

# **The Third Wave of Computing**

**Research paper on ubiquitous computing for the course  
“New Technology” at the Reykjavik University.**

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## Introduction

This research paper will apply a framework of theories, which helps to describe the past and forecast future of technologies, on ubiquitous computing. It will give a short overview of ubiquitous computing in the first part and define the framework in the second part. The third and last part, uses the framework to describe the rise of ubiquitous computing. It will also mention cases of companies and products connected to ubicomp (ubiquitous computing), which shared common destiny with certain aspects of the framework.

## Introducing ubicomp

Mark Weiser: "Probably Rock's Smartest Drummer,"  
*Smithsonian Magazine, September 1994*  
"Probably not, but he does play with a lot of emotion after a few beers."  
*Mark Weiser (Berkeley, 1999)*

## The third wave of computing

In the early years of computers, the mainframes were stand-alone devices, which needed many people to run. This first wave of computing ended with the introduction of personal computers. The second wave, which is currently fading out, is characterized by one to one relationships between the user and computers. Although, we are surrounded by many computers, only one device can be used per time, because it is taking all our attention to do so. Now, ubicomp, approaches the shores.

In ubiquitous computing computation functionality is distributed over objects of everyday use. All objects will be aware of

the context in which they are placed and how the context changed over time. This will allow them to react context driven, which means that no special user input is needed in order to interact with the object and utilize its computational power. The user will be able to interact with many computers at one time and may not necessarily even be aware about that, because the technology allows him to focus on his prime activity (Wikipedia, 2008). Hence, computing is getting a calm technology.

Additionally, the objects will get a unique identifier and communicate with each other wirelessly. This makes objects in the real world act like information in the internet. They will be able to be labelled, tagged, searched and traced (Momus, 2007).

**Ubiquitous technologies:** Are technologies, which are implemented into a huge variety of products and therefore everywhere. They get used every day and are taken for granted. A good example for a ubiquitous technology is electricity. The only time when we really recognize the importance of electricity is when we do not have it.

**Calm technologies:** These technologies stay in the background and get invisible for their users. Mostly they provide very important services to the user, but simultaneously allow the user to forget about them and therefore are very powerful. Glasses are calm. They sit on the nose of their users and enhance their visual acuity without attracting attention.

## The origins of ubiquitous computing

In 1991, the Scientific American published Mark Weiser's article 'The Computer for the 21<sup>st</sup> Century' and planted the seed for this new paradigm. During this time, Mark Weiser was working at the Xerox Palo Alto Research Center (PARC), where he developed his idea of computing which takes the natural human environment into account and therefore allows computers to vanish into the background (Galloway, 2003).

Eight years later Mark Weiser died on cancer. After he was diagnosed, he decided to dedicate the rest of his life to write a book on the real essence of ubiquitous computing. He felt that discussions about ubiquitous computing were just about the technical feasibility of the paradigm, but the non-technical part, of what ubiquitous computing is all about, was left out. Unfortunately, he died soon and was not even able to start with the book. (Berkeley, 1999)

## The four different perspectives of ubicomp

Ubiquitous computing encompasses a wide range of scientific areas brought together by a focus upon Weiser's vision. The UK Computing Research Committee aggregates these scientific areas to three different perspectives on ubiquitous computing: The user, engineering and theoretical perspective (UK-UbiNet, 2005). However, ubiquitous computing also rises very important legal issues. Therefore, the social point of view should be added as the fourth perspective to the list.

In 1999, Mark Wieser complained that "they've completely missed the non-technical part of what ubiquitous computing is all about." (Berkley, 1999) Today, it seems that this has not changed. So far, most research has focussed on engineering with very little attention on the other aspects (UK-UbiNet2, 2005).

Currently, major scientific research areas, which contribute to ubicomp are among others: embedded computing, wireless communication, human computer interaction, distributed computing and data and communication security.

**The experience (user) perspective** focuses on how people might share a world with ubiquitous computing environments. What interactive principle underpins our interaction with them, and how might a ubiquitous computing society be shaped from a socio-technical perspective? (UK-UbiNet, 2005)

**The design (engineering) perspective** focuses on the architectural and network challenges posed by the large scale, heterogeneous and dynamic nature of ubiquitous computing. What engineering principles are needed to allow a vast array of devices to be interconnected in a system, and how might we understand and respond to the system's emergent behaviour? (UK-UbiNet, 2005)

**The science (theoretical) perspective** focuses on concepts and rigorous models that capture the behaviour of ubiquitous systems at varying levels of abstraction. How do we reason about such a system, in order to understand its aggregate behaviour in terms of the behaviour of its subsystems? (UK-UbiNet, 2005)

**The public (legal) perspective** focuses on the impacts of ubiquitous computer systems on the social and political live of humans. How do we have to design these systems and adopt our law to fit them to our various human needs?

## The word cloud around ubicomp (different terms, for one paradigm)

- pervasive computing - internet of things - ambient intelligence - everywhere - physical computing - haptic computing - things that think - tangible media - wearable computing - smart objects - human computer interface - embedded networking - sentient computing - spime - thing links -

While discussing ubiquitous computing as a general vision, it is important to mention that all these terms are based on the same paradigm defined by Mark Weiser.

For example, the term **pervasive computing** was formed by the industry and represents their attempt to implement Weiser's visions into new products and services. Ubicomp has to be seen as a long-term vision, which will be realized in the future, whereas pervasive computing seeks for short-term feasibility of ubicomp fragments. (Mattern, 2001)

Alternatively, the **internet of things** refers to the wireless connection between physical objects, which share information and are traceable over the net.

**Ambient intelligence** on the other side is a buzzword, which represents Europe's political answer to the American support programs for the development of ubiquitous computing technologies. From Europe's point of view, the American program focuses on hardware technologies (Schulzki-Haddouti, 2004), whereas Europe's approach is software based and more context driven. Both approaches focus on the strengths of the local industries (Schadbolt, 2003), but are building on the principals of Mark Weiser's ubicomp.

A description of the other words in the cloud would have the same pattern as we see in these three examples. Their meanings just slightly differ from each other, because they derive from different directions of science, economy or politics.

# Building a descriptive framework in order to define technology trends

This second part of the research paper is about a framework of innovation theories, which helps to describe the past and to forecast the future of technologies.

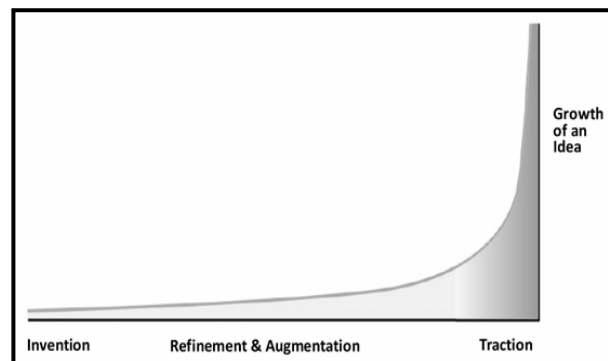
## The theories

### The long nose of innovation theory

The long nose of innovation is a theory to describe and understand the process of innovation. It states that the bulk of innovation behind the latest "wow" moment, which makes the "new" idea become generally known, is low-amplitude and takes place over a long period. (Buxton, 2008)

In general, the long nose of innovation takes the theory of exponential growth of technologies and increases the period of low amplitude growth until the birth of the technology by an innovative idea.

Research showed that it took most technology related ideas, more than 20 years to go from first demonstration to innovative products (Buxton, 2008). This period is needed to augment an immature idea or technology until it gets mature and convenient enough to create new products.

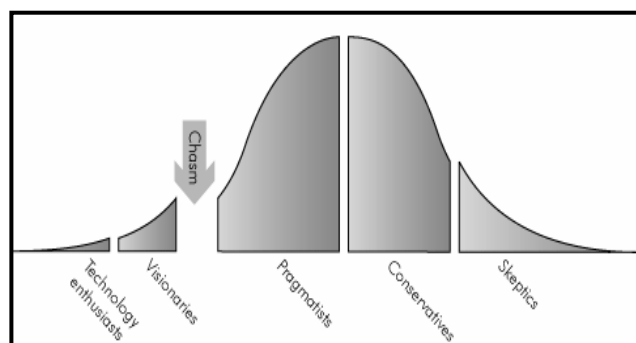


Pic 1: Longe nose of innovation

### The innovation adoption life cycle

The innovation adoption life cycle describes the market acceptance of new products in terms of the customer adoption process. It is divided into three distinct phases, an early market and a mainstream market, separated by a chasm. (HT Strategies, 2007)

Immature products are likely to fall into this chasm. These products are mainly sold on the basis of special features and technical specifications. However, most customers view products very differently to their developers and consider factors such as usability, content and product support to be more important than their technical background (HT Strategies, 2007). Hence, immature products will not be bought. To bridge the chasm of the technology life cycle, suppliers have to ensure that their products use mature technologies, which solve unfulfilled needs of their customers before they charge money for them.



Pic 2: Innovation adoption life cycle

## The resources, processes and values theory (RPV)

The processes, resources and values of incumbent companies often differ much to those needed to make money with new technologies. It is very hard for them to meet the needs of the new technology, because they would have to:

- reengineer their process (e.g. manufacturing, training)
- build up new resources (e.g. equipment , skills of people) and
- change their values (e.g. customer demands, prioritization) (Gray, 2004)

A point is that they did not develop the technology in their own house and therefore are not able to adopt their RPVs early enough. Moreover, incumbent companies often do not see the need to invest in immature technologies, because they earn enough money with their old technology until the disruptive technology gets mature.

## Combining the theories

First the long nose of innovation and the innovation adoption live cycle can be merged. The result is a long, low amplitude, nose with a chasm right before the exponential growth starts to take off.

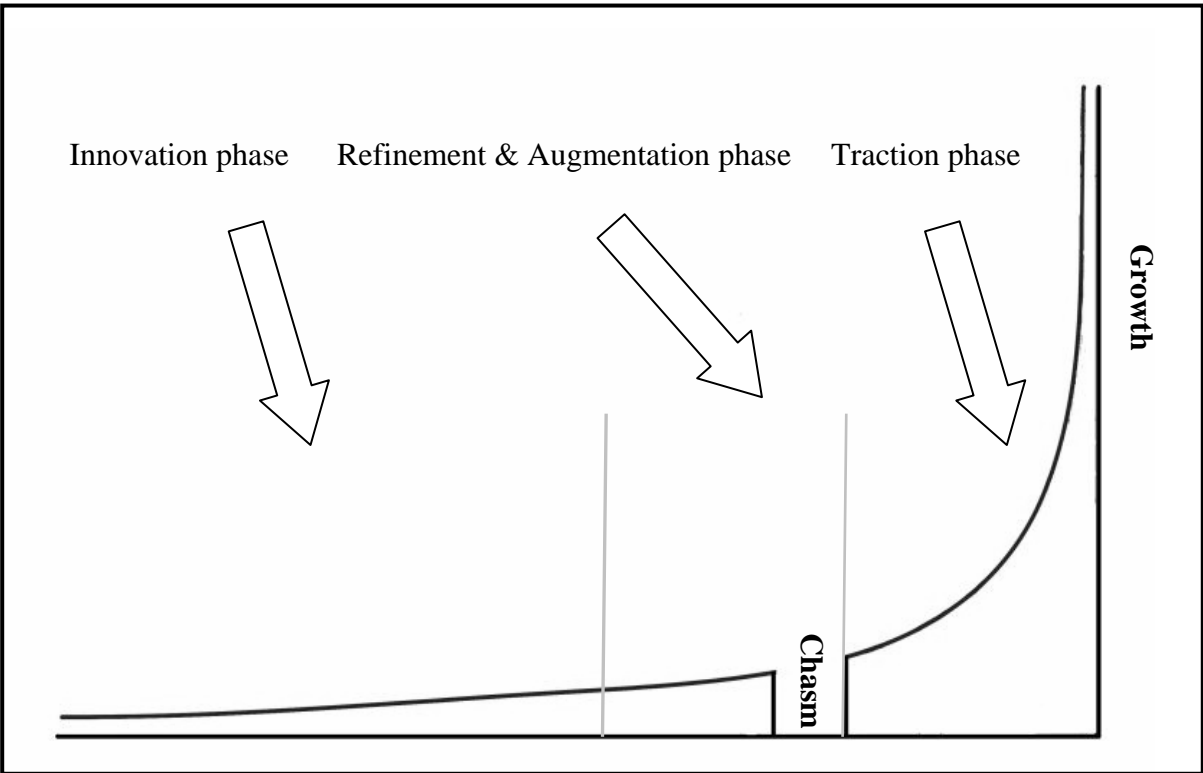
Now, it is possible to define three phases of augmentation and their according maturity level. Each phase has other indicators which help to predict the growth of a technology.

Phase	Description	Growth Indicators
Innovation phase	The innovation phase starts with the birth of the innovative idea and ends with the first products which implement the technology. During this time the immature technology has its protected playgrounds in universities and R&D departments of bigger companies.	Number of Universities and Companies doing research; Number of publications; Amount of funding;
Refinement & Augmentation phase	In the second phase the technology is premature. It starts when the first product using the technology gets on the market and ends on the right side of the chasm. This is the Refinement & Augmentation phase, because the main goal during this phase is to fulfil customers high expectations in the technology. It also marks the point where the traditional innovation adoption live cycle would begin.	Media response vs. real users; Developer vs. customer view in sales argumentation; User acceptance
Chasm	The chasm belongs to the third phase. It represents the problems that a new technology creates for its users. These problems can be of technical or social nature. (e.g. incompatibility with older products or social unacceptability). The significance of these problems is related to the size of the gap. In order to bridge the chasm the technology has to solve more and stronger problems then it creates.	Number of problems the technology creates;

Traction phase	The fourth phase starts after the chasm. At this point, the technology is mature and the augmentation is driven by the forces of the market.	Potential to solve user problems
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As long as the technology is immature, the predictability just depends on the extent researcher and investors believe in it. However, this does not mean that users will like it too. During the premature phase, the predictability for failing of a technology is high. If products are sold on technical features and user acceptance is low, although the technology is hyped in the media, then it is likely that it falls into the chasm of the technology live cycle. Once the technology bridged the chasm and is mature, the growth of the technology is exponential and equivalent to its potential to solve user problems.

But not only the growth of a technology and accordingly the growth of the industry and companies using it can be defined by this framework. By taking the RPV theory into consideration, it is highly predictable that if a technology crosses the gap and enters exponential growth, incumbent industries and companies that can not adopt to the new technology will decline.



# Applying the framework on ubiquitous computing

This last part of the research paper, will take the framework and apply it on ubicomp. It also proves its stability, by mentioning cases of companies and products, which shared common destiny with certain aspects of the framework. Additionally, it provides a forecast for the development of ubicomp.

## Growth prediction based on the phases of augmentation

### Innovation phase

After Mark Weiser introduced his idea of ubiquitous computing in 1991, scientists and investors got inspired by the idea of actively creating this future. Ubiquitous computing has a vast community and many labs around the world are researching on it. Among them are Universities like the MIT and Companies like Intel or IBM. Hence, a lot of innovation is going on and from this point of view ubicomp has a bright future.

### Refinement & Augmentation phase

The first devices following Mark Weiser's paradigm (smart phones and handhelds) were already introduced in the 90s. But Weiser's thinking was probably more influenced by these gadgets than vice versa. The first ubicomp devices resulting from his idea, are more like the iPhone, the Kindle, the Microsoft desk and the Nike+iPod Sport Kit.

The framework tells, that the predictability for a flop of a technology is high during this phase. All new devices that got introduced show a very high acceptance among customers. Additionally, they were not sold on behalf of their technical aspects but on their usage and proof to solve a lot of customer problems. This indicates that ubicomp is likely to be successful but there is no rose without a thorn.

### The Chasm and its problems

As mentioned above, ubicomp seems to be accepted by people because the devices are working as they expect it. However, three major features of ubicomp still have to be introduced. The searchability of physical objects on the web, ad-hoc communication of devices between each other and a broad scale context awareness of ubicomp devices. All three technologies pose big technical and social problems. Whereas a lot of research is done to solve the technical problems like ad-hoc networking or the recognizing and predicting human activity, little is done to solve the social problems like legal issues on privacy or personal data security.

### *Bridging the chasm*

It will not be possible to introduce all ubicomp features without weakening personal privacy, but this could be accepted by people if they trust in the organizations they give their data (Economic & Social Research Council, 2007).

To build up this trust, politics have to get aware of Mark Weiser's visions and work collectively with the technical sciences and companies to shape social solutions on a technical and legal base. If these solutions are available at the right time, it will be no

problem for ubicomp to bridge the chasm right away. Otherwise its growth may be hindered by a lack of trust of its customers.

### Traction phase

If there will be no other technology that follows ubicomp's footsteps before it bridges the chasm, it is very likely that industry, governments and customers will agree on a common way how to integrate ubicomp at any time. After that the technology is mature and will experience exponential growth till a new paradigm starts to take over.

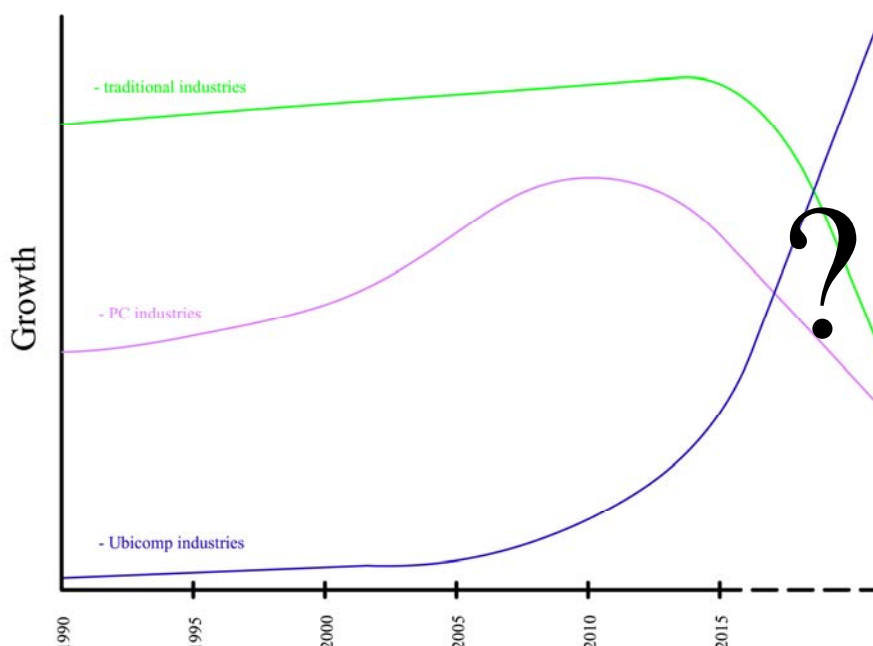
### Forecasting the near future

Ubiquitous computing is a young paradigm and most technologies involved in it are still under augmentation. Till now, a lot of ubicomp devices use traditional PC technology and are substitute products for analogue devices and (e.g. the digital VCR). Producers of analogue devices and support material lost some ground and new digital companies as well as the PC industry benefited from this development.

However, the more ubiquitous devices which are getting on the market, will also take over market shares from traditional PC industries. Companies involved in the supply chain for PC's, who stick to the PC and do not use their know how to develop and distribute more calm devices, will get into trouble during this phase.

Once devices hit the market, which will merge ubicomp technologies with "unelectric" objects of everyday life (e.g. coffee cup, cloth hanger), a disruption of old industries who produce these objects will slowly take place. These old industries, never had contact with technologies involved in producing computational devices and therefore it is very hard for them to adopt their resources, processes and values. In this stage the primary driver in the fight for the customer is improvement of the own technology (Dijkshoorn, 2007).

The development described above, can be shown in the following graphic:



## **Case studies**

The following cases of companies and products share common destiny with aspects of the framework and should demonstrate its applicability.

### **IBMs success through ubiquitous innovation**

Considering IBM, mobile phones, game consoles or cars are probably not the first product categories, that spring to mind. But Big Blue is involved into all of them. It is still a provider of server software and enterprise systems with its brand tag on it, but many of their products hide behind other brands. IBM changed its business and became a service provider, which helps companies getting technological intensive products done. Hence, IBM technology is in a variety of different products like the Nintendo Wii (Hüber, 2006), Nokia mobile phones (Morgan, 2003) or the Honda Accord (Merritt, 2003). With the sale of its PC-division in 2004, IBM turned his back on the second wave of computing and decided to ride on ubicomp.

### **The Kindle, a premature product on its way to bridge the chasm**

“It costs \$399, has a silly name, and is an attempt to open up an entirely new product category. It is bound to fail. That is what people said about the iPod in 2001, at least, and that is what sceptics are saying about the Kindle, an electronic-book reader launched this week.” (Economist, 2007)

Maybe, they are right in this case. Fact is that the reader has not the best design and some technical shortcomings (Murat, 2007), but iPod 1.0 was also not blessed with beauty. The major difference between Apple and Amazon, is that Apple has long tradition in implementing great usability in their products. Apple understands how users interact with machines and therefore is able to reduce complexity of the human computer interfaces dramatically. It is unclear, if Amazon has the proper values to turn its Kindle into the iPod for readers. However, The Kindle is doing one major thing right: Its wireless service is free and ubiquitous (in the United States), users can subscribe to newspaper and magazine articles, blog feeds and buy books wherever and whenever they feel to. (Economist, 2007)

### **WAP falling into the chasm of ubicomps innovation adoption life cycle**

In 2000, the internet was at its peak and mobile operators also wanted to have a part of its cake. WAP was supposed to make the internet wireless. But customers never used it. Although it was promoted as the mobile internet, it does not let users roam freely around the World Wide Web. A subscriber was bonded to the mobile operator's portal and got only a restricted set of proprietary text-based services. Furthermore, it was also slow and did not felt like the internet known from the PCs. Hence, consumers were not accepting WAP.

### **Apple ubicomp success story**

In recent years, a major part of Apples success is based on the iPod family. These devices are a very good example of ubiquitous computing. They are portable, easy to use, able to accept a variety of content from many sources and open to innovation by others. Their user-centred design is a very good example for context driven human computer interfaces. (Google News, ..)

A major leap forward to ubiquitous computing was the introduction of the iPhone last year. It combines three first generation ubiquitous devices in one (camera mobile phone, music player, http internet browser) and introduces the touch screen, which makes it a device of the second generation.

Additionally, some of Apples innovations in their Macs are driven by findings made with the iPod or iPhone (Jobs, 2007). This shows a tendency that ubiquitous devices take over the leading role of innovations in Apple products.

### **Traditional mobile phone producers being disrupted by ubicomp innovations**

At this year Mobile World Congress in Barcelona, some manager of mobile phone producers mentioned the iPhone as aspiration point for the usability of their own products. (Dijkshoorn, 2007) It is admirable how Apple got a leading role in the mobile industry with just one attempt. One of the main reasons is probably the multi touch screen of the phone. If traditional producers would have paid attention, they could have introduced similar products a bit earlier (Buxton2, 2007). Multitouch was not invented by Apple, nor is it a new idea.

## Conclusion

After Mark Weiser defined the future of ubiquitous computing and build up an agenda towards it, scientists and investors got inspired by the idea of actively creating this future. Hence, ubiquitous computing looks like being self-fulfilling. But it is still hard to forecast how it will be able to solve the problems connected with it.

This research paper created a framework to describe the development of ubiquitous computing, which can also be applied to other technologies. It reaches from the first public presentation of the technology, till its full implementation in the society. It states that the growth of a technology has a long low amplitude nose with a chasm right before an exponential part starts to take off. Furthermore, it divides this lifespan into three levels of maturity which have different indicators for the success of a technology.

It found out that ubicomp itself is still immature and needs augmentation to get mature. Although, augmentation happens on the technical side of ubicomp, major social problems connected with ubiquitous computing still remain untouched. In order to grow up ubicomp, these problems have to be defined and solved.

Ubiquitous computing now, is somehow like the data highway everybody was talking about in the late 80ies. It was obvious that something like this would come, but it had been unclear that it was the internet.

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## **Pictures:**

Pic 1: Buxton, Bill. (2008). The Long Nose of Innovation. Retrieved January 23, 2008, from businessweek.com website: [http://www.businessweek.com/innovate/content/jan2008/id2008012\\_396421.htm](http://www.businessweek.com/innovate/content/jan2008/id2008012_396421.htm)

Pic 2: The innovation adoption life cycle. Source: Moore (drawing from Wikipedia)  
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