# New Mobile Technologies: Sustaining or Disruptive?

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## Abstract

*This paper takes a look at Clayton Christensen's theory of disruptive technologies and how Christensen's theory relates to other innovation theories. It also proposes a new layer of analysis to this theory to better link the technology analysis to the market analysis of any given technology product. This layer suggests that complementarity and substitutability are important criteria for technologies to be market disruptions or sustaining changes.*

## 1. Introduction

The development of mobile technologies has witnessed the evolution from 2nd generation GSM to 3rd Generation mobile services. With mobile technologies development, we have also seen the development of wireless technologies such as WiFi and WiMAX that could one day compete with mobile technologies in the same market. Wireless technologies, are in some ways, seen as disruptive to the mobile market. The question as to whether a new technology becomes a market disruption or sustains the current technology is somewhat difficult to answer. This paper attempts to answer this by making use of the theory of disruptive technologies as described by Clayton Christensen as well as other related theories. Coupled with discussions of complementarity and substitutability, this paper will provide a link between technology analysis and market analysis. A study of WiFi and WiMAX is used to illustrate that a technology can be disruptive or sustaining, depending on its complementarity or substitutability within companies.

WiFi has been around for several years now and hotspots are still mushrooming around the world. The deployment of WiFi is simple and low cost for operators, and these features are seen as important advantages of WiFi as compared to UMTS. However, contrary to the low costs of equipment and setup, prices to users are still far beyond costs. Equipment such as the access points and data cards are readily available and it is not difficult to backhaul access points via DSL or fibre (and maybe WiMax in the future) to an ISP. The fact that WiFi makes use of unlicensed spectrum makes it attractive to deploy. WiFi may be deployed by virtually anyone. WiFi providers range from incumbent operators to smaller firms or co-operatives that have set up WiFi networks for the convenience of their customers and clients or as a means of luring in customers to their core business (e.g. cafes with WiFi access).

If one talks about GSM technology, then Europe is the most saturated regional market. However, operators in some European countries have had to pay the highest license fees for 3G licenses and that, coupled with high infrastructure costs of UMTS, have propelled some operators to look to other alternative streams of revenue. WiFi presents an alternative and the low costs of equipment and ease of deployment are a welcome change to what is experienced with UMTS. Table 1 shows the number of WiFi hotspots in Europe.

## 2. Disruptive Technologies

Although a disruptive technology is the essence of what causes an incumbent to fail and to exit the market, it is not only the original disruption that causes this. A disruptive technology is one that enters a different market to the existing technology as it is not able to compete with the performance of the existing product. However, incremental changes to the disruptive technology will enable it to develop in performance until it becomes possible for it to compete in the mainstream market of the original market.

A disruptive technology or innovation rarely becomes the dominant design in its own right. The dominant design is the culmination of the development of the disruption and this is what is seen by and accepted by the market. When a disruptive technology is first introduced into the industry, it often has a rather low product performance. Only with sustaining technological changes and incremental changes is it able to meet the needs the low end market segment and then to move up market into the high end market segments. The dominant product design therefore does occur from the disruptive innovation itself. It is the product of sustaining changes worked upon the

Proceedings of the International Conference on Mobile Business (ICMB'06)
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disruptive technology. It is only with improvements and development on the disruption that a dominant design will emerge (Utterback 1975). Therefore, for a dominant design to occur, it is usually preceded by first a disruptive technological change, followed by several rounds of incremental and sustaining changes to the original disruption before a true dominant product design can occur. The product that is finally adopted by industry as the 'standard' with all firms conforming to this standard is the dominant product design.

In their research, Tushman and Anderson mention that each technology cycle starts with a technological discontinuity or a disruption (Anderson and Tushman1990). Each technological discontinuity will have its own life cycle or technology cycle where the advent of the discontinuity will produce an era of ferment (Anderson and Tushman 1990). At this point in the technology cycle, the industry is volatile and competition between the firms is strong. The era of ferment is characterised by continuous substitution as well as competition amongst the different designs that have been introduced by the many firms. The design competition results in a dominant design (Utterback and Abernathy 1975). This dominant design is the culmination of many design phases and it is this dominant design that will become the accepted market standard. The Tushman and Anderson technology life cycle is one that bears similarity to Christensen's theory of technological disruption. Both sets of authors mention instability of the industry when a disruption or discontinuity occurs. Tushman and Anderson describe the life cycle of products while Christensen provides and insight into how a disruption may introduce differences into the product life cycle - such as the introduction of a new product. Tushman and Anderson look at this from more of a technology standpoint and how product innovation leads to process innovation, while Christensen argues from a market standpoint and the effects of a disruption on a market.

In 1972, Simon Kuznets said that the perspective that one adopts will determine whether an innovation is a process innovation or a product innovation (Kuznets 1972). He summarises that in process innovation, new machines and equipment in which the innovation is embodied are the norm, while at the same time, machinery and equipment are a product innovation in itself from the point of view of the firm that produces this product. This is almost paradoxical in its explanation but makes sense when considering either a process or product innovation.

Joseph Schumpeter can be seen to be one of the pioneers of evolution theory. Schumpeter's notion of evolutionary analysis starts with a non-innovative state of economy. This stable state is perturbed when an irreversible disturbance that is the creation of an innovation is introduced. After this perturbation, a new non–innovative state is regained, however in a new form (Schumpeter 1934). In Schumpeter's terms, the evolutionary process consists in a sequence of the three steps. First stability, then an innovative change occurs, and finally a new level of equilibrium that is different from the original one is obtained (Andersen 1991). He stressed that technical progress is brought on by its discontinuous nature (Andersen 1991). In addition to technical progress (either product or process innovation), this also includes the emergence of new markets, the availability of new resources and raw materials, and also the structural reorganisation of a particular industry (Schumpeter 1934). Technical progress results in discontinuities of the past or disruptions of the past. Schumpeter also emphasised the concept of creative disruption which reflects the theory of economic evolution (Andersen 2004). This also fits into the concept of disruptive change quite nicely.

Innovation may be approached from different levels. It can be viewed and analysed from a macro, as well as on a micro level. While Schumpeter's theory of creative destruction looks at the industry level, which is in line with his view on the evolution of the capitalist economy, Christensen's theory is focused on a micro level and at the firm and the strategic decisions of managers. Although addressing disruptions at two very different levels, the theories do hold some similarities. The conclusion drawn by Christensen is that good and successful companies often fail with the next wave of change because of the very management practices that have allowed them to become the market leaders, whereas Schumpeter's view is that of what happens when the economy is perturbed by a disturbance. These management practices that saw to their success now make it very difficult for them to adopt the disruptive technologies. There is also the question of self-cannibalisation of their original market that companies are unwilling to do. They thus face the dilemma that what gave the company success will also cause it to fail. This conclusion was similarly drawn by Schumpeter in his economic theory, though on a different level of analysis. Christensen's conclusion is similar in thought to what Schumpeter concluded in that capitalism will fail because of its success (Zhang 2001).

## 3. A New Possible Theory

Porter mentioned that Schumpeter's "creative destruction" characterised technological change as one in which monopolies were destroyed and new industries were created and that technology can change



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the rules of competition easily (Porter 1983). Creative destruction will lead to the business changing its character (Link and Siegel 2003). It is difficult or impossible to forecast and estimate. Technological change came in different stages: Invention, innovation, diffusion and imitation. A distinction between innovation and invention may be made by associating newness with invention and usefulness with innovation.

Rosenberg suggested that a lot of Schumpeter work has dealt with the substitution side of new technologies but not much has dealt with the equally important side of complementarity that exist between new technologies (Rosenberg 1976). Complementarity and substitutability are two side of the same coin. These possible sides of new technologies are something that may be considered before the market decides on whether a change is going to be sustaining or disruptive. Technology changes can be either incremental or radical in nature, as depicted in Figure 1. But changes in technology can then be viewed as either being complementary or a substitution to the existing technology. When this has been decided by firms, then only will the technology be categorised as either sustaining or disruptive in the market.

The issue of whether of technology being a substitute or a complement has also been looked at by Olli Martikainen in his paper, "Complementarities creating Substitutes". Here, he suggests here that "competitive disruptions occur when there is asymmetric competitive convergence" (Martikainen 2005). He makes use of the examples of the mobile phone and the lap top computer, with the mobile phone moving from a region of mobility towards a region of increasing processing capacity and the laptop computer moving from a region of processing capacity towards a region of mobility. With this, he meant that a product in one region could increase its utility towards the other region, such as from mobility to increase in processing capacity and vice versa. All this means that goods that are complementary in one sense could become substitutes as they converge in that region of utility.

The fact that disruptive technologies lead to new markets has caused much interest in industries throughout the years. Whether a technology becomes a sustaining one or a disruptive one really depends very much on individual firms and their reactions to these technologies. One could say that the whole point of the theory on disruptiveness is to empower company executives in their strategic approaches to new technologies. The purpose is not, as it is most often used, to put 'labels' on technologies regarding their sustainability of disruptiveness. The strategy of a firm in coping with new emerging technologies will steer them towards a disruption or a sustaining change. It is never easy to look at a set of different upcoming technologies or innovations and to decide which of them will be sustaining and which of them will be disruptive to the existing market. When a firm faces a new technology, it often has the means to react to it, either to treat it as a threat or to treat it as something that would be complementary to its current technology. And, if the new technology proves to be disruptive to them, it is probably because they did not foresee the consequences of their business strategy and, therefore, failed to react to the emerging technology when it first appeared. This could then be interpreted as a market disruption. But on the other hand, if the strategy had been to adopt and to see the technology as a complement or as one that could work with (instead of against) the existing technology, then the technology could likely be sustaining to the existing market. A technology only becomes a market disruption if a threatened firm does not change its strategy to encompass the new technology.

In his book, Christensen mentions that one of the strategies a company could choose was to locate the department dealing with the potential disruptive technology in a separate location to the headquarter, so that the culture and existing processes of the firm would not hold back the development of the potential disruptive technology. An alternative could be to create a spin-off company that would develop its competencies for the disruptive technology outside the jurisdiction of the original company. However, there are many mobile network operators that have reacted differently to that by incorporating WiFi technology into their suite of services. These companies have chosen to integrate WiFi into their existing technology portfolio rather than to set up separate companies or departments. One of the things that have probably propelled them to do so is to make use of existing resources, such as manpower, planning know-how and other logistical resources. Additionally, there is also the possibility of developing co-marketing strategies and to offer bundled services. As a complement, it was then introduced to the market as a supplement to their mobile network. WiFi was adopted as a sustaining technology that could complement their mobile technology network and was not viewed as a threat or as a substitute to their mobile network. A disruptive technology is, therefore, one that is not characterised by technological attributes but by its impact to the market.

A disruptive technology is probably the outcome of a substitute product which is probably the outcome of a radical innovation or technology. But it is how the company incorporates this new technology into their existing market that counts. The adoption of a new


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technology is not easy and it has to be decided within the company's strategy whether to bring the new technology under its existing company structure or to create a separate company or affiliate that will look into the new technology. When making this decision, different outcomes will result if the technology is considered a complementary product or if it is considered a potential substitute to the existing technology that the company is dealing with.

In the Christensen theory on disruptive technologies, two sets of concepts are introduced: Incremental vs. radical technologies or innovations and sustaining vs. disruptive changes. The first set of concepts is related to the technology solutions as such, while the analysis as to whether a technology innovation is sustaining or disruptive is a market issue, i.e. related to a discussion on whether incumbent operators find it profitable to explore the new technology options. Furthermore, Christensen makes the point that a radical innovation does not have to be disruptive. A technology innovation may be radical but still in line with the existing products of incumbent companies. One can, therefore, not from the degree of 'radicalism' determine whether it will be a disruptive or sustaining innovation.

This has led to many analyses and suggestions – following the theory of Christensen – regarding the disruptive nature of different technologies. In these analyses, technology innovations are 'confronted' with the term disruptiveness, and if they are seen to be sufficiently radical, they are deemed to be disruptive. However, often when adding a market analysis, it turns out that these supposedly disruptive technologies are implemented in the product portfolios of incumbent companies – which are supposed to be the hallmark of sustaining technologies. It seems that a link is missing between the concepts of incremental vs. radical technologies or innovations and sustaining vs. disruptive changes. This link is here suggested to be the concepts of complementarity versus substitution (Tan and Henten 2005).

Figure 1 shows the possible relations that could result in a disruptive or a sustaining technology change. As technological changes first and foremost involve technology, it must first be established if the technology innovation is incremental or radical. An incremental innovation is one that is reliant on the existing technology and builds upon it. A radical innovation, on the other hand, is defined as one that makes use of new, different technology to the existing one to produce an innovative product. While incremental innovations are almost progressive or a step up from the existing technology, a radical innovation breaks away from the existing technology and starts a different progress path. Incremental innovations more often than not will result in complementary products.

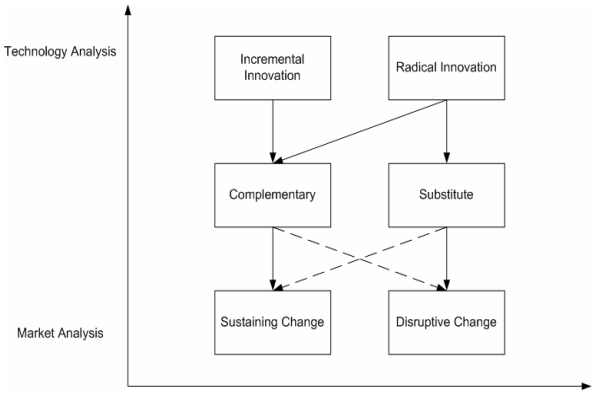


Figure 1: Relationships between innovation, complementarity, substitutability and market changes.

Looking at the technologies that exist in the mobile world today, one could quite possibly label these technologies as incremental or radical. Radical innovations will result in products with improved performance in different criteria from present products. Radical innovations are most likely to result in substitute products. This is mainly due to the conclusion drawn that radical innovations are likely to be competitive to the original products. It is only with radical technological innovations that substitution of the original is possible. Radical innovations may also result in complementarity. In this form, a radical innovation was adopted as a complement and used in harmony with the existing product. This is a strategy that the company involved chooses. Rather than compete with the existing product, the company chooses to address the radical technology as a complementary product. However, more often than not, a radical innovation is more likely to result in a substitute product than a complement. A radical innovation in this sense creates competition to the existing technology and competes as a substitute because the company involved has chosen to address the radical innovation as a competitor and possible substitute rather than a complementary product. This stance puts the company more on the offensive. A substitute product, however, may not necessarily be disruptive to the market. It could also lead to a sustaining change. But most often, substitute technologies will lead to market disruptions.

Complementary technologies are ones that work with the current technologies already in the market. These are technologies that fill the gaps that the current technologies are not able to and they work in harmony with these current technologies. Substitute



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technologies are those that present a threat to current technologies and work as alternatives to the current technologies. They are able to replace current technology and thereby possibly leading to a market disruption.

Substitute technologies are therefore more likely to result in a disruptive market change. However, substitute technologies may also lead to sustaining market changes. An example of such a technology is WiFi. WiFi was first publicised as being a potentially disruptive technology to mainstream mobile technologies. Mobile technologies are characterised by their wide coverage and mobility. WiFi was not able to match mobile technologies in these criteria; however, in the speed criteria, WiFi has a huge advantage over mobile technologies. However, mobile operators and WiFi operators alike adopted WiFi as a complementary product and have been deployed by mobile operators as part of their suite of services- catering. WiFi hotspots have been deployed in places (such as airports and cafes) where people have waiting time or time to spare which they could use by accessing the Internet with a laptop or WiFi enabled device.

Table 1 shows the number of WiFi in Europe. It shows that Germany and the United Kingdom have deployed the largest number of hotspots. Incidentally, mobile operators in these two countries also paid the most in 3G licence fees. In Europe, operators in some countries have aggressively adopted and deployed WiFi either as stand-alone systems or as part of a larger service offering. Many of these operators are in fact the incumbent operators of either fixed or mobile networks or both. For example, in the United Kingdom, WiFi provider, BT Openzone has around 2592 hotspots[1] and in Germany, T-Mobile and T-Com have 6420 hotspots[2] across the country. These operators are the former telecommunication incumbents in their respective countries and have now opted to deploy numerous hotspots. T-Mobile has not limited its operations to Europe; the company also has a large number of hotspots in the USA and across Europe.

Companies such as T-Mobile seem to have overcome the substitutability of WiFi and instead taken the technology as a complementary product and deployed it as such. Other mobile operators have also seen the advantage of taking WiFi as a complement rather than as a substitute.

Table 1: Number of hotspots in European nations[3]

| Country | Number of WiFi Hotspots (April 2005) | Number of WiFi Hotspots (Janurary 2006) |
|---|---|---|
| Austria | 675 | 802 |
| Belgium | 131 | 849 |
| Cyprus | 2 | 4* |
| Czech Republic | 151 | 217 |
| Denmark | 571 | 918 |
| Estonia | 22 | 22* |
| Finland | 10 | 370 |
| France | 827 | 3831 |
| Germany | 5618 | 8343 |
| Greece | 14 | 78 |
| Hungary | 61 | 76 |
| Iceland | 41 | 42* |
| Ireland | 72 | 259 |
| Italy | 300 | 1715 |
| Latvia | 53 | 204 |
| Liechtenstein | 5 | 7* |
| Lithuania | 12 | 18 |
| Luxembourg | 4 | 6 |
| Malta | 22 | 35 |
| Netherlands | 488 | 1398 |
| Norway | 117 | 344 |
| Poland | 103 | 119 |
| Portugal | 92 | 503 |
| Slovakia | 23 | 32* |
| Slovenia | 50 | 56 |
| Spain | 373 | 1177 |
| Sweden | 87 | 651 |
| Switzerland | 1148 | 2134* |
| United Kingdom | 1985 | 12398 |

On the other hand, when we look at the development work that is going on with the 802.11 standard now (such as the 802.11n and 802.11s), future revisions will make WiFi more substitutable to mainstream technologies. When these revisions come into practice, it would make WiFi more mobile and thereby competing on the same performance criteria as mobile technologies. Today WiFi is at a crossroads. It is a complementary product to mainstream mobile technologies but WiFi is one complementary product that could potentially lead to a disruptive change in the market. With this, the earlier assumption that complements will only lead to sustaining market changes had to be changed as the possibility of a complementary technology leading to a disruptive market change is also probable. It leads to the conclusion that radical innovations may become substitutes or complements and both substitutes and complements both have the possibility of becoming either a market disruption or to sustain the market in its original technological path. It is of course difficult to predict which of these paths a particular technology will take. And a lot of this depends on strategies of companies that actually work with these technologies and their adoption strategies to new technologies.

[1] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=477 – cited 150106

[2] http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?provider_id=420 – cited 150106

[3] The information in the second column of this table were obtained and compiled from http://www.hotspot-locations.com/ and the information in the third column of this table were obtained and compiled from http://www.jiwire.com/hotspot-hot-spot-directory-browse-by-country.htm?country_id=209, except those market with *, which were obtained and compiled from http://www.hotspot-locations.com/ . These numbers represent only hotspots that have been registered with these websites. – cited 070405 and 150106



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## 4. Discussion and Conclusion

Technical change is a multi-dimensional process and it is seen as the interplay between many different factors. The contribution of technological development, market and business issues determine the direction of a new technology. Although there is no guarantee that a new technology will become disruptive to the market (as it could also lead to a sustaining change), the amount of disruptiveness could be jointly dependent on the factors mentioned but also on the strategy of individual firms in their view of the particular new technology and how it fits into their current position in the market.

When a radically new technology becomes a reality, it will probably have a stronger chance of being a substitute technology by companies than a technology that is incremental in nature with respect to the existing technology. It is therefore, more probable that the substitute technology would therefore become a market disruption. However, on the road from being a technological breakthrough to a market disruption, the adoption of the technology by companies in the industry would play a vital part in its development. Companies have strategic choices when it comes to new technological innovations. On one hand, they may adopt the technology as a complementary and therefore one that will work with their current products. This paves the way for the technology to become a sustaining market change. On the other hand, companies may adopt view the technology as a threat, and therefore a possible substitute to their current products. This stance then paves the way for the technology becoming a market disruption. Therefore, companies either see the complementarity of the technology or the threat and thereby substitutability of a product with relation to their current technologies or products. These differences are guided by the strategies laid out by individual companies. Business models, which are representations of strategy, will then help to determine the success or failure of the technology.

Schumpeter classified the process whereby a new, superior technology enters the market place into a trilogy of invention, innovation and diffusion. The succinct difference between invention and innovation is that invention represents the first and earliest development of a technically new product, while innovation refers to the availability of the product on the market. Diffusion is dissemination and is the process that sees the product being widely available to users when they adopt the product. This is shown in Figure 2. Figure 2 also shows a mapping of each of these into more contemporary terms and ones which have been discussed here.

This trilogy and definitions, however, is representative of a linear process. It gives the suggestion that a technological change goes from invention to innovation and finally to diffusion in a one dimensional context. This is certainly not true, especially when talking about technological changes in today's wireless and mobile market. Work on technological change by Abernathy and Utterback (Utterback and Abernathy 1975), Tushman and Anderson (Anderson and Tushman 1991), and others have shown the cyclical nature of technological changes and that the end of one technology precedes a newer radical technology or an improvement or incremental change to the existing technology (OECD and IEA Information Paper 2003). This paper has shown this to be true and that the process is neither a simple nor a linear one and that to get from invention to diffusion, different complex processes take place and different factors interact with one another in the creation of a new product.

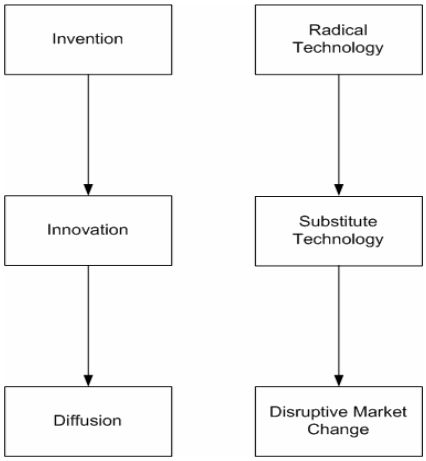


Figure 1: Schumpeter's trilogy of Invention-Innovation-Diffusion and a possible mapping

Christensen's theory does not fully explain how a radical technology becomes a disruption in the market. With the added dimension of complementarity and substitutability to explain strategic choices made by technology related companies, it is easier to see the link between radical technologies and disruptions. A radical technology that is introduced is the earliest form of the technology development cycle, as is an invention. Coupled with industry support and development, a possible substitute technology to mainstream technology is created, as is characterised by an innovation, which is the first instance of product availability to the market. Finally, diffusion and dissemination of the technology into the market which creates a disruption to mainstream technologies already



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in the market thus makes it a disruption. However, not many radical technologies ever make it to the disruptive state - due to strategic choices of companies involved. Taking WiFi as an example, it was deemed to be radical and possibly disruptive to the mobile market by many when it was first introduced. However, looking at the number of mobile operators that have incorporated WiFi into their original service offering and viewing WiFi as a complement rather than a substitute, WiFi's disruptiveness has converted to sustainability instead. It may not be the case for WiMAX or future 802.11 standards, which have a lot more to offer, compared to present day WiFi. These technologies may take a different path and be viewed as substitute technologies and thereby paving the way for a market disruption.

Although there is no guarantee that a new technology will become disruptive to the market (as it could also lead to a sustaining change), the amount of disruptiveness could be jointly dependent on the different contributing factors (e.g. technology, market and standards) but also on the strategy of individual firms in their view of the particular new technolgy and how it fits into their current position in the market. Strategies of companies will decide what a company can or cannot do or what it should or should not do in relation to new radical technologies. The added plane of analysis consisting of complementarity and substitutability shows a possible way in which companies play in a new disruption or a sustaining change. The disruptiveness of a technology is dependent not only on its technical merits but on industry adoption and strategy.

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