Adoption of Ubiquitous Computing Technologies and Devices

Emil Hellman
IT University of Gothenburg
Forskningsgången 6
417 56 Göteborg
(+46) 73 623 45 94
hellmas@ituniv.se

ABSTRACT
This paper explores the determinants of adoption of ubiquitous computing technologies and devices. It sets out to briefly describe some theory of technology adoption and then expands on the particular determinants specific to ubiquitous computing. These determinants are then appraised with respect to a few student projects that were realized during the fall of 2006. Finally, it presents a theory that for ubiquitous technologies to succeed they must encourage a change in the behavior of its users.

Categories and Subject Descriptors
K.m [Computing Milieux]: Miscellaneous.

General Terms
Economics.

Keywords
Ubiquitous Computing, Technology adoption.

1. INTRODUCTION
In the 1993 October issue of “Hot Topics” Mark Weiser states that “if technological advances were simply a continuous, linear outgrowth of past technology, we might expect future computing environments to comprise more laptops possessing more power, more memory, and better color displays” [1]. Today, almost 15 years later, the main improvements of laptops are that they are more powerful, have more memory and better displays. Obviously, this is a simplification. Laptops of today have been enhanced in other ways as well. From a ubiquitous computing perspective most notably WiFi communication is almost a standard in today’s laptop devices. Even more interesting than the laptop is the most ubiquitous device of all. That is; the mobile phone [2]. While these two examples of devices that express properties of ubiquity have succeeded in becoming widespread and accepted other ubiquitous technologies have failed. The fridge that reminds you to buy milk, the ubiquitous class room, and similar innovations related to ubiquitous computing has failed to enter into our lives. Goyal presents “what have been the successes and failures of the…” ubiquitous computing “…research community since the first…” WMCSA “…workshop?” She states WiFi and mobile phones as the two major successes for the community and for failures mobile computing, location-based services, and lack of standard platform for the creation of mobile systems [3].

But why have some devices/technologies failed and others succeeded? What have made users adopt mobile phones and WiFi while other technologies have been discarded?

2. TECHNOLOGY ADOPTION
Today two versions of the technology adoption lifecycle model exist. The first version was created in 1957 at the Iowa State College and describes the adoption of hybrid seed corn by farmers [4]. It divides the farmers into five distinct psychographic profiles; Innovators, Early Adopters, Early Majority, Late Majority and Laggards. Since then the model has been generalized to the adoption of any new product or service and has been used extensively in research [5, 6, 7]. The distribution of a user group takes the shape of a “bell curve”, i.e. the bulk is made up of the two majorities and there are relatively few innovators. The early adopters and laggard groups are roughly equal in size.

Geoffrey A. Moore described in his 1991 book “Crossing the Chasm” a modified version of the technology adoption lifecycle model shown in Figure 1. It includes a chasm which must be crossed in order for a product to be successfully introduced in a market. The chasm is “between” the early adopters and the early majority and signifies the difficult step of transitioning from an “early market” with a few “visionaries” to a “mainstream market”. Moore claims that “a successful crossing is how high-tech fortunes are made; failure in the attempt is how they are lost.”

The two versions of the technology adoption lifecycle are both considered valuable. The latter of the two, describing the adoption chasm is often applied to so call “discontinuous innovations”, i.e. products or services that demand that the adopter changes his or her behavior [4]. Where as “continuous innovations” allow the adopter to keep its behavioral patterns intact.

There is often an assumption that all high-tech products are discontinuous in nature, but this is not the case. For instance the
Figure 1. Illustrating "the chasm". Note that the names of the groups are changed (e.g. Technology Enthusiasts equals Innovators). Picture taken from http://www.testing.com/writings/reviews/page19.gif

flat screen TV could be characterized as a high-tech innovation and it demands no behavioral alterations of its adopters (as opposed to the original TV which has fundamentally altered society). On the other end of the spectrum we have the historical and highly significant innovation of the modern automobile, which has severely altered our way of life.

2.1 Demand Determinant Factors of Technology Adoption

There are many factors which determine if an innovation is adopted by a specific group or individual in a market. Much research is available on these determinants and barriers [6, 8, 9]. Hall and Khan describe their view in “Adoption of New Technologies” [6]. Aside from the obvious and rather abstract concepts of benefit and cost a number of other factors affect the adoption. In addition they note that it is very important to observer that:

“At any point in time the choice being made is not a choice between adopting and not adopting but a choice between adopting now or deferring the decision until later. The reason it is important to look at the decision in this way is because of the nature of the benefits and costs. By and large, the benefits from adopting a new technology, as in the wireless communications example, are flow benefits which are received throughout the life of the acquired innovation. However, the costs, especially those of the non-pecuniary “learning” type, are typically incurred at the time of adoption and cannot be recovered. There may be an ongoing fee for using some types of new technology, but typically it is much less than the full initial cost” [6].

As a result of this some researchers have noted that for some technologies it might be better to wait with the adoption of a technology, since the benefit of it is dependent on the number of other adopters. An obvious example of this would be the telephone, the more people that are connected to the telephone network the more beneficial it will be to invest in a telephone, since we can talk to more people.

Hall and Khan find these demand determinants to be of major interest:

- Skill level of workers and state of capital goods sector
- Customer commitment and relationships
- Network Effects

If a new invention requires a high degree of specialized knowledge to use it is likely that adoption will be slow (if there is a lack of that knowledge). Also, if prerequisite technologies are not present in order to make production of a new invention feasible then adoption will most definitely be stumped. An example would be several of the inventions of Leonardo Da Vinci which was not feasible to produce due to the lack of sufficient production technology.

Customer commitment and relationship mainly affects the probability of adoption among companies. In these cases a strong commitment and relationship increase the likelihood of adoption. This is due to that a company with strong ties to its customers will
know that it can make up for any initial cost with the benefits it will receive from the new technology. A company with week ties has a harder time to find such guarantees.

The network effect can be described by the telephone passage above. That is, increased value can be had from obtaining a technology the larger the user group grows.

There are several other determining factors on the adoption of technologies, such legislature, infrastructure etc. etc. As an example the quick diffusion of mobile telephony in developing countries is supported by the geographical constraints that make physical networks highly expensive according to [6]. Also the adoption of automatic teller machines in the states was studied by Hannan and McDowell in [8]. They found that larger banks with a more concentrated market and banks part of holding company organizations expressed a higher degree of adoption. Finally, [9] mentions in a more macroscopic view of the importance of technology adoption to the development of countries barriers such as, worker strikes, bribes needed to be paid, and regulatory and legal constraints.

3. ADOPTION DETERMINANTS AND UBQUITOUS COMPUTING

Ubiquitous computing technology innovation and its adoption by users can be characterized by the same determinants as other innovations. However, the nature of some ubiquitous devices makes the customer commitment argument mute. This is because those are targeted at individuals and not companies as a whole. A note should be made that this is of course not the case for all ubiquitous devices. The “skill level of workers” however might in the general case be attributed only a very little importance. Ubiquitous devices might need a high degree of skill to produce (i.e. a good state of the capital goods sector), but the use of the technology is commonly aimed at being very intuitive and simple, thus requiring little knowledge or skill. Lastly, the greatest determinant on the adoption of ubiquitous computing technologies and devices is probably network effects. The argument for this is that by the very nature of ubiquitous computing the devices will communicate with each other in order to increase their utility for the user. Therefore, the more ubiquitous devices there are the greater the benefit of acquiring others. Naturally, there is likely a limit to this. For the argument to work the device must be designed to communicate, something that is not yet a reality [3].

I believe that there are several determinants of extra importance to the adoption of ubiquitous devices. These are namely: functionality of the device, privacy concerns, interoperability, and ultimately and maybe most significant the enabling of behavioral change in the user.

Is there a need for ubiquitous devices? For the innovators the utility of a device could be summed up in “it’s new and shiny”, but for the early majority this is obviously not enough. Having devices that seamlessly communicate with our environment might appeal to us from a technological point of view, but what is its use or functionality? The important question to ask is if the devices will facilitate our lives or if they will simply replace already existing technologies or, even worse, makes our lives more awkward by replacing the old devices. Many ubiquitous devices exhibit properties that have no real functional benefit. While this is not the sole determinant of whether a technology/device is adopted, it sure helps if exhibits new functions which makes our lives easier than with current technologies.

Privacy is an issue extensively discussed by Langheinrich while he doesn’t give a specific definition of what privacy is he notes that “with the dawn of the internet…” it is a “…hot-button topic once again” [10]. He continues to discuss different natures of privacy, its history and maybe most importantly if it matters? But how does information privacy effect the decision of adopting a new technology? For one, security of information is very important, if not to every private person then at least to most companies and government agencies. Since all technologies that capture information can be used to violate the principle of information privacy it becomes an influence on ubiquitous technology adoption decisions. This is because ubiquitous devices by their very nature must store information about its user, environment etc. However, all technologies that capture information can also be used to safe guard the principle of information privacy. As an easy example let us examine the invention of the written word. All of a sudden people could write down any information they wanted (assuming they were literate). Doing this however leaves the door open for others to read that information and thus possibly acquiring private information. Still, anyone that has passed a note to a classmate during a lecture in high school knows that writing things down can also ensure privacy. Since passing a note to a friend is usually more private than shouting the message across the room. An example how ubiquitous computing potentially could ensure privacy is by checking if any unauthorized people are in the vicinity. Also privacy is not an issue for all ubiquitous devices. Sometimes a violation of privacy is what is sought with a device, for instance the baby monitor.

As noted in [3] interoperability is deemed important by the ubiquitous computing research community. It could be argued that this determinant of adoption is an extension of the network effects described earlier, since interoperability makes more devices available for communication. However, the importance of this feature of ubiquitous devices grants it a spot as a determining factor for the adoption of technology. This can be illustrated by looking at how we search for accessories to our mobile phones. If I own a Nokia phone, I will not even look at accessories that can only work with Ericsson phones (other than to get an inspiration looking at how we search for accessories to our mobile phones. If I own a Nokia phone, I will not even look at accessories that can only work with Ericsson phones (other than to get an inspiration to look for similar products for the Nokia phone). Naturally, things that work with both these phones will likely gain a broader adoption, unless other factors impede its diffusion.

In addition to the above, a notable characteristic of the difference between the successful and failing ubiquitous technologies, mentioned in the introduction, is that the successful ones have all promoted a change in the behavior of the user. WiFi radically changed the way we work by allowing us to connect to the web anywhere that there were an access point in range. Mobile phones allow us to be reachable by our co-workers, friends and family 24/7 (if we choose). On the other hand, the fudge aware of its contents did not encourage a change in the behavior of the user. While there might be examples to the contrary, maybe a requirement for a ubiquitous technology to succeed is that it should encourage a behavioral change in its users. This might seem paradoxical when considering that ubiquitous computing “has as its goal the non-intrusive availability of computers
throughout the physical environment…” [1], but considering how we interact with computers today it is obvious that as computers become non-intrusive then our behavior towards them (as well as in general) will change.

4. THE COURSE PROJECTS FROM THE PERSPECTIVE OF TECHNOLOGY ADOPTION

In the case of the ubiquitous devices that were produced in the project course “Ubiquitous Computing” at the IT University. The probability of their adoption in libraries (which was the theme of the projects) is likely to be controlled by privacy concerns, the expected increase in visitors (or alternatively the increase in enjoyment of the library by current visitors), and the specific library’s relation to the IT-University and their confidence in its students (i.e. customer relationship). Concerns about competing standards and skill of workers and state of capital goods are likely to be of little importance.

Interestingly, contrary to the argument above, the importance of network effect is also likely to be small. This is because few of the devices were created to connect with other ubiquitous devices, with some exceptions. Projects such as “Bulletime” or “MatchMe”, if developed further, might benefit from the presence of mobile phones. The adoption of “Tales from the Hut” would have little benefit from this however, due to it being a mostly self contained device with little interaction with external technologies.

5. CONCLUDING THOUGHTS

Whether the determinants detailed under the section “Adoption Determinants and Ubiquitous Computing” is entirely valid and relevant in every respect is highly doubtful. If there are any special determinants of the adoption of ubiquitous computing technologies is at best uncertain and the determinants mentioned could probably all be viewed as special cases of earlier researchers’ findings. However, I would like to stress what I think is the most relevant part of this essay. This is the theory that for ubiquitous computing technologies to be adopted a change of behavior in its user must be encouraged. It is either this or the cost of the ubiquitous device must be lower than that of the previously used product. If the new technology has no precedence, i.e. it is completely new, it will by its very property of being completely new, change the user’s behavior. To succeed ubiquitous computing must change the world.

6. ACKNOWLEDGEMENTS

I would like to thank Daniel Garcia, Mikael Isik and Sammer Razzook for their participation in our common project. Many thanks also go out to the helpful supervisors; Anders, Johan and Eva.

7. REFERENCES


1 See http://www.cs.chalmers.se/idc/ituniv/kurser/06/uc/ for information on the course.