Abstract

Third generation (3G) mobile systems are deployed around the world. However, user and operator requirements and expectations will continue to evolve and to meet those growing needs next generation mobile networks are in development process. Main objectives of development are to further improve service provisioning and to decrease user and operator costs. More specific targets are increased data rates, improved coverage and reduced latency. Long-Term Evolution (LTE) could be a solution for requirements and to provide substantial technical and economical benefits for operators and users.

This paper analyses next generation mobile network service LTE. The work presented here identifies the most important factors to deploy LTE service by the operators. This paper have an operator point of view.

Key Words

LTE, strategy, operator, mobile broadband, regulation

1. Introduction

Telecommunication industry is evolving rapidly at the moment. Services are shifting from voice to data and from a circuit switched network to a packet switched network (Hoikkanen 2007). Broadband Internet access is available for most consumers and many services are available on the Internet. Nowadays Internet acts a major source of information. Increased usage can be proved by a growth of total data traffic volumes. The growth of data traffic volumes is especially high in the mobile networks.

There are several technologies competing in both areas fixed and mobile networks. Today Asymmetric Digital Subscriber Line (ADSL) penetration is high and different wireless services are becoming more common day after day. Fixed broadband services with data rate and quality point of view are on totally different level than mobile 2G or 3G networks. This increased performance demand has driven the development work according the mobile networks. The standardization work of the 3G mobile networks is carried out by 3rd Generation Partnership Project (3GPP).

The investments on the field of telecommunication, like mobile networks, have often a long-term financial influence. In addition, a business case and profitability are calculated very carefully. This means that the purchasing decision for a mobile network is a complex and long process (Katajala 2005). Price and performance issues become very important factors and there is a trend towards to simplified network architecture (Hoikkanen 2007).

To ensure and improve the competitiveness of 3G for future development work of LTE has been started. LTE is not designed only for substantial performance enhancements but also to reduce the cost per bit. From technology point of view LTE concept will offer increased data rates, improved geographical coverage and reduced latency. Commercial point of view LTE offers more competitive business case for mobile operators and the base network for service providers.

The development process of the mobile networks is ongoing but at the same time some operators have announced to degrade or even remove fixed communication networks in the rural areas of Finland. The reason is simply non-profitability in certain areas. The Government of Finland has taken a more decisive role and defined a national strategy to develop equitable broadband access to all citizens in Finland. This strategy is one of the key projects in the Finnish national information society strategy (Tietoyhteiskuntaohjelma 2006).

To summarize the introduction part, LTE could enable an attractive and a profitable business case for the operators. In addition, LTE would enable new and improved services for mobile users and using the better service coverage it could enable wireless services in the rural areas as well. This paper evaluates LTE as technology and business of the operator point of view. Furthermore, the importance of regulation is also described. This paper identifies the most important factors why operators should deploy LTE technology and what benefits will become available for operators and users after the LTE deployment.

The results and findings of this paper are based mainly on literature review. Also, an operator representative interview is included.

2. Drivers

For successful technological innovation there have to be drivers both on the technological and business side. In High Speed Packet Access (HSPA), consumer expectations have evolved during recent years, users have adapted new services and flat-rate pricing models have stimulated the adaption. (UMTS Forum 2009)
Wireless technology has strong and increasing position in the global communication infrastructure. Sometimes wireline and wireless technologies compete to each other but usually they are complementary technologies because, for instance, wireline technology is needed for a core network. (3GPP 2008) The xDSL penetration has declined but broadband Internet access has grown, especially mobile access. This can be seen from the market research done by Ficora (table 1).

Table 1. Broadband access methods (Ficora 2008)

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSL</td>
<td>1 210 900</td>
<td>1 270 500</td>
</tr>
<tr>
<td>Shared housing cooperative connections</td>
<td>98 100</td>
<td>114 000</td>
</tr>
<tr>
<td>Cable modem</td>
<td>192 900</td>
<td>209 600</td>
</tr>
<tr>
<td>Mobile access</td>
<td>NA</td>
<td>143 100</td>
</tr>
<tr>
<td>Wireless access</td>
<td>NA</td>
<td>15 300</td>
</tr>
<tr>
<td>Other</td>
<td>18 300</td>
<td>7 700</td>
</tr>
<tr>
<td>Total</td>
<td>1 520 200</td>
<td>1 760 200</td>
</tr>
</tbody>
</table>

In developing countries or areas, mobile broadband technology provides an alternative access method for home user’s fixed connections. In developed countries user’s ambition is to be connected anytime and anywhere. In the history business users have been the most important early adapters. (3GPP 2008) The development of wireline and wireless technologies can be noticed in figure 1. Theoretical or laboratory data rates of wireless technology are even higher than illustrated in figure 1. Typical data rates of wireless technology means the speed in practice.

Figure 1. The development of wireline and wireless technologies with typical data rates (3GPP 2008)

If we take a look back to the history, we can see how access speed has increased during last 20 years. This can be seen from figure 2. 10 years ago typical access speed was around 128 kbps and 2005 it was around 2 Mbps. If this development still continues, it could be possible that 1 Gbps access speed would be typical within 10-15 years. (Kerttula 2005)

Figure 2. The development of access speeds (Kerttula 2005)

According to Cisco’s mobile data traffic forecast, mobile data traffic will double every year through 2013, increasing 66 times between 2008 and 2013. The growth rate is expected to be two exabytes per month by 2013 and over 1.4 of total traffic are due to mobile video traffic. Video will dominate the traffic but other applications such as peer-to-peer will increase. (Cisco 2009)

New mobile broadband handsets, which support speeds of 3.5G and more, will be common and totally portable devices will account 83 percent of all mobile data traffic by 2013. Cisco’s estimation is explained with higher usage profile of laptops and the broadband mobile handsets which support high speeds. (Cisco 2009) In practice it means that mobile broadband replace fixed connections in the future. Massive increases in data traffic will cause challenges for operators, not only on radio interface but also on backhaul infrastructure. Current mobile network architecture, which is driven by voice, needs to be optimized for data driven traffic. Otherwise, it might not be economically reasonable to provide such services with current architecture.

Dahlman et al. (2005) summarized key requirements to allow a smooth transition to LTE:

- operators are able to deploy the new system in existing spectrum
- operators are able to reuse investments to technical transmission equipment
- operators are able to keep existing customer base by smooth service phasing. This is also a requirement for service providers and vendors.
- operators are able to deploy the new technology on the areas where it is profitable.
- manufacturers are able to provide stable and reasonably priced equipment for operators and end users.

Mobile voice service is already a must by many users. Mobile data, video and TV are becoming more and more popular among consumer’s lives. Globally operators have responded to the need and they upgrade their radio and core networks towards ubiquitous
mobility service. Also, there is a greater need for service portability and interoperability in the next generation mobile networks. This will open possibilities to provide a variety of different kind of services and applications which can offer more enriched mobile broadband experience. Current mobile networks can offer higher speeds day after day but for operators the challenge is to satisfy the demand with ubiquitous service in a cost effective way.

3. Technological overview

3GPP has an evolutionary approach for standardization which means that 3GPP produces regular enhancements to standards driven by underlying technologies. Consecutive releases of 3GPP standards are always backward compatible with previous releases. It enables handovers between the releases and allows a phased approach for network deployments. (UMTS Forum 2009)

3.1. Evolution path

The coverage of HSPA network has gradually extended following the operator’s business model, strategy, user demand and legacy investments (UMTS Forum 2009). In November 2003 HSDPA was commercially available in Swindon, UK. After that introduction the growth rate of HSDPA deployments has been very quickly. In 2008 there were more than 252 commercial HSDPA networks in 112 countries. (3GPP 2009)

HSPA is followed by HSPA+ which further enhances the peak rates, lower latency and greater capacity. Higher order modulation schemes allows higher data rates and Multiple Input Multiple Output (MIMO) capabilities enable higher data peak rates and spectral efficiency. MIMO is an antenna technology to increase radio interface capacity using advanced signal processing. Using MIMO and higher order modulation it is possible to provide even 42 Mbps in the downlink and 11 Mbps in the uplink over 5 MHz channel. HSPA+ also introduces an optional all-IP architecture to decrease latency and enables backhaul transportation provided by IP/MPLS technology. (UMTS Forum 2009)

LTE provides a smooth evolutionary path for the fourth generation (4G) network. For instance, there is a direct upgrade path from HSPA to LTE which means that certain base stations can be upgraded by software to LTE. Vendors provide also new base station hardware which is attractive from the operator’s point of view. These new energy-efficient solutions support GSM/EDGE, UMTS/HSPA and LTE in a single packet. In addition, new equipment provides a clear evolution path into the future, for instance, towards Advanced LTE. (3GPP 2009 ; Operator interview 2009)

3.2. Towards LTE

HSPA and HSPA+ enhancements will help 3G/WCDMA to remain competitive for now. In long run it is not enough because of exponential data traffic growth. Also, voice driven network architecture needs to be redesigned to support better data traffic. Next generation’s network will be all-IP flat architecture without circuit-switched domain. Such transition from existing networks towards all-IP requires simplification of network architecture. (UMTS Forum 2009)

LTE is a wireless system based on all-IP upon TCP/IP protocol. LTE project was initiated in 2004 and the project focused on developing the Universal Terrestrial Radio Access (UTRA) and optimizing 3GPP’s radio access architecture. Specific targets for the project were to improve average user downlink throughput of three-to four-times the Release 6 HSDPA levels (100 Mbps) and two to three times the HSUPA levels (50 Mbps) in uplink direction. (3GPP 2009b)

3GPP’s release 8 has planned to be finalized in 2009 which adds further enhancements to HSPA technology. One important enhancement is OFDM-based air interface which is also referred to the Evolved UMTS Terrestrial Radio Access (EUTRA). Release 8 also defines a flatter-IP core network to support EUTRA through the Evolved Packet Core (EPC) architecture. Previously EPC was called System Architecture Evolution (SAE). (3GPP 2009)

For end users LTE offers higher data speeds, for both downlink and uplink directions, which is a huge improvement compared to HSPA. Downlink improvement is available because LTE’s radio interface is built on Orthogonal Frequency Division Multiplexing (OFDM) technology. Single Carrier-Frequency Division Multiple Access (SC-FDMA) technology is used for the uplink direction. OFDMA together with a sophisticated modulation methods, an error correction and complementary radio technology like MIMO enables increased data rates. A theoretical maximum of downlink data rate is even 300 Mbps per 20 MHz of spectrum. Correspondingly, theoretical uplink data rates can reach 75 Mbps per 20 MHz of spectrum. In practice data rates are lower than theory. (UMTS Forum 2008)

3.2.1. OFDMA modulation scheme

Changing radio interface to totally new OFDMA based technology was a radical move by 3GPP. Evolutionary approach using Wideband Code Division Multiple Access (WCDMA) could also have met the performance requirements but the outcome would have been unsuitable for handheld mobile devices due to the high level of power consumption and the required processing capability. (UMTS Forum 2009)

WCDMA channel bandwidth is limited by the 5 MHz frequency. LTE’s channel is up to 20 MHz and OFDMA splits the 20 MHz channel into many narrowband carriers where each signal is divided. Thousands of narrow sub-channels send many low speed messages simultaneously and those messages are combined by the receiver to make a high speed message. SC-FDMA is used in the uplink direction.
Technically SC-FDMA is similar to OFDMA but SC-FDMA is less demanding for battery power which is an important factor in handheld devices. (UMTS Forum 2009)

### 3.2.2. MIMO

MIMO is used to send data over several paths that occupy the same radio frequency bandwidth. This leads to remarkable increases in achievable data rates and throughput. The amount of information is limited by noise which can be send over a radio link. This limitation is known as Shannon’s law. Shannon’s law applies to a single radio link between a transmitter and receiver. MIMO’s idea is to use several radio links and to send the same information from two or more transmitters to equal number of receivers. Each individual radio link is limited by Shannon’s law but collectively the limitation can be exceeded. (UMTS Forum 2009)

LTE enables spectral flexibility with radio planning which offers more deployment options for the operators. Scalable bandwidth is between 1.25 MHz and 20 MHz and actual performance depends on the bandwidth allocated for services, not the certain band itself. This feature allows different commercial and technical strategies for operators. Lower frequencies can provide ubiquitous and cost-effective network coverage. (UMTS Forum 2008)

### 3.2.3. EPC

One of the most significant features is a transition towards simplified architecture with open interfaces. This standardization work aims to conversion of existing core network architecture to an all-IP architecture. EPC architecture simplifies the network and improves performance, communication and media software solutions. EPC enables more flexible service provisioning and simplified interworking with fixed and other mobile networks. As we can see in figure 3 LTE architecture is much simpler than UMTS. Flattered core network allows faster response times for scheduling and re-transmission which correspondingly improves latency and throughput. Reduced packet latency enables more responsive user experience and permits the usage of real time applications, like VoIP or videoconferencing. (UMTS Forum 2008) Latency between different technologies is compared in figure 4.

The phased approach of 3GPP allows operators to introduce LTE with flexible approach, balancing their legacy network investments, spectrum holdings and business strategies for mobile broadband. Optimized usage of existing and future spectrum allocations allows increased number of customers within certain spectrum. (UMTS Forum 2008) Also, the combination of multiband terminals with backward compatible infrastructure is key enabler for this flexibility. This allows operators to build out service capability in line with device and spectrum availability. There is also a backward compatibility from CDMA2000 to LTE which is important for operators in North America and Asia (UMTS Forum 2009).

### 3.3. The role of IMS

A major objective of LTE/EPC is support Next Generation Network (NGN) philosophies and Fixed Mobile Convergence (FMC) business models. All-IP enables effective convergence scenarios between different technologies. IP Multimedia Subsystem (IMS) allows seamless handover between multiple access technologies and provides needed mobility and routing management. It simplifies management and maintenance requirements. The combination of LTE and IMS enables a cost effective and integrated package for operators. (UMTS Forum 2009)
3.4. What happens after LTE?

LTE is expected to satisfy the market needs for next decade. However, user expectations, traffic growth and new services will demand more and more from the network in the future. International Telecommunication Union (ITU) has already set a project group to study the future requirements within the framework of the IMT-Advanced –project. IMT-Advanced will need to support peak rates of 100 Mbps for high mobility and up to 1 Gbps for low mobility. Future network will be fully IP-based and it will require 100 MHz radio channels in a new spectrum in order to respond to the data rate requirements. (UMTS Forum 2009)

3.5. Services

Smartphones and cell phones have been used traditionally for voice calls, text messaging and email access. However, the demand for wireless data services is growing faster than ever. Mobile phone usage move towards recreation and leisure. Online social networking services are growing quickly and these services are becoming available for mobile phones as well.

LTE provides attractive transmission speeds and reduced packet latency. Definitely, this enhance the usage of current mobile service and it also adds new value-added service possibilities. But what are these new exciting services and what does it means for operator revenues?

Analysys Research compared today’s mobile services provided by current mobile network technology with the richer service possibilities provided by LTE. Consumers evaluated that enriched user experience is video streaming, downloading and sharing of video and other music and multimedia content. All these services will need more throughput in order to provide adequate quality of service. For business users it means high-speed transfer of large data files, high-quality videoconferencing and secure nomadic access to corporate network and its services. (UMTS Forum 2008)

The importance of social services and environmental issues is increasing (Tietoyhteiskuntaohjelma 2006). Different technological innovations could provide clear benefits to consumers and the whole society. In Finland municipalities are facing big financial challenges now and in the future, and a trend is that they are deploying social services in cost effective way using the Internet.

4. Theoretical background

Technological innovation leads to enormous advances in telecommunication industry. Success of new technology has been very difficult to predict (Ali-Vehmas & Luukkainen 2006). However, technological innovation theories exist and strategic management of technological innovation provides tools for evaluating and predicting the success of new technology. At the end technology tends to change but economical laws do not (Shapiro and Varian 1999).

Technological innovation can be classified into different categories by the type and extent of innovation. Often innovation is divided into radical or incremental innovation. Radical innovation combines novelty and uniqueness and it is considered very different from prior solution. Incremental innovation is correspondingly a minor change or amendment to existing technology. (Dodgson 2008; Tushman 2004) A trajectory of technological change can be perceived in figure 5.

GPRS and EDGE technologies can be considered as incremental innovations in technological change. These technologies provided a minor technological amendments for connection speed and quality. UMTS technology can be considered as radical change respectively. UMTS was a huge investment for operators because they had to re-plan the radio interface and to make substantial investments to base station density to provide service coverage (Operator interview 2009). However, success of UMTS did not meet the high expectations.

![Figure 5. A trajectory of technological change (Luukkainen 2008 adapted from Tushman 1997)](image)

Radical innovations are not common but when radical innovation exists, it may disrupt the position of established firms in the market and open up possibilities for new entrants. (Dodgson 2008)

LTE provides substantial benefits for users and an attractive business case for operators. Especially, innovations such as OFDMA, EPC and MIMO can be considered as radical innovation. According to interview, it was not identified or the dominant operator representative did not want to admit, that new entrants could disrupt strongly the dominant players in telecommunication industry.

4.1. Technology cycles

Technological change can be described in cyclical model where cycles are composed of technological discontinuities (Tushman 2004). In the model each new technological discontinuity starts with disturbance which is called the era of ferment. In this phase new technology appears and firms compete with different
designs and forms of emerged technology. If the technology is success it might lead to the dominant design. In the second phase, which is called the era of incremental phase, firms focus on market penetration. Finally, the era of incremental phase is followed by the another technological substitute which correspondingly triggers the next cycle of technological variation, selection and retention. (Tushman 2004) If the market penetration is successful it may result substantial gains for purchasers and vendors of new technologies and also to other industries in supply chain (Tassey 1997). In LTE case it could mean benefits for vendors, operators, service providers and users, including its subcontractors.

4.2. Dominant design

After successful service adaption technology may take a strong position in the market. This position is called the dominant design. Once the dominant design emerges, the basis of competition changes radically and companies are put into serious test. The change is so radical that often only few companies will pass the test. The dominant design is not only successful technology. There are other factors involved like industry regulation, strategic maneuvering by individual firms, communication between producers and end users and government intervention. Industry regulation often has a remarkable power to set a standard and has an influence to dominant design. Another important cornerstone is managing the communication to customers and to end users. Knowing customer needs and staying close to customers it is possible to observe how products are used by customers and are products succeeding or failing to satisfy customer needs. However, the dominant design tends to be a set of features that best fulfills the needs of majority in the markets. (Utterback 1994) Successful commercialization also need that a product or service is marketed in a way that customers are able to identify the value added to their business.

GSM is an excellent example of successful dominant design which created huge network externalities. After successful GSM deployment the expectations were high for UMTS. However, the original timetable for UMTS deployment could not reached by many operators due to expensive UMTS licenses, lack of value added and unavailability of terminals. (Luukkainen 2008)

4.3. Regulation

There are several players in the global communication network. National telecommunication networks are connected together and interoperability exist in the global network. Due to the historical reasons the telecommunication industry has been influenced by strong and broad regulation of spectrum, technology and competition (Ali-Vehmas & Luukkainen 2006). LTE will not make exception from the regulation point of view. Government regulation has an important role in licensed band allocations and prices. Frequency availability can affect to LTE deployment in certain countries and this can open a possibilities for substitutes technologies such as Mobile WiMAX. The case study of Finland illustrates the importance of regulation which is explained later in this paper.

4.4. Financing

Several economic studies have stated that technology is the most important single determinant of the long-term economic growth. The government’s technology policy and financing are needed in order to maximize influence of investments on the growth of gross domestic product (GDP). (Tassey 1997) In the telecommunication industry R&D cost is dominating. Also, R&D costs have the biggest fixed cost and majority of the cost cannot be easily recovered if the investment fails. (Tushman 2004)

4.5. Operator’s view

Operator’s business model has changed over the time. The change has been driven by government’s intentions and technical evolution. The main changes in the telecommunication industry are summarized in tables 2 and 3.

Table 2. Change driven by government intentions (S-38.3041)

<table>
<thead>
<tr>
<th>Driven by government intentions</th>
<th>Past</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government ownership</td>
<td>Private ownership</td>
<td></td>
</tr>
<tr>
<td>Monopolies</td>
<td>Competing oligopolies</td>
<td></td>
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<tr>
<td>Local operators</td>
<td>Global operators</td>
<td></td>
</tr>
<tr>
<td>Real operators</td>
<td>Virtual operators</td>
<td></td>
</tr>
<tr>
<td>Value chains</td>
<td>Value nets</td>
<td></td>
</tr>
<tr>
<td>Long-term focus</td>
<td>Quarterly focus</td>
<td></td>
</tr>
<tr>
<td>Static budgets</td>
<td>Rolling budgets</td>
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</tbody>
</table>

Table 3. Change driven by technological evolution (S-38.3041)

<table>
<thead>
<tr>
<th>Driven by technology evolution</th>
<th>Past</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedicated networks</td>
<td>All IP</td>
<td></td>
</tr>
<tr>
<td>Dedicated operators</td>
<td>Full-service operators</td>
<td></td>
</tr>
<tr>
<td>High margins</td>
<td>Low margins</td>
<td></td>
</tr>
<tr>
<td>Wireline</td>
<td>Wireless</td>
<td></td>
</tr>
<tr>
<td>Incremental investments</td>
<td>Large investments</td>
<td></td>
</tr>
<tr>
<td>Subscriptions</td>
<td>Subscribers</td>
<td></td>
</tr>
<tr>
<td>Interconnect agreements</td>
<td>Roaming agreements</td>
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</table>

Mr. Katajala analysed UMTS features in 2005 and he summarized a holistic operator view for feature analysis with the operator’s view model. This model illustrates the most important determinants related to decision making. The model can be used for LTE respectively. Figure 6 is adapted from Mr. Katajala’s model.
Figure 6. Operator’s view to investment decision (adapted from Katalaja 2005)

LTE shall either generate revenue growth or decrease the expenditures. Services stimulate consumers and business users which generates subscriber and traffic growth. Operator’s profit can be illustrated using the simplified formula below:

\[ \text{Profit} = \text{Subscribers} \times \text{ARPU} - \text{OPEX} - \text{CAPEX} \]

Operators’ objective is to keep existing subscribers and acquire new customers. ARPU stands for Average Revenue Per User and operator can increase the usage with new services or increase prices. OPEX deals with service quality optimization and CAPEX with optimization of service coverage and capacity. (S-38.3041)

The revenue growth is generated by increased customer base, traffic growth and interconnect fees. The interconnect fees also generate OPEX costs. Operator’s objective is to use an own network when interconnect fees are avoided. OPEX consists also maintenance and operation and power consumption costs. (S-38.3041) New LTE equipment can decrease radically the power consumption, even from 3 kW to 1kW, and flatter simplified architecture enables lower maintenance and operation costs. (Operator interview 2009) The other expenditure cost is CAPEX. In case of LTE CAPEX it is not an issue because new HSPA equipment has already an evolution path to LTE. Software upgrade is not free of charge but the investments are not like in case of 3G. (Operator interview 2009)

Another important factor is regulation. Usually regulations are related, for instance, to emergency calls but in this paper case Finland illustrates how the Finnish Government has taken a role with the national broadband strategy. The regulator could force operators to provide certain and equal services with a certain pricing model. Thus, regulation has an affect to operator’s investment decision.

New services might have remarkable impact for the decision making. The improvement of connection speed and quality will open possibilities for new services but so far any specific “killer application” has not been identified (Operator interview 2009). There could be an important role for IMS in the future. IMS benefits could be available especially for service innovation.

The BTA, which is an abbreviation for brand image and technical advantage, is quite difficult to evaluate. Anyhow, being first in the market with new services may attract users and it can enhance the brand image of the service provider.

As mentioned earlier, the type of data traffic is changing from voice to data in the mobile networks. Especially, different kind of real-time applications are becoming popular, like videoconferencing and other multimedia content. These services need broadband access with low latency. One approach could be to provide different services for different customer segments. For instance, operator’s services could be classified into different service classes according to connection quality. In this way guaranteed quality can be offered to real-time applications used by business users. Pricing could be adjusted correspondingly to meet the increased quality requirements. Home users with video streaming, downloading and games do not require such high quality service and therefore there would be available low quality with lower pricing level. This kind of model is used in fixed data connections market. Anyhow, operators need to re-evaluate their business models and to evaluate how the future revenue is derived. Current flat rate trend in data communication does not support operator’s profitability (Operator interview 2009).

5. The influence of regulation: Case Finland

The objective of the case study is to understand better how regulation can affect to service adaption and decision making. The regulator in this case is the Finnish Government and its aim is to provide equitable telecommunication services to all Finnish citizens.

First, it is explained the current situation of telecommunication services in Finland. Second, the national telecommunication strategy is explained and reasons behind the strategy. Third part includes the conclusion how LTE could fit the strategy and how it could have successful service adaption in Finland.

Broadband telecommunication access has changed from luxury service to commodity for both business and leisure in Finland. Today main access method is Asymmetric Digital Subscriber Line (ADSL) technology which is used over 67 percent of all broadband connections in Finland (Ficora 2008). Fixed broadband access availability was 95,8 percent of all households in 2006 and 56,5 percent of Finnish households had a broadband access to the Internet. (Tietoyhteiskuntaohjelma 2006)

In June 2008 the share of 10 Mbps or more was only 6 percent of all broadband connections. The most common data rate is under 2 Mbps in Finland. All connections with bandwidth above 256 kbps are defined
as broadband connections. This basic level of service is adequate for sending and receiving emails and for internet browsing. It is insufficient for advanced electronic services, image and video transmissions. (Pursiainen 2008)

However, certain telecommunication operators have announced their intention of degrading or even removing fixed telecommunication network services in sparsely populated areas because it is not economically reasonable to have those services there. This means that citizens in certain areas no longer have broadband access to vital services. Due to reasons mentioned above the public sector has decided to take more decisive role to ensure equitable telecommunication infrastructure for the future (Pursiainen 2008).

In February 2005 the Finnish Government defined the targets in the national broadband strategy. In 2008 the Ministry of Transport and Communications appointed Permanent Secretary Mr Harri Pursiainen to carry out a study to ensure comprehensive broadband deployment across the country and organizing its funding, especially in sparsely populated areas.

5.1. Target for 2015

In autumn 2008 the report with exact targets was delivered to Suvi Lindén the Minister of Transport and Communications. The Finnish government made the decision of the national broadband program on December 4 2008. The target is to provide 100 Mbps connection available for at least 99 percent of permanent residences and offices of business and public administration across the country. The connection can be provided by a cable, an optical fiber or using wireless technology and access shall be available of no more than two kilometers length to network. The long-term objective is to provide an access for the vast majority of Finnish households for services like television, downloading large files (like movies) and more efficient use of several computers at the same time, like for teleworking or social networking services. In addition, an operator shall provide the service to users by a reasonable price in the areas where the operator has been assigned the service obligation by the Finnish Communication Regulatory Authority (called Ficora). (Pursiainen 2008)

In urban areas it is possible to provide broadband connections on a commercial basis by the operators. This enables approximately 95 percent coverage of households. The broadband strategy pays a special attention to the fact that telecommunication needs evolve in the rural areas in the same manner as in urban areas. To achieve 99 percent coverage of households a construction work is needed in 120 000 households.

5.2. Consumer needs in rural and urban areas

Especially higher connection rates are needed for business in the rural areas. For example, there is a need for 8 Mbps connection in animal farms for milking systems, video monitoring, and registries. In the rural areas, where distances are longer than in urban areas, also teleworking, distance learning, health care and many other social services can be provided by using the broadband network. In addition, wireless service is needed in grain farms, reindeer farms and forestry machine services. (Haantie 2008)

5.3 Last mile challenge

One of the challenges is that the operators do not have the core network within the required distance between the household and the service provider’s access point. The connection between the customer and service provider’s access point is called often “last mile”. Traditionally last mile connection is established by a copper, an optical fiber or using wireless technologies. The broadband strategy sets that the last mile is no more than two kilometers to the core network (Pursiainen 2008). This means that operators need to upgrade their core network and households need to invest the last mile connection. It is up to households to decide the technology and a connection rate.

Mr Pursiainen’s report also states that the cost to construct a fiber connection for last mile is approximately 5,20 euro per metre (including construction work and fiber). Using this estimation the average cost for consumer to solve the last mile problem is about 2000-3000 euro. This cost can be compared to the costs to build electrical connection for household. (Pursianen 2008)

5.4. Financial model

The Government’s aim is that operators will build and maintain the public telecommunication infrastructure on a commercial basis. However, the public sector will support the operator in the areas where telecommunication infrastructure cannot be provided on a commercial basis. The cost estimation to provide required coverage in Finland is around 200 million euro (Ministry of Transport and Communications). Operator’s share of the cost is at least one-third. Public contribution is divided between government, State and European Union. In addition, the cost estimation for last mile is 480-780 million euro. (Pursiainen 2008)

Also, the Finnish Government has decided that certain radio frequencies will be allocated by auctions. (Pursiainen 2008) There will be a license auction for 2.6-2.69 GHz band in autumn 2009. It is estimated, based on similar auctions in Sweden and Norway, that the license auction generates 30-130 million euro. In addition, old TV broadcasting frequency 790-862 MHz is under investigation because it could be useful due to low frequency band (Pursienen 2008). Also, the usage of DECT phones is declining and probably the frequency band 1880-1900 MHz can be allocated to LTE within 10 years. (Ficora 2007) More frequency auctions can be expected in the future if the model proves its usefulness.
6. Findings of the study

LTE can be considered as radical innovation in telecommunication industry. It provides substantial benefits for several parties. Key benefits for the operators are summarized below:

- more efficient frequency spectrum usage
- optimized network architecture
- lower OPEX
- reuse of previous investments for licenses and technical equipment
- convergence of different networks and services

For the end users LTE enables:

- improved data rates
- reduced latency
- enriched services

Technically LTE opens many possibilities but technical benefits do not guarantee commercial success. Operators are looking for smooth service phasing and deploying the service gradually according their strategic plans. In this way previous investments for licenses and technical equipment can be reused. Traffic transition from voice and circuit switched network to data optimized packet switched network is obvious but it takes time. This conservative approach could be economically reasonable, especially during the global economic downturn. Then LTE service would be available for early adapters in urban areas and later in the rural areas.

Vendors have announced to deliver LTE compatible devices in 2010. Probably, first LTE devices will be available for laptops and later for mobile handhelds. Multimode devices which support 2G/3G/4G are needed.

The case study addressed the consequence of regulation. Government regulation may have a strong influence for service deployment decision and service adaption. The national plan of Finland needs investments from the operators and the consumers. Operators need to invest to the core network and consumers to the last mile connection. Government’s objective to provide 100 Mbps for all citizens 2015 seems to be unrealistic. My argument is based on the fact that at the moment an optical fiber is the only option for connection media and it is too expensive investments for operators and consumers. Also, an analysis shall be done in order to clarify the rural areas needs. Investments makes sense for business users but not for every household.

One approach could be to have a reasonable data rate requirement, use wireless technology and to select the lower frequency band in rural areas. Lower frequency band enables lower base station density to cover the same geographical area and a reasonable data rate requirement could be applied in the rural areas where for instance 100 Mbps is not commercially and technically reasonable to build. For operators this could be economically appropriate approach and in this way service pricing could be competitively. This would stimulate to faster service adaption among the users. However, the goal should be to provide required broadband access for those who need such a connection speed and quality.

The public telecommunication infrastructure goals and the information society plans have also a consequence to overall regional and community planning. Regional and community planning shall ensure that the required telecommunication infrastructure is in place in the future. In practice, this could mean that a fiber installation will be a standard for houses in the future.

This case proves that regulation may have a strong influence to operator’s decision making and to the whole business. The government can obligate operators to provide certain public services and even with a reasonable cost.

7. Conclusion

The objective of this paper was to analyze LTE as an innovation, to clarify why operators should invest to LTE and to understand the influence of government regulation.

Nowadays, mobile phones are used much more than just voice communication. On professional users, like companies, there will be new services and applications which will set more requirements for network latency and bandwidth. These requirements will be more than email and calendar applications which are commonly used today. New services create data traffic growth and it is estimated that the growth will be massive and fast in the mobile networks. LTE provides an attractive choice from the technological and the commercial points of view. End users are able to use more enriched services and operators are able to respond the massive data traffic growth and increased user demands economically reasonable way. LTE is potential technology to become a dominant design.

According to implementation strategy the most typical approach is to provide LTE services to early adapters in urban areas where it could be provided in profitable manner. In Finland regulation may have a strong influence to deployment providing telecommunication services as a public services to all citizens.
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