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Context sensitive netbooks

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1 Introduction

Netbook is a collective term, most likely coined by Psion in 1999[1], representing relatively inexpensive small notebooks designed for wireless communication and Internet access. Lately netbooks have become an interesting tool for several reasons. Due to their small size, netbooks can potentially be used in a wide range of contexts. In general the hardware in and software on netbooks is not restricted in the same way as on most cellphones, hence 3rd party developers aren't limited to the producers visions. However, due to size, netbooks aren't optimal for handheld operation.

Our original idea for this work was to look into ways of circumventing this limitation by extending the features of handheld devices through interaction with netbooks in a context sensitive manner. During our research we discovered two things that would change our idea fundamentally. First of all we discovered that it wasn't netbooks we were interested in, but rather small portable computers. Our ideas evolved around portability not price. In other words portable computers small and practical enough that one brings them along "everywhere". Secondly we discovered that for such extensions to be successful a context sensitive framework should be available. We will in this document look at existing software, existing frameworks, literature within the field, and the ethical pitfalls that such a framework could present. Finally we will present how such a context sensitive framework could be created and how we hope such a framework will impact our lives.

As we read articles about context sensitive computing and started finding results in our survey our view of context sensitive computing changed. Originally we were a bit spellbound by context sensitive services with a high cool factor and interesting new use of technologies. Agre[2] pointed out that an important goal for system designers is to make sense of context for the user as increased mobility has made many tasks usually confined to architectures and institutions more difficult to perform. Mark mentions that "the most profound technologies are those that disappear"[3]. This motivated us to research the possibility of suggesting a context sensitive framework that would make life easier for students at the university that would integrate seamlessly with their everyday studies preferably in a way that would disappear and become expected. Ethics within the field of information technology is an important subject not to be treated lightly but is often overlooked. We did not want this to be the case with our paper hence we have thoroughly discussed the matter.

2 Netbooks

2.1 History, emerging trends and the future

The netbook is a class of laptop computers designed for wireless communications and access to the Internet. Netbooks were created to rely on web based application and thus are less powerful than the general laptop. They typically run Linux or Windows XP. The screen size ranges between 5 to 13 inches with a weight of around 1 kilo and are generally less expensive than a general purpose laptop.

At the end of 2008 netbooks started to steal some of the laptop market, with sales averaging 30 times more than earlier that year. While only 400,000 netbooks were sold in 2007[4], 30 million will be sold in 2009[5, 6] and an estimated 139 million in 2013[6, 7]

Netbooks are not used the way the concept originally was intended. Netbooks were created to be inexpensive computers relying heavily on web services. Consumers however seem to be using them simply as a cheap alternative to laptops. This suggests two features that are attractive: price and portability. Thus one could predict that the netbook of the future is either a super portable laptop for professionals or an inexpensive simple laptop for the mass market.

Many actors exist within the netbook market, all of them trying to gain an advantage in a pressed market. It also seems that there isn't much money in the market today, again suggesting that the netbook will have to evolve into something different in the future. As of today what differentiates the netbooks from the different actors are type of processor, weight, display size, video chipset, storage, RAM, battery life and the size of the keyboards. In addition the products position themselves either in the high end or low end market.

The original actor in the netbook market was Asus. They have, however, lost a significant share to Acer who now are the leading producer in the netbook segment, capturing a market share of 38.3% compared to Asus' 30.3%[8]. This means that Acer sold 2.15 million netbooks in Q3 2008 while Asus only sold 1.7 million[8].

The consumers are divided in the way they perceive netbooks. Some see the netbook as a hot consumer product while others see it as just a passing fad. The industry is trying to position the netbook as a complement to portable and stationary computers and not a replacement[9].

A survey among 1,545 US adults in early January 2009[9] indicated the following: One in ten consumers has purchased a netbook, the netbook complements the laptop and the desktop, 91% of netbook owners also own a laptop, while 87% also own a desktop, and users are evenly spread across all consumer age segments.

It's worth mentioning that even though the computer industry is going

through a tough period due to the world wide economic crisis, the netbook segment has increased with a growth of over 160% from one quarter to the next.[9]

Lenovo has introduced it's IdeaPad S10e marketed totally towards education. This netbook is designed for one-to-one computing in high schools and higher education. Several other producers followed suit with devices such as the HP mini-note, Intels Classmate PC, Asus Tek Eee PC and Dell Mini Netbooks[10]

AMD is planning to enter the market with a high end netbook during the first half of 2009 while the rest of the market is dominated by Intel's Atom processor. Currently netbook customers are demanding a more cost effective and higher performing solution than AMD seems to bring to the market[4].

There has been some concern among enthusiasts that the netbook market is nothing but a fad or a transition to a new or better technology similar to what happened to the Beta Max or the MiniDisc. Therefore Intel and AMD have been careful concerning the netbook market. However we cannot disregard the explosive growth in sales throughout 2008.

Several articles skeptical to the netbook have been published on the net. They claim that netbooks are underpowered and have substandard hardware. Size is also an issue; small is desirable only to a certain point. Certain articles also claim that battery life is substandard. While early netbooks ran Linux, Windows XP has taken over the market with over 90% of netbooks running Windows[11].

2.2 Android to refocus netbooks?

Asus is at the moment developing a netbook that will run Google Android instead of Microsoft Windows[12]. Android, developed by Google, is an open source operating system for cellphones. Although Android still is in it's early childhood (only a few handsets running Android are available at the moment), the future marked seems promising as both Sony Ericsson[13] and HTC[14] have announced that they are working on Android based cellphones.

There has been a lot of buzz around netbooks running on the ARM-processor lately. Unlike Google Android Windows XP cannot run on an ARM-processor so we will be seeing alternatives.

So what will this do to the netbook as we know it? Mainly two things. First of all this might be the first time we see Microsoft getting any real competition on the netbook operating system market. Secondly, and more important, this might very well be what is needed to bring the netbook back to it's original intention. Since Android is developed specifically for cellphones it is not a traditional PC operating system like Microsoft Windows XP. It's created to run on small devices with small screens and limited hardware, exactly what the netbook is. A netbook actually offers much more

screen and hardware than the devices Android is created to run on. Google has already created many advanced and commonly used "cloud computing" services like Google documents, Gmail, Google calendar, etc. If these are integrated in an Android powered netbook (Android is already tightly integrated with Gmail) we are back to the basic idea of the netbook, cheap hardware that relies on online services and cloud computing.

According to Leslie Fiering at Gartner Research this integration with googles "cloud computing" services is what is needed for Android to succeed on the netbook platform[12]. Windows has a much higher hardware demand than Android, and also boots slower. This might very well mean that Android is what we will see on netbooks in the future.

This might play a key role in context sensitive software running on netbooks. One very obvious benefit is the fact that two devices running on the same platform and also running similar software can, potentially, interact much easier. Secondly if users start using their netbook less like they use their computer and more like they use their cellphone, we might be in for a "context sensitive revolution". At the moment we are in the start phase of a revolution in the way we use our cellphones. Maps and location based services are becoming more and more important on cellphones. We are actually at the point where cellphones can "augment" reality by painting a map over an image of the user's surrounding produced by the phone's camera[15]. Netbooks in general have a much larger screen than a cellphone, and have the possibility to take this type of context sensitive services to a whole new level.

2.3 Are netbooks going away?

According to AMDs chief executive netbooks as we know them are going to disappear sometime in the near future[16]. According to Meyer netbook users today are compromising. They want a small portable machine, but the netbooks don't offer a full PC experience. His prediction is that upcoming ultra-thin notebooks will replace the netbook as we know it today. One has to take into account that AMD isn't in on the netbook market, and such a statement might be highly biased. However Intel might have a similar conclusion. Intels CEO Paul Otelline spoke of the netbook in past tense during his in Intels company earning conference in January. This might have been a Freudian slip, or it might be a warning about Intels plans for the future. However Intel hasn't released any future plans for the Atom processor, other than a 0.06 GHz update this year, something that might also support the idea that the netbook craze is nearing its end.

During our research we discovered that what we are interested in is not the netbook per se but rather small portable computers. Devices with enough resources to act as a personal computer, an interface that allows a similar user experience as a laptop, but still has a size and weight that encourages

mobility. According to AMD it's the netbooks as we know them that will disappear in the future. However, the concept of small portable computers that netbooks represent will continue to be the trend. Hence AMDs predictions will in no way affect our research negatively, but rather create a greater need for context sensitivity.

3 Context awareness

Agre[2] discusses context awareness in computing and suggests a framework for analyzing the phenomenon. Agre describes a conceptual framework with three levels: architecture, practices and institutions. He goes deeper and shows how new technology, like the cellphone, is breaking the barriers between these levels. The trend of breaking barriers continues as we bring higher processor capacities and device capabilities with us to new locations in the form of netbooks. Though Agre has a positive attitude towards this trend, he also claims that it highly complicates context awareness. Breaking these barriers complicates the task of separating different activities. Our location tells us much less about our activity than it used to. He also makes a point of the fact that context aware systems could fail when they are made to guess socially constructed events without the users cooperation.

Agre presents a design methodology, which he calls the "capture model". This model has certain tradeoffs that must be considered. The designers must choose between limiting the system to a subset of the aspects of the context or perform social engineering to force the users to adhere to the design.

The main methods a device uses to gather information about what context it currently resides in, is through sensor- and user-input. User input data may be based on concrete choices made by the user, or automatic observations of the users actions.

The evolution of precision positioning methods based on GPS or mobile network triangulation allows access to precise information about ones geographical location. Several detailed map-services have been launched the last few years, and these days one can gain access to huge amounts of geo-data online. Combining geographical location with such geo-data can provide more information about the surrounding architecture than what was previously available. However this data cannot provide more information about practices or institutions.

> Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence[3]

Here we find predictions about computers and context sensitivity in the 21st century. Even though we have yet to reach Mark Weisers dream of ubiquitous

computing we have the building blocks and we are on our way.

Even though Weiser might have been a bit optimistic about the 21st century, he still makes some very important comments that directly relate to our work.

> The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

He uses writing as an example and claims that the ability to "represent spoken language symbolically [...] is ubiquitous in industrialized countries".

> Whenever people learn something sufficiently well, they cease to be aware of it.

This is exactly how we would like to see context sensitive functions on netbooks work. They should be so simple and omnipresent that the user should cease to be aware of them. When a users notebook automatically opens the newspaper of your choice when you enter your local coffee shop for your morning coffee it should be something you take for granted and don't even notice. According to Weiser

> Little is more basic to human perception than physical juxtaposition, and so ubiquitous computers must know where they are.

The fact that more and more cellphones implement GPS-hardware and blossoming of services offering positioning based on network information combined with the fact that the US government is making demands on cellphone providers to enable quite accurate positioning[17] and the European Union following[18] will produce interesting possibilities, if not for ubiquitous computing, at least for omnipresent computing. Presently such services mainly require a co-operation between the netbook and a cellphone, but as high end portable computers have started implementing integrated mobile broadband hardware and also the predicted emerging LTE technology[19] should eliminate such requirements. We would also like to see netbooks implementing GPS hardware in the future.

> Most important, ubiquitous computer will help overcome the problem of information overload. There is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods.

Even though most of us find computers to be far from as refreshing as taking a walk in the woods, and perhaps find Weisers closing statement to be, well,

an overstatement (computers don't give us fresh air, the smell of autumn, or any of a whole range of senses we find refreshing) he has an important point. A point that transcends ubiquitous computing and is just as relative in context sensitive computing. A context sensitive system should not be intrusive. It should not annoy the user. Using a context sensitive service should leave a user feeling as refreshed as after a walk in the woods, or at least as close to that feeling as possible. When a user actually thinks about the service, even though they shouldn't if the service is good, they should feel that the service improves their life, makes it easier.

Rhodes et al[20] look at some of the main problems concerning wearable computing and ubiquitous computing. The problems concerning ubiquitous computing in focus are privacy issues and difficulties surrounding personalized information. The main problems of wearable computing mentioned are localized information, localized control and resource management. Their suggestion is that combining the best of these two technologies can limit the severity of these problems. They show examples of services, developed with Hive[21], that take advantage of this combination. The privacy issues can be solved by storing private information on the mobile device and context can be derived from the tags in the surrounding environment. The fact that you, in the system, always carry your personal data with you, solves the difficulties concerning personalized information and allows the information to always stay updated within the whole system. The problems with wearable computing are reduced to establishing contact with the correct components in the ubiquitous system. We will return to Hive later in this paper.

3.1 Mobility

There are several studies that discus mobility and collaboration in the workplace.

We have found several interesting findings and see parallels to students, especially the more philosophical considerations. Bellotti and Bly[22] make a distinction between "local mobility" which is walking around the office and near by structures, and mobility that is beyond walking distance. Parallel to this they use the terms "local collaboration" and "long distance collaboration". One of their findings was that local mobility enhanced local collaboration but penalized long distance collaboration. This might be the case for students studying at the university or at home too. Bellotti and Bly suggest that some of the problems could be reduced through the use of "portable computing devices with wireless communications capabilities"[22] but that this would be to expensive to implement. This was in 1996. Today mobile phones and netbook are affordable and can perform the necessary tasks.

Luff et al.[23] discuss another kind of mobility, "micro-mobility; the way in which an artefact can by[sic] mobilised and manipulated for various pur-

poses around a relatively circumscribed, or 'at hand, domain"[23]. They discuss how artefacts like medical record envelopes at a hospital and work allocation sheet at a construction site are used for collaboration. They give examples of how the micro-mobility can be hard to mimic with an electronic replacement. We think that an object of interest for studies of micro-mobility in a student setting would be the humble paper notebook. A netbook could replace many of the uses of a paper notebook in a student environment. However, not all uses of a notebook could be replicated by a netbook. A study of a such replacement and alternatives to the netbook as a replacement would be interesting for future work.

3.2 Device proximity

One very interesting aspect of context sensitivity when considering interaction between netbooks and mobile units like cellphones or PDAs is device proximity. Allowing devices to automatically configure themselves based on what other known devices they are in close proximity to can be a powerful feature. An interesting piece of software recently released for the GNU/Linux platform entitled BlueProximity[24] enables this type of features. The software can handle multiple devices, supports configuring the duration and distance a device must be within before an action is taken, and supports three types of user configurable actions; device enters the proximity, device leaves the proximity, and an action that will be triggered at a configurable interval as long as the device is within the proximity.

BlueProximity is written in Python and therefore can easily be adapted for other uses, like selecting actions based on what devices are within proximity. Being able to customize the software opens an endless sea of possibilities. From the simplest of uses, like the intended use where one can configure the computer to lock and unlock when a device enters or leaves its proximity and block the screen saver from turning on while the device is within proximity, to more advanced features like automatically starting VOIP software when a given headset enters proximity and pushing a remote control for the VOIP software to a cellphone that enters the netbooks proximity, or automatic roll call based on cellphone presence. Even simple applications like updating ones status on social networks when one comes within proximity of a device could prove to be highly popular.

3.3 Dual use

The most obvious use of context sensitive applications between netbooks and mobile units is controlling the netbook from a mobile unit. However information exchange the opposite way can also provide several interesting services. One rather interesting idea is to allow the netbook to gain access to positioning information from the cellphone. Services based on a users

geographical location are getting more and more popular and handsets today commonly offer positioning either through GPS or from the GSM/UMTS networks. Allowing a netbook to gain access to such data from a nearby cellphone can highly enrich the experience of many web services, not to speak of social navigation services.

Simple features found in more and more cellphones can be used for many other features. A GPS isn't limited to providing location data. A GPS can be used to determine if the device (and hopefully its user) is on the move, creating the possibility for a netbook to have different modes based on movement. An example could be a netbook that automatically goes into "car mode" or "public transportation mode" when it exceeds a certain speed, "walking mode" at a slower speed and "stationary mode" when it isn't moving. What these modes involve would, of course, have to be defined by the user. One could even create more complex scenarios. Imagine running to catch the bus to work in the morning, and missing it. One could define an event that detected running between 7 and 8 am. If the running event is shortly followed by high speed movement, nothing is done. If the device however goes stationary after detecting running speeds, it could automatically send an email to your boss informing him that you missed the bus, and will be running a bit late.

Some cellphones also come with one or more integrated accelerometers. This has resulted in several types of gesture based applications, mainly software that enables us to control the cellphone itself with gestures and software that enables us to use our cellphone as a gesture based remote control unit. A netbook could also use data from a phones accelerometers for new types of features. Depending upon how reliable the accelerometers are, one could for example detect if the user just sat down, just got up or did some sort of other detectable movement.

Many modern phones also include light sensors that are used for determining the need for background light on the display, background light on the keyboard, etc. This type of sensors can also be used to gather information about the surrounding environment, and help place the user in a context.

4 Ethics

There is no doubt in our minds that the ethics of context sensitive services and any type of location based service is important. Within information technology there seems to be several common trends. It's easy to pass the blame up the ladder. "I was just following order". The idea that it's not the developers responsibility to think about ethics is quite common. This attitude towards ethics is not a valid attitude and any ethical system will disregard this type of statements. As Laudon puts it "There is no ethical "invisible hand" in the moral marketplace that relieves individuals of re-

sponsibility for their actions, and all action must be attributed to human agents".[25] According to Johnson there is a strong trend in the IT ethics literature that an individual facing a moral dilemma should consult their firm or a professional society for advice and follow that advice. Laudon also makes a point of stating that this also means that one cannot blame the machine, "because the computer did it"[25] or "the computer told me to do it."[25] are not valid excuses.

This brings us to yet another important point. Often one hears people assigning ethical roles to technology. A certain technology is "evil", "immoral", "good" or "moral". This cannot be the case. Technology on it's own is morally neutral. Technology cannot be evil. It's the use people assign technology to that can be "evil" or "good". This is widely accepted in the literature[25, 26, 27]. Laudon, however, takes this one step further and claims that we as scholars must watch our language carefully to avoid such misconceptions. IT is not a force outside of society that causes things to happen all by themselves and we must carefully examine statements like "Computers solve problems in education". Commonly one sees both of these mistakes made in everyday talk and in the press, but this also shows up in the scientific literature.

> [...] RFID poses legitimate privacy concerns, the degree and nature of the technology's threat to privacy are easily misunderstood[28]

Before looking at the ethics of our project there are two more points that must be investigated. On the Internet there is a trend that individuals should be able to do whatever they want whenever they want and that one should pursue a minimally organized anarchy.[25] This is no longer the view of the aficionados only. It has rubbed of on a large part of the general population. The "fight" between the people downloading illegal copies of music and movies and the industry illustrates this. One can clearly see a gap between peoples sense of moral on the net and in society in general. Privacy and security, however, is a different issue. Although some people seem to have a completely different approach to the issue when going online (people use Facebook, people use Google latitude) there are also strong groups promoting privacy and security online, and there are many watchdog associations like the Electronic Frontier Foundation. As Harrison and Dourish say: "The kinds of ideas generally raised in discussions of privacy in media paces are, themselves, cultural understandings."[29]

Laudon also claims that there is a strong bias in the literature towards the problems of powerful groups.[25] We have seen a change in recent years, quite likely due to popular opinion and the press. However this has resulted in a lot of work being done within certain fields, like geographic information systems (GIS), location based services (LBS) and radio frequency identification (RFID)[28, 26, 27, 30, 31, 32, 33, 34], and less within other fields. A

lot of the work done within GIS, LBS and RFID can, however, be directly related to other fields, including the field we are researching.

4.1 Our issues

We have clearly showed that we have a moral obligation to consider the ethics of our work. Now it is time to look at what ethical implications our work might have. We can definitely see a connection between our work and the ethical implications that LBS, RFID and GIS may involve. We will here look at a variety of what we feel are the major ethical considerations that must be taken while doing our work.

Any context sensitive service must have some means of determining the location of the user of the service. Excluding location inherently excludes information about architecture and environment. Any LBS involves being involuntarily being covertly tracked, either by a third party eavesdropping, or by the provider of the service. Ultimately, using a LBS requires that one trusts the provider of the service. As we see it, the provider has, at the very minimum, a moral responsibility to do it's uttermost to secure transactions from eavesdropping, provide the user with information about what and how data will be gathered and used, provide the user with an agreement to that fact and last but not least inform the user of any negative consequences using the service could imply and inform them about why they might not want to use the service.

The misuse of data by a third party doesn't necessarily involve eavesdropping. A user could very easily voluntarily provide a third party with data that can be abused. A good example of this is using social web services where one provides ones location, for example a geo-blog. A thief could use this information to known when the best time to burgle your apartment. A jealous ex boyfriend or girlfriend could use the information to spoil your date. Many examples exist, but the point is that the evolution of LBS has provided the means to abuse information in a way not previously possible. This gives the providers a moral responsibility to protect their customers, and this is why we feel that a service provider has a moral responsibility to provide users with information about what actually can be done with their data.

But the abuse of data doesn't stop there. Another realistic scenario is cloning of your information. A third party could clone your identity and create realistic electronic trails in your name. There are several ways this could be done, and it could be used for a wide variety of reasons, but we will illustrate the problem with an example. Imagine that your spouse believes you have taken a lover. He or she hires a private detective to determine if this is the case. This private detective is lazy and decides it's easier to provide fake electronic trails of you being with someone rather than doing the actual work. You might be able to prove him or her wrong, but by then

the damage is already done. Or, perhaps even worse, imagine a criminal covering up his or her criminal actions by providing fake trails showing that you were present at the time of the crime.

A service that provides your location could falsely implicate you in an event you in no way are involved in. Both Perusco et Michael[26] and Dobson et Fisher[27] speak of this as a serious problem. Their example of a young Muslim woman being killed for pausing to long outside of a cinema or her boyfriends house is, though perhaps quite extreme, a realistic scenario, but it is also quite possible to relate this to ones one life.

This brings us to the geoslavery[27] that Dobson et Fisher provide as a warning. They propose that LBS and GIS can ultimately be abused to create geoslaves defined as

> [...] practice in which one entity, the master, coercively or surreptitiously monitors and exerts control over the physical location of another individual, the slave. Inherent in this concept is the potential for a master to routinely control time, location, speed, and directions for each and every movement of the slave or, indeed, of many slaves simultaneously.[27]

Although this might seem to be a conspiracy theory, or just far fetched, they show not only that the technology for such a scenario is readily available but also that their are cultures and governments that have an attitude that implies that such a scenario is realistic.

The scenario presented by Dobson et Fisher is presented quite specific for LBS. However, our presented context sensitive service could be used for the exact same means even if we disregard the LBS aspect of our suggested service. Just being able to know what context a person is in could be used to create this type of slavery. A society where a family would be willing to kill a member of their own family as punishment for going to the movies[27] wouldn't have to rely on precise location of the victim. Just being in certain contexts could result in punishments. This could actually result in a moral judgment that certain types of services should only be available to certain cultures.

There is one final point to be investigated. As we have presented earlier we feel that context sensitive services as we suggest should blend in to our everyday life and become part of it. They should ultimately not be notices by the users at all. This leaves one final problem. Do we actually want to be this dependent upon technology? Are we becoming slaves of our own technology? What happens when the system fails? What happens when the service that is so integrated in our lives that we don't even notice its presence goes away?

4.2 Possible solutions

Finally we must look at how such ethical questions can be resolved. Some laws have been proposed, like "Durocher's laws of LBS"[35, 26, 36] but as Perusco et Micahel points out such laws are merely guidelines for discussion unless they are enforced by legal regulations, and even then they would most likely only be valid during peacetime[26].

If we look at more general literature in the field of ethics and information technology we can find more interesting guidelines. Both Mason[37] and Laudon[25] present what we would call deontology, utilitarism, theory of virtue and theory of justice. While Laudon comes to no definite conclusion on how these theories should be used, Mason presents the idea of looking at the problem through the lenses of all of the systems:

> When facing a moment-of-truth, one is well advised to view the situation through each of these ethical lenses. Each provides insight into the moral complexity of the issue being examined. Frequently, however, the guidance deriving from one of these theories will conflict with that of one of the others. This requires a moral judgment, one that shows how one theory or principle trumps another. The reasons behind the choice made should be grounded in at least one moral theory and justified accordingly.[37]

This sounds like a sound way of coming to a conclusion, however one must take into account the time and effort spent on acquiring enough knowledge of all the main ethical systems to use this method. One might also have previously concluded on an ethical system that one follows.

Mason also makes an important point when noting that every decision made becomes a precedent in the future.[37] Our choices today might very well affect the future and perhaps even create worse problems than the problem we are solving. Therefore it is important that our choices and moral judgments reflect not only the current situation but also take the future into consideration.

A common view is to let the end-users do the moral judgments. Launch the service and let the users decide for themselves. Google seems to have suggested this approach when launching their new tracking service called latitude. What seems to be their solution to the moral implication of sensitive location data is to offer the users fine-grained privacy controls and the option to provide a fake location manually[38]. In our opinion there are several problems with this approach. First of all this might be a case of just passing the decision on. We say might because we have no way of knowing what, if any, moral judgments Google might have proposed. Secondly, we feel, as mentioned in the previous section, distributors of such services have a moral obligation to inform their customers of any ethical problems involved in using the service. Finally there is the problem of "sneaking" new technology

into the society. As Michael et Michael mention

> So long as individuals are "gaining" they generally will voluntarily part with a little more information. It is when they stop gaining and blatantly start being taken advantage of that the idea of Big Brother is raised.[31]

It is also very important that the consumer that decides to opt-out and not embrace the technology should not loose other rights as suggested by Garfinkel et al[28].

4.3 The mind

Neuroscientists have discovered a link between the activity in, and the size of the brains hippocampus and our ability to navigate maps[39]. Modern navigational systems, including the world wide web, the way we use our cellphones, and also the techniques presented in this article are moving towards mapping methods. Hugo Spiers has speculated that as we now rely more and more on the web to tell us how to navigate we might be reducing the growth of cells in our hippocampus[15]. This might have serious ethical implications. If the evolution of what we are using our technology for actually is affecting our brains in a negative way, then further development of this types of software will place the developers in an ethical dilemma, and might seriously affect how we use software in the future.

4.4 Conclusion

There are clearly ethical considerations that must be taken into consideration and moral judgments to be made before creating a context sensitive framework as we are suggesting. Such a system cannot be implemented without seriously considering at least the above mentioned moral questions. Quite likely other ethical issues might have to be solved. Ultimately the decision must lie on the parties that implement such a service.

One could ask if we are just passing the responsibility on to someone else, in clear violation of our suggestions above. The answer to that question is no. We have made a moral judgment that suggesting this system can be ethically defended as long as we are quite clear on the possible ethical implications and in no way try to disguise the fact that there might be moral reasons not to implement this system.

5 Survey

5.1 Methods

Two main methods were proposed regarding methods for our user survey. Our original idea was to use our research to develop an idea for context

sensitive software running on a netbook and a cellphone, and if time allowed, develop a prototype. The user survey would then be used to survey peoples reactions to context sensitive interaction between netbooks and cellphones, security issues regarding such services, and similar questions in general, and our suggested software specifically.

Further on in the process a different approach was proposed. Instead of developing a specific idea, we could use brainstorming techniques to create a larger set of ideas and perform a survey evolving around all of these ideas. Which, if any types of software would people actually use? How should the software be created to en certain that people actually would use the software? What types of services are people interested in?

There are several reasons why the second proposal is a more interesting approach to our work. First and foremost we will gather more interesting data regarding specific uses. The first method relies on our ability to, on our own, come to conclusions about the most interesting use for context sensitivity between netbooks and cellphones, whereas the second method only relies on our ability to suggest interesting ideas. There was also a time aspect involved. Developing a working prototype within the time frame of this project would grossly limit the amount of research and survey processing possible.

We concentrated on netbooks in a university setting when conducting our survey. Students represent a uniform group of users, and the university represents a well defined institution that is easily available for studies. Students in general also use a lot of technology throughout their day, and represent a very good example of context not being defined by location alone, but also activities. Dinner in the cafeteria might represent a meal, a meeting, desperately cramming for an exam or just being social. It's quite easy to imagine context sensitive services that students could benefit from.

5.2 Results

For this purpose we created a survey in a form of self-administered questionnaire for a rapid turnaround data collection. The total count of answered forms was 97 and they were not stratified and the obtained data was analyzed using Minitab. The population was sampled twice on two different days at the Humanistic Library. The median was used as a representation of the common trend.

We found that students were unsure about the weight of their personal computers hence we only took the size into consideration when concluding.

Our findings include that students who carry netbooks bring them more often (43%) compared to those who carry laptops (16%). The portable computers are seldom used during lectures, at cafeterias and coffee shops. Students often use the university computers and printers, while the scanners are rarely used.

The survey included services that the UiO already has in place in addition to services we thought would be interesting to have at the university. For a full description of these services see appendix:

With exception of S3 the answers from netbook-users and laptop-users differ only marginally. The most popular services were S3, S6, S7, S8, S17 and the least popular were S12, S13, S14, S19, S20 and S21. No services were in general considered completely uninteresting.

We also found that people showed enthusiasm about certain existing services without answering that they used them. This could imply that information about existing services is not good enough.

5.3 Conclusions

Our survey was in no way perfect, and we found several weaknesses and unexplored topics while processing the data. Hence the survey should be repeated with different phrasings, more precise questions and less ambiguity for future work. However we did discover several interesting trends and results quite helpful for our suggested framework.

6 Creating a context aware framework

6.1 Software of interest

6.1.1 Mobiola Headset for Skype

Mobiola Headset for Skype[40] turns a Symbian cellphone into a Skype handset. In addition to routing the call through the phone like any Bluetooth headset the application offers a remote control for Skype directly on ones phone. The software works via Bluetooth or USB connection, and WLAN support is promised. This is very similar to the original idea that sparked this project, and this software shows that there is some sort of demand for this type of applications.

6.1.2 JoikuSpot

JoikuSpot[41] is a very interesting piece of software. Simply put JoikuSpot turns your cellphone into a wireless access point. With the software installed on your phone, you select an Internet connection (3G, GPRS or HSPDA) and share this connection on the phones WLAN card. The phone will act as a traditional WLAN access point. This software will eliminate all of the hassle normally involved with connecting devices to the Internet on the fly. The software also actually has a small piece of context sensitivity integrated. When connecting to the access point one is directed to a custom landing page, and if the software is running on a GPS-enabled phone, an option for showing your current location on a map can be enabled.

Beyond eliminating the hassle of mobile Internet access this software also has a huge potential for context sensitive services. Because the software runs on a cellphone one allow access to several technologies that can aid context sensitive functions. The phone can, as already mentioned, aid in determining ones geographical location. Furthermore one could utilize accelerometers, light-sensors, or any other type of sensors on the phone to gather data on the surrounding environment. This software can go quite far in realizing our ideas stated in the "dual use" section. One disadvantage is that the software at the moment only runs on Symbian S60 3rd edition phones. This can however be seen as positive, since S60 3rd edition phones actually can run the Apache web server, thus it's possible to create a context sensitive "package" that offers Internet access and available sensor data directly on the access points IP for context sensitive services without demanding anything else from the user other than the ability to connect to a wireless access point.

6.1.3 Blueproximity and pyacceleremoter

We have already mentioned blueproximity. Pyacceleremoter is software written in Python. It installs as a server on a Linux computer and as a remote on a Symbian S60 3rd edition phone. The software is developed for remote controlling video software and allows the user to control the software both from the phones keyboard and by making gestures sensed by the phones accelerometer. Since the software is written in Python and is open source it could easily be extended to control other applications such as slide shows. This software represents a nice example of interaction between a portable computer and a cellphone, and we would like to see more such context sensitive interactions in the future.

6.1.4 Anyremote, Psiloc Wireless Presenter, Salling clicker and Bluetooth remote

Of the above mentioned software the free software Anyremote was the only software we tested in production. We used it during a presentation and it worked aside from problems with the phones screen saver. The screen saver would turn on demanding two clicks to advance the slide show. This stole some of the presenters focus from the presentation and the audience, since one had to keep an eye on the phone or the screen to make sure that the slide show actually advanced. It should also be noted that one of us opted out and choose to use the keyboard instead. This illustrates an important point, namely the fact that people in general prefer technologies they are familiar with. The software has an aura of untrustworthiness: Few people would use this software for an important business presentation. It does, however, present some interesting ideas: It's free software and is easily extended by people who are confident enough to edit configuration files. Programmers

and hackers would most likely find this software quite useful. The commercial software, however, is probably better suited for the general public and the industry as it is more "out of the box", integrates better with Microsoft Powerpoint and uses the bluetooth remote protocol eliminating the need for installing third party software.

6.2 How could we build a context aware system at UiO?

Implementing a complete context aware system is unfortunately beyond the scope of this paper. Several ideas have, however, presented themselves during the project. In this section we present some ideas briefly, suggest some heuristics that would give the necessary context using available information and try to show that a context sensitive system is feasible within the existing infrastructure.

Software providing the services that are survey indicated were most interesting would not be complicated to create. It could consist of two parts: An installation file that sets up the necessary UiO services and UiO configurations and an applet consisting mainly of a user interface allowing the student to adjust settings and context parameters and providing them with easy access to services as described in our survey. Different packages for different operating systems should be available.

Some important questions need to be answered before implementing such a system:

1. Which contexts make most sense for a student at the university?
2. Does the university already provide any context sensitive services?
3. Which, if any, existing resources can be used to gather information about context?
4. What types of resources would have the greatest positive impact on the system if they were added?

Some answers to the first question may be derived from our own experiences and the result of our survey. Some important information regarding context includes if one is at the university, and if so in which building and what floor, or not. Likewise one should know if one is performing the act of studying or not. Our survey showed that the students in general use the universities computers a lot. Thus easy transfer and synchronization of files should be considered important. We have also found that routing prints to the closest available printer is a service in demand. Considering the opposite situation, studying from home, easy transfer and synchronization of tiles is unchanged while the printer situation is completely changed. The printer of interest will now be either your local printer at home, or the printer at the

university that it would be most convenient to pick up your prints from at a later time.

The answer to the second question is yes, albeit not as obvious. The universities wireless network is most definitely context sensitive. Once you have created a connection to the network you will enter and leave a context as you enter and leave areas where wireless service is available. On-line is one context where certain services are offered, and off-line is a different context where such services are not offered.

Our investigation surrounding the third question leads us to believe that the wireless network is the single most valuable existing resource at the university to gather context sensitive information. Written information about the physical position of equipments like printers is also important. In outdoor situations a GPS-unit can also be used. Agre[2] stresses the importance of introducing constraints to an institution to ease the deduction of context. Similarly the already existing constraints on the universities network can be used to construct heuristics for some simple contexts. The MAC address of the wireless access point can provide information about your location on campus, or if a fingerprinting method is used the wireless network could provide a quite precise location. The network is also segmented depending on access method. The dynamic IP one is assigned would provide information about the method of network connection: VPN from a remote location, wireless access at the university or tethered access at the university.

There are many answer to the fourth question. One could easily imagine all sorts of expensive equipment, like RFID-readers, GPS-devices and similar types of equipment enhancing the system. Simple mechanisms might have a larger impact on the possibility for a context sensitive framework at the university. Introducing a simple button to the menu allowing the user to specify certain contexts like studying, taking a brake from ones studies, working in a group, and similar would have a huge impact on the system. These types of contexts are quite hard to deduct without actually asking the user. In addition this type of information combined with location, either automatically derived or input by the user, could be used to train the system to recognize such contexts based on location.

One could also enforce stricter rules on the students, like forcing them to use a certain account only for studies and a separate account for other types of work. Such a system would however most likely not be accepted by the students. If the students don't obey the rules, the system would have no value.

A more strategic location of equipment within the network would also be desirable. Access points are normally placed based on one criteria: Offering the needed capacity in needed areas at a lowest possible cost. One could however also consider placing access points and equipment like printers in conjunction when planning the network, easing the implementation of a context sensitive system.

6.3 Our suggested framework

Our suggestion is to create a framework supplying context sensitive data to end-user applications. Specifically such a service could be implemented as a D-bus service on Linux. D-bus is also currently being developed for Microsoft Windows and Apple Mac OS X[42] thus we can foresee a platform independent service in the future. The service should supply the end applications with hierarchically ordered notifications of context changes.

Such a system would greatly ease creating context sensitive applications in the sense that context would be just another service that the developer could call from a well known API. Most programming languages have interfaces for D-bus allowing the interface to be used over a wide range of languages.

We are not the first to have such ideas. Rhodes et al[20] mention several articles exploring context-toolkits including Salber et al[43] "The context toolkit". This article discusses making a widget-toolkit for context similar to systems that have had great impact on graphical user interfaces and present many important points regarding creating such a system. The Hive framework[21] also has features suitable for this purpose, though it hasn't been actively maintained since 2000 and is a large system mostly not documented.

In addition to notification of context changes, the system should also be able to supply the low-level data the context has been derived from on demand. Such data will not necessarily be available, specially if the back-end is created using sliding databases. For example a notification of speed and direction based on a certain amount of GPS-plots will not necessarily be able to supply all of the GPS-plots such calculations are based on. However, we feel it is important that any amount of low-level data that is available should be offered the end user application on demand, enabling the end user application to make more specific decisions that the framework doesn't supply.

The context sensitive framework cannot rely solely on automatically collected data such as GPS-data, wireless network information, information about applications currently running on the system or connected external equipment. The user must have the possibility of overriding the system and informing it of wrong calculations, and should also have the ability to inform the system of context changes, much in the same way that chat software allows the user to set their current status to available, busy, meeting or similar. The framework should ship with an interface that integrates into the operating system allowing users such interaction, but should in addition supply the means for applications using the framework to implement such features directly into the software.

To summarize we are suggesting a context sensitive framework that should piggyback on an existing inter-application messaging system elimi-

nating the all of the disadvantages of creating a new message system and allowing easy integration into existing and new applications. The system will consist of four entities: The context sensitive service that collects data and deduces contexts which must be created in a way that easily allows adding new sensory data input when needed, an interface allowing users to define contexts and what actions and settings should be associated with the contexts, an interface allowing users to override automatically deducted contexts and feed the service with new information, and the end-user applications that implement the context sensitive framework.

As we saw at the beginning of this paper, we predict that the netbook marked will split into a high-end and low-end segment. It is important that our suggested framework will run on any equipment hence it should be designed to run on low-end equipment, as this will guarantee more universal availability.

We suggest that such a framework could easily be tested and tuned at the university, as this would minimize the amount of work needed to be done on the two user interfaces and the end-user applications to actually allow the system to be field tested and tuned. At a later time APIs should be created allowing the system to become a general system, not limited to a given set of contexts the university represents.

7 Conclusion

When we first started this work, we were interested in looking at ways of implementing context sensitive services by having netbooks interact with cellphones and other small wireless devices like GPS-units. This was mainly based on the fact that both netbooks and cellphones are devices one often brings along "everywhere" and that both classes of devices have their advantages and disadvantages that we would like to see combined. During our research we discovered two things that changed the direction of this work. First of all we discovered that it wasn't netbooks we were interested in, but rather small portable computers. The point here is that it should be a device one brings along more often than a traditional portable computer, not what it is called.

The second discovery was that such types of interaction seem rather futile without a proper contexts sensitive framework. Creating single context sensitive services and applications has been done many a time before. Such interaction between devices really doesn't show it's full potential before a context sensitive framework exists. It's first when one can implement context sensitivity over a range of devices, and perhaps even platforms that this types of interaction really becomes interesting. Remote controlling slide shows can be used as an example. Implementing a context sensitive service that automatically detects that you want to run your slide show and control it

from your cellphone is well and good, but it's when all of the applications on your computer become aware of it things really become interesting and will become so integrated in our lives that we stop noticing them. Your mp3 player (that has been playing elevator music waiting for everybody to be seated) pauses, your chat client sets your status to unavailable and suppresses messages until the presentation is complete, your booking software sends a message to the receptionist informing that the presentation started 10 minutes late. If the contexts sensitive framework is in place, the sky is the limit.

Our research has brought us from the idea of combining netbooks and small portable devices in a context sensitive way, to suggesting a full context sensitive framework for the PC. We have looked at existing services and software, researched literature and previous suggested systems and tried through surveys to gather information about what types of services students would be interested in. Finally we have also looked at the ethical pitfalls such a system might present.

We conclude that a well created context sensitive framework could change the way we use not only our netbooks, but also our laptops, cellphones, stationary computers and other devices. We find that implementing context sensitive services and software without first creating such a framework highly limits the possibilities of such services and software. We would like to see context sensitive services as common and integrated in our daily lives as email is today. We would like our computers to, sometime in the future, realize what we are doing and aiding us to do it in a way so seamlessly integrated that we don't even notice what our computer is doing.

As mentioned, we think that implementing such a system in a small scale, like at the university, and using the small scale system as a lab for creating a finished solution is the right way to go.

You often hear people saying that they want gadgets that "just work". If we want all of our gadgets to "just work" we have to create gadgets that know what we are doing and anticipate our needs.

7.1 Future work

As mentioned we see the need for a new and improved survey in addition to observation studies like performed by Bellotti and Bly[22]. This survey should also include research on peoples attitude towards the ethical questions regarding this type of service. And off course the implementation of the framework and creating applications that make the more popular services suggested more easily available. We also see the need for better promotion of existing services at the university, however that is beyond the scope of this work.

7.1.1 An experiment at Blindern

We would have like to do a small scale test at Blindern regarding WLAN and positioning. The idea was to use WLAN for positioning of students for services like finding and connecting to the nearest printer. What we were interested in was measuring the WLAN networks locally on campus to see how spread they are, and if there actually are enough access points to use for this type of services. An actual implementation however was definitely note feasible within the time line of this project. This type of localization requires a very large database of measurements, either physical measurements or estimates created with a network planing tool based on knowledge of the exact position of base stations and the surrounding environment. In addition one must use a database correlation method like kalman filtering or map-matching to improve the accuracy of the system enough for our purpose. Unfortunately we didn't have the time to actually perform this test. We have written the software needed for such a test though. The software will run on a Symbian S60 3rd edition phone that is WLAN enabled and is written in the Python programing language.

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A Descriptive Statistics

N N* Mean StDev Minimum Q1 Median Q3 Maximum

N is the number of valid samples in the group.

N* is the number of not valid samples in the group.

Mean is the mean value of the variable for the valid samples in the groups.

StDev is the standard deviation of the of the variable for valid samples in the group.

Minimum is the smallest valid value of the variable for recorded for the group.

Q1 is the 1st quartile of the of the variable for valid samples in the group (25%).

Median is the 2nd quartile of the variable for the valid samples in the group (50%).

Q3 is the 3d quartile of the variable for of the valid samples in the group (75%).

Maximum is the largest valid recorded value of the variable for the group.

We used the median as representation for the trend, and StDev, Q1 and Q2 to keep an eye on variation and skewness. A high number of missing answers (N*) was regarded as many people did not understand this question. When the medians are equal for the two groups we have looked at the mean and standard deviation to see for differences between the groups. When the medians are different we have looked at the mean to see if they differ greatly or not.

B Descriptive Statistics: U1; U2; U3; U4; U5; U6; U7; U8

Variable A4 N N* Mean StDev Minimum Q1 Median Q3 Maximum

U1 0 77 0 1,1558 0,6701 0,0000 1,0000 1,0000 2,0000 2,0000

1 14 0 0,643 0,633 0,000 0,000 1,000 1,000 2,000

* 6 0 1,333 1,033 0,000 0,000 2,000 2,000 2,000

U2 0 77 0 1,7143 0,6039 0,0000 2,0000 2,0000 2,0000 2,0000

1 14 0 1,429 0,646 0,000 1,000 1,500 2,000 2,000

* 6 0 1,333 1,033 0,000 0,000 2,000 2,000 2,000

U3 0 77 0 1,6753 0,5242 0,0000 1,0000 2,0000 2,0000 2,0000

1 14 0 1,500 0,650 0,000 1,000 2,000 2,000 2,000

* 6 0 1,833 0,408 1,000 1,750 2,000 2,000 2,000

U4 0 77 0 1,7922 0,4394 0,0000 2,0000 2,0000 2,0000 2,0000

1 14 0 1,571 0,514 1,000 1,000 2,000 2,000 2,000

* 6 0 1,667 0,516 1,000 1,000 2,000 2,000 2,000

U5 0 75 2 1,0533 0,7333 0,0000 1,0000 1,0000 2,0000 2,0000

1 14 0 1,714 0,611 0,000 1,750 2,000 2,000 2,000

* 5 1 1,000 0,707 0,000 0,500 1,000 1,500 2,000
U6 0 77 0 0,4935 0,5988 0,0000 0,0000 0,0000 1,0000 2,0000
1 14 0 0,429 0,514 0,000 0,000 0,000 1,000 1,000
* 6 0 0,500 0,548 0,000 0,000 0,500 1,000 1,000
U7 0 77 0 0,4286 0,5719 0,0000 0,0000 0,0000 1,0000 2,0000
1 14 0 0,429 0,514 0,000 0,000 0,000 1,000 1,000
* 6 0 0,500 0,837 0,000 0,000 0,000 1,250 2,000
U8 0 77 0 1,8831 0,3618 0,0000 2,0000 2,0000 2,0000 2,0000
1 14 0 1,786 0,426 1,000 1,750 2,000 2,000 2,000
* 6 0 1,333 0,816 0,000 0,750 1,500 2,000 2,000

C Descriptive Statistics: S1; S2; S3; S4; S5; S6; S7; S8; ...

Variable A4 N N* Mean StDev Minimum Q1 Median Q3 Maximum
S1 0 59 18 2,373 0,963 1,000 2,000 2,000 3,000 4,000
1 12 2 2,167 0,937 1,000 1,250 2,000 3,000 4,000
* 4 2 2,750 1,500 1,000 1,250 3,000 4,000 4,000
S2 0 61 16 2,443 1,057 0,000 2,000 3,000 3,000 4,000
1 12 2 2,167 1,030 1,000 1,000 2,000 3,000 4,000
* 5 1 3,000 1,000 2,000 2,000 3,000 4,000 4,000
S3 0 63 14 1,683 0,947 0,000 1,000 2,000 2,000 4,000
1 14 0 1,143 0,663 0,000 1,000 1,000 2,000 2,000
* 6 0 2,333 1,506 1,000 1,000 2,000 4,000 4,000
S4 0 67 10 2,030 0,984 0,000 1,000 2,000 3,000 4,000
1 14 0 2,286 1,139 1,000 1,000 2,500 3,000 4,000
* 5 1 2,600 1,517 1,000 1,000 3,000 4,000 4,000
S5 0 66 11 2,409 1,022 0,000 2,000 3,000 3,000 4,000
1 14 0 2,714 1,069 1,000 2,000 3,000 4,000 4,000
* 5 1 2,600 1,140 1,000 1,500 3,000 3,500 4,000
S6 0 68 9 1,4265 0,7788 0,0000 1,0000 1,0000 2,0000 4,0000
1 14 0 1,357 0,633 1,000 1,000 1,000 2,000 3,000
* 5 1 2,400 1,517 1,000 1,000 2,000 4,000 4,000
S7 0 67 10 1,1493 0,5001 0,0000 1,0000 1,0000 1,0000 3,0000
1 14 0 1,214 0,579 1,000 1,000 1,000 1,000 3,000
* 5 1 1,600 1,342 1,000 1,000 1,000 2,500 4,000
S8 0 67 10 1,537 0,859 0,000 1,000 1,000 2,000 4,000
1 14 0 1,643 0,929 1,000 1,000 1,000 3,000 3,000
* 5 1 2,000 1,225 1,000 1,000 2,000 3,000 4,000
S9 0 67 10 2,075 0,990 0,000 1,000 2,000 3,000 4,000
1 14 0 2,000 0,877 1,000 1,000 2,000 3,000 3,000
* 5 1 2,400 1,342 1,000 1,000 3,000 3,500 4,000
S10 0 64 13 2,172 0,846 0,000 2,000 2,000 3,000 4,000

1 13 1 2,154 0,899 1,000 1,500 2,000 3,000 4,000
* 6 0 2,500 1,378 1,000 1,000 2,500 4,000 4,000
S11 0 69 8 1,971 0,985 0,000 1,000 2,000 3,000 4,000
1 14 0 2,071 0,829 1,000 1,750 2,000 2,250 4,000
* 5 1 3,000 1,225 1,000 2,000 3,000 4,000 4,000
S12 0 68 9 2,765 1,009 0,000 2,000 3,000 3,000 4,000
1 14 0 2,786 1,122 1,000 2,000 3,000 4,000 4,000
* 5 1 3,000 1,225 1,000 2,000 3,000 4,000 4,000
S13 0 65 12 2,692 1,014 0,000 2,000 3,000 3,000 4,000
1 13 1 2,615 1,044 1,000 2,000 3,000 3,500 4,000
* 5 1 2,400 1,140 1,000 1,500 2,000 3,500 4,000
S14 0 65 12 2,646 0,959 0,000 2,000 3,000 3,000 4,000
1 14 0 2,571 1,284 0,000 1,750 3,000 4,000 4,000
* 5 1 2,600 0,894 2,000 2,000 2,000 3,500 4,000
S15 0 69 8 1,913 1,134 0,000 1,000 1,000 3,000 4,000
1 12 2 2,000 1,128 0,000 1,000 2,000 3,000 4,000
* 5 1 2,600 1,140 1,000 1,500 3,000 3,500 4,000
S16 0 68 9 2,353 1,255 0,000 1,000 2,500 3,000 4,000
1 14 0 2,286 1,204 0,000 1,750 2,000 3,250 4,000
* 5 1 3,000 1,225 1,000 2,000 3,000 4,000 4,000
S17 0 63 14 1,730 1,081 0,000 1,000 1,000 3,000 4,000
1 14 0 2,071 1,269 1,000 1,000 1,500 3,250 4,000
* 5 1 2,400 1,140 1,000 1,500 2,000 3,500 4,000
S18 0 67 10 2,328 1,198 0,000 1,000 2,000 3,000 4,000
1 14 0 2,286 1,069 1,000 1,750 2,000 3,250 4,000
* 5 1 2,400 1,817 0,000 0,500 3,000 4,000 4,000
S19 0 61 16 2,377 1,157 0,000 1,000 3,000 3,000 4,000
1 13 1 2,462 1,127 1,000 1,500 2,000 3,500 4,000
* 5 1 2,800 1,304 1,000 1,500 3,000 4,000 4,000
S20 0 67 10 2,597 1,102 1,000 2,000 3,000 4,000 4,000
1 14 0 2,429 1,222 0,000 1,750 2,500 3,250 4,000
* 5 1 2,200 1,304 1,000 1,000 2,000 3,500 4,000
S21 0 68 9 2,456 1,263 0,000 1,000 3,000 4,000 4,000
1 13 1 2,385 1,325 1,000 1,000 2,000 4,000 4,000
* 5 1 3,200 1,304 1,000 2,000 4,000 4,000 4,000

D Subset bring to UiO often Descriptive Statistics: U1; U2; U3; U4; U5; U6; U7; U8

Variable A4 N N* Mean StDev Minimum Q1 Median
U1 0 12 0 0,000000 0,000000 0,000000 0,000000 0,000000
1 6 0 0,000000 0,000000 0,000000 0,000000 0,000000
* 2 0 0,000000 0,000000 0,000000 * 0,000000

U2 0 12 0 0,917 0,900 0,000 0,000 1,000
1 6 0 1,167 0,753 0,000 0,750 1,000
* 2 0 0,000000 0,000000 0,000000 * 0,000000
U3 0 12 0 1,000 0,603 0,000 1,000 1,000
1 6 0 1,333 0,816 0,000 0,750 1,500
* 2 0 1,500 0,707 1,000 * 1,500
U4 0 12 0 1,583 0,669 0,000 1,000 2,000
1 6 0 1,833 0,408 1,000 1,750 2,000
* 2 0 1,0000 0,000000 1,0000 * 1,0000
U5 0 12 0 1,333 0,651 0,000 1,000 1,000
1 6 0 2,0000 0,000000 2,0000 2,0000 2,0000
* 2 0 1,500 0,707 1,000 * 1,500
U6 0 12 0 0,917 0,515 0,000 1,000 1,000
1 6 0 0,667 0,516 0,000 0,000 1,000
* 2 0 1,0000 0,000000 1,0000 * 1,0000
U7 0 12 0 0,583 0,515 0,000 0,000 1,000
1 6 0 0,500 0,548 0,000 0,000 0,500
* 2 0 1,00 1,41 0,00 * 1,00
U8 0 12 0 1,750 0,622 0,000 2,000 2,000
1 6 0 1,833 0,408 1,000 1,750 2,000
* 2 0 1,500 0,707 1,000 * 1,500
Variable A4 Q3 Maximum
U1 0 0,000000 0,000000
1 0,000000 0,000000
* * 0,000000
U2 0 2,000 2,000
1 2,000 2,000
* * 0,000000
U3 0 1,000 2,000
1 2,000 2,000
* * 2,000
U4 0 2,000 2,000
1 2,000 2,000
* * 1,0000
U5 0 2,000 2,000
1 2,0000 2,0000
* * 2,000
U6 0 1,000 2,000
1 1,000 1,000
* * 1,0000
U7 0 1,000 1,000
1 1,000 1,000
* * 2,00
U8 0 2,000 2,000

1 2,000 2,000
* * 2,000

E Existing and non-existing services

Page 2 of the survey have 21 questions regarding 21 services. We have assigned them codes S1-21 from top to bottom and ordered them in two tables "non existing service" (to our knowledge) and "existing service". In the tables we have suggested a program or service that could perform the service or approximate it. This might be what people mean when they answer that they use a service. The entries marked with * exist in some sense, but I believe they are a bit cumbersome for most students at UiO.

E.1 Non existing service (to our knowledge)

S2: Remote desktop. Shared file-space. MSN S7: To our knowledge no department has this service. S8: There are web-pages listing most printers, their capabilities and location, but it is a bit of a treasure hunt and a lot of the information is not updated. Again we do not know for absolute sure about all departments. S9: We do not know of any such rooms available for all students. You would have to use something like remote desktop if such a room exists. S10: Class Fronter. One informant had actually written this on the questionnaire S14: Again you could browse the above mentioned web-pages. S21: W do not know of any such service. Blueproximety could be used for this with some modifications.

E.2 Existing services

S1: Group management in UNIX *S3: Remote desktop *S4: Remote desktop *S5: There are no such facilities at UiO to our knowledge. You could use the equipment connected to the stationary PCs, but this would be frowned upon by Drift. S6: Mounting your net-disk. One informant wrote "hjemmekontor" on the questionnaire. This can refer to one of the ways described on: `http://www2.usit.uio.no/it/hjemmekontor/` For many students this is not simple. *S11: Gmail, MSN, Class Fronter *S12: Google Latitude *S13: Several programs including AnyRemote which we used for our presentation *S15: You need to use a cable if you want to use the UiO machines and your phone must support the mass storage device profile. This is quite easy if you have Bluetooth on your computer and phone. *S16: Many phones have GPS. What we really wanted to know was GPS data transferred to the computer and used in software there. For example geo-tagging field studies. *S17: Mobilia as mentioned earlier in the paper. This is only for Symbian phones. S18: Most mobile phones can deliver this service. It is almost as good as Mobile Broadband if you have the right phone and deal with your

mobile provider. You do not need to pay for two separate subscriptions. As mentioned in the paper software like JoikuSpot could greatly ease the use of this service. *S19: Many people use their phone as a Dictaphone, but automatic synchronization? *S20: A lot of software exist that could do these transformations, but we do not know of a single service that do them all.

F survey

Questionnaire regarding the use of portable computers at the UiO

We are a group of student taking the "INF5261 - Development of mobile information systems and services" course. As part of our assignment we want to survey how portable computers, especially combined with mobile phones, can ease students activities. We would be very grateful if you would spend a couple of minutes answering the questions below. Some of the services mentioned exists already, while others don't. If you have any questions about the survey or the services mentioned, feel free to send an email to inf5261-netbooks@googlegroups.com. Please leave the questionnaire on the desk as we will collect them at a later time. Best regards Adriana, Brendan and Morten.

Your portable computer and mobile phone

Portable computer size	☐ larger than an A4 sheet of paper	☐ smaller than an A4 sheet of paper
Weight of portable computer	☐ less than 2 kg	☐ more than 2 kg

Please check the boxes that correspond to the functionality available on your portable computer and mobile phone.

	Portable computer		Mobile phone	
Mobile broadband	☐ yes	☐ no/unsure	☐ yes	☐ no/unsure
Bluetooth	☐ yes	☐ no/unsure	☐ yes	☐ no/unsure
Wireless Internet	☐ yes	☐ no/unsure	☐ yes	☐ no/unsure

Usage patterns

How often do you bring your computer to the university?	☐ often	☐ sometimes	☐ never
How often do you bring your computer to lectures?	☐ often	☐ sometimes	☐ never
How often do you bring your computer to the cafeteria?	☐ often	☐ sometimes	☐ never
How often do you bring your computer to a café?	☐ often	☐ sometimes	☐ never
Is your computer troublesome to bring with you?	☐ often	☐ sometimes	☐ never
How often do you use the universities computers?	☐ often	☐ sometimes	☐ never
How often do you use the universities printers?	☐ often	☐ sometimes	☐ never
How often do you use the universities scanners?	☐ often	☐ sometimes	☐ never

(Please flip the page)

What services would you use?

Please indicate the likelihood of you using the following services, if they were available at the university.
0. I already use it
1. yes
2. maybe
3. unlikely
4. never
5. I'm uncertain what this is

Share a folder on your network drive (M:) with other students.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Possibility to share your clipboard (what you copy and cut from documents) with other students.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Possibility to share your clipboard (what you copy and cut from documents) between your portable computer and the universities computer you are logged on to.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Workspace with the possibility to connect your portable computer wirelessly to an external screen, mouse and keyboard.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Workspace with the possibility to connect your portable computer with cables to an external screen, mouse and keyboard	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Simple wireless file transfer between your computer and the universities computers	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
System that ensures that prints from your portable computer automatically go to the closest printer.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
System that gives directions to the closest printer that has the capabilities (duplex, color, etc) that you require.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Work room with a projector for presenting your work that can be connected to wirelessly.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
One click request to get in touch with the students you are working with	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Notification when students you are working with are online	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Notification when students you are working with are physically close to you	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Mobile phone as remote for presentations	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Mobile phone service that guides you to the closest resource you require (printers, scanners, etc.)	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Mobile phone as storage facility (instead of USB-memory)	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Mobile phone as GPS-unit (shows you your location on a map)	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Skype running on your computer controlled from your mobile phone in a way that you talk on your phone but the conversation is routed through skype on your computer.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Use your mobile phone to get Internet access on your computer.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Use your mobile phone as a Dictaphone that automatically synchronizes with your computer.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Service that creates mobile phone friendly versions of your documents.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5
Use your mobile phone wirelessly to automatically confirm your presence at mandatory activities.	□ 0	□ 1	□ 2	□ 3	□ 4	□ 5