Municipal Wi-Fi value network configurations: impact of motivations, pricing and topology

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***Abstract*—This paper is motivated by the fact that municipal Wi-Fi is not an unambiguously successful concept and research to the determinants of a successful case is desirable. Municipal Wi-Fi is the idea to let a cloud based on Wi-Fi technology span the municipality. Our research figures as a prestudy. The author believes that for the definition of what is a successful case the principal motivations of the leading actors should be taken into account. We therefore search for a classification of municipal Wi-Fi cases based on their value network configuration and search for the relation with leading motivations, topology and pricing model. Based on a sample of 19 cases we find four types of cases: the integrator model, the public service model, the wholesale model and the community model. For each of these types one prototype case is described from the Benelux. We observe that community models have a more user centric approach, focussing on offering their users universal access and lower access fees, public service models are initiated by the local municipality and focus on the indirect effects incurred from the network and the integrator and wholesale models are centred around commercial parties aiming to make financial profit.**

I. Introduction and Motivation

Municipal wireless internet access is a concept that grew steadily since the years 2004-2005 [1]–[3]. The idea to let a wireless cloud span (parts of) the municipality is believed to benefit the city and its population in various ways [1], [4]–[7]. Not only do these networks provide both fixed and mobile wireless internet access, but they also generate several indirect benefits. Performant wireless networks could entice business settlement; it is believed that universal internet access can bridge the digital divide; wireless networks can help governments and other local public institutions become more efficient and cost effective; etc...

Multiple networking technologies are available for the deployment of these municipality wireless networks. On the one hand, there are the ones that are based on the standards of the Institute of Electrical and Electronics Engineers (IEEE) and which led most notably to Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave access (WiMAX). On the other hand, there are the cellular technologies that are based on specifications of the 3rd Generation Partnership Projects (3GPP and 3GPP2) which led to GPRS, UMTS, CDMA2000, HSPA, LTE, LTE-Advanced etc...

The authors believe that Wi-Fi, the focus of this paper, is a viable technology, both economically and technically, but do not intend to put it or any other technology forward as the most appropriate choice, a discussion which is outside the scope of this paper. Wi-Fi clearly has its merits: the different Wi-Fi standards are relatively inexpensive and according to [3] entail projects that cost significantly less than the existing cellular networks [3], they are also widely adopted and already embedded in many end devices: 90% of modern laptops [4] and 92% of modern mobile phones [8]; but Wi-Fi also has its drawbacks: despite having physical data rates of 150-600 Mbps for the 802.11n standard [9], which compare well with e.g. the specifications of IMT-2000 [10] and IMT-Advanced [11] adequate provisioning of Quality of Service (QoS) is lacking.

The history of municipal Wi-Fi projects can be captured by a change in their leading motivations [2]. Early initiatives had the local public services in mind; e.g. providing communication facilities to the city's fire department and other emergency response teams. Later on the idea emerged to let these networks provide a low cost alternative for people's domestic broadband connection. In this way these networks competed directly with the existing Digital Subscriber Line (DSL) and Hybrid Fibre Coax (HFC) operators. Finally, with the large increase in mobile internet usage, following the large scale adoption of smartphones, municipal wireless networks became perceived as an alternative to the aforementioned cellular technologies as well.

Notwithstanding the technological and economic feasibility, municipal Wi-Fi is not an unambiguously successful concept. [3], [12], [13] argue that municipal Wi-Fi has failed or is bound to. They point to incumbent competition, regulatory and political issues, financial hurdles and other problems. Despite these issues cases do exist that lead to more optimism with experts, examples thereof are Minneapolis and Oklahoma [14], or engage a large community of users such as Leiden [15] and Berlin [16] (cfr. infra). Thus, instead of dismissing the option entirely, it is desirable to research and identify those factors that contribute to the success and failure of municipal Wi-Fi cases. This paper argues that when defining whether a case has been successful or not one should take into account more than the economic sustainability and profitability that is of essence in a commercial case. The paper thus aims to figure as a prestudy by defining a categorization of cases based on their value network configuration and related to the initiator's

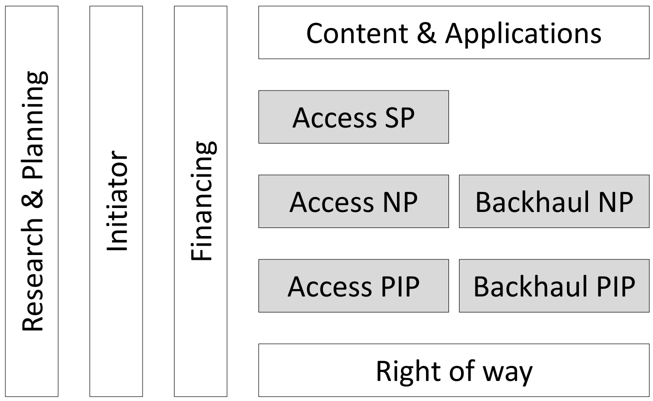

Fig. 1. Roles in a municipal Wi-Fi initiative

leading motivations.

The remainder of the paper is organized as follows. Section II treats the parameters we use for the description of cases. It introduces the categorization of value network configurations and explains the other case related parameters. The section is followed by section III which analyzes the relation between these parameters and the value network configuration. Finally, after having illustrated the analysis with four prototype cases from the Benelux in section IV, section V concludes with our most important observations.

II. Parametrization of the cases

A sample is selected of 19 municipal Wi-Fi cases, listed in table I, that are compared in a search for similarities and differences. We use a list of parameters which aims at providing a structured framework for the description of wireless cases and contains information on geography, demography, topology, motivations, value network and business model as defined within the IBBT-project GreenWeCan. For this analysis we focus on four criteria of this list: the value network configuration which is at the base of the categorization, the leading motivations, the pricing model and the topology that is used. The remainder of this section explains these parameters in detail.

A. Categorization based on the value network configuration

A set of business roles is defined following the work in [17] on FTTH cases. These roles are depicted in figure 1 and can be defined as indivisible groups of business activities that are required in a municipal Wi-Fi project. The value network configuration of a specific case is defined as the mapping of the project's various involved actors on these different roles, i.e. who is responsible for which part of the network. These actors can either be public institutions, commercial organizations or individuals.

A distinction is made between the network roles (grey) and the peripheral roles (white) and within the network between the wireless access network and the backhaul network. The access network is defined as the network that is generated by the different access points, it is the network the end user connects to. The backhaul network indicates the network that is used to connect the access points to the network provider's central office.

The following network roles are identified for the access part of the network:

- **Physical infrastructure provider (PIP):** The PIP owns the network equipment such as base stations and antennas. It provides this equipment to the NP.
- **Network provider (NP):** The NP is responsible for the network's operations, maintenance and central office. He in turn provides bitstream or wholesale access to the SP.
- **Service provider (SP):** The SP is concerned with reselling the internet access to the network's end users.

The backhaul network roles are analogous except there is no SP since no direct access is sold to the end user. Next to the network roles we have the periferal roles, these are:

- **Initiator:** launches the idea of developing the network in the first place. Can deploy the network on its own, subcontract it or figure as anchor tenant.
- **Research and Planning:** helps the initiator in analyzing technical and economic feasibility of the project and provides fiscal and legal services, e.g. writing out a tender.
- **Financing:** responsible for the network investments.
- **Right of way provider:** owns the buildings or other non network infrastructure on which the PIP is allowed to place its infrastructure.
- **Content and application provider:** provides network specific content and applications. Possible examples are a mobile touristic information platform, a parking space monitor or an e-government window.

The key question in the definition of the value network configurations is who is responsible for the network roles, the financing and the projects initialization. The remaining peripheral roles are ignored in the classification since they are of lesser importance. We introduce four configurations in which some roles are fixed and some are free to vary over the actors. This section is limited to the definitions of the configurations, the analysis of how they operate is treated in section III.

1) Integrator model (figure 2): In the integrator model the network roles: PIP, NP and SP, are the responsibility of a single integrating actor. This is a commercial network operator who invests into the network and exploits it. In the integrator model it is not fixed who takes the role of initiator of the project, it can be the network operator as well as any other stakeholder.

2) Public service model (figure 3): The public service model is similar to the integrator model in that one party, private or public, is the sole responsible for the network roles.

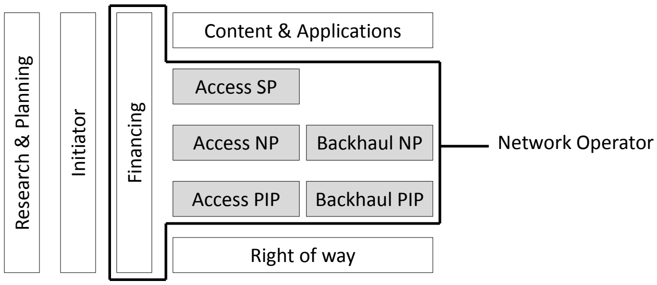

Fig. 2. Value network configuration of the integrator model

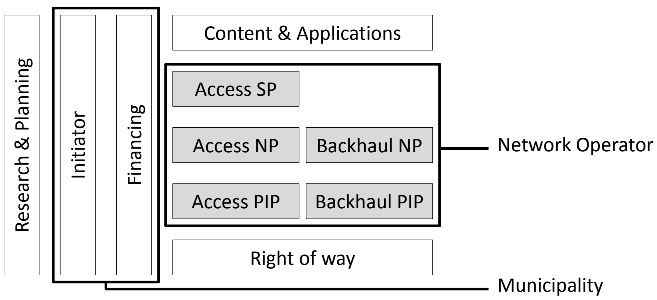

Fig. 3. Value network configuration of the public service model

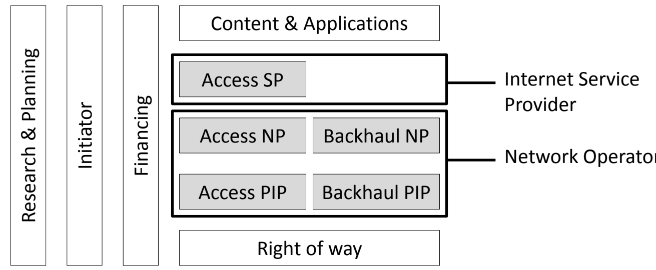

Fig. 4. Value network configuration of the wholesale model

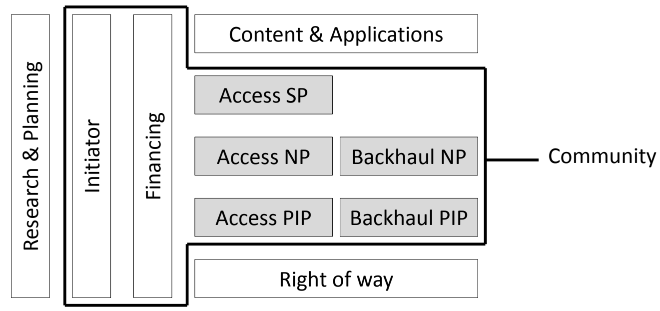

Fig. 5. Value network configuration of the community model

The difference lays in the fact that in this value network configuration the initiative and investment into the project are the responsibility of the local municipality.

3) Wholesale model (figure 4): The wholesale model is a value network configuration in which two or more players are fulfilling the network roles. One network operator is responsible for the physical infrastructure, operations and maintenance of the network (PIP & NP). Contrary to the integrator model however, this party does not function in the role of service provider. In this configuration the SP role is performed by one or several different commercial internet service providers (ISP) that buy wholesale access from the network operator and sell this to the end user. Like in the integrator model, no constraints are placed upon who performs the role of initiator.

4) Community model (figure 5): In the community model, the Wi-Fi project is not initiated by a formal organization but by a community of volunteers. This community takes responsibility for all the roles related to network and no role is limited to a single actor or participant. Even the project's investments are completely financed by the community.

B. Description of the different motivations

The evolution of municipal Wi-Fi shows that the motivations driving the initiator and other actors can be diversified. This is confirmed by table I. If we look at what motivations play in the different cases we can distinguish four main motivations: universal access, lower access fees, various indirect benefits (influencing social cohesion (Soc), the local economy (Ec) and innovation (In)) and profit. The latter can implicitly be inferred from the pricing strategy (fourth column).

1) Universal access: Some municipal Wi-Fi networks offer internet services for which no alternative was at hand yet. The network caters to unsatisfied needs. Certain desolate and sparsely populated regions, for example Denmark's Djursland, are not served with residential broadband since they are not financially interesting to the incumbents. In these cases, Wi-Fi networks with wireless backhauling can prove a solution.

2) Lower access fees: The motivation of low cost, or free, networking is the belief that the municipal Wi-Fi network can be used as a cheaper alternative to a currently existing offer. The difference with the previous motivation is the presence of an existing alternative network, be it residential broadband through DSL, HFC, WiMAX or FTTH or mobile internet via cellular technology. In this sense municipal Wi-Fi can be in direct competition with the incumbents. Note that broadband incumbents use Wi-Fi in inter platform competition with mobile incumbents as well.

3) Indirect Effects: Indirect effects are those positive effects that result from the presence of (free) wireless networks but cannot directly be internalized by the project initiator or the core networking players. Three categories of indirect effects are relevant with respect to municipal Wi-Fi: economic, social, and innovation stimulating indirect effects. Examples of economic benefits are improved municipal efficiency through e-government services, cost reduction on government communication costs, attraction of tourists and businesses and improved competition on the telecom market. Social benefits are sought in bridging the digital divide, i.e. improving the connectivity of the poor by offering them low cost internet access. Providing cheap services to stimulate the educational, cultural and other nonprofit sectors is considered as well. Innovation stimulating benefits aim at improving the regions innovatory position by attracting more high tech businesses and allowing the network to function as playground for technological experiments.

4) Profit: Especially when the initiator is a private party profit cannot be overlooked as a fourth and final motivation. Profit can be raised through sales of internet access and services, but also through advertising (cfr. infra).

It is interesting to note that the motivations also relate to the different actors in the value network. These can be either a public party, e.g. the local government, a private commercial party such as the network operators and service provider or the individual end users. The first two motivations, lower network fees and universal access are rather end-user centric, the motivation of profit on the other hand is rather commercial and the different indirect benefits are most of all taken into account by the local public parties.

C. Description of the different pricing models

With respect to pricing we can clearly distinguish two types of cases. The case where the service provider asks an internet access fee from the end user and the case where the end user, i.e. inhabitants or tourists, can freely utilize the network for internet access. In the latter case, if the service provider or network operator is a commercial party, it generates revenues through contributions from the local government, advertising revenue or both.

In reality multiple hybrid forms exist in which some usage is paid for and other for free. Four main grounds of distinguishing usage forms can be identified: location based, time based, user based and bandwidth based. In the first category the network access is paid, however certain public locations offer free access, e.g. libraries. In the second category some of the users periodically get a fixed allotment of time credits after which access becomes paid for. In some cases a user based distinction is made based on social position. The final category of networks are continuously available for free, but at a low bandwidth rate, improved bandwidth can be paid for. For the remainder of this document these hybrid forms will be called freemium models. Table I lists for each case the pricing model that is used.

D. Description of possible topologies

We distinguish two network topologies: meshed networks and star networks. In a meshed network some of the access points are gateways to the backhaul network, a connection that can be either wired or wireless. The other access points connect to these gateways by hopping along a path of interconnecting access points called nodes. In the star network each access point is immediately connected to the backhaul network through a wired or wireless point to point connection. If we look at table I we can observe that even though star networks occur, meshing is the dominant topology.

Note that different Wi-Fi standards aren't taken into consideration as this would lead to a classification that is highly dependent on the network's rollout year. This approach limits the technological variability to backhauling and internode communication.

III. Linking the Value Network Configuration to the Other Parameters

In the previous section we introduced the categorization based on the four possible value network configurations and described the other parameters that can be used to distinguish cases. We observe that the network roles are either the shared responsibility of a community of end users, integrated in a single actor or jointly operated by a network operator and one or more ISPs. We also identify four leading motivations: indirect effects, profit, lower access fees and universal access. With respect to topology we distinguish mesh networks from star networks and with respect to the pricing model we make the distinction between free, freemium or paid access. Table I lists these parameters for the cases in our sample.

In this section we analyze how the different value network configurations operate and focus on the relation between the value network configuration and the other parameters.

A. Analysis of the integrator model

By looking at the definition of the integrator model that was introduced in section II we note that the role of initiator in the integrator model is left open. Cases in which the initiative comes from the integrator as well as cases in which the initiative comes from the local municipality are possible. The two cases in our sample are of the latter type. Since motivations are strongly linked to the initiator we can make no predictions on what motivations to expect in the integrator model apart from the commercial ambitions of the network operator.

The commercial motivations of the integrator can also be related to the financial structure of this configuration. The integrator is the main responsible for investing in the network and as such wants to earn back the money invested. The primary source of income are sales of internet services. Advertising can be a secondary source. This explains why we see the networks of Cardiff and Brugge opt for the freemium model which is a pricing model that can generate both sales and advertising revenue.

We see no apparent links between the value network configuration and the choice on topology and cannot explain that in the sample all the integrator cases have opted for a star network.

TABLE I
OVERVIEW OF THE CASES

Case	VN Configuration	Motivations					Pricing	Topology	References
Bristol (UK)	Public Service Model		LAF	Soc	Ec	In	Free	Mesh	[18]
Groningen (NL)	Public Service Model		LAF			In	Free	Mesh	[19]–[21]
Paris (FR)	Public Service Model		LAF	Soc	Ec	In	Free	Mesh	[18]
Saint Cloud (US)	Public Service Model		LAF	Soc	Ec	In	Free	Mesh	[18]
San Fransisco (US)	Public Service Model		LAF	Soc	Ec	In	Free	Mesh	[18]
Berlin (DE)	Community Model		LAF				Free	Mesh	[16]
Dharamsala (IN)	Community Model	UA	LAF				Free	Mesh	[16]
Djursland (DK)	Community Model	UA					Free	Mesh	[16]
Leiden (NL)	Community Model		LAF				Free	Mesh	[15], [16]
Turku (FI)	Community Model	UA					Free	Star	[18]
Bologna (IT)	Wholesale Model		LAF	Soc	Ec	In	Freemium	Mesh	[18], [22]
Boston (US)	Wholesale Model		LAF				Paid	Mesh	[18]
Luxembourg (LU)	Wholesale Model	UA			Ec		Paid	Star	[23]–[25]
Minneapolis (US)	Wholesale Model	UA					Paid	Mesh	[26], [27]
Philadelphia (US)	Wholesale Model		LAF	Soc	Ec	In	Freemium	Mesh	[18]
Portland (US)	Wholesale Model	UA	LAF	Soc	Ec	In	Freemium	Mesh	[18]
Sacramento (US)	Wholesale Model		LAF	Soc	Ec	In	Freemium	Mesh	[18]
Brugge (BE)	Integrator Model		LAF	Soc	Ec	In	Freemium	Star	[28]–[30]
Cardiff (UK)	Integrator Model			Soc	Ec	In	Freemium	Star	[18]

Abbreviations:
Universal access (UA), Lower access fees (LAF), Social indirect effects (Soc), Economic indirect effects (Ec), Innovation related indirect effects (In)

Due to their commercial nature, the success and sustainability of these models is primarily a function of the profitability of the private partner and only to a lesser degree of the fullfillment of the initiator's ambitions which on itself is no conditio sine qua non for the network's prevalence. In public private partnerships (PPP's) this might lead to a principal agent problem that should be carefully addressed in the contracts.

B. Analysis of the public service model

The public service model was described similar to the integrator model but with public initiative and investment. The network operator can be either a public institution as well as a private subcontractor leaving open the possibility for a municipality owned network or a PPP in which the municipality, figuring as anchor tenant, is the sole customer of the network. This setup spurs the assumption that the primary leading motivations that are taken into account are the indirect effects generated by the network. If we look at the public service model cases in table I we see that this is indeed the case. However we also see that in every case that fits the public service model the motivation of lowering access fees is listed. This observation is not contradictory to the assumptions as lower access fees can be seen as conductive to network uptake and the generation of indirect benefits.

The domination of the free pricing model among these cases can be linked to the leading motivations and the financial structure of the model. Free access is, as explained in the previous paragraph, beneficial for the network uptake and the resulting indirect benefits and is financially achievable because in this model the network is publically financed.

No explanation is found for the dominance of mesh topology in the public service model.

As the prime motivation in these cases are on low access fees and its incurred indirect benefits the measure of success of these cases should rather than financial profitability be searched in non financial performance indicators such as network uptake, digital literacy, e-government uptake and other ratios. We are of the belief that links should be forged with the literature on indirect effects of wired broadband networks [31].

C. Analysis of the wholesale model

Like in the integrator model, the wholesale model has no fixed actor allocated to the role of initiator. The model does not exclude cases in which the leading actor is, instead of a commercial entity, a public party with more socially oriented incentives. This model can e.g. be appropriate if the belief exists that competition between multiple Wi-Fi ISPs and the cellular or domestic broadband incumbents would reduce the networking prices and thus invoke network uptake and lead to various indirect benefits. The openness of the initiator role is reflected in table I as we see that the listed motivations for wholesale cases are very diversified.

Another similarity to the integrator model is the fact that the wholesale model is a value network configuration with a commercial take. The distinction between the sales oriented ISPs and network operators that is similar to the opened up energy market in which the supplier buys wholesale energy from the producer and sells this to the households would not make sense in the presence of free access. By looking at the sample we indeed observe that no single wholesale case is found that provides access completely for free.

In this model also, the choice of topology cannot be predicted from the value network configuration.

The parallels between the wholesale and initiator model lead to similar definitions of success, which is primarily a function of the financial position of both the ISP and the NP. Measures to be taken into account can thus be found in customer uptake and financial performance indicators.

D. Analysis of the community Model

Initiated by the community of end users, the motivations in a community project are assumed to be user centric, focussing on obtaining universal access or lower access fees. This assumption is reflected in the sample in which the motivations that are listed for the cases Berlin, Dharamsala, Djursland, Leiden and Turku are indeed limited to these two. [16] analyzes the motivations of the community models on an individual level. The distinction is made between techies, idealists and resident users. The first group is interested in experimenting with new technology whereas the second group is motivated by the sense of doing something for the community. The third group is primarily interested in the usage of the network.

The pricing model is in all cases that of entirely free access. This can be sustained because of the way in which the community model is financed. Each volunteer participates in the procurement of the network equipment by purchasing his own access point which results in a capital expenses (CapEx) per user ratio that is kept constant and low on one hand. The operational expenses on the other hand are kept low by relying on volunteers and open source software. Despite the absence of access fees, the participants put considerable time and money into the project. The question could be asked whether a more cost effective solution could be found if the community of end users organized as anchor tennant and contacted a specialized network operator.

The dominance of mesh topology in these networks can also be explained by the community model's financial structure. The mesh topology is most conductive to an organically growing number of nodes and as added benefit it limits shared backhaul infrastructure which is difficult to finance through end user procurement. The exception to the rule is the network in Turku in which the community members use their preexisting domestic Wi-Fi equipment as access points that are backhauled over their broadband connection.

The success of a community network can be captured by its participation ratio. This ratio is indicative of the community member's willingness to participate and in turn captures the believes that joining the network provides added value to the participant. In an end user centric model this is of prime importance.

IV. Description of prototype cases

To illustrate the value network configurations that are defined and analyzed in the previous section, this section describes four existing cases in the Benelux that figure as prototypes for the respective models.

A. Brugge as prototype of the integrator model

The network of Brugge is an example of an integrator model that was initialized by the local municipality. In 2009 Brugge's citycouncil (the initiator) decided on the adoption of a Wi-Fi network that would enable the inhabitants and tourists to freely access the internet. The city opted to figure as anchor tenant and issued a tender for EUR 1 million which was won by ZapFi (the network operator). ZapFi is a company that was previously involved in installing Wi-Fi in hotels, restaurants and bars.

A Wi-Fi network was developed that offers 1Mbps access for free. Higher bandwidth could be purchased as well as a transceiver that enables inhabitants to use the network as a replacement of their domestic broadband connection. With this freemium model, ZapFi believed that it could compete with the Belgian incumbents on the domestic broadband market.

It was chosen to build a star network in which the access points were directly connected with a fibre backhaul network. The contract between both parties stipulated that ZapFi would be allowed to place its base stations on Brugge's public buildings and that it was allowed to use Brugge's existing fibre network as a backhaul. For another part of the backhaul network ZapFi deployed new fibre which created a second option for access points placement: Brugge's public schools. In return for letting ZapFi place access points on their buildings the schools would be granted inexpensive access to the newly deployed fibre network. The network aimed at providing full coverage.

In the meantime a dispute has arisen between Brugge and ZapFi. The latter is changing its business model from full coverage towards hotzones and from a sales model to an advertising model. This way ZapFi cannot deliver what it has promised in the initial contract. This is a clear case of the principal agent problem described in section III.

B. Groningen as prototype of the public service model

The project in Groningen can be classified as public service model. In 2008 Stichting Draadloos Groningen, the "wireless Groningen foundation" (the initiator), was founded following the student request for an affordable wireless network. The foundation was formed of several interested partners such as the city, the university, other local educational institutions, the police department and local emergency response teams. After research in the university and Stratix, a consultancy firm, the foundation decided to take the role of anchor tenant and issued a tender in search of a private partner that could help deploy a free municipal Wi-Fi network. This tender was won by Unwired Holding, an American investment company, that would function as the network operator.

The goal of the foundation was to invest EUR 3 million into the network under the form of an internet service purchase. These services would include video surveillance for the police

TABLE II
OVERVIEW OF THE PROTOTYPE CASES

Case	Initiator	Principal investor	Network Operator	Service Provider
Brugge	City	ZapFi	ZapFi	ZapFi
Groningen	Stichting Draadloos Groningen	Stichting Draadloos Groningen	Unwired	Unwired
Leiden	Community	Community	Community	Community
Luxembourg	City	City	City + P&T	Hotcity SA

department, free VOIP services for the students and free networking for all the network's stakeholders.

The foundation would also provide right of way to Unwired Holding. The network would become a mesh of interconnected nodes placed on buildings owned by the partners in the foundation.

The contract and network was terminated when Unwired Holding failed to deliver the network in time, partly due to licensing issues concerning the placement of base stations and partly due to financial issues following the global financial meltdown in late 2008.

C. Luxembourg as prototype of the wholesale model

The network of Luxembourg exists as a wholesale model in which the network operator is a public party. In 2007 a Wi-Fi network was developed in Luxembourg which is entirely in hands of the city. The city is majority shareholder in the company owning the network. Bitstream access is sold to Hotcity SA, a limited liability company in which both, the municipality and its main commercial partner, P&T telecom have a participation. Next to its role as shareholder in Hotcity SA, P&T, a local incumbent, also provides the backhauling of the network. Hotcity SA figures as an ISP that sells internet access and access to commercial applications and provides applications of public utility for free.

The network was set up with the goal of offering the inhabitants a service platform as well as internet access and serves as an inexpensive communication channel for government personnel. The public service platform aims to facilitate citizen-government interactions.

A captive portal platform is used to redirect users to the free services of public interest or to the paid services offered by the ISP and other content providers. The different access points are placed in a star topology.

D. Leiden as prototype of the community model

In 2002 a wireless network came into existence in Leiden which is entirely supported by volunteers. These volunteers are responsible for equipment, operations, services, maintenance and right of way for the access points. They are also the dominant source of investment into the project as each participant purchases his own access point.

The network's primary goal was to set up a large scale local area network that allows free local communication and although such a network enables internet connection sharing, this goal was only secondary.

The network itself is a Wi-Fi mesh with approximately as many nodes as there are end users. Access to the internet is provided through the participant's domestic broadband connection as well as through a supportive local ISP, Demon internet, that freely connects some of the nodes. Operational costs are kept low by using open source software and non paid volunteers. Some local enterprises support the network with sponsorship, this is the way other equipment such as servers is paid for.

Table II summarizes the key information presented in these cases.

V. CONCLUSION

This paper analyzes a sample of 19 municipal Wi-Fi projects and identifies four categories of projects within this sample: the wholesale model, the integrator model, the public service model and the community model. We learn that these different value network configurations, based on the distribution of responsibilities among the different actors involved in the project, are related to the topologies, pricing models and motivations driving these networks.

In this light we observe that the integrator and wholesale models of which respectively Brugge and Luxembourg are exemplary are of a more commercial nature with focus on paid access, profitability and sustainability whereas the community model, in this paper represented by the case of Leiden, is end-user centric with a prime focus on universal and inexpensive network access. The public service model finally, implemented in Groningen, has a prominent role for the local government that counts on various kinds of social and economic indirect benefits for the municipality and its inhabitants.

This brings us to conclude that the definition of what constitutes a successful municipal Wi-Fi project cannot be seen as a fixed concept but should be based on the case's leading motivations and by extension also on its value network configuration, an observation that needs to be considered in future research on the determinants of success. Future work will also include a financial analysis of the different actors involved based on techno-economic modelling as well as a comparative analysis of fixed and wireless business models.

Acknowledgment

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