiFi Lugano" network shared the same IP address and those with different IP addresses (e.g. Exhibition center, Stadium) were dislocated in distant areas, it has been decided ***not to study mobility of single*** users within the range of the MWN.

Radiation and ***data tracking*** problems have not been addressed in this study as they were out of the study's scope

5.5 Future Research Lines

To be able to better compare motivations and participation in pure and hybrid CWNs, it would be interesting to conduct a new study, similar to this one, but on ***pure communities*** in Switzerland.

As Fon's strategy has significantly changed in the years after this study, it could be of interest to conduct a ***similar study under the new conditions*** and see whether the changed strategy had some influence on user motivation, participation and user profiles. As Fon gave up social participation nearly entirely, it is expected that member motivations have shifted even more towards utilitarian motivations. Idealistically, socially and intrinsically motivated members might have left the community network and other more goal-oriented members might have joined. Likewise, it would be insightful to conduct a ***similar study with other hybrid communities*** inside and outside Switzerland (e.g. UPC Cablecom) and

see how member motivation and participation are alike or differ from those of Fon and thus, to understand whether the results of this study can be generalized to all types of hybrid CWNs. A further step would be to see if members of ***other types of online communities*** such as P2P networks, open source projects, community of practices, social networks, user-generated content communities and other forms of web 2.0 collaborations have similar motivations and barriers and also whether they have different types of participation.

During 2017, "WiFi Lugano" has been extended and improved by placing additional APs and replacing old ones with newer, more performing ones. It might be of interest to ***repeat the study on "WiFi Lugano"*** in one or two years' time in order to see how usage will evolve over time and whether and how the improvement actions will influence usage. At that point, it might be also possible to study user's mobility, provided that the new APs have distinct IP addresses. Future studies on "WiFi Lugano" should also try to include the voice of those ***people who are not using the MWN*** and hence, try to understand the reasons behind the non-use. Moreover, stakeholders' motivations to provide a MWN might be investigated.

A further approach could be to ***replicate the study in other Swiss cities*** having a mature MWN such as for example Luzern, Baden, Geneva or Aarau (or even other European cities) in order to compare the results and see which ones can be generalized to all types of MWNs and which ones depend on local, cultural, geographical, political or economic factors. In order to be able to compare Wi-Fi networks, it would certainly be beneficial to study how ***policy and regulations of different countries and regions actually influence the deployment and usage of public Wi-Fi networks***. It would for example be interesting to deepen how policy in the U.S., Canada and the EU evolved, how their current state of regulations are and how it compares to Swiss policy. Especially the "no roaming in EU" policy might in the future impact on the use of public Wi-Fi networks. However, it has to be mentioned that Switzerland is not part of the EU and as such still has high roaming rates for both Swiss people going abroad and foreign visitors coming to Switzerland. It is true that nowadays providers start including some amount of roaming data in contracts but customers still pay for it through their monthly fee. It will be interesting to see how the Swiss market evolves and if there will be some rules to adapt to the EU roaming regulations.

In section 2.5, this study distinguishes between different combinations of provider-, municipality-, user- and 3rd-party-driven public large-scale Wi-Fi networks. In this dissertation, only a user-, provider- and 3rd-party-driven network (FON) and a municipality-, provider- and 3rd-party-driven network ("WiFi Lugano") have been analyzed in detail. Studying usage and motivation of public large-scale ***Wi-Fi networks with other combinations of driving forces*** might allow identifying similarities and

differences and to see whether driving forces influence usage, motivation and participation, and in which way.

Research should further investigate strategies on ***how cities can take advantage of their MWNs***. A forthcoming study (Picco-Schwendener et al., forthcoming) has already explored the possibility of "WiFi Lugano" to provide customized landing pages for different audience types. Based on the distinction between business travelers, tourists, and locals and based on their network behavior it was possible to define classification rules which enable the system to assign future users to one of the three user groups only with the help of data known at the moment of connection and thus, to provide each user group an appropriate landing page.

In addition, future studies should investigate how ***MWNs and CWNs*** (especially hybrid CWNs) might ***complement*** each other and identify ways of collaborating to provide users and members with even better services and networks that cover vast and different areas (urban, residential, etc.). To this scope a deeper analysis of the ***current state of business models for public Wi-Fi*** could be beneficial, eventually also analyzing differences in markets such as Switzerland, the EU, the U.S. and Canada.

Another interesting line of research might be studying the ***evolution and development paths of CWNs and MWNs*** particularly using contextual factors and keeping in mind Fon's strategy change and "WiFi Lugano's" extension and upgrade.

The two cases analyzed in this thesis used two different perspectives: the Fon case focused on the ***supply*** side that is on the provision of Internet and less on the user experience, while the Wi-Fi Lugano case mainly examined ***demand*** for pubic Wi-Fi. It was beyond the scope of this thesis to ***examine both the demand and supply perspective*** within a single case. However, combining both perspectives in the analysis of one single Wi-Fi network could be of interest for future studies.

Finally, it might be of interest to understand how public Wi-Fi networks ***influence urban public space*** in general but also to go beyond that and expand the impact of public Wi-Fi networks beyond infrastructural issues of urban public spaces to cover also technology, social, economic and policy dimensions of smart cities.

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Appendixes

Appendix 1: Interview Guide for Swiss Fon Members

Introduction

- Presentation of interviewer (name, working for USI, doing PhD, working on Wi-Com Project)
- Presentation of Wi-Com Project
- Show interviewee the value of his/her testimony
- Inform about confidentiality (anonymization and standardization of answers)
- Ask permission for registration and explain importance of audio registration

Warm-up

- To start it would be nice if you could tell us sth about your person (occupation, interests, relation with technologies)

Part 1 – FON participation

1. **How did your experience with FON begin?**
   - 1.1 How did you first hear about FON? (when, who told you, what did you know)
   - 1.2 What were your motivations to join FON?
     - Checklist of motivations (1st let them talk without mentioning possible motivations)
       - Idealistic rewards, enjoyment, social, incentives, promotional aspect (promote a place or company)
   - 1.3 What kind of concerns did you have before joining?
   - 1.4 What kind of Fonero are you (Bill, Linus, Alien)
     - How did it come that you have chosen that Fonero type?
   - 1.5 What happened in the time between you 1st heard of FON and you actually joined?
     - How much time passed?
     - When did you join?

2. **What about your experience offering Internet Access to others:**
   - 2.1 How do you decide whether to turn your Fonera on or off?
     - How often is your Fonera on / active?
   - 2.2 How did you decide on how much bandwidth to dedicate to FON? (Fonera set-ups)
   - 2.3 What did you do to increase the signal quality / to make your access point more attractive? (Fontenna) → effort
     - Did you do something in particular?
   - 2.4 How important is it for you whether your access point is used by other Fonersos or not?
     - Is it used? (→ maybe look at data with him at the end)
   - 2.5 What do you think of the position where your FON Spot is?
     - Is it in a good position? (city center, near to a park, near to a place of interest)
     - Usability (does it reach the street; bench nearby, …)

3. **What about your experience accessing Internet using other FON Spots:**
   - 3.1 In what occasions did you use a FON Spot? (travel, leisure, work)
     - Where (abroad, CH, park, street)

- How often did you connect with success?
- Public FON Spots? (café, hotel, park,…)
- When

⇨ **If never used**: In what occasions would you like to use a FON Spot to access Internet?

3.2 What devices do you use to access a FON Spot?
3.3 How do you detect the signal of a FON Spot? (print maps, wifi detector,…)?
3.4 What for do you want to access Internet through FON Spots? (email, websites, skype, …)
3.5 What difficulties did you encounter when trying to access a FON Spot?
3.6 What are your reasons / motivations to use FON Spots instead of other ways of accessing the Internet (Public Wi-Fi Points, 3G)
3.7 If you cannot connect to the Internet through a FON Hotspot what other, alternative ways do you use to connect?

4. What about your Community Experience of FON (interaction with other FON members):

Community as Interaction, Socializing, Exchange of Knowledge and Ideas

4.1 Tell me something about / How is your relation to other Foneros?
4.2 How do you interact with other Foneros?
- Forums? → Which ones
- Meetings?

4.3 How important is community in a Wi-Com for you?
4.4 Do you feel being part of a community?
4.5 Which other wireless communities do you know?
4.6 Are you part of other Wi-Coms / Communities?

5. What do you expect from being part of FON?

5.1 What do you expect from FON as a company (information, maps, feed-back)?

6. How do you evaluate your FON participation over time?

6.1 How did your participation change over time?
6.2 How did your motivations change over time?
6.3 How did your attitude towards FON change over time?
6.4 Is being a Fonero what you expected it to be?
6.5 What about your concerns now?
6.6 Did you ever earn some money?

7. Why would you / would not suggest FON to other people?

7.1 What do you like most of FON?
7.2 Is there something you don't like of FON?
7.3 Why do you think that the number of Foneros is still quite small?
- What do you think are other people's fears?

Part 2 - Understanding Wi-Fi usages of mobile device holders

8. What is your experience using Wi-Fi with your mobile device?

8.1 What mobile devices do you use?
8.2 In what situations / occasions do you use Wi-Fi (instead of 3G)? → context
- Holiday, business trip, work, home, university…
- Where (in your town, country, abroad, inside vs outside, public places)?
- How does your Wi-Fi usage differ depending on the context you're in (holiday, office, home, abroad)?

8.3 What do you use it for?
    - Content, Interactions, Skype, Facebook, Apps,…
8.4 Can you tell me about your last experience using Wi-Fi with your mobile device?
8.5 What was your best (a good) experience using Wi-Fi with your mobile device?
8.6 What was your worst experience?
8.7 What are the major problems you encountered using Wi-Fi with your mobile device?
8.8 How often do you connect through Wi-Fi?
8.9 How long do you usually stay connected?

9. How important is it for you to access the Internet with your mobile device?

10. How do you usually connect to the Internet with your mobile device and why?

10.1 3G, Wi-Fi, Cable?
10.2 Why? (advantages of Wi-Fi over 3G / cable)
10.3 Which one do you prefer?
10.4 How often and for how long?

11. What type of Wi-Fi accesses have you ever used?

(home, municipal, restaurant, not protected private)

11.1 How did they work?
11.2 Do you know other Wi-Fi access points, which you have never used?
11.3 Can you tell me something about the advantages and disadvantages of the different types of Wi-Fi accesses?

12. What are your expectations towards Wi-Fi?

12.1 Availability (where, when); Signal Quality; Ease of access (distance, passwords); Cost of access?
12.2 How important are the various aspects to you?

Closing Question

- "Would you like to add sth to what we have talked about?" "Did I forget to ask you sth important?"
- In case we have other questions, or we forgot sth can we contact you later on by phone or email?
- Do you know other FON members who we might ask for an interview?
- Can we contact you again in 1 year time to ask you how your FON experience evolved?

Checking Demographic Data

- **Demographic Data:** First Name, Last Name, Email, PhoneGenderAge, What kind of Fonero: Bill, Linus, Alien

1-shot question

- What are your motivations to participate at FON?

Appendix 2: Survey Addressed to Fon Members

Membership	
1	Are you currently a member of Fon ?
2	When did you join the Fon community ?
3	What kind of Fonero are you ?
4	What are your future intentions about Fon ?
	I intend to remain an active Fon member in the next 12 months
	I expect to use Fon in the next 12 months
5	Do you know other wireless communities ?
6	Which ones?
7	Do you participate in (are a member of) some of them ?
8	Do you participate in Open Source communities?
Contribution and usage	
9	Please indicate how much you agree with the following statements regarding your contribution to the Fon community:
	My Fonera is always on and connected to the Internet
	My Fonera is installed in a way that it is easily accessible by other members
	My Fonera reaches attractive or frequented public places (parks, cafés etc.)
	I interact with other community members (Fon messages, forums, meetings)
	I promote or recommend Fon to potential new members
	I volunteer my skills to help members or improve the Fon offering
10	Please answer the following questions, if possible by looking at your Fon statistics on your account:
	How many active Fon Spots do you have ?
	How many Fon Spots did you access in the last 12 months?
	How many users did use your Fon Spot in the last 12 months ?
	How many messages did you receive from other members in the last 12 months?
11	Which bandwidth limits have you set for your Fon Spots ?
12	Please, indicate how often you use the following applications when you are connected to a Fon Spot of another member:
	Email or chatting
	Searching local or touristic information
	Web browsing
	Voice communication services (VoIP, skype calls, ...)
	Bandwidth-consuming applications (audio/video streaming, gaming, ...)
	File sharing (Peer to Peer)
13	Which devices do you use to connect to a Fon Spot ?

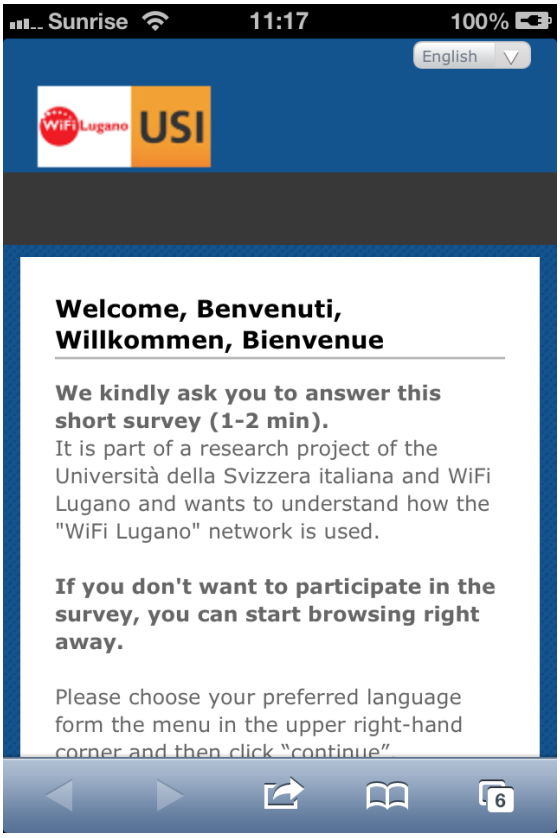
	Notebook / netbook Notebook / netbook
	Tablets / iPad Tablets / iPad
	Mobile phone / smartphone / PDA Mobile phone / smartphone / PDA
	Other (es. gaming devices) Other (es. gaming devices)
14	Please, indicate how often you perform each of the following activities
	Using Fon or other WiFi spots (in my country)
	Using GPRS or 3G data networks (in my country)
	Using Fon or other WiFi spots (abroad)
	Using GPRS or 3G data networks (abroad)
Motivations and experience	
15	Please indicate how much you agree with the following statements :
	1. Participating in Fon is fun
	2. I would describe participating in Fon as interesting
	3. Participating in Fon is quite enjoyable
	4. Participating in Fon allows me to learn or apply technical skills
	5. I am interested in Fon from a technical viewpoint (to see how it works)
	6. I would like a chance to interact with other Foneros more often
	7. I feel close to the other members involved in the Fon community
	8. I feel like I can trust other people in the Fon community
	9. Being appreciated by other Foneros is important to me
	10. I feel that it is important to receive recognition for my contribution to the community
	11. Participating in Fon is useful to get free Internet access when not at home
	12. Participating in Fon enables me to get free Wi-Fi access worldwide
	13. Participating in Fon allows me to get a cheap router
	14. I would like to earn some money in exchange for the connectivity I offer
	15. It is important to get some compensation for sharing with the community
	16. Participating in Fon allows me to do something for a cause that is important to me
	17. I participate in Fon because I feel it's important to give connectivity to others who need it
	18. I like the idea of sharing and helping others through my involvement in Fon
	19. Participating in Fon makes me feel like a good person
	20. Participating in Fon makes me feel useful
	21. Participating in Fon is a way to support an alternative to mobile operators
	22. I like sharing in order to help better exploiting existing infrastructure
	23. I can use other people's access points, so I desire to give back
	24. I know other Foneros share their access with me, so it’s fair to share my connection too
	25. When I contribute to the Fon community, I expect others to do the same

	26. Since other Foneros can use my access point, I expect to be able to use theirs
16	Please indicate how much you agree with the following statements concerning your involvement in Fon
	The Fonera is easy to setup
	It is easy to find other Fon Spots
	Fon Spots are easy to use

Appendix 3: Scales used for Survey Adressed to Fon Members

#	Questions	Scales
1-3	Membership	
4	behavioral intention	UTAUT behavioral intention (Venkatesh, et al., 2003)
5-8	Other communities	
9	Contribution	Social capital contributions (Abdelaal, et al., 2009)
10	Community network use	Community activities (Bina, 2007)
11-14	Fon/Wi-Fi behavior	Developed from our interviews
15.01-03	Intrinsic motivation	IMI enjoyment/interest (Ryan, 1982)
15.04-05	Competence	BPN competence (Bina, 2007)
15.06-08	Relatedness	IMI relatedness (Ryan, 1982)
15.09-10	Recognition	VFI recognition (Esmond & Dunlop, 2004)
15.11-13	Usefulness	IMI value/usefulness (Ryan, 1982)
15.14-15	Revenue sharing	Rewards (Bina, 2007)
15.16-18	Values	VFI values (Esmond & Dunlop, 2004)
15.19-20	Self esteem	VFI self-esteem (Esmond & Dunlop, 2004)
15.21-22	Idealistic motivation	Based on interviews (Camponovo & Picco-Schwendener 2001)
15-23-26	Reciprocity	Reciprocity (Bina, 2007)
16	Effort	UTAUT effort expectancy (Venkatesh, et al., 2003)
17	Concerns	Concerns (Matthew Wong, 2007)
18	Satisfaction	
19	Fon perceptions	Based on interviews (Camponovo & Picco-Schwendener 2001)
20-27	Member data	

Appendix 4: Mobile Survey Addressed to “WiFi Lugano” Users



(1) What type of device are you currently using?

- ❍ Laptop / Notebook / Netbook
- ❍ Smartphone
- ❍ Tablet PC (e.g. iPad)
- ❍ Other (e.g. Game Console)

(2) What are you going to do online? (multiple choices allowed)?

- ☐ Checking email
- ☐ Looking for tourist information (hotel booking, museums, …)
- ☐ Looking for free time activities / events
- ☐ Using maps (for orientation)
- ☐ Connecting to social media / social networks
- ☐ Other web browsing
- ☐ Voice over IP calling (e.g. Skype)
- ☐ Using / downloading apps (e.g. video, audio, games, …)
- ☐ Other (e.g. file sharing)

(3) Where are you currently in Lugano?

- ❍ City-Center / Lake front
- ❍ Exhibition Center (Padiglione Conza)
- ❍ Casino Lugano
- ❍ Lido
- ❍ Stadium Cornaredo
- ❍ Airport Lugano-Agno

(4) Where are you from?

- ❍ Lugano
- ❍ Ticino
- ❍ Switzerland
- ❍ Other Country

(5) You are in Lugano for ...

- ❍ Day Trip (not overnight)
- ❍ Tourism (at least 1 night)
- ❍ Work (regularly work in Lugano)
- ❍ Business Trip
- ❍ Study
- ❍ Shopping / Errands / Going for a walk
- ❍ Event / Festival
- ❍ Other

(6) Length of your stay?

- ❍ 1 day
- ❍ More than 1 day

(7) Do you have a data contract (3G) with a Swiss telecommunication company?

- ❍ Yes
- ❍ No

(8) In this moment are you ...

- ❍ Alone
- ❍ Together with other (e.g. friends, family members, colleagues, …)

(9) Gender

- ❍ Female
- ❍ Male

(10) Year of birth ----

(11) Comments / Suggestions