MOBILITY IS THE MESSAGE

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Experiments with Mobile Media Sharing

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Abstract

This thesis explores new *mobile media sharing applications* by building, deploying, and studying their use. While we share media in many different ways both on the web and on mobile phones, there are few ways of sharing media with people physically near us. Three systems were designed, built, and studied: *Push!Music*, *Columbus*, and *Portrait Catalog*, and a fourth commercially available system was studied – *Foursquare*. This thesis offers four contributions: First, it explores the design space of co-present media sharing of four test systems. Second, through user studies of these systems it reports on how these come to be used. Third, it explores new ways of conducting trials as the technical mobile landscape has changed. Last, I look at how the technical solutions demonstrate different lines of thinking from how similar solutions might look today.

Through a Human-Computer Interaction methodology of design, build, and study, we look at systems through the eyes of embodied interaction and examine how the systems come to be in use. Using Goffman's understanding of social order, we see how these mobile media sharing systems allow people to actively present themselves through these media. In turn, using McLuhan's way of understanding media, we reflect on how these new systems enable a new type of medium distinct from the web centric media, and how this relates directly to mobility.

While media sharing is something that takes place everywhere in western society, it is still tied to the way media is shared through computers. Although often mobile, they do not consider the mobile settings. The systems in this thesis treat mobility as an opportunity for design. It is still left to see how this mobile media sharing will come to present itself in people's everyday life, and when it does, how we will come to understand it and how it will transform society as a medium distinct from those before. This thesis gives a glimpse at what this future may look like.

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Contents

Introduction

At the heart of modern technology is its use for communication. One key example of this is social media sharing - we share media with others in many different ways. For example, people share links on Twitter, and videos on Youtube (e.g. Ding et al, 2011). Yet the specific forms of social media sharing are under constant change. As new services appear, old ones fade from use (e.g. Torkjazi et al, 2009). Although certain platforms are dominant today, it is clear that this can change quickly. Social networks are predominately based around websites and are predominantly through web browsers (boyd and Ellison, 2007). Recently however applications on mobile devices have become important, and for some services even the dominant way they are accessed (e.g. Weilenmann et al, 2013).

Just as the web dominated over other online media, it is clear that mobile will become the dominant way of communicating using computers. Indeed, more broadly mobile devices have quickly become the predominant way that the world uses computing technology. Yet social media in some ways retains its web focused way of working. There is much new potential in exploiting the opportunities of mobile situated social interactions. It is not just that location can now be used in applications, but that the whole situation and mode of use can enable new applications.

People take photos and share with friends using their mobile phones (Kindberg et al, 2004). There might however be more to mobile media sharing, than simply media sharing on mobile platforms. If media sharing is sharing photos, videos, and text with friends and others, what is it then that makes mobile media sharing different, apart from running on a mobile platform?

To answer this, the key focus of this thesis is a set of experiments with new *mobile media sharing applications*. The thesis documents the design, building, and study of four innovative mobile media sharing applications. The research covers not only different phases of this process, but also different ways in which applications and their use can be studied. This includes building new systems and giving them to users, deploying software on users' existing devices, and even studying software that users are themselves already using. What brings all this research together is a focus on applications where the mobility of the user is a key resource in the design of new communication media. By this I literally mean that the physical movement of users themselves (and their devices) becomes an input and enabler for the

system. Mobility for the thesis is therefore not just the portability of a device - that it can be used in different places, or even that location and context can influence use. Rather it is that the movement of users enables the systems to work. Mobility in a sense is the key resource for systems design that is under study in this thesis.

Research has often seen mobility as a problem that has to be fixed (Bassoli et al, 2007). Issues such as how to best connect remote participants in collaboration (e.g. Ishii et al, 1993), or how to make information accessible anywhere. However this view in some ways neglects the opportunities that the mobility of people presents. Instead of looking at mobility as a way to maintain access to people and information, this thesis therefore looks at mobility as a source of interactional opportunities.

Key to this is that mobility allows us to design for co-present use (Kun and Marsden, 2007). That is, leveraging users proximity and face-to-face social interaction with each other as a resource for new systems. The opportunities for the way social interaction can include mobile systems are currently under-explored. How can interactive technology be incorporated in an already rich social context, for people to communicate through sharing of media? With a sufficient density of users one can even exploit the chance encounters of users who do not know each other. While people may not know, or even notice each other, there is something (such as shared interests) that brings them together at that point in space and time.

As mobile devices have become more advanced and broadly available one consequence is that they are much easier to leverage in research. Application development frameworks, and mobile software development more broadly, have become something that can be done as part of the research process in a way that would not have been practical before (Cramer et al, 2010). This has encouraged a growth in research around mobile systems, and their deployment in trials (e.g. Henze et al, 2011; Korn and Bødker, 2012). A change in technology thus supports a whole new range of experiments with mobile devices and their use. Since advanced mobile handsets are already owned by so many it is now possible to build, test, and deploy new applications without having to rely upon supplying new hardware, or custom devices to users (McMillan et al, 2010). “Application stores” of different sorts allow for the deployment of experimental systems to a potentially large audience. Even currently popular applications can be instrumented and used to study users, as a side effect of their current behavior.

This thesis documents in *five papers*, key studies of four *mobile media sharing applications*. Three of these explorations (Push!Music, Columbus, Portrait Catalog) involved building new software systems to support new uses of social media. The fourth is an exploration of an existing commercially successful system (Foursquare). In each of these explorations the focus was on understanding the use of these systems in a relatively “real world” context as opposed to laboratory studies where the importance of situation

and social setting is lost. That is, not simply building systems, or giving them to users to test, but rather understanding prolonged use to develop new insights and understandings of how users and technology work together.

For example, I built and studied Columbus to explore how geotagged photos can be reconnected with their location, and how the photos and places can be experienced together. I built and studied Push!Music to explore a new way of sharing music, where music files could copy themselves between nearby devices.

The papers span a five year period, and while the designs remain innovative, obviously technology has changed considerably in this time. It is therefore important to emphasize that the focus here is not on particular technologies, or particular technical systems. The contribution of this thesis is not simply building particular applications. Rather it is how in the design, building, and study I developed new findings concerning the design space of technology for mobile social software; understanding users and their technology practices; and lastly, how technical advances can result in interesting design insights.

This work is capped by a final *sixth paper* which rather than looking at the design or use of systems, reflects on the trial methods and testing of technical systems. For the changes in mobile technology, while this thesis was being researched, have enabled not only different kinds of mobile applications and services, they have fundamentally changed how we can do user centered technology research. Deployments "in the wild" with potentially thousands of users are now practical, although still with challenging methodological issues. Indeed, for mobile social software these large deployments are particularly interesting because they enable much more in the way of sharing and potential communication - exploiting co-presence in new ways.

As the thesis is done in a multidisciplinary field, there is not a single research question that has been answered through the work in this thesis. Rather it is in the strength of conducting this research in a multidisciplinary field, that I have sought to answer a set of questions:

1. How can we design new mobile media sharing systems?
2. What do people do when they use these systems?
3. How can we study these systems in naturalistic settings?
4. What are the technical challenges for creating mobile media sharing?

I am particularly interested in what it is for a system to be mobile, beyond the idea of information being accessible anywhere and anytime. Instead I am exploring how we can design and build systems around the actual mobility of people, and use this as a resource for people using these technologies.

The title of this thesis reflects a particular view on communicating using digital technologies. It is paraphrasing the famous saying of Marshall McLuhan "The medium is the message". With this he means that in order to un-

derstand media, one has to look at how a medium extends human abilities. The particular content communicated through the medium, while media in itself, is not relevant for the study of the medium itself. It is instead the medium that changes societies. While we shape media, at one point they turn around and shape us. Looking at computers as a medium for communication (Thomas, 1980), we can try and understand computers through this perspective. With the work in this thesis on mobility as an enabler for mobile media sharing, it is therefore this perspective that can give us an insight on how mobility shapes us as a medium. Similarly to how early television programming resembled radio shows before television became its own medium, as mobility starts permeating mobile computer systems mobile systems can develop as their own media distinct from those that came before.

The overall result of this research is in some ways quite simple. The thesis demonstrates new experiences of sharing - the joy that comes from sharing media. The different systems, with different shortcomings, are still surprisingly effective in supporting quite different modes of use from what has gone before. The thesis is at its heart then about creating new opportunities for technology. Each of these systems is not the final instantiation of an idea but rather the first: the thesis offers concepts for other researchers to develop further, taking from the lessons learnt from these careful studies and the contributions of the concepts described herein.

The thesis in context

The background section puts the thesis into a broader academic context. The research here has been published in a range of academic fields within Computer Science - namely, CSCW (Computer Supported Collaborative Work), HCI (Human Computer Interaction), and Ubicomp (Ubiquitious Computing). These research fields overlap to a great extent, sharing concerns and methods, and have to an extent a shared intellectual research community. These will be discussed in the background section below, but before that three particular areas of commercial systems are important to mention. These are music sharing, photo sharing and location sharing.

For music sharing one contemporary system that has grown in importance is Spotify (www.spotify.com). Spotify offers the legal listening of a large catalogue of music streamed from Spotify's servers. For our purposes what is perhaps most interesting is that Spotify has used this functionality to support music being easily shared through the sending of links and building in connections to other social networks (such as Facebook and Twitter). This functionality shares some similarities with Push!Music, but with a major difference. While Push!Music supported music sharing it did so between those who were co-present. There was an important mobile component thus to its design which contrasts with Spotify.

A second area of considerable commercial activity is photo sharing. In particular Instagram has grown considerably as a way of sharing photographs between friends. An important innovation with Instagram is the focus on the mobile client. Interestingly, Instagram has little web presence, whereas as mentioned above most social network applications have been web based. The creation of photographs, for example, must take place on a mobile camera phone (although it does offer connections to web based social media for the sharing of those photos). Instagram shows some echoes of both Portrait Catalog and Columbus. However, with PC the sharing of photographs was particularly between those who were co-present. Similarly for Columbus the focus was on how ones mobility - moving through the environment - enabled the display of new sets of photographs from new locations. Yet Instagram is perhaps developing a little in this direction too - one new feature they have added is the ability to see photo maps, viewing Instagram photographs taken and shared by others on a map.

Lastly, location sharing, while a relatively longstanding academic research topic (Iachello et al, 2005; Benford et al, 2004; Barkhuus et al, 2005; Brown et al, 2007), has had considerable success in terms of systems such as Foursquare and Google's latitude. The way these systems deal with mobility is a particular one, one that is not extensively explored in this thesis. Instead the notion of location goes beyond context sharing, letting mobility play a more active role in how a system functions. That said, one of the included papers in this thesis is a study of Foursquare use - here leveraging the commercial success of a particular system to further the thesis' focus on technology in use.

Research setting

The work in this thesis was done as a collaborative effort of a research team. While all work was done in the research group Future Applications Lab led by Lars Erik Holmquist, it was conducted at two sites. The first site was the Viktoria Institute in Gothenburg. The second site was Mobile Life Centre in Stockholm. As often in research, no project was conducted as an individual project but rather a team work effort. Those involved were (in order of appearance) Maria Håkansson, Mattias Jacobsson, Zeynep Ahmet, and Henriette Cramer, with support from Fredrik Bergstrand. Without those team members none of the work would have been what it became. Below I will list more on what I did in each project and how the others contributed.

Review of the papers

The six papers included in this thesis are as follows:

1. Håkansson, M., Rost, M., Jacobsson, M., and Holmquist, L. E. (2007) Facilitating Mobile Music Sharing and Social Interaction with Push!Music. In Proceedings of HICSS-40 2007, Hawaii, USA, January 3-6, 2007
2. Håkansson, M., Rost, M., and Holmquist, L. E. (2007) Gifts from friends and strangers: A study of mobile music sharing. In Proceedings of ECSCW 2007, 10th European Conference on Computer-Supported Collaborative Work, Limerick, Ireland. September 24-28, 2007.
3. Rost, M., Cramer, H., and Holmquist, L. E. (2011). Mobile exploration of geotagged photographs. In Personal and Ubiquitous Computing August 2012, Volume 16, Issue 6, pp 665-676
4. Rost, M., Cramer, H., Ahmet, Z. and Holmquist, L.E. (in submission) Teens using Portrait Catalog: An Evaluation of a Mobile Photo Sharing System. In submission.
5. Cramer, H., Rost, M., and Holmquist L. E. (2011). Performing a Check-in: Emerging Practices, Norms and 'Conflicts' in Location-Sharing Using Foursquare. In proceedings of MobileHCI'11, Stockholm, Sweden.
6. Cramer, H., Rost, M., and Bentley, F. (2011) An introduction to Research in the Large. Guest Editorial Preface to Special Issue on 'Research in the Large' of the International Journal of Mobile Human-Computer Interaction. Volume 3, Issue 4, pp i-vii.

Below I will summarize the research documented in these papers.

Push!Music

The first and second papers are on a system called Push!Music (see Figure 1). Push!Music is a mobile music listening and sharing application, that supports sharing of music amongst co-present users. It manifests two kinds of sharing: manual and autonomous. The manual sharing is done by a user sending a song wirelessly over a mobile ad hoc network by pushing the song to another user's device. The autonomous fashion is through a distributed collaborative filtering algorithm that automatically pushes a song if it deems it fit. Users of Push!Music can therefore get music sent to them from people nearby, either in the form of a personal recommendation, or recommendations made by the system.

The system was implemented on WiFi enabled PDAs that were handed out to students at a university where two trials were conducted. The first trial was a pilot study where a group of friends used the app for two weeks. The second study was a study among both friends and people who did not know each other, but frequented the same building. The latter group of participants used the system for three weeks.

In these trials we find examples of issues arising when both people and the system can send songs to people nearby. We learn about how the participants feel about their impression management being mediated through the system, and the consequences of having the collection of music altered by the system on behalf of the user. At the same time however, the autonomous manner of music recommendations relieved them from accountability when songs were unintentionally pushed to someone else. Thus there is a tension here between how the system made the individual less accountable for the systems action, but at the same time compromised their self-image as mediated through the system. The trial method included daily visits where we would collect field notes, together with conducting a set of focus groups at the end of the study. The material was evaluated using coding analysis to highlight issues.

Figure 1 Two PDAs running Push!Music.

The contributions to this thesis are multiple. The first contribution is in the design of a novel music sharing system where music files are shared among co-present people, both manually and automatically. Second, the trials give insights into the use of the system, and the perception of how the users are presented through the system. Third, the system implementation gives an example of how a solution based on legacy technology constraints, are transferrable to new system designs even though the constraints are different.

The Push!Music papers as with the other papers in this thesis were produced by a team. My contributions were to design the system together with Maria Håkansson and Mattias Jacobsson. I did the technical implementation and technical design of the system, which included finalizing the implementation details of the algorithm developed by Mattias Jacobsson. I collabo-

rated together with Maria Håkansson on the evaluation, where we both did field observations and conducted the final focus group interviews. Myself and Maria Håkansson co-authored the papers.

Columbus

The third paper is on a system called Columbus (see Figure 2). Columbus is an application for exploring photos taken at your current location. By using the system the user then can explore the physical surroundings together with any photos taken by other people at that place. By forcing people to physically move around the world to see these photos, our aim was to see if we could bring back a sense of exploration to the consumption and browsing of geotagged photos. The system was designed, built, and used in two trials with eleven participants.

Two complementary trials were conducted, and highlight issues with how people perceive the photos taken at their location differently depending on whether in known or unknown locations. The first trial was conducted with 3 participants who used the application while walking around their familiar city center while reflecting on what they found. The second trial was conducted with 8 participants in a previously to them unknown area. It was clear how the application had different roles in the two studies. In the familiar locations people had expectations on what photos to find and explicitly tried to find specific photos by physically exploring the city. In the unfamiliar location however the participants rather complemented their impression of the place with the photos they saw in the app. For instance, in familiar locations people went to bar areas to find pictures of “drunk people”, and when walking by their work place they tried to see if colleagues had left any photos. In a telling example from the unfamiliar location study one participant commented on a photo of a vending machine for energy drinks calling the photo “ironic”. By this he explained he got the impression that the place was a place where many engineers worked, and as such his prejudice towards that category of people was that they consumed a lot of energy drinks. In this way he complemented the idea of what place it was, and when finding “evidence” in the photos, it completed the image he had.

The contributions of this paper to the thesis are again multiple. First the design of a novel application for browsing photos taken by people at the location you are at. Second the study of the system in use, and how people appropriate and make sense of the place and photos dependent on their familiarity with the physical surroundings. Third it gives a second example of how outdated technical challenges can teach us about future system designs.

My contributions in this work were to design the system together with Maria Håkansson and Fredrik Bergstrand. While Fredrik Bergstrand did an initial implementation of the system under my supervision, I finalized the

system and redesigned both client and server code. I planned and executed both trials, and co-authored the paper with Henriette Cramer.

Figure 2 Four screenshots from Columbus.

Portrait Catalog

The fourth paper discusses a system called Portrait Catalog and its user study (see Figure 3). Portrait Catalog is a system for sharing photos with people face-to-face. A photo can be given, but it cannot be forwarded by the receiver. This adds to the collector value of the photo, in the way that its use is restricted. In this system, if one has a photo to show to a friend, it means that is was sent by the person who took the photo.

A trial was conducted at a large youth festival and was installed on around 400 devices. The trial investigated a new deployment method of a new type of research prototype, runnable on the participants' own hardware. It further investigated the use of the application and the meaning and experiences it created.

The contributions from this paper come from the design of the system, studying the system, and building the system. First the design contribution is in its exploration of an application where photos are restricted to be sent only from the originator face-to-face and not forwarded. It contributes to how this type of applications can be studied in a large setting. Second it contributes to our understanding of how such an application is experienced when in use.

The concept was the outcome of a workshop within the Mobile 2.0 at Mobile Life. My contributions to this work included designing the system together with interaction designers at Sony Ericsson while at an internship in

Lund. I did the technical system implementation. I planned and ran the evaluation at the youth festival together with Zeynep Ahmet, and wrote the majority of the paper.

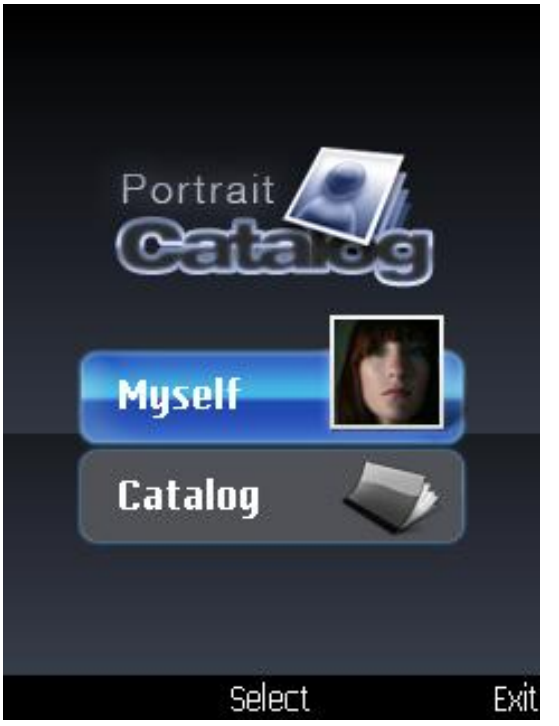

Figure 3 Main screen of the Portrait Catalog application.

Foursquare

The fifth paper is a study of an existing commercially successful service called Foursquare. Foursquare is a location-sharing service where users can share their location with friends and the world. Users of Foursquare share their locations with their social circle by 'checking in' to a venue. These check-ins become the starting point for interacting with the service. The check-ins can be shared over Twitter to a general public for even wider spread. The check-ins allow friends to see where you are, but also to uncover tips and recommendations in the city one is in.

By looking at an existing service that is already in use, the user appropriation and adoption of the service has already taken place. While in a regular trial with an in-house built research prototype, there are always concerns about not finding issues resulting from long-term use. These issues are here overcome by looking at the service already in use, with the sacrifice of not being in total control of the design parameters.

The study was conducted through interviews and questionnaires with users of Foursquare, to investigate their motivations and attitudes towards their service and about their day-to-day use. The findings from this study were how the people checking-in did this as a performance. The act of checking in was hardly just a matter of telling the world about one's whereabouts, but rather a well planned action that took into account the audience of this check-in.

The contributions from this paper to the thesis again is multifold. First it shows how we can learn about the design space from an already existing service, without the need to build and deploy the service ourselves. Second it contributes to our understanding of how such a service is used. In particular it shows how people present themselves through the system, through the act of checking in, illustrating how the check-in is more than a location disclosure.

My contributions were in interviewing some of the subjects. Myself and Henriette Cramer analyzed the data and wrote up the results.

Research In The Large

The sixth paper takes a step back and looks at the current state of the mobile landscape of consumer devices, platforms, and application distribution channels, and the opportunities that have opened for conducting system trial based research. The paper sets a research agenda and suggests ways how this can be exploited for conducting mobile systems research. People now have advanced mobile phones and the means to distribute apps to them has been democratized through the app stores. This opens up for the fact that there are opportunities for researchers of mobile systems to write applications that require a certain density of users before it is interesting - a critical mass of adoption. While in the study of Foursquare, we were able to benefit from that many people were using it (at the time of the study more than 8M active users). While that might be an unreasonable amount of users for any research project, there is at least the possibility to reach thousands of users through the mechanisms of the popular app stores - a possibility that was completely unrealistic before, especially when there was a need to supply hardware. Therefore this paper highlight what the opportunities are, calls for new methods to accommodate this style of research, and discuss challenges.

My contributions to this paper was in co-authoring the paper, and to a large degree basing it on my own previous experience with developing services for different platforms. As an extension to my involvement in many mobile systems and ubiquitous systems, the agenda follows naturally from the technical developments that have occurred, and what it means for conducting Ubicomp research.

Thesis Contributions

With all these published papers, the contributions of the work are not only the papers themselves, but also in how others have built on them citing the papers. According to Google Scholar, the papers in this thesis have already been cited 55 times.

For instance McNamara (2010) developed and built a system for content sharing in the subway system of London where no network coverage exists (for more than certain stations). In this work he looks to find a solution for making sure to connect with fellow passengers who will travel with you long enough for file transfers to have time to finish. He developed prediction schemes for whom to connect to, and investigated methods for making advertising content trustworthy.

The system Pulse developed by McGookin & Brewster (2012) builds on the work of Columbus and is designed to allow users gain a vibe around their current location, based on messages shared on Twitter. Here they relate their ideas to Columbus in which they take existing user generated content and re-introduce it to the environment of its creation.

Specifically in the papers, however, the thesis aims for four key contributions. The first is in how the papers explore new designs for mobile media sharing. Each of the systems explore this design space in an original direction, allowing users to share media in a different way than is currently possible. What brings them all together is in how they use mobility as a source for interactional opportunities. Push!Music is perhaps the clearest example of this in how music moved between individual's devices without them needing to explicitly share their media, but also in how it allowed them to put media on other people's devices.

Second, the thesis offers a contribution in terms of the insights into users' practices and relationships with technology. The Foursquare paper, for example, documents how Foursquare users present themselves to others through the simple act of checking in to different locations. This contribution documents how studying current practices allow us to better understand how new uses and new practices might develop.

Third, the thesis offers a long term engagement and development of different methods for user centered design research. As the thesis progressed the deployment of technology changed from creating custom hardware, to deploying devices to users, to using users own devices, to finally being able to study software that is already in use. This is a progress that increases the 'naturalistic' nature of the experiments, as well as decreasing the amount of technical effort required to run a trial.

Finally, there are a set of technical contributions in terms of how technical limitations were overcome. As is discussed later in the main contributions section many of the technical limitations are now outdated - for example by the broad availability of high speed cellular networks. Yet as is argued there,

overcoming the previous technical limitations enabled innovative solutions that suggest different ways in which systems could work. The contribution here is not that these technical solutions would be directly implemented now but rather that they suggest quite different ways of approaching particular features and functionality. There are still however domains where the solutions are still applicable. Ways of dealing with ad hoc peer-to-peer networks, is important wherever there is lacking cellular connectivity (such as the New York and London subway systems, certain rural areas, and maybe even outer space). However, the solutions can also be seen as features in themselves. For example, the recommendations given in Push!Music are based on partial information, a partialisation based on proximity of users. As such, these technical contributions stand both as resources for new technical systems, and as technical solutions to similar problems.

Work not in this thesis

While the thesis spans a number of years, the work described in it is not an exhaustive enumeration of work that I have done. There has been a lot of work done that is not documented here, but that has influenced the thesis outcome. For instance I developed a tool for students learning how to do fieldwork - a tool that allow users to collect geotagged content such as photos, videos, text, and text notes (Rost and Holmquist, 2009). Push!Music influenced the work on Push!Photo (Rost et al, 2006) - a system where instead of music being shared, photos could be shared with people around you. It explored serendipity in that it automatically presented users with photos from events where he or she had been, that could be found on nearby devices.

Before studying people's behaviour around location sharing by studying Foursquare, I created a number of web services that explored different ways of sharing one's location. Each one explored different ways that a system can use location in mobile web browsers (Rost et al, 2010). These systems included ways of sharing your future location, finding friends nearby, and placing web links in the surroundings. One particular system combined the use of Foursquare and Spotify to connect Spotify playlists with Foursquare venues (Cramer et al, 2011).

While that work is not documented in this thesis, they are examples of hacks and prototypes that have had a strong influence on the exploration of the domain of mobile media sharing, and how mobility comes into play in mobile computer systems design.

Background

The work in this thesis follows and develops previous research in the field of HCI. Specifically it extends research on media sharing and mobile interaction. It also explores new methods for conducting trials of systems, and ways of studying technology in use.

In terms of the previous literature there are three main research fields where the topics explored here have been discussed. The first is Human Computer Interaction. As I describe it this is a growing research field that focuses not simply on technology, nor on humans and their interactions, but on humans and technology together. This research field has had a strong design component - in Alan Kay's words "the best way to predict the future is to invent it" (Kay, 1989) - and this has been at the heart of HCIs continual exploration of new technological systems. A second field which this thesis touches on is Ubiquitious Computing. While Ubicomp has taken a more technical focus than HCI, it too is concerned with questions around technology and its use. Yet with Ubicomp the focus has been specifically on mobile and embedded systems. A third field is CSCW - which while connected to both HCI and Ubicomp, has been much more focused on collaboration and co-operation.

After discussing these research fields, the thesis moves on to discuss the technologically focused developments that are most relevant - in particular context aware computing and location based services. This develops into a discussion of different key systems which inform this thesis, in particular those that explore location and sharing in new ways. It continues with an overview of studies of technology in use relevant for this thesis, especially studies of media sharing practices and mobile technology use. The background then finishes with a discussion of the history of trial methods and their use to explore and investigate research questions.

Three research areas: HCI, Ubicomp and CSCW

The work in this thesis has been published and presented at venues related to three main research areas: HCI, Ubicomp and CSCW.

Human-Computer Interaction

Human-Computer Interaction (HCI) is the study of interaction between people and computers. It has pioneered the investigation and understanding of how it is that technology comes to be used and adopted, how technology can be better designed so as to fit with human understandings, and how technology is itself changing society, work and play. One way of understanding the broader history of HCI is in terms of different "waves" or paradigms (Harrison et al, 2007). Most contemporary accounts of HCI describe the development of HCI in terms of three waves, although there is some divergence in what these three waves are.

Harrison et al (2007), for example, describe the first wave of HCI as with concerned with engineering efforts and usability of computer systems. The focus here was on creating new interfaces and technology that supported new ways of using computer systems - as Harrison puts it "cool hacks". Perhaps most indicative of this wave is the so called "mother of all demos". This was Engelbert's 100 minutes long live demonstration where he demos a range of technologies and interfaces that have only now - nearly 40 years later - have become widespread. Most notably the mouse and early graphical user interfaces. It was in a sense concerned with new ways information could be exchanged between the computer and the user of the computer - interaction in the most basic of terms.

In the second wave, there is a richer theoretical move in terms of the development of cognitive science and how humans process information - modeled in both the user and the computer. Key here was using cognitive science to understand how humans use cognitive processes to see the world, and how to model and present information such that it would be easily grasped. Perhaps the clearest example of work in this wave is the classic textbook "psychology of human computer interaction". Here we have the modeling of human attention and activity in terms such as "GOMS: goals, operators, methods and selectors".

The third, and current, wave is instead focused on how computer use is situated. This wave has taken more centrally the complexities of the social situation in which technology is used - moving away from modeling individual cognition, to instead understanding how social situations of technology adoption evolve over time.

If the first two waves were to a large part positivistic in their use of primarily quantitative methods, the third wave is interpretive. Interpretative refers to the importance of the interpretations and understandings that users make about technology. These are subjective understandings, not simply the processing of information but judgments of utility, value, emotion, use, etc. The third wave is exemplified perhaps by the system evaluations performed in the wild. Rather than comparing two systems in experimental conditions, the system under investigation is rather studied using (for example) ethno-

graphic methods. The result is a thick description of what happens when the system is in use in normal conditions, and what meaning people make of it.

The description of HCI in terms of these waves draws on a Kuhnian notion of paradigms (Kuhn, 1962). That is to say that for researchers each new way is a different approach to thinking about humans and computer use that in some ways is incompatible with the previous. Of course research is still conducted simultaneously in previous paradigms and previous research findings are still valuable and valid, yet over time new paradigms come to dominate. In HCI these waves have allowed richer and more nuanced understandings of technology use.

As mentioned earlier, however, what exactly these three waves are differs between different authors. Bødker (2006), for example, similarly presents three waves of HCI. In her terms there are changes both in settings and focus. In the first wave there is a focus on individual human actors and "human factors", in the second on groups and "human actors" (in Bannon's terms (Bannon, 1992)), and lastly in the third wave on a phenomenological understanding of technology use in non-work settings. The setting then becomes less strict, more mobile, and the situations of use less predetermined. The evolution has thus gone from the single user purpose-driven and task-oriented use situations and work applications, to broadened and intermixed use contexts and applications. What both Bødker and Harrison share is that the move to the third wave is characterized by a richer and less postivistic view of technology use, and a great focus on complex non-work or office settings, where technology is reinterpreted and understood in cultural terms.

We can understand these three waves in terms of the different kinds of work they would motivate. In the first or second wave a study would perhaps let users complete a given task with an existing system and measure aspects such as task completion-time. If this is done in a controlled environment, these results should be reproducible (if done right). Clearly there is a focus on a controlled understanding in experimental and narrow contexts.

Yet a third wave HCI understanding would critique this narrow focus. While the generalisability of a behaviour may hold true in such a controlled environment (if such an environment could be created), nothing is being said of how systems would compare outside this controlled environment. While this may be important knowledge in certain situations, the third wave is primarily concerned with the complex situated world outside controlled setting. Third wave research can in some ways be characterised as "in the wild". Yet this is not just a change of setting, but a change of approach too - an interest in understanding the situated use of technology where it gains its meaning through its use in a variety of contexts. Taking this approach to technology sees everything as situated. The meanings people make of the world is dependent on the situation they are in. The decontextualised work of the first or second waves of HCI then seems as lacking the important role of interpretations and meanings which are made when technology is adopted and appro-

priated. Meaning is created in the interaction with computer systems in the world.

While the three waves of HCI co-exist and important work is done in each area and important questions answered, the work of this thesis is done in the third current wave. For example, with Portrait Catalog we took the application into the world. We went to a festival where teenagers already were. The answers sought could not be answered from people using it within a laboratory setting. The festival is a place in the world outside the lab, where there is already a rich social environment. Furthermore, we deployed it onto the participants own devices. Instead of introducing new hardware which the teenagers had to familiarise with, we put the software onto their own phones that they already were familiar with. From having the participants using the application, we were not interested in whether this type of application was better in any measurable way than another already existing or prior application. Instead we were interested in how the particular design attributes in the application were experienced, and what meanings people made of the application in this setting.

Computer Supported Cooperative Work

Here it is interesting to mention the field of Computer-Supported Cooperative Work (CSCW), which by some researchers is seen as a subfield of HCI but with a more traditional rooting in work systems and groupware. Here the focus is on how computer systems can support cooperation and collaboration. Both co-present and remote collaborative situations are considered. Long-lasting goals of CSCW research is to "support co-presence, collaboration, and shared experiences between distant individuals" (Brown et al, 2005). While remote communication is something that is enabled by the communication technology, CSCW is not only concerned with such remote settings, but with co-present work as well.

Just as Bödker points out that HCI primarily focused on work settings, so was CSCW (as can be seen in the name) primarily focused on work. However as in the last decade the computer has moved out of the office, into our homes, and into our palms, the line between work and personal use has blurred. From the traditional roots in work, research within CSCW has therefore broadened out and started to include systems aimed for leisure (e.g. Brown & Barkhuus, 2007).

Looking through the proceedings of the premier conference for CSCW research (the ACM Conference on Computer Supported Cooperative Work), we find studies both of leisure activities as well as actual systems for leisure, systems that in many cases can be considered Ubicomp technologies. Early studies on how the perception of mobile phone use changes as it is adopted into everyday life (Easton, 2002) and instant messaging use among teenagers (Grinter & Palen, 2002) illustrate the emergence of computing as consumer

technology in the eyes of CSCW research. Later work includes studies of games and gaming (Brown & Bell, 2004; Bardzell et al, 2008; Bardzell et al, 2012; Voida et al, 2010; Go et al, 2012; Yoon et al, 2004; O'Hara et al, 2008; Golder & Donath, 2004; Su, 2010), blogging and bloggers, technology in the home (Nagel et al, 2004; Voida et al, 2010), tourism (Grinter et al, 2002), SMS text messaging (Birnholtz et al, 2010) and music creation (Benford et al, 2012).

There are also multiple studies of online social networks such as Facebook, Twitter and Last.FM. Of particular interest for this thesis, however, is the prototype systems that have been built and studied. These include games for encouraging social interaction (Yoon et al, 2004), a Ubicomp application that determines users' availability from their actions and the environment using ambient sensors (Begole et al, 2004), and systems for media sharing (Fono & Counts, 2006; Engström et al, 2012; Mentis et al 2012). What these studies and the systems clearly show is that CSCW is no longer concerned with only work. As people come together with technology to communicate and participate in activities, this becomes an arena for research that has shown to fit with the field of CSCW.

While the systems of this thesis are not primarily within the area of CSCW research, they do fall within the intersection of CSCW, HCI, and Ubicomp research, with a particular stance in mobile systems. In relation to HCI, at times CSCW has been described as a 'sister' field of HCI - HCI with a more social focus. Yet as HCI has changed, and arguably become more ethnographic and sociological (Crabtree et al, 2009), this distinction is perhaps now harder to make.

Ubiquitous Computing

Ubiquitous computing is an area of research focused on building and understanding computer systems that are embedded into the world in some way. Primarily it was focused on so called "smart" homes and offices, where sensor technology and wireless communication networks would allow computer resources and services to be embedded in the environment around the users in order to be out of the way.

Initially it started out as a vision of the late Mark Weiser. In Weiser's vision the next era of computing was an era where computing was "weaved into the fabric of our lives" (Weiser, 1991). In his foundational paper "computing for the 21st century" he outlines a number of future scenarios where technology is not only physically embedded into the environment, but also fits carefully with an individual's life - for example, an alarm clock that adjusts a sleeper's wake time based on traffic patterns. While there have been those that have critiqued this use of visions and future scenarios in Ubicomp research (reeves; Bell and Dourish, 2007), traditionally these visions have been key in creating technical requirements that Ubicomp has attempted to

address. In contrast to HCI, Ubicomp is therefore often more technical in terms of developing new hardware and algorithms. However, it is also concerned with issues that come with the vision, in terms of for instance privacy.

Early Ubicomp research dealt with mobile technology in a range of different ways. Technologies such as activity recognition (e.g. Buettner, 2009), location technology (e.g. Holmquist, 1998), smart sensors (Cohn et al, 2010), sensor networks, pervasive games, smart homes, etc, are now common within Ubicomp research. However, mobile phones present something of a challenge to Ubicomp's initial dreams of embedded systems (Bell & Dourish, 2007; Barkhuus & Polichar, 2010). Instead of having a world in which we are surrounded by embedded systems, where the computation lives, we instead have incorporated computing into our lives differently. For instance, we are constantly carrying around mobile phones. These in a way are ubiquitous in the sense they are always around (Abowd et al, 2005). The vision of Ubicomp has as a result changed and broadened to adapt to a future that is today. Today we are surrounded by sensors and carry recording devices that have the potential of recording many aspects of our lives. Ubicomp researchers have therefore come to think about these opportunities, and discussed issues such as security, privacy, and interaction.

Recent work in Ubicomp have dealt with things like location sensing (e.g. Kim et al, 2009), smart sensing in homes (e.g. Gupta et al, 2010), health monitoring and behavioral change (e.g. Chiu et al, 2009), security (e.g. Nithyanand et al, 2010), privacy (e.g. Consolvo et al, 2010), and novel interaction techniques (e.g. Costanza et al, 2010). Although mostly technical, studies of the world as it is also occur. For instance, studying how far away people are from their mobile phones (Patel et al, 2006), thus naturally becomes relevant to Ubicomp, as an assumption is often made that we always have the phone within arm lengths. However, as the study shows this is not the case.

Some of the work of this thesis was demonstrated at the Ubicomp conference. Push!Music was featured as a demo at Ubicomp 2005 (Jacobsson et al, 2005) and Columbus was featured in 2008 (Rost et al, 2008). The two studies of Columbus were also published in PUC - Personal and Ubiquitous Computing.

Context aware computing

One type of applications that has received a lot of attention within Ubicomp is so called context-aware applications and much Ubicomp research adhere to the area of context-aware computing which we discuss next (Schillit & Theimer, 1994).

Context-aware computing is a field of computing that deals with systems that adapt to the current context of the user. The idea of context-aware computing was originally systems that examine and react to an individual's

changing context (Schillit et al, 1994). However, later work instead looks more deeply at how a model of the user's context, or parts of it, can be incorporated in the design of the system, to allow for new experiences. What the context is has been defined differently by different researchers. Schillit et al in their seminal paper on context-awareness applications defined the context as the location of the user, the identities of nearby people, and objects and their states (Schillit et al 1994). They later classified the context into three classes: computing, user parameters, and physical properties. Chen and Kotz (2000) later added the class of time, which includes time of day, day of week, month, etc. While these attributes and properties are technically plausible, Dey (1998) extended this list to include harder to measure properties. The user's emotional state, focus of attention, location and orientation, date and time, objects and people in the environment, were things of interest in their definition of the context. While attempting to make a list of important properties of the context, there can never be an exhaustive list. Brown (1996) instead defines the meaning of the context as the parts of the user's environment that the device is aware of. Ward et al (1997) view it as the state of the setting in which the application is operating, which Schmidt et al (1999) define as "...knowledge about the user's and IT device's state, including surroundings, situation, and to a less extent, location". Here Schmidt deemphasizes the location as part of the context, in order to highlight other aspects. Dey and Abowd (1999) end up broadening the whole definition into "... any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant or the interaction between a user and an application, including the user and applications themselves." (p3-4).

Much like how the first and second wave of HCI was to a large part technical and positivistic, so was this early work on context and context-awareness. Dourish (2004) however criticized this way of treating context. He argued that context so far had been viewed as a problem of how context could be represented. He turned this by instead viewing context from a phenomenological perspective. He argued that the context is something that is not a stable well defined entity in which we interact with computer systems, as Dey did. Instead context is the result of people interacting with the world. As such, it is not something that can be predefined, sensed, and encoded by a computer, but rather something that is agreed on by the people while participating in the interaction. Thus instead of trying to figure out how to represent the context, and then figuring out how this context can be used in computer system designs, we should instead investigate how computer systems can support this ongoing process. In conjunction then with the shift from second wave HCI to third wave HCI, researchers became less concerned with context-awareness as previously thought of as "computers that examine and react to an individual's changing context", and more concerned with the design of systems for use in changing contexts.

Mobile Systems

One of the ways in which this thesis explores the design space, is through systems research. As this type of work is all across the board of both HCI, CSCW, and Ubicomp, it is worth while to review some of those systems that are directly relevant to this thesis. There have been many location-based systems and media sharing services built not only in academia but also in industry. They span a wide range of areas, and I will here review some of the many influential systems in these areas.

Location-based systems

As mobility to one extent deals with movement and the change of location, it is worthwhile reviewing mobile systems that in one way or another use the notion of location in the function of the system. Location-based systems are systems where a computer system is aware of its location relative to the environment. This can mean where it is in relation to earth, a building, a room, people, and objects. This information can be used as a resource in different ways in computer system designs.

An early example of a location-based system is the Active Badge (Want et al, 1992). The Active Badge was a computation enhanced name tag which emitted a radio signal to receivers in an office building. Each wearer had a unique ID which was the information in the signal, such that the system would know at all times where wearers were. The infrastructure was thus such that the receivers had known locations, so that when they reported to the system that it received a signal from a specific badge, the system would know where in the office building the person associated with the ID was. On top of this distributed location network, a set of applications were described and built that in different ways leverage the knowledge about the whereabouts of a device. One example is how a phone call may be forwarded to the telephone closest to the person being called. Another example is how to bring the control of applications on a nearby display, based on the location of the user. Here the location is used both to determine which display to use, and also to determine the context of the user to present relevant applications. In order to deploy such a system, this infrastructure had to be setup, and each worker had to be equipped with a badge.

Where Active Badge was a badge emitting a signal to a fixed infrastructure, the Hummingbird was a device that both emitted and listened to incoming signals (Holmquist, 1998). By carrying a Hummingbird device, the device can tell who else is nearby, by showing nearby devices. This system does not know where the wearer is. However, the utility of the system, knowing who is nearby, is still accomplished. This is an example of a distributed system that uses the relative location of nearby devices.

GroupWear uses IR to let two co-present electronic badges exchange information (Borovoy et al, 1998). The information contains details about what the wearer thinks about a set of questions. The information from the two badges is compared and they display how alike the two wearers have answered the questions. While the systems do exchange information, they do not use locations, rather than for the proximity of each other due to the nature of the communication medium. This is however similar to how I state that Portrait Catalog has elements of location, as it requires users to be nearby. As part of the GroupWear project, the researchers also developed Meme Tags. With Meme Tags the tags instead exchange memes with each other. The memes are input and chosen by the wearers, and spread as people meet and choose to pick up a meme from someone else. The idea here is to spread the collective dynamic of ideas at a conference where people meet and mingle.

There have been many systems proposed that allow for digital content to be put in the physical environment. One such early system is GeoNotes (Espinoza et al, 2001). GeoNotes let users place text notes in the environment by using the location of the user and further specify the name of the location in the vicinity. This allowed users to leave text messages later to be found by others. PlaceMemo is another such system for leaving geotagged voice recordings designed for road workers (Esbjörnsson, 2006). PlaceIts extends the concept of location-based messages by instead creating location-based reminders (Sohn et al, 2005). In PlaceIts, users can create schedule reminders to activate when arriving at or leaving a location.

All of these systems show how location and mobility have been used when designing and building systems. These early explorations into this field are to a large degree technical in the way they explore location as a resource for systems design. It is in a sense an early start for looking at how the mobility of people can be picked up by these systems. The systems in this thesis expand this work, but also merge it with media sharing looking to expand both location-based systems, and media sharing, to include both.

Location sharing

This thesis deals with mobility, and with the idea that sharing media is a social communicative activity many people engage in. It is therefore worthwhile to consider systems and research that look at how people deal with sharing their locations. In other words, systems where location is the primary part of the message content.

There have been several systems that allow users to disclose their location to friends and others. Most recently commercial systems such as Foursquare and Facebook let users share where they are with their social network. Similarly Google Latitude and Apple's Friend Finder (as found on iOS) allow you to give access to friends to track where you are. These two means of disclosing location to others exemplifies the two most prominent mecha-

nisms for sharing locations. In the first examples, people share their location by manually telling the system to disclose where they are, referred to by Benford et al (2004) as your self-reported position. In the second examples the location is passively updated to the system and shared, either by continuously tracking the location, or on request. The significant difference here is that in the first case the user chooses to share his or her location each time, whereas in the second case the system shares it on behalf of the user. Other commercial systems for location sharing, include the friend finders Dodgeball, Loopt, and AT&T Find People Nearby.

Prior to the current commercial systems, there have been several research systems for sharing one's location in different ways. While Active Badge and similar systems do "share" people's (or devices) location with the system, it is not with the explicit intent to be disclosed to other people but rather have other uses in mind. Here we focus on those systems where a location is disclosed to other people. Connecto (Barkhuus et al, 2005) allowed groups of friends to tag locations and automatically share these particular locations. The Whereabouts clock (Brown et al, 2007) predefines three types of locations, home, school and work, and is meant to give assurance for family members about where people are. In Reno, the location is not automatically shared (Iachello et al, 2005). Instead users can request a location from a friend, or choose to update it themselves to disclose it to a friend. In each of these examples, the location being shared is a name of the location, as described by the user (or the system as in the case of Whereabouts clock).

Obviously, sharing one's location can compromise privacy, and ways of dealing with this within location-sharing systems has been addressed extensively in the literature. Issues such as with whom to share, when to share, and what granularity of location to share, has been discussed. In the cases where the system discloses the location on behalf of the user this becomes especially important. Studies have shown that one crucial issue is with who you want to share your location. Therefore, many systems let you control with whom the location is disclosed. In Connecto and the Whereabouts clock it is further addressed by restricting what locations are being shared. Although the user is entirely in control of which location is being shared and when in the self-reporting systems, it is not without controversy. Boorsbom et al created the web site Please Rob Me to create awareness of the issue of over-sharing one's location publicly (http://pleaserobme.com). Many early studies of privacy concerns in location sharing systems were based on surveys and interviews based on speculative systems, or short-term studies of research systems. These pointed out how in many ways users would not be keen on disclosing one's location to strangers. However, as is seen in the use of existing commercial systems, this is not the case. Barkhuus (2012) suggests that this is due to the fact that these studies of people's concerns for privacy in general situations, is not generalizable to specific situations. Although, in principle people are reluctant to disclose their locations at any

point in time with anyone, there are specific occasions when this is a non-issue.

Location-based Games

Another group of location-based systems, are location-based games. While none of the systems in this thesis are games, these early explorations of the use of location in game designs, show examples of how the mobility of people can be incorporated in the design of systems. Pirates! was an early game where proximity-sensors were incorporated into the game design such that as the players were moving around in the physical world, game events were triggered in the digital game (Falk et al, 2001). Similarly Can You See Me Now (CYSMN) allowed mobile players to move around in the streets, while online players moved a virtual avatar from their desktop computers (Benford et al, 2006). The street players could see the online players on mobile computers, and their locations were updated using GPS. The aim of the game was for the street players to chase the online players by moving physically to the locations of the avatars and hence catch them.

In Treasure players are equipped with a GPS and WiFi enabled PDA (Chalmers et al, 2005). The aim of the game is to collect coins displayed on a map, and deliver them to your treasure chest. Meanwhile, other players can take the coin you are carrying by physically moving close to you. Leveraging on the fact that one can move in and out of WiFi coverage, people could hide in radio shadow, and sneak up on other players. Here the game design includes the use of seams as found in technology, where imperfections in technology is being used as a resource rather than trying to correct for the imperfection or ignore (Chalmers and Maccoll, 2003). A contrast to this is how in CYSMN, the occurrences of bad GPS reception in urban settings is not accounted for in the design. Similarly Feeding Yoshi extends this further by also considering other aspects of WiFi networks (Bell et al, 2006). At locations of WiFi coverage depending on whether the network is public or private, the area gets different characteristics in the game. Here players move around their city, and the game depends on the properties of the networks found as discovered thus taking advantage of the digital properties as found in the physical world.

Media Sharing Systems

Sharing media is common practice. Throughout history people have told stories. Ever since the personal computer came, they too were used to share stories and other types of content. Historically this sharing of content using computers from a consumer perspective has had a problematic past. People have engaged in distributing computer programs and other media to be consumed on those devices. In the end of the 90s, broadband and Internet access

was starting to become mainstream, and so was people's hunger for media such as music and movies. The first widespread system for sharing and distributing music was perhaps Napster. Napster allowed individuals with an Internet connection to download music from each other's machines in a peer-to-peer fashion (Brown et al, 2001). This gave people a fast, easy, and virtually free access to music of one's own choice. While music played on the radio had supplied people with samples of music earlier, Napster gave people the means to explore and find new music in non-curated way. However it was highly problematic for the music industry who saw lost revenue, and a "content war" was initiated (Carlsson & Gustavsson, 2001). Now, legal alternatives such as Spotify and Rdio have brought legal ways to freely consume music. The media industry is however still struggling with piracy of movies. Peer-to-peer technologies are still used, which makes it easy for individuals to share, and download movies (and other media) while it makes it difficult for copyright holders to track down the sources due to the distributed way these technologies works.

However, privately created photos and movies are distributed freely on online sharing web sites such as Youtube, Vimeo, and Instagram, and shared on social networks such as Facebook and Twitter. While all of these options for creating, and sharing media, are supported on mobile devices, it does not take advantage of the mobile context in which it is created or shared. E.g. despite being a completely mobile service (it is only used through the mobile phone), many photos are uploaded after the fact (Weilenmann et al, 2013). This is not to say that people are using it wrong or that the designers have done something wrong with the service, but rather to say that the design of the service is not taking advantage of the mobile context. Creating affordances for taking and sharing photos while being mobile, is not the same as taking advantage of the mobile context.

There have been several research systems that look at novel ways of supporting mobile media sharing in mobile contexts. For instance, peer-to-peer music sharing has been previously explored in different ways. SoundPryer is a system for creating a joint music listening experience for unacquainted people in cars (Östergren & Juhlin, 2006). By creating an ad hoc connection between two mobile devices in two cars, music is streamed from one to the other to create a shared music experience during brief moments in traffic. SoundPryer employs WiFi to create ad hoc connections between devices. TunA allows users to listen in on what other people are listening to, and to browse the playlist on the other person's device (Bassoli et al, 2004). The purpose is to allow anyone to act as a radio station, and to allow tuning in to those radio stations. Like SoundPryer it uses WiFi enabled PDAs to create ad hoc connections between devices to discover nearby devices and for communication. Both these systems, like Push!Music, form an ad hoc network between devices and support co-present people to experience music in a new way.

Hocman is meant to facilitate communication and information exchange between motor bikers (Esbjörnsson et al, 2004). A web server and client are running on PDAs that form ad hoc networks with nearby devices using WiFi. When driving, information is downloaded automatically from nearby devices, and can be browsed afterwards to see who you have been driving with. When meeting at a stop, nearby devices can be browsed while nearby. MobiTip is a distributed recommendation system where recommendations are sent over Bluetooth when passing nearby MobiTippers (Rudström, 2004). A recommendation engine matches preferences and only gives relevant preferences. Besides doing peer-to-peer recommendations between devices, they also incorporate stationary Bluetooth beacon devices that act as passive users when no others are nearby.

While these systems have dealt with different ways of consuming media from co-present devices, not much work has looked at how to allow for sharing in a group as media is created. An exception is MobiPhos which is a photo sharing application for co-present use. The idea is that a group of people take photos together, and each other's activity is displayed in real time (Clawson et al, 2008). Similar to MobiPhos is the system developed by Kun and Marsden (2007) supporting co-present photo browsing. Instead of a shared experience when taking photos, it was focused on supporting current practices around paper photos. They investigated different policies of controlling the display of everyone's device.

George Square (Brown et al, 2005) was in a way a mobile media sharing system for tourists. Running on a "handheld" tablet computer, it allowed visitors of a city to find shared content left by others, but also let people visit the place virtually from their computers. Both physical visitors and people in front of a computer could look at the map and be guided around the place, and find relevant content about the place of interest. The system trial conducted explored how two persons, one at the location and one using the system online, interacted through the system.

While past research has shown that sharing of photographs is most enjoyable when done face-to-face (Kun & Marsden, 2004), it is surprising how little support for face-to-face, or co-present, media sharing currently exists.

Studies of Mobile Systems and Media Sharing

While we can explore the future opportunities for technology by inventing it, it is also worthwhile to look at how current technologies are used and the practices around them. Especially for the purpose of this thesis, what is of interest is the practices around media sharing, mobile interaction, and social networks. By doing so we cannot only take inspiration for new systems designs, but also understand issues that might arise as new technology comes into use.

Kindberg et al (2004) looked at the use of camera phones and found among other things that most photos are taken with the intent of sharing. Voida et al (2005) investigated how people use iTunes music sharing in an office. One of the key findings in this paper concerned the importance of impression management around media sharing. Users talked about issues with being "seen" as having a particular taste in music through what parts of their collection they shared online. Yet the partial anonymity that iTunes offered (where the name of the shared library could be change) offered some potential for manipulation and impression management.

Similarly, in Push!Music the content of the media library is revealed by the songs that are sent from the device. As songs are autonomously copied between devices, without interaction from the user, this influences how users perceive that the system presents themselves to others.

The role of the mobile phone in people's everyday lives has been studied from different angles. Taylor and Harper (2002) looked at the practice of sending text messages and compared this to the practice of gift-giving. This work documented how receiving a text message was, in a manner, like receiving a gift from a friend. Since the practices around text messaging and the way text messaging was ingrained in the teenagers' lives, both the messages and the actions around messaging took different meanings. This technical message passing was reciprocal in that to reply to a text message was in turn to exchange a gift in a similar way, and so text message conversations were not only technical exchanges of information, but also like classical rings of gift giving and receiving. Apart from how the text messaging resembles gift giving practices, the embodiment of the text message, and the way they are written, also bear meaning. A text message from a close friend revealing a secret cannot be saved in the case an outsider may accidentally read it. A cute loving message from a significant other however is worth showing to friends and may therefore be saved, both to be shared and to cherish. However, sloppy written text messages are frowned upon and are of less value. When designing Portrait Catalog, there was an emphasis on looking at the photos as something of value, and as gifts. Similarly to how a text message is a personal entity sent with a special purpose and for a special meaning, the photos would be exchanged between two people for a special purpose and carry a deeper meaning than any other photo on the phone.

Weilenmann conducted ethnographic studies of teenagers using mobile phones in public spaces (Weilenmann & Larsson, 2001). Similar to observations done by Taylor and Harper, the mobile phone is not only seen as a personal device. Instead, in groups of people, the phone serves as a shared resource. Phones are sometimes the focus of attention while talking, and sometimes it is handed over physically to another person, even using it to make phone calls to a presumably shared friend. In studies of mobile phone conversations, Weilenmann found the importance of the activity as a means to decipher the location but most importantly the availability of the person on

the other end (Weilenmann, 2003). Another study by Barkhuus and Polichar (2010) shows that multifunctional phones are actively adopted and adapted to the situation and lifestyle of the adult users. The individual users tend to make the modern smart phone into their own by way of adapting it into their lives and into the situations they are in. This was enabled by the affordance of customizing functions by selecting and blending functionality.

While studies have shown how the implicit assumption of the mobile phone as a personal device is wrong and that these devices sometimes become group resources, little research has been looking how to design for this. Since the connectedness of the mobile phone allows for remote communication and sharing of media, research into these use cases are common. However, research into how the technology can also support co-present use cases, especially for media sharing is lacking, despite studies showing that people are already using the technology in this way. There is therefore a need for research that looks at how technology can support these situations, and how they can be adopted into and change practices.

Photo sharing practices

Richard Chalfen (1987) wrote about consumer photography and coined the term the Kodak Culture. Belonging to this culture were the everyday photographic amateurs who took photographs of mainly special events. These photographs were then shared and shown in home events where the photo viewing and sharing was accompanied with telling a story around the picture, and the event in the picture. He made an important point in that the picture itself did not tell the entire story, but the story was only available by the photographer telling the story as it was shown and the people portrayed. The photo sharing that takes place by those belonging to the Kodak culture thus is done together with the stories told while showing the photos.

In comparison, Miller and Edwards (2007) studied the emergence of sharing photos online. In their study they contrast the photographers that use these photo sharing web sites, to those in the Kodak culture. The reasons as they see it is due to the lack of support for the rich story telling that is important for the Kodak culture. Rather than the photos supporting the story, instead the photo often is the story, and the only thing being shared, rather than as part of a whole. The authors therefore termed some people from these web sites as Snaprs, to contrast to those in the Kodak culture.

Frolich et al (2002) also looked at conventional and digital photo sharing and the practices around it. They found that people organise the photos for social purposes. These social purposes are for sharing activities in which they support what Frolich termed photo-talk. Two kinds of photo-talk were found; storytelling and reminiscing. When more than two people took part in the event from which the photos were taken, a more collaborative story telling took place, and reminiscing among those who shared the experience.

Crabtree et al (2004) similarly studied collaborative use of paper-based photos. Here again the photos served as resources in the story telling, but also as a conversational resource for those not present at the event. What these studies all echo is how the most enjoyable method of photo sharing is the sharing of photos face-to-face (Kun & Marsden, 2004).

What the study of the Kodak culture and the snaprs in particular show is that technology may transform the reasons and motivations for both taking a photo, and for sharing it. Thus while sharing it conventionally should support story telling and reminiscing, new affordances of the technologies may bring other demands to the table. Our use of photos in Columbus and Portrait Catalog are inherently different. The photos consumed in Columbus are taken as part of the story about the place where they are taken while there. In Portrait Catalog, the affordances of the photo as it is embedded into one's device and social setting depict another use and meaning. By exploring this area, we may see new types of use (and users), beyond Snaprs and Kodak culture people.

Social Media

Social media and use of social networks has quickly been integrated into many people's everyday life and daily practices. While the technologies used are a few decades old, the form and use has only recently reached the general public. As these technologies get adopted, it is interesting to study how these get adopted into everyday practices, and how they change everyday life. While people have described what social networks are (boyd & Ellison, 2007), few studies detail what people do there in a general sense. One of the earliest studies of Facebook use, and probably the most cited, only asks the question whether people make new connections on the site or only maintain connections made offline (Lampe el al, 2006). Interestingly, the answer to this question (which is that they use it to maintain connections) later on is taken as the de facto definition of what a social network site is by boyd and Ellison (2007). The most extensive endeavor into figuring out what life on social networks is like is probably the work done by danah boyd. She looked at how teenagers have integrated social networks into their lives and how they maintain their social life using these technologies. Beyond this extensive study, other studies are often concerned with more specific questions regarding the use of social networks and social media. Studies investigate impression management (boyd 2004), privacy, online and offline couplings (Lampe et al, 2007), and use of social networks for information seeking (Lampe et al, 2012). As the use of these networks has increased rapidly, it has been viable to investigate how the use of these technologies change, and how the perceptions change. One such study showed that in the early days of Facebook, while the change of use was small, the perceived audience of user profiles and general attitude to the site changed. (Lampe et al, 2007)

History of Trials

As I wrote above, the third wave of HCI is interested in the situated use of technology, and not technology isolated from the social context. The way research systems are evaluated then is through the use of trials. Trials can be said to be test runs of systems in their "natural environment". Some of the earliest system trials employed in HCI is from the early 90s, as the interest in the systems became more than in the technology and rather about interacting with technology (Brown et al, 2011).

Depending on the research questions at hand, different methods have been used when evaluating computer systems. In usability studies, where the research question might be about efficiency of task completion, laboratory studies may prove to be sufficient, if not necessary. However, to evaluate how users adopt the system into their existing practice, and how practices change to fit the affordances of the technology, laboratory studies are not sufficient. Instead it has been argued that the systems have to be studied in situ (Rogers et al, 2007). In situ trials have the opportunity to study how the system becomes adopted into users existing practices over time, in addition to finding issues that arise when in use.

An in situ trial then involves supplying study participants with the technology under investigation. It depends then on the technology, how this is to be done. To evaluate a system run completely on custom made hardware, this involves equipping people with hardware. Such was the case for the Active Badge system (Want et al, 1992). As technology platforms mature, systems can be written on consumer devices. In the case of Push!Music, no custom hardware was built. However, as few (if any) potential participants owned devices capable of running the system, to supply the study participants with the technology still involved giving them hardware. As this consumer technology then matures and gets adopted by the mainstream, this requirement disappears. One such mainstream platform technology is today's smart phones.

McMillan et al (2010) outline some of the negative aspects of running trials with researcher-supplied equipment (whether it be custom hardware, or consumer devices of no mainstream adoption). The fact that people are not familiar with the device may have impact for the use the system to be trialled. Having to carry around an extra device for a longer period of time may be a burden for users already carrying multiple devices, and can thus have negative impact on their perception of the system. It limits the scale of the trial as it is limited by available devices and resources of the research project. For it to be feasible to deploy physical devices to participants in a study, the tendency is to recruit participants close to the research site, and thus can have a limited span of culturally different participants.

Thanks to the recent years of development of smart phones, it is now possible to run such trials on peoples own devices. This way of conducting trials

"in the wild" have just started to be explored, but offers not only remedies to issues with equipment-supplied trials, but also offers ways to answering new questions and new ways of answering old questions.

McMillan et al (2010) describes a trial of Feeding Yoshi (renamed Hungry Yoshi) that ran on people's own devices. The first trial of Feeding Yoshi was described as a large trial (long-term, three cities wide, 12 participants). The later trial comprised 8676 participants from all around the world.

Jensen (2007) describes a framework for how mobile HCI research can move away from lab studies to field studies. In doing so he describes methods collecting data from people's use of the mobile phone for later analysis. His method is similar to how web site owners and developers use web analytics to draw general conclusions from people's behavior on web sites. Instead of developing specific measurements for investigating a specific thing, general measurements are used, to conclude specific findings.

Other researchers are using large scale deployments to answer questions in new ways taking advantage of the sheer size of participants one can get. Henze et al (2011) used large scale deployment of an app to record more than 100.000.000 taps in order to check for skewness in terms of touch accuracy depending on target size. In this case the trial was not of the system, but the system was an instrument to collect the data. This type of study would not have been previously possible.

While it has long been popular to conduct field trials as opposed to laboratory studies, it is only recently that large scale deployments have been feasible. Field trials typically combine quantitative and qualitative methods. Usage logs are used to quantitatively analyse how the participants have used the system. This can help to tell the researcher e.g. how much the system was used overall, and which features or functions were used more than others. Qualitative methods can then be used to gain insights into why this was so. The qualitative methods then include interviews and field observations.

The results from a trial conducted in this way have however been critizized. Brown et al (2011) made a meta trial in which they investigated the researchers influence on the trial findings. Here they claim that the use of the system under trial, and the perceptions of the participants, to a large degree reflect the expectations of the researcher. The relationship between participant and researcher therefore influences the participants' use of the system. When conducting trials then, we as researchers have to be aware of this influence and perhaps adapt the way in which we conduct these trials. For large scale trials, we may ask in what way the researcher is visible to the users of the deployed system, and in what way the users are treated as participants.

From a quite similar field trial as the one we conducted for Portrait Catalog, Korn and Bødker (2012) reports on their experience as it relates to iterative design of Ubicomp systems. Following a set of design steps they produced a polished version of a mobile application for discussing topics on a

map for empowering citizens with a discussion forum about their city. They found that while a few people downloaded, installed and registered the application, it saw limited use. They conclude by echoing Brown et al that these types of naturalistic field trials are difficult to setup. They instead propose a method in which the researchers interact with the potential users of the systems, rather than just freely releasing the system. In this way, rather than looking back at how people are using the system after the system has potentially been in use, they propose that by more directly interacting with the trial one can gain "in-depth explorations of their perspectives and insights about the concrete system, the broader concept, and potentials and tensions for future approaches in general". That is to say that rather than releasing things into the wild, one would rather cautiously use the naturalistic setting in the iterative design process. The question still remains though as of how or when to change the system as it is being in use. Korn and Bødker's proposal hints at that one should scale down the ambition of the naturalistic field trial, and instead focus in individual use. However issues still remain as to how that should be done in practice.

A better strategy might however be what Morrison et al (2012) describe as a hybrid method for iteratively designed mobile systems. Here they propose that a mass participation trial should be run simultaneously with a local small scale trial. The use of the local trial is in figuring out how people use the system and inform changes to the system. As changes are made, the large scape trial then can be used to show the effects of the changes at a larger scale. Large scale phenomena can then be explained by observations in the local trial.

The required scale of a trial depends on the research questions at hand. For social software, it may be more or less dependent on the density of people with whom it is possible to socialise. However, for some systems there may be a critical mass of users in order to render a system useful. In the case of Push!Music, such density of users was obtained by choosing the research site at a university of appropriate size such that participants would meet on a daily basis, but not predictably. In the case of Portrait Catalog however, such setting was not found and thus the use was lacking. For systems where scale can determine success of the trial, the opportunities then offered by mainstream platforms is highly beneficial.

Theory

The theoretical starting point of this thesis is that in order to learn about systems, one has to build systems. We build them because that is the only way we can introduce them to the world. As a part of the third wave of HCI, it is the interpretive understandings of these systems in use that is of interest. I build on this notion from the idea of embodied interaction as formulated by Dourish. Embodied interaction can be seen as an example of third wave HCI. It emphasises the importance of the situatedness of interaction.

While I employ methods popular in HCI, one still needs a theory in which one frames the understandings of the results. By understanding the social order of interactions between people, we can relate how this social order becomes relevant when using social software. Here I use the framework from Goffman on presentation of self.

This chapter will first explain embodied interaction, and its origin, as explained by Dourish. Second, it will present the work of Goffman as related to this thesis when it comes to understanding social order. Lastly, it will present McLuhan's work on understanding media. While not used in the papers accompanying this thesis, it helps the kappa to frame my view on mobility as seen in these systems as a medium.

Embodied Interaction

Dourish's book on Embodied Interaction was published in 2001 and acts as a summary of much previous work in CSCW and CHI, as mentioned above (Dourish, 2001). The synthesizing move it makes however is important in that it presents clearly a particular approach to understanding computer systems, one that motivates the design, build, and study methods used in this thesis.

The theory of embodied interaction states that in order to design for interaction, one has to see the interaction as something that takes place in the world, and not separable from the constrained contexts where they occur. It is presented as a unifier of *tangible computing* (dealing with physical computing artifacts) and *social computing* (the study of computing that sees computing introduced into a social world and as such a world that has to be studied through a sociological understanding of the world). Therefore, in

order to design for human computer interaction, one has to recognize that the systems designed and built are to be embodied in the world.

Dourish starts off with tangible computing. Tangible computing is computing with physical artifacts. Instead of interacting through interfaces, the artifact is the interface, and you interact with it directly. Looking at a typical computer, we interact with what is displayed on the screen through keyboard and mouse. In tangible computing, the information shown on the screen would rather be captured as one of the properties of a physical object, and to interact with it, one would interact with the same object. In a sense it means that you interact directly with what is conceptualized by the object and the information it encodes. But rather than only manipulating representations of this information through an interface, you change the representation directly.

A typical example of this is perhaps the Marble Answering Machine. The marble answering machine was a design concept for a new manifestation of an answering machine. The concept was that instead of incoming messages only holding an internal representation inside the machine, they were represented by physical marble balls. Each ball represented a message left by a person. The user could see how many messages were left in the machine by how many balls there were outside the machine. By picking a ball up and placing it at a certain place on the machine, the message would be read back to the user. In this way, the information (the voice message) was made into a tangible physical thing with which one could interact directly.

Today's multi-touch interfaces come close to what tangible computing attempts in the way that you interact directly with the representations on the screen. You pan a map by holding finger on the map and moving the picture according to your fingers' position on the screen while touching the surface. However, the screen is still used as an interface for displaying internal representations of information. Tangible computing rather deal with that information being represented in the physical manifestation of the artifact that you interact with, rather than interacting directly with something virtual. Maybe the most prominent manifestation of tangible computing in our everyday lives is the key card which encodes a digital code, but lets us take it with us and open a door by placing it in front of the reader.

The second strand of work in HCI that Dourish brings forth is social computing. Social computing deals with a sociological understanding on how to design interactive systems. While sociology is a broad term, social computing looks at the use of the interactive systems as something that takes place in the world and is not separated from the situation in which it occurs. To understand the interactive system then, it is not enough to look at the system, or the system and the user interacting, but rather to look at the whole situation and social context in which it takes place.

There is a huge volume of work that broadly falls under this title. Even limiting oneself to research concerned with designing systems, and avoiding pure social science work on technology, there is a large set of theories, stud-

ies, and approaches. What, however, unites this work is a belief that to understand technology one must understand how it supports communication between people. That is, social interaction is a fundamental resource in the design of computer systems.

Perhaps two main concepts from social computing are most important for this thesis. The first is the importance of studies and social science research methods - employed for both evaluation of systems, and to inspire design. Most prominently is the use of ethnography to collect data about a practice, site, or the use of an interactive system. As the ethnography records the actions made by people in a naturalistic setting, the role of the situation and context is captured. This point is covered in more depth in the methods section here.

A second important contribution of relevance to this thesis is the importance of social interaction. Thereby things can be understood about what takes place, and in the case of HCI how interactive systems takes part in the interactions between people and between people and machines. Obviously this is a core foundation for the thesis, as discussed in the introduction. Theoretically, however, and while it is not dealt with explicitly in this thesis the influence of ethnomethodology can be described. Broadly across social computing, ethnomethodology and its focus on "member's methods" has influenced conceptions of human action and human interaction. Ethnomethodology, in its home disciplines of sociology and lingustics, has generated a large body of empirical work too. Yet in social computing perhaps its biggest contribution has been to focus attention on practice - on the details of how actions are done with technology. As Dourish writes, one of the key concepts from ethnomethodology used in social computing is the notion of *accountability*. Accountability as an ethnomethodological term refers to the ways in which actions are seen by others and can potentially be questioned or queried. The means that when we act our actions are "made accountable", they are done in such a way as to not cause questions, queries, or problems to those around us. The classic example of this is when someone walking down a street might quickly cross the road when traffic is waiting. The "walking quickly" is not done just for speed but to show to the drivers that the pedestrians are aware of them - the actions are "accountable". In terms of this thesis the concept of accountability of action is most clearly discussed in the studies of Push!Music.

Social computing and tangible computing then both highlight the move of computing into the world. Technology is increasingly embedded in the environment and everyday life, but what we get from embodied interaction is that in order to design such technology and to understand it, one must employ methods for understanding technology in situ - and not constrained contexts.

Following then this view on understanding how we interact with computing artifacts, what follows in Dourish's book are principles for what it means

for designers of this type technology - design guidelines if you will. His first principle is that computation is a medium. What is communicated with this technology shapes what is communicated and is thus a medium. The interactional aspect of computing becomes the medium over which we communicate, but what we communicate is also a medium, and thus parts of the computational artifact. For instance talking through Facebook is different than email or talking on the phone, and the argument is that partly what is being communicated is due to the fact that those technologies afford different modes of interaction.

The rest of the principles in essence deal with how meaning is created. The meaning is not created by the artifact itself, but rather, the meaning is created in interacting with the artifacts. It is negotiated over time by those participating in the interaction over time, and can thus change. However the meaning is not a static property of the artifact, or even a property of it at all, but the properties of the artifact rather only play a role in the meaning that is created in the interaction with it, in much the way the interacting partners play a role in this negotiation.

This is also further emphasized by the way in which these embodied technologies participate in the world. The fact that they are embodied, they are part of the world, and do not exist outside it. The world and the meanings that it entails, are so from the way people interact with each other and with technology.

What all this means for the work in this thesis, is how it emphasizes the way the technology is embodied in the world. In order to make meaning of it then, it is not enough to look at the technology isolated from the world where it will come into use. Instead, it has to be studied in-situ for those meanings to arise. The meaning is not what is embedded in the technology. The meanings arise from the actions people make. Thus we need to study people interacting with the artifacts, systems, technologies, in order to learn about the embodied technologies.

Presentation of Self

While embodied interaction helps us understand how to look at and make sense of computer systems, we still need a tool to help us understand how to look at and make sense of the people using them. Although social computing provides us with methods and ways to study the systems and people using them, we need a framework for understanding the people and how they come to make sense of the systems in use. Through the ethnographic nature of this work, we obtain accounts of what people do with the technology, and by applying the framework, we gain an insight into the meanings of those accounts.

One framework frequently used to understand how people present themselves in the world, and in which one can explain behaviors, is the framework presented by Goffman (1959) in Presentation of Self in Everyday Life. Goffman was particularly interested in social interaction and in social order. He attempts to explain what the social order of conduct is and how it presents itself in the world, and how it forms and in some ways creates society. In his framework of how we present ourselves in the world, Goffman uses a dramaturgical metaphor to describe social rules of conduct.

He describes many aspects of social interactions. This thesis is primarily concerned with his work on how people present themselves.

Presentation of Self in Everyday Life, starts with the follow paragraph:

> "When an individual enters the presence of others, they commonly seek to acquire information about him or to bring into play information about him already possessed. They will be interested in his general socio-economic status, his conception of self, his attitude toward them, his competence, his trustworthiness, etc. Although some of this information seems to be sought almost as an end in itself, there are usually quite practical reasons for acquiring it. Information about the individual help to define the situation, enabling others to know in advance what he will expect of them and what they may expect of him. Informed in these ways, the others will know how best to act in order to call forth a desired response from him." - (Goffman, 1959, p1)

This sets the stage for the rest of the book. It comes to deal with how information about others, and information we know is conveyed to others, affect our interactions with one another. To act appropriately "when we enter the presence of others" we use information available from the situation, the situation including those who are there. The fact that we are aware of ourselves, that others can see us and what we do, means that we are both observers and observed. In Goffman's words, we are both performers and audience.

According to Goffman, people engage with one another in *performances*. As performers we take on a character with certain attributes. The performance then has to be done such that the character is believable. In order to make the character believable, the performer has to make sure to conform to what the audience expects of it. As the audience are also performers this becomes the starting point for the social order to unfold.

What ultimately decides what character one then performs is decided by what Goffman calls the *front stage*. The front is composed of the setting, appearance, and manner. The setting is the milieu in which the performance takes place and includes all attributes of the setting that constitute the scenery. The appearance is the physical display which gives information about the performer such as social status, age, and sex. Manner then is the way in which the performer behaves. What typically is the case then is that the

manner conforms to the appearance, such that a person presented as a professor, acts as such.

As a complement to the front stage is the *back stage*. Here things that would normally be displayed and used in the performance can be hidden. The back stage can then be a separated area or region close to the scenery of the performance where physical things can be hidden. But it can also be a part in time when the members of the audience are absent. Here a team of performers can run through its performance beforehand.

Maybe of most importance is the attention to our awareness of how we present to others, and how that reflects in how we behave. This has a direct influence as to how we choose not only to talk, act, and behave, but also we choose to dress, as a measure of something we want to convey. A police in uniform is expected to act as a policeman, while in civil clothing he is not. This is not only due to that police put on an act, or a show to audience, but as he has an idea of what others expect of him, so he conforms. Conformity is important here, as people not only conform to their expectations but are at the same time aware that they will, even before they present themselves. Thus how one presents in terms of body idiom (all non-verbal aspects communicated such as clothing, way of moving, pacing, facial expression, etc) is therefore intentional (Goffman, 1966). Going to a party one dresses up, but one would not dress up in the same way going to work as that would be misconfirming with the social order. In Goffman's words "an individual can stop talking, he cannot stop communicating through body idiom; he must say either the right thing or the wrong thing. He cannot say nothing" (quote from Burns, 1992, p38).

One characteristic of the work in this thesis is the settings in which the interaction occurs. Goffman distinguished between situated and merely-situated interaction. Situated interaction is such that occurs in social gatherings where there is a social occasion. This means that such situations when there is a reason for people to be together. Merely-situated interactions occur in social gatherings which are not "occasioned", i.e. the fact that there is a group is just circumstantial. In the case of mobile social media applications, only a few such services are considering social occasions. However, as communication is mediated through technology, especially mobile technology, the gatherings come to involve not only the physically present people, but also people's presence mediated through the technology. We will also see examples of 'situated' activities where such presence of others mediated through the system is a prerequisite (for instance the use of Foursquare).

Burns (1992) writes in his writings on Goffman's legacy how he dismissed small-group laboratory experiments. Similar to how HCI went away from laboratory studies, so did Goffman dismiss the idea that one could uncover the social phenomena by looking at individuals. Perhaps most telling of his way of conduct was his way of "looking at how people behaved rather than listening to what they said about how they behaved" (Burns, p24). Thus

he clearly was not content with the way social psychologists studied human behavior in a decontextualised way. Similarly, the third wave of HCI moves towards looking at situated use of technology. This becomes perhaps extra important when one looks at mobile social applications. When such applications are meant to be used in social situations (remote or co-present), looking at individual use in isolation from other people makes it impossible to uncover the social phenomena of using these systems. What Goffman and embodied interaction then have in common is the emphasis on how to study interaction in naturalistic settings where the entire social situation is of importance, and where the individual is not enough.

As Goffman's primary focus is on face-to-face interactions - social interactions and actions that occur in the presence of others - it has most appropriately been used where computer systems have been intended for such use in HCI. Licoppe and Inada (2012) for instance studies how people use a proximity-based mobile video game in urban public places. For example, they show how aspects of civil inattention (the way strangers politely ignore one another as to not cause uncomfortable, unnecessary interactions) comes into use by strangers coming into proximity of one another. Paulos and Goodman (2004) also in a way build on civil inattention when they design and build a system for people who do now know each other but often frequent the same space.

While face-to-face interactions are the primary focus for Goffman, his ideas extend beyond social interactions occuring when face-to-face. Bellotti et al (2002) use Goffman and others' understandings of social interaction to inform design of interactive computer systems. Here they use the notion of frames as delimiters of appropriate action, to be used when users interact also with computer systems. Similarly, Voida et al (2005) describe how people do impression management when using iTunes music sharing mechanisms over local networks.

What we take away then from Goffman's writings on how we present ourselves in the world, is the way we do this through performances. As such, we take on roles based on what is expected of us, and we present ourselves (choose our front) in a manner that will conform with who we want to be. Goffman's method of looking at social gatherings to understand social order, rather than understanding social behavior through lab studies, resonates with the third wave of HCI, and emphasises the use of ethnographic methods, rather than other positivistic methods.

The Medium is the Message

In his seminal work "Understanding Media: Extensions of man", Marshall McLuhan writes about how one should go about to study and understand media (McLuhan, 1964). In particular he describes how any medium is in

itself an extension of man. Media extends our senses in the way it augments how we can sense and act in the world. While we as humans create and shape these media, so do they shape us. McLuhan gives this light on media to offer us a tool to be able to understand different media.

By looking at media as extensions of our senses he quickly comes to his famous statement that the medium is the message. With this he essentially means that it is not the content that is carried over the medium that transforms and changes our world, but it is the medium itself. To understand a particular medium then, we should not look at the content or the message of the medium, but look at the medium in itself, and how it affects our society.

The written word allowed humans to communicate with others both over a distance and over time, and to pass down stories restricted to verbal communication before. The printed word accelerated the spread of this communication and brought the world close together. McLuhan is however not only restricted to media used to exchange information. For instance he describes the wheel as an extension of the feet, and as such it allows humans to transport heavier loads with more ease. It is thus more than extension of our senses, but how technological advancements change society in how it allows us to do more than what our primitive bodies allow. However, it is perhaps McLuhan's interest in electronic media that is most relevant for HCI and for this thesis. The telegraph for instance enabled communication over long distances virtually instantly, something that we can say still holds true for radio, TV, and the telephone.

McLuhan distinguishes between hot and cool media. Different media invite a different degree of participation on the part of the person who chooses to consume a medium. Media that invite participation is cool whereas non-participatory media is hot. For instance where a lecture requires less participation than a seminar, the seminar is cooler than the hot lecture. To understand what McLuhan means by hot and cool media however, it is not enough to talk about participation as an active part on the person who consumes the media. For instance, a cartoon is cool because it requires the consumer to interpret the image, whereas a photograph is hot in that the visual sense is completely filled with the detailed picture. For this reason, high definition media is often hot media, whereas low definition media is cool. One way to understand this is that low definition often creates fuzzy images, whereas high definition completes the picture more fully and leaves less for interpretation.

This should however not be confused with whether YouTube (the video sharing web site) is hot or cool, as YouTube is in itself something different from the video in itself. YouTube serves videos and video is transmitted over its channel, but YouTube in itself is something different than just the video. I would argue that it is highly participatory, just in the way you interact with it (likes, sharing, comments, etc), but also how anyone can upload videos for it.

McLuhan views the movie as a hot medium, and the TV as a cool medium. Where the movie fills your senses completely, the TV draws you in for participation. He gives an example where people can tolerate the graphic portrayal of a war in a movie but on TV it would be upsetting. This is due to the participation of the medium, that make the viewer feel involved and draw more closely to the nature of the TV medium. While the quality of the TV in the 60s was very different from the quality today, the point is that the TV medium is different from going to the movies.

This is an example of how while the nature of the two may at first seem quite similar, picture and sound stimulating the auditory and visual senses, they are distinctly different due to their role in society and people's lives. The two media serve a different purpose and are distinctly different.

What is interesting for this thesis is how he claims that the electronic media were reminiscent still of their analog counter parts for a long time despite being a new medium. When the TV was introduced, most TV productions looked like radio shows, and it was not until a couple of decades in that the TV exerted characteristics of its own medium. Similarly, when the web came about, it to a large degree mimicked the way news groups and bulletin board systems worked before. It is only quite recently that the web has showed characteristics of its own medium as opposed to the one before it.

Turning this argument to the systems in this thesis we can start to see how McLuhan is relevant for mobile media sharing. My systems are communication systems and can therefore be seen as *media*. That is, media that allow users to consume and share content in new ways. Yet these mobile media are distinct from the web, just as TV is distinct from the cinema. What differentiates these media from web media is how they take advantage of the mobility of the user. Mobility then, I would argue, is its own medium, and is distinct from the web medium that came before.

In the studies later in this thesis we will see how the characteristics of the systems are such that new meaning that arises, is in how the users interpret and negotiate what is communicated. As such, these media are "cool media" that invite for participation, not only in the use of the system, but also in how they force interpretation. They do not completely fill the visual or the audio sense like a movie, but rather suggest and open up the consumer for interpretation.

McLuhan was interested in how the medium in itself affects society, rather than the content that is carried over the medium. Similarly the third wave of HCI is interested in the situational aspect of the technology, rather than the details of the technology in itself. Rather than looking at how bits are pushed in the computational artifact, the interest is in how this pushing of bits is done by people.

Method

In this thesis we have built and studied a number of systems. To summarise the method used in the thesis, it can be thought of as "design, build, study". I designed innovative systems, built them, and then studied their use. To the overall method of the thesis then this movement is crucial - systems need to be designed with an eye to what already exists and what can be found out in terms of research questions, a building process which is also an exploration of the materials that are available, and studies to understand what an artifact does in use.

The focus of this thesis is in how people use technology that before we built them, did not yet exist. HCI is to a large degree design-oriented in that it "have at its heart the design of novel information, interaction, and communication technology" (Fällman, 2003). By bringing forth systems belonging to a possible future, we gain an insight into how that future may look, and may inform future designs. But ultimately, this thesis' aim is to explore and understand mobile media sharing. This thesis explores this through designing, building, and studying, and in doing so, answering the research questions laid out in the introduction. Through conducting this research we aim at answering questions about how we might design mobile media sharing, how people might use it, how it can be studied, and how it can be built. As this process is exploratory in nature, what is to be designed is not decided beforehand, but is rather the result of an ideation process.

There is an extra emphasis on that the systems we have built and studied are actual working and robust systems. While there is a trend in contemporary HCI to study systems in situ, many aspects of human computer interaction are still studied through low fidelity mockups both in lab studies and in more naturalistic situations. While this can be feasible for some aspects, it clearly loses much of the creation of meaning that Dourish talks about when he talks about embodied interaction. This adds to the requirement that the systems that we study in use, have to be fully working, and robust, systems. Except for the study of Foursquare, care has been taken to make sure these services and systems can be fully integrated in users daily lives with as little technical difficulties as possible. Also, except for in the study of Columbus, people have been allowed to integrate these technologies in their daily lives and daily practices, to see how this may occur.

Design-oriented research

Fällman (2003) describes HCI as a design-oriented discipline. As researchers in HCI we engage in a design process as we develop new novel interactive technologies. He contrasts between design-oriented research and research-oriented design, the difference being in the intended outcome. In design-oriented research, it is the knowledge produced about the designed artifact or the process of bringing forth the artifact that is of interest. In research-oriented design, the artifact is the intended outcome. While both follow a design process in that they both deal with developing an artifact, in design-oriented research, the artifact is merely a means to an end.

Similarly, Zimmerman et al (2007) sets forth a model for how interaction designers can make research contributions. This model focuses on the interaction designer's attempt to make the right thing. This right thing is explained to be something that changes the current state into a preferred one. Here it is assumed that there is a desired outcome and that it is the designer's task to make it so. The explorative nature of this thesis however is not in creating the right thing, but rather to explore a set of potential designs. Further, the designs are not supposed to accomplish something, but rather we seek knowledge about how these designs come to create meaning when in use.

In Zimmerman et al's (2007) model they set forth how research through design should be employed within HCI for scientific rigor. Here they outline what the criteria are for the process, invention, relevance, and extensibility. The process has to be well grounded and you should provide a rationale for the selection of methods and technologies. The invention has to be well situated in the world and positioned with other inventions within the same domain. They also claim that the work is relevant if the research describes how the researchers and designers have described the current state of the world, and what their notion of a preferred state into which the design attempts to take the world. However, in the process we have followed, we are not interested in meeting certain specifications or to reach a preferred state. Instead of generalizability, Zimmerman et al argues for extensibility. The extensibility is the delivery of knowledge such that the community can leverage it as derived from the work. If the study results can show how aspects of the design influence how the system is used, this knowledge can then be leveraged in order for the community to decide what to build to achieve certain goals.

Fällman's (2007) discussion on research-oriented design vs design-oriented research shows that the work may not have to be as strict as the model described by Zimmerman et al (2007). Instead research can be done anywhere in the spectrum between the two. As the work in this thesis has resulted in both design based on research, and knowledge based on the designs, the work is thus somewhere between the two extremes. Looking instead to Fällman's "Triangle of Design Practice, Design Studies, and Design

Exploration" (Fällman, 2008), we find this work to lie heavily in design explorations. Here what he means with design explorations is such work that tries to answer the question "what if?". As he puts it:

> "Design in this area typically is driven neither by how well the product fits into an existing or expected future market, nor based on the observed needs of a group of users. Rather, design becomes a statement of what is possible, what would be desirable or ideal, or just to show alternatives and examples." (Fällman, 2008, p7)

As the built systems in this thesis are explorations of what is possible and to show examples, they are as such design explorations. However, to stop at building the systems would not be to "embody the systems". To learn about these systems, more than just the knowledge that they are not in mere existence, is to bring them into the world through trials. In other words, the systems built are in no way the end result in themselves, but rather instruments to learn about the systems and how they come into the world through trials.

Ideation

The systems that were built were technologies for mobile media sharing. Precisely what has been built has come from an ideation process grounded in technology and the curiosity to explore novel systems. Thus the artifacts created have come out of an innovation process. This means that the goal of the systems has not particularly been to fulfill a certain specification. Rather the goals have been to explore. Holmquist (2012) explains this using Verplank's spiral. The spiral describes a model for innovation from where an idea is formulated and tested and developed into a product. In the spiral, a project starts with a hunch which is a vague idea of what to do. The hunch leads to a hack which is a first technical implementation of some primitive sort. The hack both verifies and elicits aspects of the hunch and turns the hunch into an idea. The idea is a more concrete version of the hunch, based on which a set of design exemplars can be created, and only after which they can be implemented into prototypes which can be tested. Verplank's spiral goes on to describe steps where the tested prototypes go into principles which go into products, markets, and paradigms. Each step in this process is verifying and rectifying the outcome.

While taking the idea from idea to design, the idea is formulated into something that can actually take form into a prototype. Prototypes can of course take many forms, and many different levels of fidelity. Low fidelity prototypes such as paper prototypes may be used to try different interaction flows, and to get early user feedback. The higher fidelity of the prototype, the clearer is the picture of what the intended artifact may come to be like. The prototype may be used by the designers and researchers in the process of making design decisions. As such, low fidelity prototypes may suffice.

However, with increasing involvement of users follows increasing demands on the prototype. As our purposes of the prototypes are in that they are to be used in naturalistic settings by potential users, the demands are high. Ideally, for our purposes, the prototypes should be virtually indistinguishable from a commercial product. As such, the demands on the prototypes are such that they are fully functioning computer systems that are robust enough to be used without interruptions caused by immature technology. Failing to produce such prototypes, the resulting use of said prototype will be affected by those shortcomings.

The method then that this thesis has followed throughout, is that which sets out to explore an idea. An idea however is merely an idea unless it is manifested and acted upon. That is done by taking the idea of e. g. a system feature and building a system around that feature. Now, the idea is the focus of attention, which we want to learn about through study. We can study this by implementing the system in which this idea lies, and so to get an understanding of this idea we go about and trial the system by letting people use it. By building the system and testing the idea, we thereby embody the idea as we present the idea into the world.

Building computer systems

The software development process followed in this thesis can most closely be related to that of Agile software development (Beck, 2012). While there are many takes on agile development, the core idea is that of short iteration cycles, where problems are discovered and solved quickly. By finding and solving problems quickly, the risk of them emanating into a large complex system is limited. As such, agile development is a sort of iterative development process, where the emphasis is on very short iteration cycles. The benefit then is that the design of the system can change quickly.

For research systems such as those in this thesis, but also for research systems in general, it is important to allow for short iterative changes to the system to occur, and that they are allowed to emanate to the surface of the building process. As the purpose of these systems is to manifest an idea, it is important that the core of this idea is not lost in implementation details. From a developer point of view, when one writes code and implements a system there are many decisions taken along the way. All of these decisions are on such a scale that they are not part of any prior specification (if one exists in the first place). However, although not deemed to be crucial, when many of these small decisions are combined, they can easily obfuscate many facets of the idea. It is for this reason important that the developer building the system is part of the research project, rather than a consultant hired to implement it from specifications. As a member of the research team, and part of the research agenda, the skilled developer will make sure that those

decisions taken during implementation will be appropriately addressed, and when needed, brought to discussion with the rest of the team.

Therefore, having short iteration cycles while building the system, issues not possible to foresee through non-functional sketches are brought to the surface early and can be discussed in the research team. Throughout the work of building the systems in this thesis, care has been taken to stay close to the research at hand, and not just to build a "system that works".

Studying computer systems

A computer system can be understood in many different ways. One might want to make sure it works as expected, that the performance meets a criteria, or that it fulfills some specifications. For each of these cases of evaluation, there is a measurement, and a target measurement value to which it can be related. However, while computer systems can be studied as separate entities and optimized for certain things, it becomes more complex when put in the real world. A person using a computer system will use all preceding experience to make sense of the system and constantly redefine what it is as it is being used. This also makes sense thinking about Verplank's spiral of how prototypes are tested to find principles which then can go into products, rather than an idea going directly into a product. We cannot know what this product is to be in the world without putting it into the world, and thus they have to be built and trialled.

Once the systems are functioning they have to be tested. The work in this thesis relies heavily on field trials, in that the systems have been tested in naturalistic settings. As has been stated several times before, this is important in capturing the meaning people make of interacting with the systems in the world.

Data collection

Several qualitative data collection methods have been used. While quantitative methods have been used to some extent, such as logging how much the system has been in use, the analysis is heavily based on the qualitative data. The quantitative data have been used to verify the story of the users of the systems.

Through ethnographic methods, field observations and interviews have been used to understand how the systems under investigation come about when in use. While the details of the methods have varied between studies, they have all followed the same overall procedure: have people use the systems, observe people use the systems, and talk to people who have used the systems. But the details varied. For Push!Music we conducted focus group interviews at the end of the study to inquire about the perception of the sys-

tem. With Columbus, Portrait Catalog, and Foursquare we conducted individual interviews. As each study was an exploratory one, the interviews were semi-structured and open-ended. They were semi-structured to get to cover the themes we believed to be important, but open-ended to learn about aspects we might otherwise miss.

Analysis

The findings of the studies were the results of qualitative analysis. The analysis of the data gathered from the studies was done inductively rather than deductively. While in some instances we had a vague idea about what we envisioned to find in the trials, we did not try to pose these as hypotheses to be found true or false. Instead the analysis of the data was rather used to inductively produce our findings out of the data. That is to say that the reported observations were grounded in the data.

The analysis therefore followed a coding strategy as the one described in Lofland et al (2006). By categorising the data into general themes of issues around the use of the system, those became the general findings that were looked at in detail using the frameworks through which we looked at the data. By going through the data (transcripts and observations) repeatedly, common issues were identified and grouped together to find themes. As one goes through the data the way one looks at it changes, and the data changes character from its raw form into a collection of accounts of issues from different themes.

Lofland describes this coding process as two distinct processes, namely initial coding (or open coding) and focused coding. Initial coding is the starting point in which you start to identify the first issues and catagories of issues. Here each instance of the data is scrutinized to answer questions about what it is, what it is an example of, and what is happening. This initial coding typically results in a diverse and numerous set of codes. Focused coding then looks at the data together with the results of the initial coding, is more conceptual and tries to grasp a limited set of concepts from the data. This type of coding instead of looking at individual instances of data, tries to identify topics from the data. The topic then should have a question that the data suggest and that can be answered.

In this thesis this was typically done by printing out the transcripts and notes, and manually coding each line of text. The initial categories then went onto post-it notes that would later be easily moved around into groups that would identify emerging topics.

Methods used in the papers

As technology has advanced, the means for studying computer systems has changed. Much of early HCI research looked at prototypes of systems employing technology yet to come. This would sometimes be done without a real system, but rather using wizard-of-oz style evaluations or different types of mockups. However, as technology has become more mature, the technology has ended up in the hands of consumers. This dramatically changes the development processes, and the means of studying these systems. For instance, systems running on mobile phones with constant connectivity can upload usage statistics and performance statistics in real time to the researchers. This has incredible potential for designing, developing, and studying such systems. However, the systems and their design still need to be made sense of in use.

Overall, the studies have been designed to create an as naturalistic use of the systems as possible. When it comes to social applications that depend on a rich social setting, this can present challenges. If evaluating an application that functions based on people nearby who also use the system, it is important that we can ensure that there will be people nearby. Otherwise the use of the systems is rendered pointless. The exact requirements differ for the different systems. Push!Music and Portrait Catalog clearly require that users can occasionally find people nearby. In Columbus it is enough to be in places where people have been before and who have left content. Thus, these concerns have been met in different ways in the different studies.

How each system has been built and trailed will be discussed for each system individually below.

General implementation details

The systems have been implemented on two platforms, Windows Mobile and Java ME. While incarnations of both of these platforms exist today, little attention is given to these today. An exception might be seen with Windows Mobile, however the current version of Windows Mobile is in such a state that it is completely incompatible with past versions. While there used to be a strong tendency for mobile platform manufacturers to maintain backwards compatibility, at some point the old must vanish to give room for the new. As Steve Jobs puts it in his Stanford commencement speech “Death is the single best invention of life”, which should hold true not only for living beings but systems as well. It is a dramatic way of saying that systems evolve.

Many of the functionalities required to implement the systems could fortunately be found in readily available libraries and APIs. In this way, only new elements of the system had to be invented and written. Unfortunately for research projects, some of the technologies that one wants to explore is not yet readily available. One therefore has to build those systems without

the support of existing components. As the platforms and the mobile technologies have matured however, more and more technologies have become readily available for developers. However, while e.g. today, fully embedded maps in mobile applications is a common thing due to the native maps APIs in most common mobile platforms, when developing Columbus no such ready to use software component existed. Thus while the map was not the core of the idea in the system, as part of the work with implementing the system, the component had to be built. This entails not only the rendering component of the system, but a set of cooperating components such as a server API for fetching map tiles, and a client map tile cache for managing the map graphics on the phone.

Push!Music

Push!Music was built around the idea of music files able to move wirelessly between co-present devices. To accommodate this idea a few things had to be invented such as media agents, and the means to manually push songs to other's devices. The user interface was graphically designed by mainly mimicking existing mobile music playing applications. We took the controls from an already existing app, and added the necessary controls for our purposes to the application. This allowed us to focus on the functionality that was specific to our application, and not pay much attention to an already established way of designing the music listening controls.

The system was evaluated in two trials. After the first trial, minor design changes were made to consider issues that arose in the first trial.

Push!Music was built as a Windows Mobile application running on WiFi enabled PDAs. These devices were far from reaching consumer adoption on mass scale. In order to evaluate the system we instead recruited participants at a nearby university and equipped them with a device running our software. We were therefore limited mostly by the number of devices. The first trial ran for two weeks and included a group of team members working on a study project together. The second trial ran for three weeks and included both friends and people unfamiliar with each other. The challenge in these trials was to keep the software up and running, and required one of the researchers to visit the participants every day to make sure everything was working, in order to keep technical difficulties to a minimum.

Both trials were concluded with focus group interviews with the participants. The interviews were transcribed and analysed together with the field notes.

Columbus

Columbus was built around the idea of enforcing a connection between a place and geotagged content. The design process around this application

consisted of brainstorms around a set of topics, and a bodystorming session where we played out the scenario of using the thought application. This allowed us to establish the essential design specifications for the applications, such as the use of a map, the grouping of photos, and the zoom level to be given to the map when exploring the world.

Columbus was written in JavaME for GPS enabled phones. Although written for a platform meant to work on a large set of device, GPS enabled Java phones had yet to reach traction in the consumer market. We ran two trials, in which each trial was run with one participant at a time. Here we gave a phone running the software to the participants and had them explore it together with the researcher who took notes of the use, followed by an interview. The application was dependent on content to be of interest, and was therefore bootstrapped by the vast material already shared publicly on other photo sharing networks. Leveraging this existing database allowed us to quickly build the system and perform the trial without having to first fill it with content, as the content creation was not of concern in this study.

Portrait Catalog

Portrait Catalog was built around the idea that photos could only be sent face-to-face and not be forwarded. The idea came from a workshop on new mobile systems within the Mobile 2.0 project, held together with researchers at Mobile Life and representative from the industry partners in the Centre. This workshop resulted in 12 application concepts, of which the idea for Portrait Catalog was one. The application was developed during an internship at Sony Ericsson together with skillful interaction designers at their premises during design sessions where we developed sketches. The final UI was finalized by a graphic designer and implemented by me. Before the trial however, the graphical elements of the UI were changed to match the theme of the overall activity at the festival.

In the process of designing and building Portrait Catalog we wanted to make sure to be able to get a large set of users. In order to do so, we knew that we would not be able to supply the hardware ourselves. The software was therefore built in JavaME which at the time was the most common platform. We deployed the system at a large youth festival where people allowed their photo to be taken, and the application installed on their phone. Setup as a competition, users were encouraged to return with their devices every once in a while to know how they were doing in the competition. After the festival, a number of participants were contacted for an interview and were interviewed about their use and experience of the application.

Foursquare

In order to understand how people use location sharing, and what their motivations are, we interviewed frequent users of the commercial location-sharing service Foursquare and ran a survey. In this case we did not have to build a new service which offered the intended feature of allowing people to disclose their location to a set of people, but instead could make use of an already readily available service. This not only allowed us to use the existing service, but as the service was commercial and had reached considered uptake, it was already seeing use. We could thus interview users who already had extensive experience with the service. Although not in control of all design aspects of this service as we would have been if we developed the application ourselves, the benefits outweighed the limitations. From the study we find aspects of what it means to share your location in this manner. While an early inspection of what the service allows may show that one's location is the primary element, we find in the study that the primary element is the user and how the action of disclosing a location is used to show aspects of oneself and one's identity.

This study was part of a greater initiative in understanding the role of location in interacting with mobile systems. Before the study of Foursquare a series of early prototype services were built in order to explore different uses of location as the main resource in the design of mobile systems. However, with the increasing popularity of Foursquare at this time, we saw this as an opportunity to study a system with an obvious emphasis on location.

Research in the Large

During the time working on this thesis the possibilities for carrying out this type of research has changed dramatically due to a number of reasons. First, the means for distributing applications has become immensely more simple and mainstream. In 2005 when I started, there was no central repository of mobile applications and services. Furthermore, it was, compared to today, quite difficult to install custom software on a device of your own. Although there were some mass distribution platforms, they were not a commodity and not used on a large scale. This changed dramatically with the Apple iPhone and the AppStore, followed by Google's Android and the Android Market (later Play Store). Having a distribution channel built into the software of the phone has dramatically lowered the burden for researchers to reach users, and for users to find, download, and install, applications on their mobile devices. Second, the devices that people carry are advanced computers carrying sensors and with constant connectivity. This means that advanced applications that leverage advanced sensor technology can be built for people's own devices, and the applications can be downloaded through the app stores. Researchers have therefore the opportunity to try out ubiquitous computing

applications that used to require the building of special hardware and to hand this hardware to participants in small trials limited by the resources and the cost of hardware. Third, together with this development, development tools and software components have reach a stage where development is much more efficient. As the companies providing the app stores, earning money on application sales, are fighting for developers developing for their platforms, they are constantly attempting to lower the burden for developers to develop novel applications. This is to the benefit of the developers, as development becomes easier, and consequently applications and underlying libraries are becoming more stable.

In the paper on Research in the Large, we outline these opportunities for researchers of mobile applications, and present the methodological challenges and considerations that have to be considered in terms of ethics and validity. The difference in methods from previous research in terms of conducting trials are considerable. Instead of making small scale trials where participants can be observed, interviewed, and log data analysed, we can now have large scale trials in the world. However, when virtually anyone can be using the system being trialled, the question is who are the users. So it becomes a matter of selecting participants to observe and / or interview, and strategies for analysing any data produced have to be considered.

Research contributions of the papers

This thesis covers work published in six papers published in a range of venues. This section summarizes the findings from the research published in these papers, bringing out the key contributions. The contributions of the papers span the social and technical aspects of these systems. For this reason we do not separate the findings from each paper in this section, but instead address the work collectively.

A key point of HCI research is to provide research contributions that inform future work. As discussed above, the goal is not simply to develop or deploy technology, or to study humans, but rather to develop focused contributions that inform the development of future technology. The contributions of this thesis are clustered into four main threads. Each of these threads takes on a different type of contribution that the papers make. The threads are directly related to the research questions stated in the introduction. That is to say that the contributions of each thread is an attempt to answer the questions.

First, we have the three systems that were designed and built. They show examples of three designs of mobile media sharing systems. They show how we have used different notions of mobility in aiding the functionality of the systems. Second, we have through studying these systems learned about how these systems come about in use. We learn what meaning people make of them when they use the systems, and how the systems come to be appropriated. Third, we show how we can go about studying these systems. The requirements for studying systems that require an increasingly complex social setting is not immediately trivial. Social interaction is a complex phenomenon, and adding technology to this does not make it less so. The nature of the systems in this thesis is predominately not task based, and can therefore not be evaluated in a task oriented fashion (e.g. how well the task can be accomplished). However, through the studies we have conducted we can document and reflect on what have worked and what have not, in terms of exploring their use. Lastly, through building the systems, we gain experience in what the technical challenges and requirements are in implementing mobile media sharing systems. We especially document how one can meet the challenges for bringing in the notion of user mobility into mobile systems.

In this chapter, we will discuss each thread separately. For each thread we will take a few examples from some of the studies. More details are to be found in the individual papers however. Going through the main themes

from a sample of papers and issues found in studies, the reader can find more details and more about them in the papers.

Designing systems: Lessons learnt through design exploration

For the first thread we will discuss concerns about the design exploration that was conducted in this thesis. Through building and testing a range of systems one of our goals was to map out the design space, and understand how different ways of building and using these systems might unfold. Mobile media sharing is still in its infancy and there are many different systems one might build. The specific systems here act as particular types of systems that we can learn from - critically evaluating the design decisions made, and how those decisions impacted on use. Accordingly, our first thread is focused on this "design exploration": what did we learn about how you can design mobile media sharing from these studies.

Broadly our systems investigated two different design spaces. The specific systems that we looked at combined features from each of these spaces in different and original ways. The first design space was media sharing. That is, allowing users to share different sorts of media, such as photographs and music, with others. Obviously this has been a predominant use of technology - popular (and controversial) applications such as Napster and BitTorrent are built to support media sharing in different ways. One could argue that in terms of broader effects it is media sharing that has had the largest impact on contemporary culture - with the radical reconfiguration of the music, newspaper and video industries. In more technical terms media sharing is now something that is built into the very fundamentals of different operating systems of computing (e.g. Mountain Lion and Windows 8). In terms of the systems here, we focused specifically on media sharing in local contexts - situations where the users who are sharing the media are physically present in the same place. This changes the dynamic when compared to the more anonymous mass sharing supported by legally contentious systems such as Napster, in that there is less potential for large scale media piracy, and a more intimate and potentially more valuable exchange.

The design of our applications, however, spanned beyond simple media sharing. We are rather interested in users' mobility and how it can play a role when sharing media. Obviously, with our interests in co-present media sharing location becomes an interest. More broadly, locative media has also been a topical area of innovation in the design of commercial systems. Therefore, the second design space that we worked with is locative media - how location can be used as a resource for system design, with applications that make use of a user's location in inventive and original ways.

Each of our systems explores these two spaces in a slightly different way, but they all combine aspects of media sharing and location. In terms of media sharing, for example, Push!Music explores both automatic and manual means of sharing music. Columbus looks at browsing of shared photos. Portrait Catalog looks at a restrictive way of sharing photos where photos can only go one step and not spread further. Lastly, the study of Foursquare looks at how the idea of a location is being shared by people, and what the entity of the location and the act of sharing it means. In terms of using location in original ways - with Push!Music and Portrait Catalog, this location is given by co-present people, while in Columbus and Foursquare it is the geographical location which is used to control the user interface.

Indeed, all the applications in this thesis make use of the local context in some way. What is important to emphasize however is how both media sharing and location are brought together in these systems. So with Push!Music you can only share music with those who are local to your location. Or with Columbus you can only view photographs that have been taken close to where you are now. That is to say, the systems explore both media sharing and locative media together. An important concept to bring these together is the notion of the local context. This refers to the sense that the use of an application is taking place at a particular place where the meaning of this place is given by the people being there. In the case of Push!Music, that place is the group setting of the people nearby in the moment. In Columbus it is the physical location of where a photo was taken. This is an important distinction from a system where the use is independent of the local setting, such as a mobile web browser. Although the meaning of the mobile web browser may be different for the user from context to context, the affordance of the application is the same. However with the applications here their use depend on (for example) the physical proximity of that someone. This is a natural outcome of the mobility of the users and the mobile nature of the system. The mobility of the people using the systems means that the local context of one user is ever changing.

More broadly, each of these systems can be thought of as a “design instance” - a particular combination of functionality that demonstrates particular design ideas. As discussed above in the methods section a particular design idea is made tangible in a specific system. What is important to realize is that as design explorations, we do not need each system to be massively successful in its own right. These are not products or prototypes in that sense. They are also not the only realization of that idea. There is no “right” or “wrong” design here, but rather experiments that help to map out the design space in a new and original direction.

To explain the contributions in terms of design explorations the next sections focus on two systems in particular. The work on these systems made specific contributions in mapping out potential design in both media sharing and locative media: Push!music, and Columbus.

Push!Music

Push!Music is perhaps the most representative in terms of exploring mobile media sharing. Push!Music is a mobile music sharing application that allows manual and autonomous means of sharing music files with nearby people. Just like a regular music player, it has the typical music listening capabilities one would expect from a music player. It has a collection of music from which songs can be selected to create a playlist. One can play, pause, skip songs, and set the position in the song. Added to these normal means of listening to music, we added sharing capabilities. Utilizing WiFi enabled PDAs, the application continuously connects to music players nearby. Associated with each PDA is a user selected name which can be seen among others in a list of nearby players. From the playlist, users can choose to push songs to a particular person. This will result in the music file being transferred to the other person's device. Once transferred, it will be queued to be played as the next song. If the song already exists, the song is only queued. The result is that the recipient will hear a new song which he may or may not like.

Along with the manual process of sharing a song, the application also supported autonomously pushing songs to other nearby devices. It does this using a distributed collaborative filtering algorithm, which we refer to as media agents. Each music file is a media agent, and stores information about how it is being listened to, and in what context. The agent's behavior is then to try and make sure the music file is being enjoyed on the receiving device, in order to make good recommendations.

In terms of design contribution, perhaps the most obvious aspect is in allowing media sharing between mobile devices. At the beginning of Push!Music, work in this area had recently just started. Even today there are few commercial applications that successfully tap the potential of sharing media between mobile devices, in particular in terms of sharing between devices using peer to peer connections. This design contribution is interesting because of the personal nature of mobile devices. As we discuss in the papers mobile devices have a close personal connection for users. They are not simply mobile versions of other devices, but are much more personal. So sharing media between mobile devices is also sharing media between systems that are distinctly personal. This is a point we return to when we discuss how the music that was on a mobile device could be read as a form of "presentation of self".

A second important contribution is in terms of designing for media sharing between users in co-located settings. Co-located mobile media sharing means that you share with people in your vicinity. Again there has been surprisingly little development that focuses on this area of potential system use. Perhaps the biggest problem is that with density of users. With the Internet one can potentially have any other user in the world as a connected user. As

long as you are on the same network, you can communicate. With the Internet, that means more than 2 billion people and counting. As long as there is a way of referencing content on this network, or people with whom to share, the location of these people is irrelevant. This obviously has enormous value for many situations. It has also been argued that the advancement of societies is based on how ideas can spread (Ridley, 2011), and shows what can happen the more we connect the world. However, the potentials of co-present sharing is under explored. Here there lie different motivations, different challenges for privacy and integrity concerns, and new meaningful ways of sharing with people nearby.

One interesting observation that we can make is that with a specially chosen community of users (in our case students at a specific university) there can be sufficient co-present situations of contact to make this functionality interesting to users. While a few people over a large area may never be in one another's vicinity, in restricted space such co-present interactions occur and meaningful use takes place. We can therefore see that as such a system would reach a certain density at large, the meaningfulness of such a design does exists.

Third, it let you push songs to people nearby, rather than pull songs from people, as was the usual means of finding new music. Looking at traditional means of music sharing and downloading systems, music was searched and found following an intent to acquire new music. Similarly in contemporary research systems such as TunA, one could actively listen into other people's music, which again is a way for a user to himself or herself potentially find new music. However, when the way music is shared is changed from pull based to push based, music is no longer actively searched for. Instead we become active distributers of music, where the means for finding new music, is now put into the hands (or rather devices) of the people who have this music. The means for seeking out new music one only has to go into situations where one believes such music may present itself. Similar to going to a festival with a specific theme where one might find new music, people with Push!Music may seek out areas where people with "good" taste in music are.

Lastly, it incorporates automatic as well as manual types of sharing songs. As the available amount of information grows, the need for aid in finding and discovering information of relevance for you increases. At one point it is no longer feasible to manually go through all possible information. Much like in the early days of the Internet, web sites could and were put in a catalog. However, as the number of web sites exploded, this became less and less feasible. Instead search came to be dominated by how to find specific web pages. This type of design for information retrieval works when the information need is known. However, when not knowing what to look for, this approach no longer works. Instead other mechanisms for filtering out the available content have been introduced. Early on recommender systems provided means for helping people find relevant content based on the persons

previous perceived preferences. Amazon was an early online merchant who provided customers with recommendations based on "other customers who bought this item also bought:" and subsequently listed a few related products bought by perceived likeminded customers. MovieLens was a research project that made collaborative filtering algorithms based on movie taste from a large database of movies and their subjective ratings (Miller et al, 2003). They also made a distributed version of MovieLens with their PocketLens system (Miller et al, 2004).

In Push!Music, the automatic sharing provides one such means of recommendation. First it tries to make educated recommendations based on previous interactions with music. As the nature of the system is to push rather than pull content, users passively receive new songs based on these recommendations. Thus while the recommendations made in Amazon and MovieLens (and PocketLens) are given to the user, the user still has to make the ultimate choice. In Push!Music we instead investigate what happens when the system proactively makes this decision. Naturally one would not like Amazon to automatically purchase more items on your credit card. However, in the mobile setting of Push!Music, where meetings between devices may be short and sporadic, having the song already be pushed over to the other device, before the two persons carrying the devices are long gone from each other, circumvents these problems. At the same time, it enables serendipitous moments of music discovery.

Push!Music extends the exploration of mobile music sharing systems. It extends it in the way music is distributed between mobile devices. While previous systems looked at the synchronous experience of listening in on what other people currently listen to, Push!Music takes it into a more fully fledged music recommendation and distribution system that allows for presence and awareness of people nearby, and for making personal recommendations.

Columbus

The work on Columbus explored the possibilities of locative media. The application allows users to explore the world of geotagged photos by forcing them to go to the places where the photos are taken. The motivation is to bring back a sense of exploration to the world of geotagged photos by restricting the way these collections can be accessed. By doing so it opens up a way to explore and experience the world around you.

In a sense this is exploring locative media from the perspective of the observer, rather than – what is often done – from the perspective of the creator of media. Normally you would be able to browse from collections of geotagged photos from anywhere in the world, where the location would be freely picked by the user. In Columbus, the location is also free to the user, however, the user has to physically move there. As the user then experiences

the photo while at the location of where it is taken, the place and the photo is re-coupled. What follows is an experience where the photo and location go together, and both can be discovered simultaneously.

The first aspect that makes this system special is in its inherent restriction how it operates - the way in which a user has to physically move to change his/her location within the system, rather than freely pick the location in the application. While previous systems allowed users to find photos taken nearby (e.g. Zurfer (Hwang et al, 2007)), Columbus was the first to utilize this as a design feature. While this restriction is limiting, this design feature is what brings out the magic. It forces a particular use where people have to physically move about in the world, but by doing so it tries to offer a richer experience of the places visited and the photos discovered as they come together. Similarly we believe that by designing such restrictions consciously can produce more than just a limited system, but rather a rich and novel system that offer new types of experiences. For instance, we further investigate this in Portrait Catalog where we restrict how personal portraits can be sent between devices, in an attempt to augment the value of the photograph.

Designing restrictions can as we have explored in this thesis come in different forms and is obviously in the hands of the designers. In Columbus we lock a parameter within the application to sensory inputs of the device. In Portrait Catalog we separate between one's own photo, and received photos, such that photos one owns can be shared, while received cannot. By differentiating between them on the design level, this becomes not a limitation in terms of "you can forward this photo but not this", but instead it encapsulates what the system is all about. Columbus does this by locking down the map view to your current location not offering any means to pan or zoom. Instead it makes the map view respond to changes in GPS readings to show the liveness of the view.

A second design exploration was in supporting the emotional attachment to a place and the focus on where a user is and their connection to that specific place. This goes beyond the restriction as it is more specifically about photos as the media. Through not showing photographs from other places, users cannot be distracted by other ideas or other places, it helps them focus and appreciate the place they are in and not be drawn away to think about other places. Similarly it is more difficult to "get lost" in the vast amounts of photos available. When it is as easy to move from Tokyo to New York as it is to click the button of a mouse, it can be tempting to browse photos from anywhere. However when the opportunities decrease one has to make choices more cleverly. When one has to transport oneself to another place in order to explore it, the idea was that excitement about finally arriving is built up as the difficulty increases. Thus, from only needing a mouse click to having to buy a ticket and take the ride to New York, immensely adds to the excitement and value of looking at the photos from exactly there. However, while it may be easy to see this in the extreme scale of the displacement of

New York and Tokyo, it also holds true on a smaller scale. Standing at a point in the world one has 360 degrees to choose from as to where to go next. Once a step is taken in any direction, another time consuming step has to be taken to get back. So the design rationale was that when it takes an effort to go somewhere, that place and what can be found there becomes more interesting.

When discovering the photos at the location one is in, the place is experienced together with the photo. As the effort to go there is related to the value of it, so is the interest in the photos. Thus when exploring these two things together, it opens up a new dimension of the place and location one is in. It was our attempt to bring back this sense of exploration to the collection of geotagged photos that now exists. But, while it creates a new experience of how to explore and look at these photos, it also opens up a new way to experience the place where one is.

The third aspect is how this allows for the user to move about the physical world in order to unlock photos - gems found throughout his explorations. Columbus allows users to later go back and reminisce about these unlocked photos. One may envision that by looking at photos from places they have been, they can bring the memories from these places back to life. Similar to how people create and look at photo albums from trips taken for later reference, looking at photos from places one has been is enabling a different kind of reminiscing than being able to look at random photos from anywhere.

Design conclusions

Push!Music and Columbus both develop and explore the design space in different ways. So do the other systems in this thesis. While more details can be found in the papers it is interesting to mention the ways in which these contribute to the explorations. Portrait Catalog further investigates the restriction of forwardability of photos and the study of Foursquare looks at a system where the actual location of oneself is shared. These both serve to illustrate a way in which one's location can be shared with friends, but also how the world can be experienced as an audience through the check-ins of friends and how the system design can alter the temptations and expectations of places in the world. While the design of Foursquare is not an exploration of our own, it lies within the space that is being explored.

In the design space of mobile media sharing, the interest of this thesis is with media sharing that is mobile - that is to say mobile media sharing as opposed to non-mobile media sharing. What then is it for media sharing to be mobile? Mobile systems differ from non-mobile systems in that their use context can change. The mobility of the system and the user means that things can change. What is changing is the situation of the person using the system and other entities around him/her, but it is also that the other systems around have a past that has changed. The same system is used in many dif-

ferent surroundings and situations, and in a sense when two systems meet it is two situations that meet, creating a new situation. Allowing for these different locations, and different situations, to come into play at the moment of media sharing then, is to design for mobile media sharing.

For instance then when we talk about sharing media, it is with the people nearby. In Push!Music this opens up for, but also limits, with whom we can share music, and what music we can get and discover. In Portrait Catalog it determines who we can share photos with.

However it is not only people nearby at the moment, but also the history of people nearby. This social history comes to play both when at a particular location, but also when looking back at your content. In Columbus it is the photos taken by people at this location in the past and who have chosen to share these photos. In Portrait Catalog it is the people you can see in your catalog and that you can show to your friends, that tell a story of who you have met and who have agreed to give you their portrait. It shows a trace of your social history. It is enabled by the fact that you are operating the system from a mobile terminal in a mobile setting.

Through the interactions with the system you collect more than just the content – the content gets automatically coupled with information about the use setting, things that have to hold true in order for it exist to be presented in your system. Photos in Columbus come with information that they are taken where you are by people who were there taking photos. Portraits in Portrait Catalog carry information about who you have met. New music discovered through Push!Music means you have been near people who have had that music. The added information of a check-in is not in that a person is at a particular venue - that information is in the check-in already. The added information is rather the fact that the person has made the active decision to share this information, to check in.

The design lessons from this work then is in opening up how mobile systems can take in the mobile setting in new ways to allow for different types of media sharing. It is not so much about how media is shared, but how that media is shared between devices, between people, between places, and through time – in how mobility can allow for a new mode of sharing media.

Using systems: Lessons about human behavior with systems in use

The design lessons in the previous section show ways that technology can be assembled to produce new systems. They show what is possible in terms of new kinds of mobile media sharing, and their prototypes show their feasibility. However, building those systems are not the end goal. The end goal is what we can learn from the process of building them, and what we can learn

from studying their use. In this section we will discuss the lessons we learn when mobile media sharing systems are put into use by people in naturalistic settings.

Here we will focus on the study findings from Push!Music and Foursquare. Building Push!Music demonstrated its feasibility, and through putting the system in use we learned what it actually means. Foursquare on the other hand gives us a rare opportunity to study a system that has already reached commercial success. This means that the users of Foursquare have already adopted a practice around using the service. As such, they have had time to explore and appropriate the service and adopt it into their daily practice.

As the design explorations from this thesis are put into use, they come to illustrate examples of issues that arise as mobile media sharing is enabled. As the design space has been drawn up through the systems under study, we by studying their use learn what the use of this class of mobile systems is about.

Using Push!Music

Push!Music was studied in two trials. To recap, the first trial was among a group of friends who often worked together at the local university. The second trial involved a larger group of participants who did not all know each other. While the first trial only involved people who knew each other, the second trial also involved strangers. However, by conducting the trials at a local university where people engaged in group work settings, there was a high chance for the participants to cross paths. This would enable the system to find devices from both friends and strangers and so we would be able to study what happens when both people who know each other and strangers can exchange music as it is done in Push!Music.

Push!Music offers a new type of experience around music listening and sharing. As seen in the study, it allows people to give songs as gifts as one meets others, and to get serendipitous recommendations. It let you find new music, and get inspired. It also showed to allow for social awareness, and to see if there are friends nearby in a crowded space.

However it also comes with unresolved issues. Impression management as seen in the iTunes study is turned on its head when the music library can be changed by the system. Does it still project one's identity? While accountability seems managed by people, the fact that you have a song and that the system sends this song, what does that say about your identity?

A large part of the findings from the studies of Push!Music was the importance of reciprocity. Reciprocity has to deal with responses, such as the act of returning a polite greeting. Taylor and Harper (2002) found that text messaging was a practice related to gift giving. Similarly we found evidence of the same for songs shared through Push!Music. As in the gift giving prac-

tices, reciprocity plays two parts. First, from a sender's perspective, one can assume that the receiver will give something in return. Not getting a token of appreciation or something back may have negative implications. Second, as this is part of the gift giving practice, the receiver feels the urge to reciprocate, as to not cause any before mentioned negative implications. As a negotiated and agreed upon protocol of conduct, not being able to follow it gives cause for conflict.

Push!Music only allowed for two ways to reciprocate. The first was to push a song back. The second was to talk about it verbally. Both of these two means were used between friends, but between strangers it was more cumbersome. To push a song back, the user who sent the song must remain in the vicinity for the time it takes to transfer the song. However, the user who sends the song may be long gone before the receiver notices the song and wants to send something back. This lack of means to reciprocate, further inhibits the means of building identity through the actions of pushing songs. As one participant states: "I want credit, yes, ...". This, according to the participant, would enable him to build a reputation. Without the feedback from others, and the means for him to reciprocate, the means for this is non existent.

This interest in getting credit and building a reputation is a way of managing one's identity. While the participants picked their screen name that was used to identity users in the system, identity is more than what is at one point printed on the screen. It is the collection of attributes portrayed for this person. In the case of a music sharing application, what songs the person has is one such attribute. As in the study by Voida et al (2005) of iTunes, people take care in managing their music collection to display what they want to convey about their personality when forming their music sharing identity. In Push!Music however, this becomes an issue.

At the beginning of each study, participants were asked to choose a set of songs that they would have in their music collection. This naturally became music that they wanted to listen to during the time of the study, and music they might want to share. (One participant for instance explicitly chose one song for fun, that he would aim to get to send to anyone he would meet, if not for anything else, then as a prank). However, as the nature of the application is that you receive songs from others, the music collection changes. Furthermore it changes due to the system making decisions on behalf of the users. As these decisions may be far from perfect in terms of music that the receiver may like, the identity shaped by the music collection may appear compromised.

In one instance, a participant manually pushes a song to a friend. However, following this manual recommendation, the system starts to automatically push other songs by the same artist to this same friend. While the first song was an actively chosen action based on the relationship between the two friends, it was not apparent what the cause of the automatic recommen-

dations meant. The participant was uneasy about the way things played out as he got concerned that he may be seen as a fanatic about this artist. While he wanted to just send one song by this artist, the system made it seem like something else. He felt accountable for the action made by the system on his behalf. This sense of uneasiness hints that his identity got compromised, and that what these actions meant to the receiver, was not what he intended. The participant felt misunderstood by the system as it started to behave on his behalf. To the participant it was not immediately clear what motivation the system had for sending a song. Thus as it started doing something unexpected, those motivations got questioned, and he was worried the actions of it would be attributed to himself and affect how he was presented through the system.

While initially not meant as anything but a way of displaying to whom you could push songs, the list of people nearby proved to be an effective and highly appreciated awareness display. The awareness of people nearby, proved to be more than just a tool for knowing who was available to send songs. When getting on the bus, that most study participants used, they reported that they would sometimes turn the device on just to see if the crowded bus was hiding someone they knew. They did not do it so that they could send a song (although they might have), but rather to know if it was worthwhile to look extra carefully to seek out a friend. It thus becomes a filter of a not immediately visible landscape of faces in a crowded space.

Similarly to what was seen in a study of Hummingbird among ski instructors (Weilenmann et al, 2001), it is however important that it is collectively negotiated when and in what situations this function is used. While people appreciated receiving music from strangers, it never spurred a face-to-face interaction. This may be due to not knowing what is appropriate or not. If sending a song is seen as intrusive, it tells us why actually making contact and interrupting what someone is doing may be seen intrusive as well. Thus the awareness in this case becomes most useful for spotting friends; and finding an unknown person when you think you are alone in the building did give cause for an intriguing experience. This might explain why many of the "friend finding" applications of recent times have failed commercially []. It may be explained by what Goffman termed civil inattention, the act of politely ignoring one another. Licoppe and Inada (2012) found similar behavior when studying a mobile game.

Using Foursquare

The study of Foursquare looks at what checking in means, and what the practice looks like. While marketed as a tool for discovering a city, and elements of gamifications are in place as incitements for users, the reasons for checking in is neither utilitarian nor motivated by game elements. Rather, as

the study shows, reasons for checking in and not checking in is of a performative nature.

Goffman describes people's actions in the world based on a theatre metaphor where we stage a performance in front of an audience. We actively manage our performance aware of the setting we are in, and maintaining coherence with expectations. In Foursquare the setting is projected through the service. The receivers of the check-ins, whether to be public or only disclosed to friends, are seen as the audience and are considered before making a decision to check in. For instance, one user would not check in late at night with respect to not wake someone up, in case they had enabled notifications on their phone and forgot to turn the sound down. Much like one would not call in the middle of the night with the concern for not waking someone who is sleeping, they choose not to check-in, to avoid the risk of having the notification waking the person up. While this is an obvious example of how the audience is considered, multiple implicit accounts of performances through the service were found.

People care about what a particular check-in says about themselves and others. Choosing where to check-in is a complex matter in itself. The granularity of venues on Foursquare is rather varied. One may check in to a mall, but you may also opt to check in to a specific store or venue within the mall. Similarly, visiting a new city, one may check-in to the city, as well as a particular venue. While the service may not have been intended for this kind of use, it is nevertheless designed in a way to be open for the users to appropriate to fit the situation.

Let us consider the case where a person goes out of town to a new city. Let us consider he or she wants to disclose this to his or her audience. Making a check in to the first restaurant visited will not only tell about the whereabouts, it will tell a richer story. Performing the check-in is unavoidably telling this story. For the audience who knows him, aware of the person's usual whereabouts, this act of checking in is telling them something beyond his whereabouts, and for the forthcoming future they can act accordingly as well, as he or she has set the stage for future performances.

The rules for what is accepted in different social groups and between different people is still being negotiated. While some people check in to their own homes, others frown upon that practice. As one interviewee states it "I'm not your mother" reflecting to this interviewee that it is not interesting to know every time his friend comes home when doing so repeatedly. However, if someone else goes to the same person's home, the story is different. In this new setting, where a visitor checks in to someone's home, it is "an information thing". While checking in to one's own home is repetitive, information sans interest, checking into someone else's home tells a different story.

Similarly to how in Push!Music no face-to-face interactions occurred, it was not clear to the users of Foursquare what is appropriate to do. To some,

a check-in is an invitation to show up where a friend is, while to others it is not. Comparing this to what Goffman terms mutual openness, it is not yet established at large what these check-ins allow. However, while not knowing what it would mean, the participants are still keen on not making 'fake' check-ins - checking in at venues where one is not at or just passing by. This creates both an incentive to go to places where 'it would be cool to check in', but also gives cause for people in the audience to go and check up on the check-in by making sure that the person checking in really is there.

Not all check-ins were meant for others and thus lacked these performative aspects. That is, when doing these they chose not to share them with their audience. Again they avoid sharing this check-in based on their idea of what it would say. Repeating Goffman again "an individual can stop talking, he cannot stop communicating through body idiom" – meaning that checking in is effectively going to say something about the person. Wanting to check in to a venue to remember it for personal use and not disclosing this to their friends, versus checking in to say something about themselves, are both aspects of their impression management.

A big difference between the study of Foursquare and the studies of systems built in this thesis, is the fact that it is a commercial service that is already in use. The results of this is that we can see emerging properties of the service, and potential impacts on the person's daily habits, and people in their surroundings. For instance, we find issues around using the service among other people. In order to check in, focus has to be given to the mobile phone in order to use the application. This takes away the focus from the people nearby with whom they may be engaging. This concern by users of the service, makes them handle this through different strategies. When out, they may wait for their friend to go to the restroom. One illustrative example is from one participant who tries to check-in while having breakfast with his wife:

> "I've been caught by my wife, ehm… doing it under the table. I pulled it out, like, like at breakfast, like what are you doing? And I'm like... she's like: 'you're checking in to Foursquare' she's like: 'that's not coming here. Like, it's Sunday morning, like what are you doing?'"

This shows the tension between the user of Foursquare and his Foursquare use, and his wife. Clearly, he is known for using the service, and the wife who is clearly not an avid user seems to object to the way he is using it. As he tries to do it under the table, it is obvious that he is aware of this issue. Here we have an emerging issue around the use of the service, which would be difficult if even possible in a regular time-limited system trial. This phenomenon, or social faux pas, is perhaps not isolated to the use of Foursquare but in the use of technology all together. However, as a mobile communications service, it invites more people into the otherwise intimate situation

between the husband and the wife. In the example above the husband is keen on using the service to communicate with his Foursquare followers, or to see where his Foursquare friends are. Thus the social and communicative nature of this mobile media sharing service has an impact on the physical social situation as the mobile service mediates a different kind of social situation. If nothing else it shows how the use of Foursquare has permeated his daily habits.

Mobile Use of Media Sharing

Studying these mobile systems in use teaches us what meaning and issues arise when media sharing is conducted in mobile settings. As stated above, the mobile setting is comprised here of people nearby and the social history. The lack of reciprocity in Push!Music teaches us the importance of reciprocity. The way people present themselves through the systems illustrate how they take care in what is mediated through the system when it comes to their own identity.

The mobility involved in these systems then means that what is said through these systems also carry with it the mobile setting. The performer uses whatever props he/she can find in this setting, and the audience is aware of it. It enables and also restricts what people do. For systems like Push!Music it means people must take this into consideration, so that the body idioms (e.g. the music that can spread from one device) is under control of the user. In Foursquare the performer uses the stage prop of the venue name and what it means to the participants, and the audience makes the interpretations. The performer also considers the settings that the audience might be in and refrains from potentially disturbing in the middle of the night unless necessary. The fact that the use of these systems is inherently mobile, and that people mediate through them, becomes an integral part of the use and what and how users come to communicate through them. For these types of systems, the mobility is inseparable from other service elements such as music, photos, or text. It is complementary but also what shapes the use and the meaning making.

When photos are viewed in Columbus, the identity of the people going there is not under scrutiny. However, the identity of the place, or the meaning of the location, has been socially constructed. This is reflected in the pictures and is mediated through the service. It is not that the photos are just objective accounts of what the place looks like, but it is subjective accounts of what the photographers have found interesting to capture. Again following Goffman, one would perhaps say that people behave in these settings in the way they believe they are expected to. This social order then is reflected in the photos we get to see in Columbus, and thus shapes the experience - and as seen in the trials of Columbus - shapes the impression of the place.

Studying systems: methodological contribution of the papers

The methods employed for studying the systems investigated in this thesis have developed over time. While the mobile landscape and opportunities for developing and deploying mobile services and applications have changed, so have the opportunities and challenges for evaluation methods. While the questions at large have remained the same, the means for answering them have evolved.

In terms of evaluation scale, we have gone from the ability to develop mobile applications with relative ease to be tested with an increasing number of participants. For the type of applications in this thesis, the trial size has correlated to the technical advancements of the field of mobile computing. The development processes and tools have enabled quicker development, which has enabled more advanced and robust applications. (Although we also see a direction where the applications actually become less advanced but rather aim to be single-function). The state of the art of mobile consumer devices has put advanced sensors into the hands of people. Their increased programmability has in turn made it possible for researchers to deploy research prototypes to a larger group of people. This results in the possibilities of running field trials in naturalistic settings with more users easier.

Increased trial size can help the users of a prototype application to find others who are also using it. With media sharing applications this means more people to share with. However, it is not the size that is important, but the setting of the trial. Social software (for example many instances of media sharing applications) depends on there being others to use the application together with. It is this setting of – other people – that has to be sought after when trialling this type of systems. This section will discuss how the studies were designed in an attempt to find these settings.

We wanted to study the use of these systems to see how people come to use and make sense of them. To enable the users to use them in a naturalistic way, we had to make sure all necessary components existed. This requires not only that the systems are possible to use from a technical or user interface perspective. As the interaction with the technology occurs in situational settings, we need to also enable these situational settings. While what enables this differs for each system, it is this focus on situational settings, beyond the technical implementations of the systems, that is discussed in this section.

Stimulating situated use

The first system trial of Push!Music followed a rather traditional methodology as employed within the field of HCI. The system was deployed to a set of users recruited for using the system over a period of time. In order to de-

ploy it, hardware was put into the hands of users who were instructed on how to operate it. They were also given instructions on how to cope with technical issues such as battery life and network connectivity as could arise during the trial period. This was further accompanied with regular visits by researchers to the field where the participants were, to see if there were any issues that had to be addressed on the spot. When the trial period was over, focus group interviews were used to inquire about the use and experience of the application. Together with the transcripts of these interviews and observations made in the field during field visits, the results were analyzed and written up to report on the study findings.

Push!Music being a social system meant for use when making sporadic encounters with others running the system, the density of people running the system becomes crucial. Since we had to supply the hardware to the participants, the number of participants was relatively low. The low number of participants therefore required us to pick a setting which would allow for these encounters. By choosing a university setting where the participants (students) hung out during the days (and as the reality of being students also late at night) we found such a setting where meaningful encounters took place, and where potential encounters were investigated by the participants - for instance checking for nearby people on the bus.

In Columbus the same need for sporadic encounters of users was not required. Instead what is important in Columbus is the sporadic encounter of photos nearby. We therefore bootstrapped the system by using already available photographs from an existing open database. We were instead exploring the point of discovery, when people find these photos as the location where they were taken. Thus while there was a need for a fairly dense database of photos, we could use an already existing one for our purposes. While it would be of interest to study the use of a system like Columbus when together with friends and in everyday use, the use of the application is not immediately dependent on such situations. Technical challenges of distributing this particular application at the time of the study prevented us from employing a pass participation trial. Therefore, as a first step in understanding this class of applications, we considered sufficient a study of individual use, to whom we could supply available hardware in our disposal.

For Portrait Catalog however we needed a more dense population of users. In an early attempt, we tried to go to an after school activity centre and recruit a small set of participants for a trial with an early version of the application. While some tried the functionality they did not really use it. Informally they told us (unsurprisingly) that it was not that interesting when there were no one to send the portraits to. Trying to alleviate this issue, we therefor sought out an event where we would get a larger group of participants.

We therefore wanted to evaluate Portrait Catalog with a large group of users. At this point in time, Java was popular as a mobile platform, and we

built it for Java-enabled phones. Because of the first failed attempt at the youth centre, a lot of thought went into figuring out how we could deploy it at a larger scale. Still there were no mainstream mass-channel distribution mechanisms that people knew about and used. One idea that came up was to put ads in newspapers, to "put it out there". However, there were still no proper ways for people to install the apps. Instead we got the chance to co-organize an event at a festival where teenagers would come to us for having their photo taken. Here we bundled the photo together with the app, and to get the photo they had to get the photo installed. We made this easy for the visitors by simply installing it on their phones for them.

Similar to how the Push!Music trials sought out a setting where the limited set of participants would have a high enough density of spontaneous meetings, we now had a setting where we would be able to deploy it to people who had compatible phones in a socially rich setting. By co-organizing an event where a lot of people would be, we gained access to potential users of the application. By having their photo taken and bundled with the application, they got the choice of receiving their photo by having the application installed on their phone. To add incentives to use the application, we organised a competition where those who shared and collected portraits the most could win a prize.

As a result, the application was installed on more than a few hundred devices. In sheer numbers this is a massive leap in comparison to the 12 participants in the Push!Music trials. As such there was potential in uncovering issues that may otherwise not unravel, as the social nature of the system required more people.

Finding situated use

As the mobile landscape of apps and services exploded after the massive uptake of smartphones, more and more services and applications with features similar to those investigated in academia in the decades before started to be put in use by millions of people. Therefore instead of developing new applications replicating already existing functions we can instead investigate already existing applications and practices around them. When there are already existing services in use that can be investigated to answer research questions, the instrument for answering them already exists. This takes away many of the previous issues, but mostly, lack of users and everyday use. This is what we did with the investigation of Foursquare.

With the study of Foursquare the issues of supplying hardware, distribution, and use, did not exist. As Foursquare was already a commercially successful application that people were already using, what we had to do was to seek out those users as participants in the study. With our interest in sharing location, Foursquare allowed us to do this without the need to build the service and do a trial. Only recently have mobile services and especially loca-

tion-based services been in use. What is particularly interesting about Foursquare is the fact that it is actually being used - that users share where they are publicly - which goes against much previous work within academia (e.g. Iachello et al, 2005; Lederer et al, 2003). Instead of trying to build a system that tries to incorporate whatever measures previous research have suggested in a system similar to Foursquare, it makes much more sense to look at Foursquare - a service that is actually being used despite its theoretical shortcomings. E.g. Toch et al (2010) looked for an empirical model for people's attitudes of where and when they would like to disclose their current location with friends. These preferences however are based on how a user may setup rules for what locations to disclose. Namely, to grant the system the right to disclose certain locations and not others. This I think is based on the idea that computer systems should do things proactively for us and have agency. Maybe this is the cause of many concerns with computer systems, such as privacy and integrity.

Research in the Large

The last paper in this thesis presents opportunities and challenges with using wide distribution channels for deploying research applications to conduct studies of technology and user behavior. These opportunities have been brought up by developments that have occurred during the development of the work in this thesis. The way Push!Music was developed for less than popular consumer devices demonstrates the maturity of wireless consumer devices at the time. The fact that it was difficult to deploy Columbus to a larger user base demonstrates the maturity of the distribution channels. Further, it demonstrates the state of the use of mobile services. The study of Foursquare then, demonstrates how, only a few years later, it was possible to do research in the same domain by studying an existing service that had millions of users. This fact, and the fact that it is increasingly simple to develop advanced mobile applications utilizing a plethora of (what used to be) advanced sensors, that run on people's personal and intimate devices, highlight the opportunities that exist for designing, building, and studying mobile research applications.

This last paper was one of the starting points of a series of workshops that we organized together with a disperse set of international researchers. Since then there is a smaller research community that discuss the theme of research in the large. What is most evident from this work is how wide deployments can aid the research question, but that one also has to conduct research in the small - a way of saying that we need to complement the deployment and data acquired from the sheer fact of having the system in use, together with methods for acquiring more qualitative insights. E.g. Morrison et al (2012) propose a hybrid methodology for mobile software trials.

With the opportunities of wide distribution channels such as the popular app stores, and the use of the open mobile web, we have seen that you can perform mass participant trials with relative ease. The special issue in IJMHCI documents (ref) some early experiences with these methods, and the set of workshops held on the theme has nurtured an ongoing discussion within the HCI community.

These opportunities highlight new considerations for developing research systems. As users find these systems among other commercial applications, the demand for a well-polished system is higher. There are ethical concerns for informing people about their participation in a study (through terms of consent), which may influence the perception and use of the system. However, the potential of actually creating a meaningful experience of mobile media sharing applications at large grant making the extra effort for these types of systems, as they allow the systems to be trialled.

Participants vs Users

In the trials of Push!Music and Columbus, each and every user who we gave the system to was a participant in the study. In the Portrait Catalog trial this was not the case. Instead we deployed the application for people to use. As they used it they became users, but only those who we inquired about their use became participants. While we were unfortunate to not see much use of the application, the participants did provide us with insights. When we start to look at trials where applications are deployed in the wild, users are no longer necessarily participants. With our focus on qualitative research methods rather than quantitative, we are mostly interested in a manageable number of participants. That is to say a number of people with whom we can get qualitative data, through for instance interviews. However, for many of these applications, as we have seen, a larger number of users is necessary. It would be excellent if we would be able to successfully deploy a service like Foursquare every time we wanted to trial a system. This would allow us to study the emergent practices around the service and its design. We would however still not look at what each and every user of the service does with it, but still look at a diverse subset of users to answer questions about how they are using it and why. While valuable research questions can be answered through quantitative measures, it has other issues and concerns. For instance how to get a representative sample from the population of users, and who the users are.

For the studies in this thesis, the emphasis then would be to go for use in the large to achieve a situated use of these services. But to answer the research questions, one would go back to the small, to see what issues arise. The use of the service by a sheer number of users is then part of the social situation in which the service is used, where emerging practices may develop. And to see what these emerging practices are we do not need to look

at each and every one of these users, but to employ a smaller set of participants to study.

Conclusions on studies

Conducting these studies during an ever increasing maturity of mobile technology and user adoption, we learned about how we can go about doing trials of such systems. From the Push!Music trial we learned that by introducing the system to people in a particular setting, we can create a dense enough environment for spontaneous ad hoc connections to occur - something that was a prerequisite for the particular design attributes that we wanted to investigate. The Columbus trials showed that deploying that particular system was difficult despite running on consumer devices according to the specifications. With Portrait Catalog we learned about conducting field trials at a larger scale. Deploying an app directly to people's phones was possible, while spurring use proved more difficult. With Foursquare we show how we can gain insights into this design space that we explore, by looking at an existing service that has already attracted a large user base.

In terms of trials this thesis contributes to show the development of how trials can be conducted depending on the maturity of devices, development tools, distribution, and user penetration of the technology at hand. At the time of Push!Music there were very few mobile services in use by consumers. When we investigated Foursquare, smartphones, and mobile applications and services were already an integral part of many peoples everyday life. The means of conducting trials, and the methods for doing so, has changed dramatically.

To conclude, the work of this thesis has dealt with conducting trials of mobile systems with different demands on use setting. The individual trials have dealt with this in different ways and illustrate how issues with critical mass can be overcome when deploying such systems. Further it points to using mass distribution channels to deploy services in the wild, in order to gain further insights in people's practices around mobile services when critical mass is needed. This becomes especially important when dealing with mobile media sharing, which has a requirement in users to use it.

Building systems: technical advances and lessons learnt from overcoming technical challenges

This thesis has dealt with mobility as an opportunity rather than as a problem. The opportunity has been to see what can be done with the fact that people are mobile and throughout their daily lives go about many different ever changing situations. These situations comprise many things, but for the

case of our media sharing applications, it primarily deals with people going in and out of situational settings; that is to say, the set of people with whom you directly or indirectly interact changes continuously. For instance in the case of Push!Music it is the people you are nearby and exchange music with, and in Columbus it is the photos people left for you to find.

The technical contributions of this thesis is both in how mobile systems can be built to allow the mobility of users to be used as a resource in systems design in general, as well as in what we learned while building these particular systems. While there are more details in the papers at the end of this thesis, we will here highlight two lessons learned from Push!Music and Columbus and some implications to draw the reader's attention to how these technical solutions can be seen through a different light than just as solutions to a particular problem.

Lessons learned from building Push!Music

Having the devices communicate with one another in an ad hoc manner and not through a server, means that all information that is available at one point is bound to be the information available on the device, and any device to which it is connected. Push!Music therefore had to use a distributed collaborative filtering algorithm to work over a mobile ad hoc network. In effect this means that the algorithm only had a partial image of all information about music and people.

A potential solution that would be available today would of course be to use the ubiquitous cellular networks to communicate through a server. Therefore the server could keep track of users and the music listened to by the users. It could use the locations of people to determine where they are, and who is nearby. It could use the information about what songs people listen to and not listen to to make recommendations. Given that recommendation engines can make better recommendations given more information, this approach makes sense.

Thus, in theory, the recommendations given in the server based solution of Push!Music would be better than the ones in the original system. However, as stated in the study, the recommendations from the system seem to have their value from the fact that they make unpredictable recommendations - recommendations that would not have been given by a friend. Now, if the recommendation engine therefore only has partial information, it would make more "mistakes". However, those mistakes would be such that they would make unpredictable recommendations. Even though the information is partial, it does not mean it would make a faulty recommendation, it would just make a recommendation based on the available information.

While having a subset of available information then, the recommendations might become less optimal in terms of certain performance metrics. However, that might not mean that they are sub-optimal in terms of user

experience. Thus making a selection of a subset of information might actually make more nuanced recommendations. Borrowing from how this was already done in Push!Music due to the network setup and its properties, one way of doing this is then to delimit the amount of information the recommender can use to the information available on the devices in the vicinity. This would also potentially keep the characteristics of Push!Music where one hypothesized use was to be able to harvest a certain type of music at certain locations due the type of people at those places.

At the time, the use of mobile ad hoc networks was a means to achieve communication between physically close devices. However, by doing so it also highlighted a property that can be useful when designing systems, even though the underlying technical infrastructure does not have to be the same.

Lessons learned from building Columbus

Another example comes from the work with Columbus. Columbus shows photos from where you currently are on a map. To achieve this it therefore had to have a set of geo-tagged photos. It also needed some way of knowing where you are (where the device is), and a way of displaying this on a map. On order to display a map, it had to have map logic for rendering a surface according to the world, and graphics that can be mapped to this world. To simplify it a bit, there had to be a database of geotagged photos, a sensor (or other technology) for figuring out your geographical coordinates, and a way of rendering a map. Columbus also distinguishes between places you have been to before and places not before explored. When looking back to pictures that one has unlocked or discovered, the map shows unexplored areas as dark areas and explored areas as bright areas.

Many of these things are today so common that they are readily built into the operating systems of most mobile platforms. However, this was not so at the time of building Columbus.

Fortunately for the database, there was already a large corpus of geotagged photos on, at the time, most popular photo sharing web site - Flickr. Flickr further offered public APIs for querying their data which made the photo collection part easy. The way one would do the same today would probably look the same, although one might use other sources of photos, or combinations of, such as Instagram.

Figuring out your location is also something that today comes natively in mobile phone operating systems. Today location APIs are easy to use and hardly distinguish between locations given by the GPS unit in the phone or a network based triangulated location. However, before they existed, other mechanisms had to be used to obtain a location in mobile phone based systems. Early work we did on location for instance used custom made algorithms for recognising locations from cell IDs (Rost et al, 2009). Fortunately, at the time we started work on Columbus, GPS devices had just started to be

integrated into mobile phones, and Java ME had already included JSRs for using it when available. Obtaining the location could thus be implemented using open Java standards, much like one would do today with native function calls from iOS or Android.

Maybe surprisingly the example here comes from the use or rather implementation of the map renderer. The mere measure of including a map over where you are and rendering icons of photos on top of it would be a simple matter today. Again, most mobile platforms include map widgets ready to be deployed in applications and ready to use classes for controlling their behaviour, including drawing overlays on top of them. However, to do this in Columbus several things had to be implemented. A collection of map tiles would be stored on a server and a web API created for requesting those tiles. Second, the client had to request those APIs in a clever way and render them appropriately, and both the server and the client had to cache the tiles. The important part here is that the server requests tiles from the server, which sends back the tiles requested. With this request comes information about which tile to get and who the user is.

In order to render areas bright or dark depending on if the user has been there or not, one could do this in either of two ways. Either let the server keep track of this, or let the client keep track of it. In either way, the client has to have some way of showing these areas as bright or dark. Using existing map APIs, what one would have to do is basically to draw an overlay over the map. In Columbus however, since the map server logic, and map rendering are part of the application, we combined these two logics. When requesting a tile in ‘explore’ mode, it means that the user is exploring this area and is physically at this location. The server can then store this information into a database keeping track of where a user has been. Later, when requesting tiles in ‘browse’ mode, the server checks this database and returns tiles pre-rendered as either dark or bright. This has two effects. First it relieves the client from the burden of having to check where one has been and render tiles differently, and it does not have to keep track of where one has been. Thus in one go, the client requests the tiles and gets back all information needed to display the right thing in one response. Using the current map APIs, the system would instead let the native API render the maps as it gets them from the server. Then, the client would have to render an overlay on top of the map, making the map darker or brighter. To do this, it would have to know where it has been, or request this from the server. By combining the server call that requests maps with storing information about where one has been (essentially repurposing the cache), both less work has to be done by the client and less data has to be sent between the client and server.

Looking at the development of technology, both data storage and communication bandwidth is increasing fast. The bottleneck will be establishing connections with the server, as latencies will not be able to drop as fast as

data rates. Thus by combining and repurposing the server requests, we found a way of lowering the number of server requests made.

Again, even though one would not go about writing a new map system today instead of using already existing, ready to use, native APIs, one might take a second to think about how this can be used elsewhere to optimize for a better user experience in terms of responsiveness, when one find the bottleneck in an app to be network calls.

Conclusions about building systems

When building systems you can learn many things. You learn about the difficulties you face on the way, and you learn about how to overcome them as you do. These solutions can also show you new ways of doing things.

While mobile technologies face rapid development, the development also presents new challenges. The technology used in Push!Music allowed the implementation to identify people nearby. Current technology does not allow this as easily. What used to be a selling point for devices, built in peer-to-peer media sharing (Bluetooth) is today virtually non-existent in mobile devices sold today. Bluetooth is used extensively for connecting peripheral devices, but not for exchanging media between mobile phones. Third party apps such as Bump (http://bu.mp) makes this possible, but it does not do it over a peer-to-peer connection but rather over the network.

While Push!Music and Portrait Catalog relied on peer-to-peer technology that was available at the time, to make a commercial application using these technologies today would not be feasible. Leveraging WiFi connectivity in the way we did with Push!Music is not allowed in current popular platforms such as Android and iOS. While Bluetooth is implemented in both operating systems, there are incompatibility issues that makes it difficult, if at all possible, to use for peer-discovery. The feasible way is then to do it in the way Bump does it. When two devices are bumped together, they figure out which two devices are bumped by a clever use of timing and location and then establish a network connection through their servers. While it appears to be between devices, the underlying network architecture is not different from if the devices had been in different countries. Similarly, Push!Music and Portrait Catalog could leverage the location of the device (much like Columbus uses GPS) to figure out which devices are near.

In order to technically introduce mobility as an opportunity for interaction we must find a way for technology to allow this. For the systems in this thesis it is done in different ways. First of all, they are all running on mobile devices. To interact with people currently nearby, WiFi is used in Push!Music and Portrait Catalog leverages Bluetooth. Columbus use GPS to figure out the location of the user, and in a way Foursquare does the same. Foursquare however rather uses its database of semantic names of location, created by the users of the system. It is in how the design of the systems

makes use of these technologies that open up for new possibilities for interacting with people and the world. In a way, the core technologies are reappropriated to implement the desired function. But it is not so much in what the technology do, but rather in what we do with the technology. As much as it is what users do with the systems, it is what the systems do with the technology that is interesting here, rather than what the technology do for the systems.

Push!Music is based on the music devices being able to detect who is nearby and to be able to send songs between them. Push!Music implements this by employing WiFi. WiFi allows the formation of mobile ad hoc networks, which means that the networks form when devices are near each other, without the need of an infrastructure of access points. This immediately serves two parts. First, the people nearby are the people with whom the devices have formed a network with. By each device broadcasting each other's identity, the application can know who those devices belong to and who the people nearby are. Second, as the networks are formed, communication channels are created between these devices and the music files can be sent over these channels. The interactions that can take place around this implementation then is for people to see who is nearby, to send songs to those people, and to automatically receive recommendations through the autonomous behaviour of the system.

By using Bluetooth, rather than network based communication, users of Portrait Catalog have to be near each other to exchange photos. Furthermore, the application only allowed your own portrait to be sent to people, and not portraits you had received. When showing your catalog to friends then, they are certain that the photos in your catalog are actually from friends you have met and who have wanted to send their portrait to you.

As we see a potential future of these types of systems, there is still a lack of underlying technology. While it is possible to simulate peer-to-peer connections, there is no easy way to establish true peer-to-peer connections between mobile devices today. While there are wireless communications protocols they are rarely used in mobile phones. Protocols such as ZigBee (www.zigbee.com), ANT+ (http://www.thisisant.com), etc are mostly used for embedded systems. If these were to be implemented in mobile phones, they could potentially allow for some interesting new mobile systems.

Conclusion

This thesis consists of the work of investigating four systems and reflections on the progress of the research process for these types of systems. The last paper looks at how the current state of the art of mobile platforms can afford opportunities for mobile systems research within HCI and UbiComp.

The contributions are fourfold. First we have explored a design space that despite longevity of research remains under explored. Second, we have studied systems within this design space to learn about the systems in use. Third we have followed progress in terms of how trials are conducted as realised by the progress of the mobile landscape of devices, platforms, and service distribution. Last, we look at how the technical solutions are not only transferrable, although dated, but are, rather, beneficial as they show a different line of thinking from how similar solutions may look today.

Although we have witnessed an explosion of mobile applications, social media, and locations based services in the last couple of years, there are still elements missing. One such is that of co-present interaction in mobile media sharing. While we with ease can communicate with people on the other side of the world, you mainly do so in the same way as with the person next to you on the bus. What this means for content discovery, exploration of the world, and intimate contacts with people close to us, is still under explored. We will undoubtedly see many incarnations of ideas emanating from the work in this thesis in years to come, as we have already seen some. There is room for both continued research in this area, but also for commercial applications.

The advancements of research in the large now incorporate its own community of researchers, and many more are exploring the use of large scale deployments for mobile application research. As new methods are developed, so will the results from these endeavors excel. Care must be taken to not get lost in the large, but to also make the effort to go small, while considering what the data obtained reflects.

The way we see ourselves more and more surrounded by devices in our everyday lives, getting these to work together is still challenging. The easiest way to send a photo to someone you are having lunch with is still through email, although we do see instances of use of NFC for this. There is obviously still room for many new interaction modalities to be explored, and ways for people to interact with one another. Much like there is now maps data readily available for us to virtually see every street of the world, indoor

maps is still in its infancy. Similarly, while to share photos, videos, and text with everyone around the world, how to share with people right next to us is also in its infancy. Maybe the reason for this is in how we as humans want to explore places further and further away from us. We now have more than one Mars rover exploring Mars, but we still have no clue of what is at the bottom of the earth's deepest oceans. The next step might not be to enable media sharing with people on Mars, but to enable media sharing with the person next to us on the bus.

My experiences working with these systems and studying them in use, allow me to think about what it is that is still missing in the services that people around me use every day to share media. Looking at the systems as media we see in the studies how people attempt to find strategies for creating a self-image through performances. In Push!Music they send particular songs to strangers, but it falls short when there are no immediate means to reciprocate. We see how people check in on Foursquare as a performance. Columbus enables users to look at the world through other people's eyes and as such communicate a shared understanding of a place.

The music files stumbled upon using Push!Music are more than the music files that they can listen to, but it is also the places that one is in when this happens and the people present. Photos in one's catalog in Portrait Catalog is more than a photo of someone - it is a photo of someone you have met and who has agreed to send it to you. Showing this to a friend communicates this fact. The media content shared through these mobile systems is not just the media, but it is in interacting with the media and people in situated occasions that create added meaning that is not found in the media content by itself. In this sense it is the mobility that allows for these meanings to arise. As it is through the mobility that the systems allow users to interact with each other, mobility is the medium. It is not just the photos and the songs shared that immediately affect what people do with them, but it is the medium in which they are shared and consumed. As the medium is mobility, mobility is the message.

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