“It’s the services, stupid!”: Identifying killer applications for next-generation networks

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Article history:
Received 9 March 2012
Accepted 18 March 2012
Available online 23 March 2012

Keywords:
Value-added services
Fiber to the home
Next-generation networks
Expert study

ABSTRACT
Cities and countries all over the world are currently in the process of developing large-scale broadband projects in order to upgrade their Internet access infrastructure. They justify this costly endeavor of rolling out fiber to the home (FTTH) networks in believing that state-of-the-art ICT infrastructure will function as a growth engine, bridge the digital divide and increase quality of living. In the meantime, they believe it to be simply indispensable because an ever increasing demand for bandwidth-intensive applications is anticipated. The former goals, however, can only be achieved if citizens and companies alike migrate to this new technology. Hence, it is essential to consider the utility of fiber networks for future users and to explore applications that can convince end-users to migrate from their current connections to high-bandwidth networks. By means of an international expert survey, this paper tries to identify value-added services that benefit from fiber's network potential and that can stimulate users to switch to fiber. Health monitoring, online content storage and management services, and desktop sharing were identified as the most promising fiber applications in the short term based on a combination of technological feasibility, time to reach the mass market and overall persuasiveness. Augmented video applications such as health monitoring and virtual classrooms on the other hand were deemed very persuasive but long-term oriented.

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1. Introduction

In recent years, literature has witnessed an explosion of buzz words such as ‘digital’, ‘intelligent’ or ‘smart’ cities. Cities are trying to compete with each other, thus they seek for ways to distinguish themselves and to put themselves firmly on the global map. Deploying new ICT infrastructure, which is the common foundation of the above-mentioned notions, is one such method. Cities believe that novel ICT infrastructure such as fiber to the home (FTTH) will function as a growth engine, bridge the digital divide and increase quality of living (Caragliu et al., 2009; Dolente et al., 2010). They may have good reason to think so, yet new technology can only fulfill ambitions if there exists genuine demand for such ultra broadband networks, hence if people actually adopt and switch to it. With regard to this, the establishment of fiber broadband networks should be studied within a wider socio-economic context, challenging such a positivist, rather techno-optimistic vision on ICT development.

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0736-5853/$ - see front matter © 2012 Elsevier Ltd. All rights reserved. http://dx.doi.org/10.1016/j.tele.2012.03.009
Especially in Western-Europe, where the broadband penetration is already high, this demand is still mainly unproven. In general, the number of homes passed is still small and commercially available offers have not yet fully convinced potential customers, which seem satisfied with their existing connection, to migrate to fiber (IDATE, 2010). Furthermore, as providers seek to compensate for high investment costs, they tend to demand higher prices for next-generation network (NGN) subscriptions compared to regular broadband. If the perceived utility for end-users is not in access prices, it might be in the supply of value-added services (or ‘killer applications’).

To date, however, many studies have focused on technological excellence of this new ICT infrastructure. While technological excellence is an important driver for cities to roll out new broadband networks, it is not the leitmotiv for users to adopt them. Users will only adopt new technology if it provides them with perceived added value and benefits (Rogers, 1995). Instead, in this paper it is proposed that services are the predominant factor while the infrastructure should be regarded only as the enabler and thus not in itself as the unique selling proposition. That is why this study renounces the technology-centered approach of traditional ICT research and adapts a more user-oriented method to study the perceived benefits of fiber to the home broadband networks. However, as is outlined in the next sections, these benefits are relatively disputed in literature. Hence, some authors doubt that current networks will become obsolete or that cities should invest public money. This paper first reviews the literature on smart, digital and intelligent cities, the rationale behind the deployment of new ICT infrastructure and the existing debate on the need for new broadband networks to meet future bandwidth demand. Secondly, the methods section briefly discusses the research on which the analysis is based. Finally, results of this study and concluding remarks are presented.

2. Why cities want to become smart

In bygone days, cities were enclosed entities, clearly separated from each other by distance and thriving on natural resources such as coal and iron ore. The major concerns of those cities were, roughly speaking, accommodating manufacturing enterprises and optimizing accessibility infrastructure, so as to ensure that laborers, feedstock and products could easily enter and leave the city. Globalization together with technological revolutions, however, have put a stop to that. Castells (2000) suggests that ICT has intensified the intercity competition in network societies, and that a worldwide network of interconnected city hubs has been established. This represents major opportunities but at the same time also threats for cities since, as physical movement is facilitated, manufacturing, capital, trade and consumption are less bound to a particular area, and become more flexible. This is sometimes referred to as the ‘end of physical distance’. In practice, this implies that multinational corporations (MNCs) increasingly take decisions with no regard to national boundaries as technology substantially reduces coordination costs (Thornley, 2000). In consequence, cities enter into fierce competition with peers that previously never posed any threat (Giffinger et al., 2007).

New technologies and innovation are often referred to as means to an end for cities to distinguish themselves from others. Williams et al. (2009) state that some aspects of cities are getting more similar but that in general, local differences still make it possible to distinguish between them. Freeman (1991) declares that, next to technology, other factors are also important in this global competition. According to Florida (2003), this focus on technology is too narrow, since talent and openness to new ideas are important as well to become a prosperous region. It should be clear that in this development process, other factors are as vital as technology, although this technological component is mostly overemphasized in policy overviews. These nuances already indicate that the notion of a ‘global village’ is not commonly accepted, emphasizing that local influences act as a powerful counterforce to this enduring globalization wave. For example, adherents of Behavioral Geography contend that contextual factors (for example birth place) affects the location where companies and citizens end up as well (Boschma and Lambooy, 1999). Sassen (2008) adds that the dominant narrative of the transnational and global companies is only one part of the story since strategic nodes are required in information industries. Hence, globalization and localness are considered two sides of the same coin.

However, policy makers tend to overstress the importance of technology to attract new citizens or companies. As a consequence, cities all over the world have engaged in a race to become a ‘smart’, ‘digital’ or ‘intelligent’ city. As an example, the ‘Smart Cities’ project creating an innovation network between cities and academic partners in the North Sea Region could be mentioned, as well as the various living lab initiatives all over Europe coordinated by ENoLL. Pioneers of such networks have abandoned traditional value creation via manufacturing and instead invest in a ‘creative city’ in which value creation is derived from the conception of creative ideas and innovative services. Certain proxies are used to benchmark these cities, city-rankings and city-branding are two key parameters. City-rankings are a central instrument to assess the attractiveness of urban regions. They are used to indicate shortcomings and advantages of a city on certain criteria as opposed to rival ones and make it indispensable for a city to improve certain factors if it wants to be regarded as a genuine centre of excellence (Giffinger et al., 2007). This is closely linked to the phenomenon of city branding. The image of a city can affect whether potential citizens and companies settle there (Hospers, 2003). Hence, cities expect to benefit from branding themselves as ‘smart’ and substantially invest in maintaining this image.
3. Smart cities and similar concepts

The traditional conception of a city as an assembly of resources and enterprises and a work force to master these resources has thus been exchanged for a novel conception in which the city is a center of excellence, optimizing quality of life in every possible way. Hence, it is not the production and distribution of products but instead the development of knowledge and innovation that is assumed to boost a city's economic welfare (Hospers, 2003).

As a consequence of the increased competition between cities, more and more of them all over the world are beginning to brand themselves ‘smart’. Next to smart, however, ‘digital’, ‘intelligent’ and similar notions are increasingly being used to refer to such cities. Although these expressions are becoming more and more popular, it is often fuzzy what exactly they refer to. A literature review demonstrates that all these concepts are interconnected. The aim of the digital city is ‘to use communication technologies to connect citizens to each other, to local governments and to information repositories’ (Middleton and Byrne, 2011, p. 163). That must allow them to interact and share knowledge, experiences and mutual interests. Characterizing a digital city is that it harmonically combines flexible and service-oriented ICT infrastructure with innovative services (Civitium, Wireless Broadband, 2010). Similar to this notion is the idea of the intelligent city, which aims at uniting, promoting, acquiring and stimulating diffusion of information and in doing so, enhancing the quality of life for all citizens. To achieve this, the latter combines infrastructure and ‘infrastructure’ of information technology, electronic and mechanical communications while also deploying the latest developments in telecommunications (Malek, 2009). In order to do that, according to Komninos (2008), an intelligent city should apply electronic and digital technologies, develop ICTs and embed them in the city in order to enhance innovation, learning, knowledge and better problem solving with the ultimate goal to transform life and work within the city.

The most interesting notion in this list, however, is that of the ‘smart’ city. Many authors focus on the ICT infrastructure component of smart cities, which makes them very similar to digital or intelligent cities. Caragliu et al. (2009), however, do not solely see the availability and quality of the ICT component as decisive for such an urban territory. Instead, they define a smart city as having the following distinctive features. Next to having deployed a well-developed networked infrastructure, the city should focus on business-led urban development and social inclusion as well as on social and relational capital to ensure that people have the necessary skills to manage technological advancements. Hence, where ICTs used to be the main identifier for smart cities, the concept is broadened and now includes more components than merely Internet-related aspects. According to Giffinger et al. (2007), smart cities comprise six main dimensions: smart economy, smart people, smart governance, smart mobility, smart environment and smart living. The availability of ICT infrastructure is only one, but nevertheless indispensable part of the smart mobility axis and thus of a smart city in general. Therefore, Caragliu et al. (2009, p. 50) define a smart city as ‘a city in which investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance’.

The availability of these ICT infrastructures and services could affect how people function and communicate within cities. According to Foth et al. (2008) telecommunications also affect how people interact on a local level. From a more extreme point of view it would be possible to state that cities would disappear if these broadband networks become abundant. However, this is a rather utilitarian vision on cities as facilitators of communication. Glaeser and Shapiro (2003) conclude that face-to-face communication is still important and that computer-mediated communication is merely complementary to real life interactions. Furthermore, industries tend to evolve in clusters. Cities thus play an important role in the economic development of a region, which is reflected in the investments in these cities, for example, in mobility, health care, and utility infrastructure. Offering citizens superfast and state-of-the-art Internet access would not only increase quality of place, but also contribute to bridging the digital divide, considering the ability to search and share information through ICT infrastructure a prerequisite for citizens to be able to learn and evolve (Dolente et al., 2010). As a result of this urban-centered perspective, rural areas are often deprived from investments in new infrastructures. This is most clearly visible with rural wireless broadband, which is considered ‘no substitute for wired (fiber or coaxial) systems for meeting foreseeable needs for increased throughput, creating a new digital gap’ (Noam, 2011, p. 470).

4. NGNs for a smarter city

Whether or not cities focus specifically on ICT infrastructure, it is obvious that broadband Internet access is a prerequisite in all the above-mentioned conceptions of a city because it is a key enabler of many of the proposed processes. Fiber to the home (FTTH) is a specific fiber configuration that deploys fiber optic cables up to every single room in connected premises – whether these are houses, office blocks or multi-dwelling units – thus replacing the complete copper local loop by fiber to bridge the last mile Internet connection. Next to wired solutions, mobile technologies also offer broadband and are also considered NGNs. The third generation mobile (3G) technology is not ubiquitous yet, but the faster fourth generation (4G) is already being rolled out by telecom operators – albeit that these do not provide transmission speeds as high as those performed by wired connections. Despite rapid evolutions, it should be noted that the discussion about these NGNs is not that new anymore. During the end of the 20th century, the concept of an ‘Information superhighway’ became prevalent. Instead of being a limiting factor, broadband would become abundant while facilitating new applications and digital lifestyles (Negroponte, 1996). As a game-changer in the telecom industry, networks would impact and even disrupt existing business
models. The belief was that it was going to happen and it was going to happen fast. While copper networks often have been rolled out under monopolistic market conditions, this was no longer the case during this period. This led to a lot of nervous reactions from companies but also from regulatory institutions. Estimations predicted that the growth in demand for bandwidth would double every 100 days, but it soon became apparent that the demand was heavily overestimated (Fransman, 2004). A bubble followed and the discussion disappeared from the rhetoric of policy makers, although it is put back on the European policy agenda these days.

The process of FTTH development is clearly driven by local governments and cities, in a combined effort with new and incumbent telecom operators, which are heavily investing in the rollout of high-speed broadband networks. Despite nationwide rollouts supported by incumbent operators, an increasing number of cities have deployed community broadband networks. Whereas the passive layers (infrastructure) are largely owned by the city, the active ones (services) are often operated by telecom firms. In Europe, municipal fiber networks are relatively successful in Scandinavian countries, the Netherlands and Germany, whereas, the establishment of city networks in several U.S. cities is backed and largely financed by companies such as search giant Google. More recently, the notion of broadband as being a disruptive force on both an economical and a societal level, is reappearing. Apart from labeling themselves ‘smart’, ‘digital’ or ‘intelligent’, cities may have other and genuine reasons to deploy FTTH. It is assumed to stimulate a city’s welfare because it functions as an economic engine for attracting more companies and creating new job opportunities. McLuhan (1964) stated ‘the medium is the message’ by which was meant that the medium defines which specific message can be conveyed and the way it can be put across to the public. Following this rationale, the deployment of a sophisticated technology should thus allow cities to expand the services they offer to more effectively serve and communicate with citizens, companies and tourists in a creative fashion while in the meantime supporting their creative and knowledge economy.

5. The need for FTTH

Deploying NGNs also meets an evolution that has quickly gathered pace in the last few years: the increasing demand for higher bandwidth. This demand for FTTH would be induced by the growing penetration of broadband Internet and by the growing demand for high-bandwidth applications including high-definition video and video conferencing. More specific, FTTH is often pursued because it is deemed having some major benefits over existing fixed broadband infrastructure. One of the most important benefits is the increased speed with which fiber can transfer data. Where current network configuration offers bandwidth limited to 100 Mbp downstream and 4.5 Mbp upstream, FTTH could easily provide up to 1 Gbp both upload and download speed (Yao et al., 2002). Another major benefit is that FTTH networks are often being considered future-proof as well as energy efficient. This is very important for cities, since the former renders obsolete the need to continuously dig streets in order to renew the infrastructure. Along with speed, symmetry (i.e. identical up and download speed) is considered an important fiber advantage. Until now, asymmetrical bandwidth did not pose any problems, but consumption patterns are changing and innovative services such as Electronic Program Guide (EPG) and file sharing together with novel public services such as remote check-up and e-learning require that information can easily be sent in the opposite direction (upstream). Hence, Cave & Martin (2010, p. 508) believe that ‘it is likely that services will increasingly require symmetric capabilities’. This techno-dominated vision, which urges the roll-out of NGNs, sharply opposes the belief that existing infrastructure will be able to carry future broadband services and that value-added services will be scarce (e.g., Kenny and Kenny, 2011; Noam, 2008).

Thus, countries and cities all over the world share a profound belief in fiber as the Internet access infrastructure of the future. At the moment, the investments are mainly located in Asia and in Eastern–Europe since their broadband infrastructure is often less developed. As Table 1 illustrates, there are also differences between countries in the same continent regarding the investment level. Although the number of homes connected could provide a more realistic overview of the situation compared to the number of homes (merely) passed with fiber, this data already indicates that Swedish cities are investing more heavily in FTTH than UK ones (considering the number of homes passed versus number of inhabitants) with regard to Europe.

The deployment of NGNs and FTTH is a costly endeavor. This obstacle is often overcome by establishing Public Private Partnerships (PPPs) in which private players such as network operators and service providers, and public parties such as local communities, municipalities and local or national governments collaborate. These joint ventures allow public players to pursue their goals of becoming a creative region while private companies can tap into a new pool of revenues by providing innovative and enhanced broadband services (Nucciarelli et al., 2010). At the same time, this orchestration of investments enables all parties involved to share expenses while nevertheless resulting in fully equipped NGNs.

Cities and regions pioneering in developing NGNs often do so with the adage ‘if you build it, they will come’ in mind. This push strategy, implying that supply comes first and that it automatically evokes demand, is often applied when launching innovative products or services. This viewpoint makes sense for public players since it counters the traditional chicken and egg problem; the availability of high-capacity applications necessitates improved network infrastructure, while investments in upgrading infrastructure may stimulate the development of capacity-requiring applications (Falch and Henten, 2010). Regions deploying NGNs believe they can resolve the abovementioned chicken and egg problem by securing the supply–side of this equation. They assume that the provisioning and consumption of bandwidth-intensive services and applications will automatically develop as a simple consequence of supplying the infrastructure. This reasoning is a very technology-deterministic stance and similar past
### Table 1
Total of broadband subscriptions per country (Based on FTTH-council, 2011; OECD, 2011; “data for Canada and the US”)

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<thead>
<tr>
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<tbody>
<tr>
<td>France</td>
<td>16,825,000</td>
<td>8,600,000</td>
<td>40,000</td>
<td>4,455,200</td>
<td>18,493,000</td>
<td>1,020,000</td>
<td>69,000</td>
<td>5,700,750</td>
<td>19,147,000</td>
<td>89,000</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>3,563,000</td>
<td>2,192,000</td>
<td>100,000</td>
<td>413,500</td>
<td>3,645,000</td>
<td>2,351,000</td>
<td>134,000</td>
<td>576,500</td>
<td>3,645,000</td>
<td>2,452,000</td>
</tr>
<tr>
<td>Sweden</td>
<td>1,737,000</td>
<td>563,000</td>
<td>590,000</td>
<td>910,000</td>
<td>1,666,134</td>
<td>579,141</td>
<td>687,403</td>
<td>1,296,900</td>
<td>1,633,000</td>
<td>590,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>13,556,860</td>
<td>3,682,800</td>
<td>n.i.</td>
<td>5,180</td>
<td>14,370,000</td>
<td>3,840,000</td>
<td>3,290</td>
<td>86,180</td>
<td>14,878,224</td>
<td>3,942,644</td>
</tr>
<tr>
<td>Turkey</td>
<td>5,660,000</td>
<td>67,408</td>
<td>n.i.</td>
<td>n.i.</td>
<td>6,216,028</td>
<td>146,622</td>
<td>41,000</td>
<td>230,000</td>
<td>6,464,418</td>
<td>191,331</td>
</tr>
<tr>
<td>United States</td>
<td>30,439,000</td>
<td>41,468,000</td>
<td>3,061,051</td>
<td>11,763,333</td>
<td>31,190,000</td>
<td>43,392,360</td>
<td>3,945,977</td>
<td>15,171,900</td>
<td>30,930,000</td>
<td>43,924,000</td>
</tr>
<tr>
<td>Canada</td>
<td>4,300,694</td>
<td>4,973,552</td>
<td>1,072</td>
<td>n.i.</td>
<td>4,440,000</td>
<td>5,540,000</td>
<td>n.i.</td>
<td>4,433,438</td>
<td>5,075,303</td>
<td>n.i.</td>
</tr>
<tr>
<td>Mexico</td>
<td>5,436,668</td>
<td>1,980,319</td>
<td>n.i.</td>
<td>n.i.</td>
<td>7,308,791</td>
<td>2,097,872</td>
<td>n.i.</td>
<td>8,378,187</td>
<td>2,166,165</td>
<td>n.i.</td>
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<td>Japan</td>
<td>11,594,082</td>
<td>4,083,072</td>
<td>14,417,207</td>
<td>n.i.</td>
<td>10,134,491</td>
<td>4,300,594</td>
<td>17,195,696</td>
<td>42,500,000</td>
<td>9,361,054</td>
<td>5,391,342</td>
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<td>South-Korea</td>
<td>3,718,135</td>
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<td>6,670,506</td>
<td>n.i.</td>
<td>3,222,419</td>
<td>5,147,994</td>
<td>7,977,303</td>
<td>11,534,000</td>
<td>2,883,139</td>
<td>5,169,811</td>
</tr>
</tbody>
</table>

*Note: n.i. = Not available.*
technology-push introductions have revealed that this argumentation does not always hold. They have proven that users are only willing to adopt new technology if it provides them with perceived added value and benefits and that an innovation’s mere technological excellence is hardly ever decisive. With regard to fiber networks, Noam (2008, p. 2) postulates that ‘it is common to rush into talk of technology or roll-out strategy without first considering the utility to users. If one builds an oil pipeline one must first be sure that there is an oil supply at one end and demand for it at the other. The economic case for investment in super-broadband must rest on its meeting a demand/price combination that is not satisfied today’. That is exactly where the shoe pinches. There is a lot of debate among experts whether broadband countries have a genuine need for fiber networks. Some believe that existing network infrastructure will suffice to deliver enhanced applications and services to end-users in the future and that fiber’s bandwidth is largely excessive for what end-users (will) require. Fredebeul-Krein and Knoben (2010) for example, argue that research shows limited evidence of increasing demand for high-bandwidth capacity. At the same time, they believe that technical progress may allow the current networks to meet future bandwidth requirements.

The conclusion that urges oneself is that it is essential to also take contradictory viewpoints into account besides the sheer optimistic ones when deciding whether or not to deploy NGNs. Although the costliness of such roll-outs may be partly set off by splitting up the investments by means of PPPs, there is a danger that some parties involved overestimate the advantages of and demand for fiber and engage in projects that offer only a marginal benefit compared to existing broadband Internet access. Moreover, research tends to focus on the technological excellence of fiber and on the specific topology that is most advantageous to users from a technological point of view, but this technological excellence does not constitute the main driver for users to switch to fiber. Hence, there is an urgent need for a more user-oriented perspective in which research focuses on the subjective added value that fiber presents according to users, instead of the more objective performance-based benefits according to technologists. One study, conducted by RVA LLC (2010) partially fills this void by demonstrating that the most common Internet applications used over fiber include downloading and streaming video and game playing. Applications which use grew steadily since 2009 include VoIP for audio, two-way video conferencing and downloading or streaming video to a TV set. Transferring files for remote offsite storage, cloud computing, remote monitoring cameras and participation in a virtual world were less used. In asking which potential fiber services respondents deemed most interesting, RVA derived a list including super resolution HDD, two-way video calling, advanced online college and to a lesser extent 3DTV. Older respondents also valued online face-to-face healthcare. Our services-oriented approach focusing on end-user benefits should supplement the RVA study by exploring expert opinions on promising fiber applications and provide added value to most other studies which are either economic or technical in nature.

6. Research method

The results are based on the interdisciplinary TERRAIN project (Techno-Economic Research for future Access Infrastructure Networks), which focuses on a better cooperation between all public and private actors that are involved in optimizing the roll-out of new telecom and utility networks, and to align the operational processes in a more consistent way. In this project, most aspects will be analyzed from a techno-economic point of view, but regulatory and user-related sub-problems will also be taken into account. The results presented in the remainder of this paper solely focus on user-oriented research.

The aim of the user-oriented research within the project is to identify which applications and services hold potential to stimulate adoption of fiber to the home Internet access and which of these applications can fully benefit from superfast and high-bandwidth network infrastructure. The primary goal of this research was to draw up, evaluate and narrow down a long list of applications into a manageable set of the most interesting and viable FTTH use cases. This has resulted in valuable input for the next phases of the project including a large-scale end-user survey (see Fig. 1).

Exploration of existing FTTH projects combined with literature research resulted in the above mentioned long list of possible applications. This list was then discussed, refined and narrowed down to the following 10 use cases in an interdisciplinary workshop with project partners:

- **Surveillance cameras**: indoor and outdoor monitoring of homes and offices. In case of a security breach, the owner as well as the security firm and the police are automatically notified and sent full video streams.
- **Virtual classrooms**: students and teachers are represented by an avatar in a virtual classroom and experience real-life interaction and an enriched learning environment (i.e. 3D holograms for example).

![Fig. 1. Research design.](image)
7. Results

7.1. Satisfaction of fiber services and fiber benefits

Experts were asked how they judge users’ overall satisfaction of fiber services. In general, overall satisfaction was quite high (19% rated ‘excellent’ and 62% rated ‘good’). More peculiar, however, was that results demonstrated a significant difference between the assessments of experts originating from countries where fiber is already rolled out (whether on a national or more local scale) compared to experts from countries without fiber projects (see Figs. 2 and 3).

Strikingly, experts’ views from countries that have no experience with fiber are more positive compared to ‘hands on’ experts living in countries that already have deployed fiber networks. This might suggest that the expected overall user satisfaction is higher than the perceived satisfaction once fiber is rolled out. Thus the opinion of fiber networks appears to be more balanced and critical in FTTH countries than in non-FTTH countries. This might explain the aforementioned differences in opinion between believers and non-believers considering optical fiber access networks. A possible explanation could be that the opportunities of fiber infrastructure are overvalued beforehand, in which case it would be a logical consequence that countries without fiber roll-outs tend to have a greater belief in fiber. Once these fiber networks are rolled-out, however, they might be unable to meet high expectations. As such, the number of believers in those countries would decrease. These graphs also indicate the ambiguity in experts’ views on whether or not fiber should be deployed.
Subsequently, experts were asked what they consider the added value of fiber over traditional network infrastructure, which unearths some of the possible drivers for users to migrate to FTTH. Bandwidth and speed, symmetrical bandwidth and lower latency or response time were the benefits most mentioned. This is in line with literature, which has also identified these characteristics as major fiber benefits. The other benefits (immunity to electromagnetic interference, a more stable network, less signal degradation, etc.) that emerge in literature are all also mentioned, albeit to a far lesser extent.

7.2. Overall use case popularity

In a following question, panel members were asked to choose their personal three most convincing services and to rank them subsequently. Use cases were allocated five (ranked first), three (ranked second) and one (ranked third) point(s). These points were then summed resulting in an absolute order of rank (see Table 2). Because of the explorative nature of this study and the small sample size, one should more take into account the relative position of the use cases instead of the absolute scores.

The resulting ranking summarizes the experts’ views on the general market potential for each use case and brings to light some very conspicuous and perhaps unanticipated conclusions if the RVA research is taken into account. Health monitoring systems and online content management are clearly deemed most convincing, considering their high score and the fact that three experts rated them most convincing of all use cases. Whereas RVA confirms this for health monitoring, it does not for

<table>
<thead>
<tr>
<th>Rank</th>
<th>Use case</th>
<th>Score</th>
<th>#1</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Health monitoring systems</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Content storage/management</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Desktop sharing</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Virtual classroom</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Online multiplayer gaming</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Video telephony</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Surveillance cameras</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Internet-protocol television</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>On-demand video streaming</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>3D tourist environment</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
online content management and storage. The top three is completed by desktop sharing, leaping over virtual classrooms and online multiplayer gaming. Streaming, however, might not yet be widespread, but since its use has increased according to RVA, it might be more promising than our results have indicated. While labeling these services 'killer applications' might be an overstatement, they should clearly be born in mind when rolling out fiber network infrastructure. Results further demonstrate that the other use cases might make less of a difference because the absolute scores significantly decrease. The market potential for the 3D tourist environment appears to reach rock bottom since the absolute score is nil.

7.3. Time horizons

For public and private players alike, it is not only important to understand thoroughly which services can benefit most from FTTH's ultra-high bandwidth, high speed and low latency. It is also essential to know in which time frame a service can be expected to be technologically feasible and when it will reach the mass market (i.e. is adopted by the early majority segments). Thus, this study also aimed at gathering experts' forecasts on the development and breakthrough of these services.

With regard to the underlying technology of the use cases, experts believe that most of the applications are feasible at this moment or within 2 years (see Fig. 4). Experts regard no applications' underlying technology completely infeasible. Three use cases (content management, desktop sharing and on-demand video streaming) are expected to be market-ready in the short term (i.e. in 2 years at the latest). That is an important conclusion since two out of three of these services were very highly ranked in the abovementioned ranking. Surprisingly, health monitoring systems (identified as the most promising service) together with virtual classrooms and online multiplayer gaming (the remaining top-5 services) were seen as less market-ready. IPTV might be considered the least plausible use case as a minority of experts indicated the current readiness of technology. These findings suggest that technology will not be the main barrier in developing bandwidth-sensitive applications. Experts believe that a vast majority of services can be developed within 2 years.

Regarding market acceptance and penetration, the above graph (see Fig. 5) demonstrates that in general, there is a time lag between the actual possibility to technologically enable an application and the time needed to reach critical mass (about 15% of the market), as can be expected. Nevertheless, a majority of experts believes that the three most technologically feasible services (i.e. content management, desktop sharing and on-demand video streaming) should be able to reach the mass
market already today. For three other top-5 use cases, however, we can discern a far less positive scenario. Health monitoring systems and virtual classrooms are by some experts expected never to find acceptance with the general public. Thus the time horizons for these two services together with gaming appear far less positive. Surprisingly, IPTV is again the least plausible scenario in terms of mass market acceptance. Generally, the time lag seems bigger for less popular use cases than for the most likely services, with the exception of health monitoring systems.

7.4. End-user groups

After assessing time horizons considering technological feasibility and reach of the mass market, the experts were also asked whether they believe a specific use case to be primarily a B2C, B2B scenario or both. For obvious reasons of return of investment (ROI), service providers are eager to develop services that entail market potential for both business and consumer markets. With respect to this, most cases are, to a significant extent, seen as potentially utilized by both residential and business users.

Fig. 6 clearly shows that especially content management and surveillance cameras could be employed in both a business and consumer context. Health monitoring, online gaming, Internet-protocol television and on-demand video streaming are seen as applications almost only relevant for consumer markets. In contrast, video telephony and desktop sharing are identified as business applications. Apart from this analysis, most use cases can be utilized by private as well as business end-users, which hold prospects for further development of these applications.

8. Conclusions

Cities and regions all over the world are currently in the process of deploying NGNs, often more specifically fiber to the home Internet access. They do so with pertinent reasons in mind of developing into a smart region, stimulating welfare, bridging the digital divide, etc. However noble and well-intended these reasons are, cities often forget to gain an insight into user requirements before deploying new technology. It is primordial to first consider the utility of these networks to users because the latter are only willing to adopt if novel ICT technologies provide them with genuine added value over traditional Internet access. While adequate ICT infrastructure is a prerequisite, the above-mentioned goals can only be achieved if users actually switch to and use these innovative ICT services. To date, however, literature mainly deals with objective technological excellence and network topology instead of attending to subjective user perception of the added value of the services that FTTH enables.

This paper attempts to fill this void by explicitly renouncing the prevalent technology-centered approach to study the roll-out of NGNs and by adopting a user-oriented approach do to so instead. As such, it focuses on the identification of applications that can generate added value to fiber networks and that can convince users to migrate from their existing connection to high-performance broadband networks. In contrast to the belief that demand follows supply, a user-oriented approach allows to identify which services future users want to utilize and when these services will be able to reach critical mass. The outcome of such a user-oriented approach is sometimes surprising since it may tackle taken-for-granted beliefs and provide refreshing insights.

Regarding fiber networks, experts pinpoint augmented video applications such as health monitoring systems, virtual classrooms and online multiplayer gaming to drive fiber adoption. Moreover, such services can largely increase quality of place in aiding health care, learning opportunities, working at home and bridging the digital divide. At the same time, they might – at least for the time being – abandon allocation of resources to 3D tourist applications. This study suggests that fiber adoption and the accompanying goals can indeed be effected, albeit that not all fiber services are deemed genuine drivers for migrating to FTTH. It was beyond the scope of this paper to unearth whether cities, countries and other players should indeed invest in a fiber future, not in the least because specific conditions, which are very tied to a particular area, highly determine the necessity of and resources for NGNs in that area. Nevertheless, the results indicate which services are identified as
value-added services and which can drive the adoption of new ICT infrastructure if it is decided to pursue fiber deployment. It is important to note that these findings should be considered explorative as they are only based on the views and opinions of 21 international experts. Since it does happen that expert and end user opinions diverge, a large-scale end user survey will be conducted to validate the proposed results and to explore similarities and differences in expert and end user views.

Acknowledgements

This research was carried out as part of the IBBT TERRAIN Project. This project is co-funded by IBBT, IWT and Acreo AB, Alcatel-Lucent, Comsot, Deutsche Telekom Laboratories, Digipolis, FTTH Council Europe, Geosparc, Stad Gent, TMVW, TE Connectivity, UNET and WCS Benelux BV.

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