Financial Assessment of Fourth Generation Mobile Technologies (*)

Joakim BJÖRKDAHL, Erik BOHLIN & Sven LINDMARK
Chalmers University of Technology, Göteborg, Sweden

European 3G operators face not only the challenge of recovering from the cost of their licenses, but also the threat of their networks being bypassed by other technologies. New broadband wireless networks are emerging that may coexist, or even compete with 3G. WLAN (sometimes also referred to as WiFi), Bluetooth, Home-RF, UltraWide Band and other technologies might interact, either with each other or with 2G and 3G. Among these, WLAN in particular can be seen both as a threat to 3G and as a strong candidate leading the way towards the future communications scene.

Increasingly, these new, emerging technologies are denoted 4G, although the original vision of 4G was different. We now find two visions of 4G emerging, one *immediate* and co-existing with 3G (WLAN) and one *linear* – the traditional telco-equipment supplier's point of view – which targeted an orderly, chronological succession of mobile generations (post 2010). Not only do these competing visions create a flux and uncertainty over what will happen next, but different policy options and actions will also emerge depending on what will take place. However, technologies interacting with 3G are already making their way into the market and therefore a situation of increasing technological diversity is unfolding, with a number of consequences.

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The main objectives of this paper are to analyse emerging and future technologies in the context of 4G and their financial implications, based upon a report on 4G mobile systems (BOHLIN *et al*., 2003b) submitted to the European Science and Technology Observatory (ESTO), requested by the DG JRC/IPTS of the European Commission [1]. The paper analyses and synthesizes the financial impact and prospects of the two 4G visions that have been addressed above. An assessment will be made of the financial status of a prospective 4G operator, assuming that such an operator will be based on 3G technology. More simply, what investments and revenues will be necessary in order to make the linear 4G vision a success financially? The other model will address the prospects for the concurrent vision (more specifically the emerging public WLAN technology). This analysis will also be based on a typical operator and with certain general assumptions.

The paper is structured as follows. Firstly, some definitional issues relating to 4G are addressed. In section 3 the financials of the immediate 4G vision are assessed by modeling the stand-alone public WLAN business case. In addition, a number of considerations and developments that may impact the business case of WLAN are discussed. The business case of the long-term (sequential) 4G vision is subsequently assessed. Section 4, concludes the paper by summarizing the implications of each scenario.

■ Defining 4G

The development of mobile communications has been characterised by a number of technological transitions, corresponding to a fairly orderly series of generational system shifts. While preparing for the introduction of the most recent shift, the industry started to use the term (though not entirely consistently) "third generation" (3G), concurrently dubbing the preceding ones 1G (analogue, launched in the 1980s) and 2G (digital, launched in the 1990s). However, a few years ahead of the launch of 3G, the "fourth-generation" 4G concept started to emerge, and now the "fifth-generation" 5G is starting to attract attention at events such as the IST Mobile Summit 2003,

[1] For other papers forthcoming from the ESTO project led by DG JRC/IPTS, see BOHLIN *et al*. (2004), RODRIGUEZ CASAL *et al*. (2004), and WEBER *et al*. (2004). For a related ESTO study on European 3G networks, see BOHLIN *et al.* (2003a), BJÖRKDAHL & BOHLIN (2003), and LINDMARK & BOHLIN (2003).

for example [2]. Some early clarifications on 4G for the purposes of this paper are therefore necessary.

Originally, 4G was expected to sequentially follow 3G and to emerge over the 2010-2015 time period as an ultra-high-speed broadband wireless network. For the purposes of this paper, this is referred to as the *4G linear vision*. This vision is not yet very precise or standardised, despite the fact that industry collaboration forums such as the Wireless World Research Forum (WWRF), ITU and IST supported conferences devoting sessions to the long-term development of mobile communications systems. In its essence, the vision is about a future kind of network that will be deployed several years after 3G has been commercialized and will provide very high data rates, exceeding 100 Mb/s. Moreover, these 4G networks are assumed to operate seamlessly and interconnected with other mobile networks. Generally, 4G networks are assumed to have a cellular structure, building on the fundamental architecture of previous mobile generations.

Meanwhile, a different version of 4G has emerged in various discourses. This vision can be viewed more as a counter-reaction to the present 3G standard and raises more questions about a competitive situation emerging between 3G and other technologies, but also possibilities of complementarities. In the European Commission IST programs, the term beyond 3G has been used to denote the manifold systems and standards that are emerging to both complement and compete with 3G. One technology in particular has attracted attention – WLAN. A wireless local area network (WLAN) is a data communication system implemented as an extension or an alternative to a wired Ethernet LAN either within a building or on, for instance, a campus. These WLAN networks can be combined with other emerging technologies such as Bluetooth, 3G and 2G. For the purposes of this paper, the WLAN-based networks are denoted the *4G concurrent vision* (alternatively *4G immediate vision* is used). WLAN is considered a necessary component of the concurrent 4G vision, but a 4G concurrent network can include other network technologies as well.

Given the fluidity and imprecise nature of the 4G concept in the industry and policy fora, compared with the relatively stable consensus achieved around 3G in its formative stages in the late 1990s, it would perhaps be

[2] See plenary presentation "3G, 4G and 5G", available at: http://www.mobilesummit2003.org/plenary/p1-2.pdf, in which M. NAKAGAWA presents research from Keio University defining 5G as a generation of wireless communication with even higher data rates and carrier frequencies compared to current 4G visions.

useful to develop a less ambiguous terminology. However, for the purposes of this paper, findings will be discussed in terms of the linear versus the concurrent 4G visions, more as an approximation of a least common denominator than an optimal or "best" use of the 4G term. Certainly, better terms and definitions could be developed and this is an important research task in itself. Indeed, the two visions should properly be seen as a heuristic/stylised example, useful as a conceptual benchmark, rather than as an agreed-upon 'vision' held in its pure form by mobile industry participants[3].

■ The business case for the immediate 4G vision

Emerging WLAN technology

As mentioned above, a wireless local area network (WLAN) is a data communication system implemented as an extension or alternative to a wired Ethernet LAN either within a building or on, for instance, a campus. Private WLANs are being deployed for in-home, institutional (e.g. universities and hospitals), and single-company use, often instead of a wired LAN. Public WLANs are being deployed by WLAN service providers and public operators in high-traffic "hot spots" (i.e. hotels, airports, convention centres, and cafés) to allow high-speed internet access "on-the-go", meaning that while WLAN could be used in different "hot spots". It requires the user to be stationary or moving slowly while accessing services.

The first experimental WLANs were created in the mid-1980s in the U.S., encouraged by the FCC's opening up of three unlicensed industrial, scientific and medical (ISM) frequency bands. Initially, companies deployed WLANs in offices and factories as replacements for wired LANs. Spurred by the rapid take-up of laptops in the early 1990s, Wireless LANs were increasingly deployed to provide *mobility* to LANs. They have become increasingly deployed to provide employees with mobile wireless access to the corporate network. Universities and hospitals are also deploying WLANs.

Standardization further stimulated WLAN diffusion. In the mid 1990s the IEEE started specifying a standard for WLAN in order to get to grips with

[3] The authors have benefited from comments by Martin Fransman on the definition of 4G.

incompatibility and other technical problems of WLANs. The first standard, 802.11, was passed in 1997. This original IEEE standard only supported data rates of 1 and 2 Mbps. In 1999, IEEE released amendment 802.11b, allowing for, among other things, higher data rates (a theoretical 11 Mbps). Since then IEEE 802.11b has become the dominant de facto WLAN standard. A number of other amendments have been released since then (a, g, e, h etc.). Another potentially important standardization initiative is the IEEE 802.16 for wireless MANs, aiming to include mobility support in later releases. In addition to these standards, there are a number of industry groups that addressed WLAN issues, the most widely known being, WECA, the Wireless Ethernet Compatibility Alliance (known as the Wi-Fi alliance), which supports 802.11 and certifies "Wi-Fi" products and WiMAX, which supports 802.16.

Table 1: European operators that have launched public WLAN

Operator and service	*Country*	*Launch Date*
Swisscom Eurospot	Europe-wide	March 2003
O2 Ireland	Ireland	February 2003
France Telecom/Orange	France (will spread across all subsidiary units)	February 2003
O2 Germany	Germany	February 2003
Westel Mobile	Hungary	December 2002
T-Mobile	Germany	November 2002
D2 Vodafone	Germany	November 2002
Connex Romania	Romania	November 2002
TDC Denmark	Denmark	July 2002
BT Openzone	UK	April 2002
Telefonica Moviles	Spain	February 2002
T-Mobile	Austria	November 2001
One / Ewave	Austria	October 2001
Telenor Mobil	Norway	February 2001
Sonera (*)	Finland	June 2000
Telia (**) Mobile Homerun	Sweden	October 1999

(*) Has merged with Telia.
(**) Has merged with Sonera.

Source: Pyramid Research

The increasing popularity of WLAN began to have an impact on the 3G community. When 3G operators acquired licenses they saw it as the correct choice, but these investments now seem far more ambiguous (FRANSMAN, 2003). The emergence of public WLAN technology made the investments and the business case for 3G even more ambiguous. The argument for public WLAN relates to the attractiveness of the high data rates offered and low investment required. While the operators' deployment plans have been pushed forward and criticism of 3G has increased, public WLAN has created new possibilities for operators. Branded a 3G killer by some and a 3G savior by others, the technology has resulted in different beliefs among the telecommunications players regarding its future impact on the industry. While some operators have embraced public WLAN, others have taken a more conservative approach. Today over 15 fixed-line and mobile operators have launched public WLAN networks across Europe (see table 1).

There is a diverse group of players trying to cross-sell public WLAN access on the backs of their existing, but also non-existing, operations, including mobile operators, fixed-line operators, start-ups, and hardware manufacturers. The largest public WLAN provider in 2003 was the operator Korea Telecom, which had over 8,000 hotspots and was planning to have around 14,000 at the end of 2003 [4]; (see table 2).

Table 2: The largest public WLAN providers (worldwide)

Operator	*Operator type*	*Region*	*Hotspots (mar-03)*
KT	Fixed-line	South Korea	8,000
T-Mobile USA	Mobile	U.S.	2,326
Boingo	Start-up hotspot aggregator	U.S.	1,000
NTT Communications	Fixed-line	Japan	1,000
China Mobile	Mobile	China	900
TeliaSonera	Mobile	Nordic	700
Wayport	Start-up operator	U.S.	535
Hanaro	Fixed-line	South Korea	500
Toshiba	Hotspot aggregator	U.S.	300
Metronet	Start-up operator	Austria	250

Source: Planet Wireless

4 Planet Wireless, Wi-Fi hotspot operator database.

The fixed-line operator, British Telecom, had deployed 400 hotspots and had a target of 4,000 hotspots in the UK by the summer of 2004 [5]. Fixed-line operators see the technology as a new means of making money and at the same time as part of a broader push into mobile solutions. British Telecom expects that its new mobility strategy will generate USD 261 million by 2004-2005 and as much as up to USD 725 million by 2008 or earlier [6].

The deployment of public WLAN might cast some doubt on the role of 3G networks. It has been argued that 2.5G networks in combination with public WLAN will be sufficient for users' needs. T-Mobile USA, for example, is planning to integrate 2.5G with public WLAN networks and does not have plans to go into 3G [7]. At the same time there are fixed-line operators that see a chance to take part in the mobile market. Although many operators with 3G plans are embracing public WLAN, there are also 3G operators that are taking a more conservative approach toward the technology.However, as far as 3G is concerned, it is fair to ask where the profits are? Although operators have deployed public WLAN networks for some years now, all providers of public WLAN access have one thing in common – no one is making any money out of public WLAN today, and it is consequently far from a proven business case.

The stand-alone public WLAN business case

The public WLAN business case differs in many respects from that of 3G. The spectrum is free for the providers, while players in the 3G market in many cases paid billions for licenses. In addition, players can enter the market with relatively low investment costs and on a small scale, compared to the more mainstream technologies. Besides, WLAN uses the unlicensed spectrum, enabling players to set up businesses without the need for licenses. This implies that the entry barriers are low, attracting many players into the market for deployment of public WLAN networks. However, the relatively low investment required does not necessarily make it a worthwhile business for the players involved. Below are estimates of public WLAN as a stand-alone business case for an operator, without a backbone network; the investment horizon being 10 years. Due to the uncertainty involved, the

[5] Planet Wireless, Wi-Fi hotspot operator case studies, 2003.

[6] Planet Wireless, Wi-Fi hotspot operator case studies, 2003.

[7] Mobile Communications International, Friend or foe?, Issue 97, 2002.

authors have chosen to estimate the number of users and their monthly spending on public WLAN access required for the operator to recoup its investments. This approach makes it possible to assess the requirements for a profitable investment.

Capital and operational expenditure

The capital expenditure of public WLAN relates to access points, switches, converters, central systems, physical servers, installments, and connection of fibers. The calculation has been carried out based on an average cost per hotspot, which according to TeliaSonera is EUR 16,600 (between EUR13,300 and EUR 18,300 according to TDC). TeliaSonera claims to have invested around EUR 11 million in its public WLAN network, consisting of 700 hotspots [8].

According to this estimate, the typical operator will build up a network of 8,000 hotspots, which can be related to a deployment of an operator in a larger country (it can be compared with a provider such as Korea Telecom that has deployed 8,000 hotspots, or British Telecom, which is in the process of mass deployment).

Table 3: Assumptions of network deployment and cost

Assumptions	
Investment cost per site	€16,600
Number of sites	8,000

Although the investment cost for each spot is not huge, multiplied by hundreds of sites it can become a burden, especially for start-up hotspot aggregators (see figure 1).

As far as operational expenditure is concerned, it will be necessary to set up an organisation, backhaul transport rental, site rental, network maintenance and marketing efforts. These expenses will swallow most of the cash outflow after the network deployment (see figure 2). This expenditure is not in any way insignificant. For example, the backhaul transport, if connected to fiber, is rather expensive – as much as up to EUR 1800 per site and month (we have based our calculations on EUR 780 per site and month on average) and the rental of sites can cost approximately EUR 3300 per year (THOMSSON, 2002). (The above estimate is based upon a

8 The information in this paragraph is based upon: Ny Teknik, TeliaSonera tvärbromsar, April 3rd, 2003.

hypothetical negotiated settlement between a local fiber owner and a WLAN operator. Even if the WLAN operator should own a fiber network, we include the rental because it represents the opportunity cost.) For the work force, one person per 50 sites can be expected. The marketing costs account for quite a small part of total costs, given that the operator is an established telecommunications provider.

Figure 1: Cost of network investment (in millions of EUR)

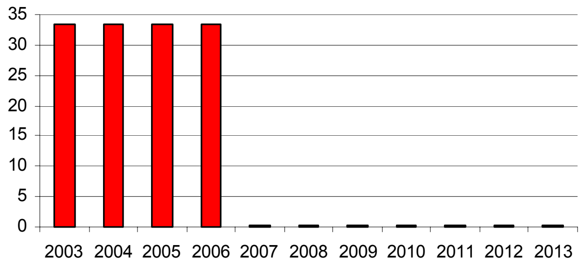
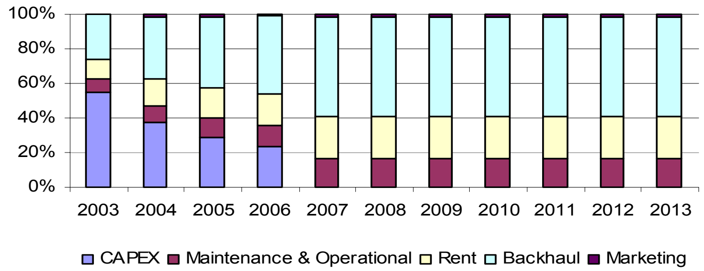


Figure 2: Cash outflow components

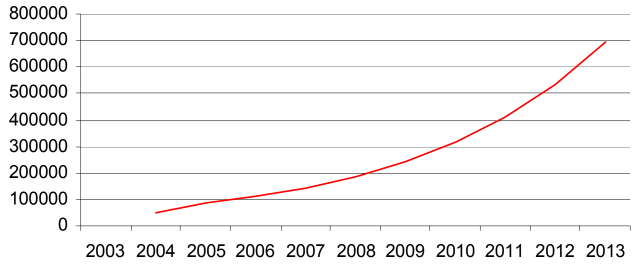


Requirement for a positive NPV

To get a positive NPV, the operator has to attract at least the number of users presented in figure 3 in combination with a flat ARPU of EUR 46 for the whole time horizon.

Both the number of users and what they have to spend on public WLAN access have to be quite high. Even in this, from the authors' perspective, quite optimistic scenario, operators should only break-even after seven years (2009). However, since the rental of the backhaul network accounts for a major part of the cash outflow, operators owning a backhaul network will require fewer customers than stated above to be able to make the stand-alone business case of public WLAN profitable, as the rental charge for the backhaul network used here is likely to be higher than actual costs.

Figure 3: Required number of users for positive NPV



Business model for public WLAN

Although the investments associated with public WLAN are relatively low, business cases are not only about cash outflow. To get leverage on the investments there must also be customer value and a market for the product. What every manager has to ask in every business is (SJÖLANDER & MAGNUSSON, 2002):

- Who is the customer?
- What does the customer value?
- How do we make money in this business?
- What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?

While the answer to the first question is defined (business users), the questions about customer value, how to deliver value at an appropriate cost, and how companies can make money out of the business, are not very well understood. It is difficult to see how everyone can expect to make money out of public WLAN. The key issue is a lack of qualified users. Players are currently having trouble attracting customers in volume, which is what the telecommunications industry is all about. This also explains why no providers are making money today and why several providers have gone bankrupt. MobileOne had plans to complement its 3G network with public

WLAN, but abandoned this idea after a four-month trial, because the coverage did not meet customer needs [9]. As a natural result of the current situation – a wide range of companies seeking profits in an uncertain market – the industry is likely to see consolidation (this is one of the implications of the product life-cycle literature; see, for example, ABERNATHY & UTTERBACK, 1978).

Although TeliaSonera was the first player in the European market to embrace public WLAN, the company is conservative regarding further network deployment. According to the company, it will be increasingly necessary to get more customers before further deployment can take place. Although TeliaSonera sees the user needs for public WLAN, its competitors in Sweden, Tele2 and Vodafone, are of the opposite opinion, which shows the ambiguity of market players. According to Vodafone's former CEO in Sweden, Jon Risfelt, only a very small group of its customers wants the service – "a bunch of technological freaks" [10]. The Vodafone Group, which is the largest player in Europe and the second largest in the world, has decided not to build its own public WLAN network. This is because the company does not see any profitability for the business. Moreover, the Danish mobile operator TDC, which has deployed public WLAN, admits that it will take a long time to recoup the investment, if it ever does. Neither can TeliaSonera specify when the company will recoup its investment. Despite all the hype surrounding public WLAN, the market does not appear to be that large. TeliaSonera has less than 10,000 customers in Sweden and thus remains a long way off the number of users necessary to recoup the investment (compare this to its 3.5-million-wide area network customers).

Even if the public WLAN market is in its infancy, with its progress to-date restricted by barriers (technological and user) and commercial uncertainty, there are inherent limits to the technology's success in the marketplace (from a profitability perspective). There are currently problems with the security and the hand-over function. Although solutions to these problems are expected to be found– and user barriers expected to decrease –questions remain regarding its usability, what the technology addresses and the market structure. Firstly, the technology only addresses a really small market with a relatively unknown demand pattern. The target segment consists of travelling business users. Hotspots are located at places where business

[9] CDMA Development Group, CDMA2000 & Wi-Fi: Making a business case for interoperability, 2003.

[10] The information in the rest of this paragraph is largely based on: Ny Teknik, TeliaSonera tvärbromsar, April 3rd, 2003.

people can find a need for the service, such as airports, train stations and hotels. Is this market big enough to recoup the investments? Is it certain that public WLAN is more attractive than 3G in these locations? If public WLAN is not better than other enabling technologies, the target segment is unlikely to adopt the service.

Secondly, the public WLAN market is very fragmented. There are many players that compete for the profits: service providers, site owners and network owners. Certainly, each player will attempt to secure as much value as possible. To find a business model that will allow all these players to make money out of public WLAN may be difficult. Moreover, since the technology is restricted to certain locations where the value of public WLAN is considered to be high for consumers, different operators will compete for the same spots, meaning that at some locations only one operator can install a hotspot, or that several operators will place hotspots at the same location.

Thirdly, the usability of the technology is restricted. Users of public WLAN do not know whether they will find a hotspot or not. While 2.5G and 3G enable the users to carry a phone 'just in case they need it', laptops are not carried unless the users have a definite need to use them. Users must find it worthwhile to spend some time accessing the services; they have to find a place to sit down, start their computer and perhaps install software to access the network.

Public WLAN as a new niche with strategic value

If a product is a perfect substitute for another product, the new product will exclude the original product. For this to be the case, however, the products need to have the same functionality and attract customers with the same preferences (e.g. SAVIOTTI, 2001). The question is how public WLAN could replace a wide-area technology such as 3G. What distinguishes public WLAN from wide-area networks is that the technology currently only covers spots of 50 meters in radius. Therefore, the technology is more about portability than mobility. This implies that the user experiences it quite differently from technologies such as 3G. The public WLAN user is someone with a laptop or a PDA, who has time to sit down, log on to the network, check e-mail and surf the internet. As far as mobile telephony users are concerned, they are typically accustomed to getting information quickly on the move, and without necessarily intending to sit down while looking for specific information. At the same time, public WLAN is currently aimed at one segment –business users. This segment accounts for only a small part of the total number of mobile data users.

NTT DoCoMo launched its mZone hotspot service in 2003. At the same time, its FOMA (3G) service will cover the larger part of Japan. The company provides public WLAN services for USD 16 a month for unlimited usage, which is far below most other operators' prices. Why does a company provide public WLAN for this price if the technologies are substitutes? NTT DoCoMo's CEO, Keji Tachikawa, argues that, 'If we combine all these services, users will be able to communicate anytime without choosing a certain network. WLAN is a niche, with limited range and best used indoors. So what if it is cheaper and faster than 3G? We can turn that to our advantage. Although embracing WLAN, we are not downgrading 3G, which is essential for wide-area coverage on the move' [11]. Another company that cannot see public WLAN as a substitute for wide-area networks is AT&T. The company might offer public WLAN services for free as a bonus to its GPRS and 3G users [12].

What, then, is the value of public WLAN? Public WLAN might be of high strategic value and an important source of competitive differentiation for 2G/3G operators, more than a direct threat in terms of revenue loss. It is in this respect that public WLAN may be viable for mobile operators, but only in the sense that it might help the entire business as a value-added service. Operators can become a single source of access, regardless of technology. This is how TeliaSonera and NTT DoCoMo see their public WLAN entry, and hence not as a separate business. For the customers, integration between different networks might add significant value. Mobile operators could integrate service packages for their customers that include voice and mobile data, regardless of network and with unified billing. This is a way to reduce churn and protect existing businesses. The point is that if the mobile operators do nothing, their core business might be vulnerable to outside attacks from companies that can offer complements, and thus more value to their customers. Thus, even if the direct revenue impact of public WLAN may be low, it has important implications for subscriber retention.

For a fixed-line operator such as British Telecom, public WLAN networks are a way into the mobile market. The wireless networks are a competitive threat for fixed-line operators without a wireless network. It was estimated

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[11] Mobile Communications International, Friend or foe?, Issue 97, 2003.

[12] Evolution, Will mobile move into the hotspots?, April 1, 2002.

that the number of wireless subscribers would exceed fixed line subscribers for the first time in 2003. Furthermore, nearly half of its revenues came from wireless networks in 2003, and since 1997 the revenues from each line have fallen by one-third [13]. Indications from Japan are that the number of fixed-line subscribers is decreasing. In Finland it was estimated that 25 percent [14] of the households did not have fixed-line access. However, although public WLAN may be a niche, it may not be much of a lifeboat for fixed-line operators.

Future opportunities for WLAN and possible distruptive technologies

In spite of this scepticism regarding the profitability of public WLAN, some important considerations have to be raised. With IP running over WLAN it may be possible to provide voice over IP, but there is still great uncertainty as to how voice over IP would be implemented (LEHR & McKNIGHT, 2002). However, if this were to prove possible, the market for public WLAN should open up new opportunities.

In addition, although the viability of stand-alone public WLAN appears to be low, if made compatible with wide-area technologies, the business case might be more promising. If, for instance, terminals could roam seamlessly between cellular networks and WLAN, with preferred access to WLAN when within coverage, then there is clear possibility that much of the traffic that otherwise would have been generated by cellular networks may be generated by WLAN hotspots instead. The consequence would then quite naturally be higher revenues for public WLAN and lower revenues for 3G. Such gate-way interoperability solutions may therefore threaten the business case for 3G and provide an opportunity for WLAN, thus disrupting the current state-of-affairs.

Although WLAN might not change much of the structure in the telecommunications industry due to its restricted coverage range, it might just be the first step towards an emerging technology that could reshape the telecommunications industry. A new technology is expected to enter the telecommunications market within the next couple of years that has a range up to 30 miles, namely WiMax. With its low production cost, attractive bit-rate capacity and high coverage range, the technology might be an

[13] *Business Week*, The wireless challenge, October 20, 2003.

[14] *Business Week* (2003), The wireless challenge, October 20, 2003.

alternative to more traditional cellular technologies. The technologies, emerging from the computer industry, and particularly WLAN, may look inferior at present, generating low profits for service providers, attracting a small market with limited coverage, as well as offering poorer product performance and can be seen as an underperformer in the telecommunications industry. However, future developments like WiMax may change the mainstream technology in the telecommunications industry (in the spirit of CHRISTENSEN, 1997) , shaking-up the dynamics in the telecommunications industry considerably.

■ The business case for the linear 4G vision

Next we will assess the business economics of 4G networks that are expected to sequentially follow 3G and to emerge in the 2010-2015 time period as an ultra-high-speed broadband wireless network. In its essence, the vision is about a future kind of network that will be deployed several years after 3G has been commercialized and provide very high data rates, exceeding 100 Mb/s. Moreover, these 4G networks are assumed to operate seamlessly and interconnect with other mobile networks. Generally, the 4G networks are assumed to have a cellular structure, building on the fundamental architecture of previous mobile generations.

We look below at the prospects of such a 4G investment for a large European operator, assuming that the growth of 4G will take place in the 2010-2015 time frame. The method of appraising the business case builds upon a model developed in an earlier study by BJÖRKDAHL & BOHLIN (2003). As in the earlier study, Vodafone in the UK country market is the reference case. As for the public WLAN business case, the focus is on estimating the required revenues for a profitable business case for 4G. The calculation is a stand-alone business case for 4G. It is assumed that the license duration is 20 years and that the license is distributed the year before the initial investment. No license fee is assumed.

Capital and operational expenditure

In terms of investment in 4G, a typical industry assessment has been that operators will have to make an aggregate investment in equipment similar to that required for 3G [15]. High bit-rate results in small cells, i.e. each base-station will cover a smaller surface area, and thus require more base-stations. To cover the same surface area as a technology with larger cells (e.g. 3G), it will consequently require more base-stations (here, a reservation for new solutions for antennas, etc. has to be made). Otherwise, the signal strength has to increase, which requires more current and results in difficulties with terminals.

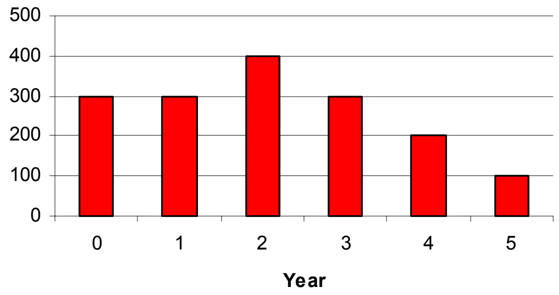
To be able to cover the same surface area, one can therefore expect that the operators will have to invest more in 4G than in their 3G networks, unless there is a dramatic decrease in the cost of 3G equipment. Each step in technology and towards higher bit-rates will require smaller cells, leading to de-facto hotspots of WLAN type. Somewhere along the line it will not be feasible to aim for nation-wide coverage. This is more evident for some countries, which have relatively small populations. Given that a country like Sweden has both a large surface area and is sparsely populated in comparison to many other European countries, it will always be more expensive for network operators to cover the larger part of such a country.

For future telecommunications systems, it is questionable whether covering large parts of the country is feasible (for 3G network the Swedish operators have to cover around 99 percent of the population). To avoid complex estimates of coverage ratios, the 4G estimates below assume the same aggregate cost of investment as in the 3G case in BJÖRKDAHL & BOHLIN (2003) (see figure 4) without a future possible license fee. This estimate can be viewed as the lower end of the investment range required for a nation-wide 4G network.

As for operational expenditure, the estimate only includes expenses that are additional to existing costs. Thus, only the incremental costs associated with providing 4G services are taken into consideration. This should give us a better understanding of how high additional revenues must be in order to recoup the investment.

[15] *Nätverk & Kommunikation*, Issue 13, 2001.

Figure 4: Investment in 4G for UK reference operator (£m)



Requirement to recoup investment

Given that the network coverage of 4G is likely to be restricted, its penetration level will not be as high as for former telecommunications networks (see figure 5). However, it is worth noting that this penetration is highly dependent on the time of deployment. To be able to achieve this penetration probably means that adoption rates of 3G will have to be high before an eventual deployment of 4G. If 4G is launched when 3G adoption rates are low it will probably be slow to penetrate the market.

Figure 5: 4G penetration

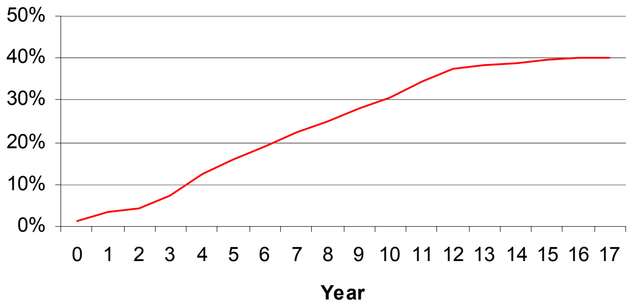
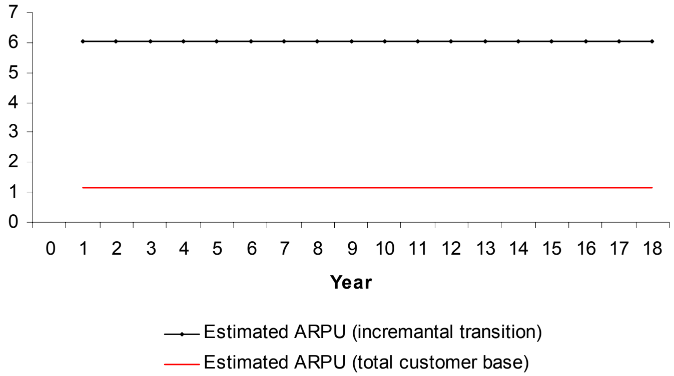


Figure 6 provides an estimate of the additional revenue per user needed to achieve break-even with an NPV estimate for a typical large-scale UK network provider (the Vodafone example). Given that only the estmate only includes the additional costs of 4G and that the only difference between 3G and 4G is that the latter will enable a higher bit-rate, it is worth emphasizing that the required revenues from 4G presented in figure 6 are revenues recognized as applicable to services that will require this high-bit rate. Figure 6 thus presents only the additional minimum required ARPU deriving from additional consumer demand for these high-bit services.

Figure 6: Required average revenue per user (£ per month)



According to the bottom estimate in figure 6 each customer has to contribute at least GBP 1.1 per month for an operator to recoup its investments, provided the whole customer base is included in the estimate. (In an earlier estimate reported in BOHLIN & BJÖRKDAHL, 2003, the required additional contribution for 3G to be profitable during the license period was estimated to be GBP 8.2 in the case of Vodafone in the UK market. The difference depends heavily on the 3G license fee.) In the top estimate in figure 6 with a gradual transition of the customer base to 4G (compare with figure 5), customers have to contribute GBP 6.0 per month.

However, there are other considerations to be taken into account. Depending on when (or whether) the investment takes place, it will affect the business cases for 3G and 4G differently. Early deployment of 4G lowers an operator's chances of recouping its investment in 3G. However, if 3G has not taken off, it is unlikely that 4G will take off since the technologies can be considered as substitutes. Alternatively, 4G may take customers from 3G. Acting as substitutes, the technologies and the investments may therefore interfere with each other. In any case, the profitability of the business cases for 3G and 4G will be determined by the time of deployment and the adoption of each technology.

Compared with the 3G investment, investment in 4G and required customer spending will be much lower. However, this is based on the assumptions that no license fees are charged and that the operator does not have to provide nationwide coverage. There is consequently a downside risk in this estimate.

■ Who will finance 4G investment?

A central question for future telecommunications system investment, and eventual license fees, is how these future investments will be financed. What have the players learnt from the dark period four years ago that is still affecting many European operators? Will the operators be backed up in the same way as they were during the period with acquisitions and investments in 3G licenses? Hopefully regulatory authorities, the capital market, vendors, and operators have learnt a few lessons from their past experiences. What can be said is that the industry is highly unlikely to take the same road it did some years ago. One argument supporting this statement is that the industry would run into financial difficulties.

The telecommunications sector became an under-performer post 2000 due to excessive debt, equity overhang and major disappointments in the sector. The downturn wiped out EUR 1.8 trillion in capital-market value [16]. Although many players are beginning to see some positive signals, they will certainly attempt to avoid a similar situation in the future. The debt burden for many operators has been heavy. As a result, major credit agencies downgraded their ratings for most telecom operators.

The fallout in the telecommunications sector can be traced back to "irrational exuberance" in capital supply at the end of the '90s and the beginning of the new century. Optimism ruled in the industry and operators, particularly in Europe, strove to obtain 3G licenses almost regardless of price. Operators that had almost no debt in 1998 increased their debt burden heavily (see figure 7). It was not until 2001 that restructuring efforts were seen in the sector. Debt trduction has since played a large part in the financial strategy of many players.

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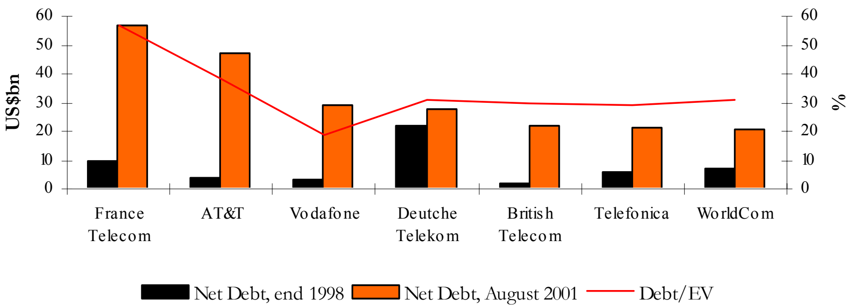
16 *Business Week*, For Telecom, Wireless Signals Hope, October 13th, 2003.

Figure 7: Total debts forselected operators an the end of 1998 versus August 2001, and debt per EV



Source: Bank of America

In 2003, most European investment-grade mobile operators put in strong operating performances, inducing improvements in credit ratings [17]. However, operators continue to focus on debt reduction, with cash flow being used for debt repayments. Even four years after many of the auctions, only a small number of 3G deployments have actually taken place. This means that the upside of the credit ratings is still limited by 3G concerns. It does not seem likely that players in the telecommunications industry will behave in the same manner they did in the context of 3G, nor that 4G will be given the ready supply of financing enjoyed by 3G.

■ Conclusions

New emerging technologies are making their way into the telecommunications market, creating a situation of increasing technological diversity. The main objective of this paper has been to analyse the financial implications of the two 4G visions that have been presented respectively.

Public WLAN is at the core of the *immediate* 4G vision. Telecommunications players have differing views on the technology's future impact on the industry. The paper shows that the stand-alone case for public WLAN is unlikely to prove a sustainable business model in the short term, in spite of free spectrum and relatively low investment costs compared to 3G.

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17 Standard & Poor's, Industry report card released on European investment-grade telecommunications, October 21st, 2003.

However, even if public WLAN fails to show profitability as a stand-alone business case, and if the technology cannot be seen as a substitute to 3G but rather as a niche, it may prove to be of high strategic value and an important source of competitive differentiation for 2G/3G operators. Despite the fact that WLAN is inferior to mainstream telecommunications technologies, WLAN is probably just the first step in an emerging technological trajectory from the computer industry that is entering the telecommunications industry. The development of further technologies that will enter the telecommunications industry such as WiMax may eventually reshape the structure of the telecommunications industry and its dynamics. In addition, although the viability of stand-alone public WLAN appears dubious, if made compatible with wide-area technologies such as 3G, the business case might be more promising, since WLAN may then increasingly substitute 3G. Finally, if IP-telephony over WLAN becomes feasible; it could further increase the attractiveness of WLAN technologies.

As far as the business case for *linear* 4G is concerned, the paper estimates the required revenues for a profitable investment for an operator such as Vodafone in the UK. This assessment builds upon a model developed for 3G by BJÖRKDAHL & BOHLIN (2003), which showed that operators may not recoup their 3G investments. The assumptions in the refined model presented here include a cost of equipment investment equal to that necessary for 3G, but representing a smaller area coverage than that for 3G, due to the fact that 4G each base-station is likely to cover a smaller surface area. The results show that these additional payments may be significant.

In studying the business case for 4G, it is also pertinent to ask how the future investment will be financed? Considering the fallout in the telecommunications sector due to excessive operator debt and major disappointments in terms of market growth, as well as the extreme cases of vendor financing, it will most likely be more difficult to secure financing for a fresh round of investment in a future generation of mobile communications systems, in spite of heavy investments in networks and license fees. Given the authors' belief that several 3G operators will not recoup their investments, operators are unlikely to invest in 4G by 2011, the predicted date of 4G introduction by several equipment vendors. Instead, this investment lies much farther in the future for most operators. However, before more accurate predictions of operator investments in 4G can be made, 3G adoption will have to take off. Moreover, it does not seem likely that a very high-speed mobile data network will gain user acceptance unless successful mobile data applications have been developed and commercialized with 3G.

As a general conclusion, European operators and interest groups are well served to focus on making the 3G networks a success. This paper advocates building upon 3G networks in an evolutionary manner, rather than aiming for a quick transition to 4G based on WLAN standards and warns operators of making large-scale commitments to long-term 4G networks of the linear type described above. However, WLAN may serve as a strategic complement to both fixed and mobile operators. This paper takes a cautious approach to a full-blown public WLAN network, but incremental and complementary investments of a smaller scale have an entirely different risk profile. Finally, we note that WLAN may be a pre-cursor of things to come. New technologies such as WiMax may develop technological performances and cost conditions that would give rise to far more disruptive dynamics in the telecommunications industry.

References

ABERNATHY W. & UTTERBACK J. (1978): "Patterns of industrial innovation", in *Technology Review*, 80(7), pp. 78-89.

BJÖRKDAHL J. & BOHLIN E.:

- (2002): "Financial analysis of the Swedish 3G licensees", in *info*, 4, pp. 10-16.

- (2003): "Competition policy and scenarios for European 3G markets", in *COMMUNICATIONS & STRATEGIES*, 51, pp. 21-34.

BOHLIN E., BJÖRKDAHL J., LINDMARK S., DUNNEWIJK T., HMIMDA N., HULTÉN S. & TANG P. (J.C. BURGELMAN & G. CARAT, eds.) (2003a): *Prospects for the Third Generation Mobile Systems*, IPTS Technical Report prepared for the European Commission – Joint Research Center, 2003, EUR 20772 EN (available on-line on www.jrc.es).

BOHLIN E., BALLON P., BJÖRKDAHL J., LINDMARK S., WEBER A. & WINGERT B. (2003b): *The future of mobile technologies in EU: assessing 4G developments*. ESTO 4G project final report submitted to DG JRC/IPTS, European Commission, November 2003, forthcoming as IPTS Technical Report prepared for the European Commission – Joint Research Center (cf. www.jrc.es).

BOHLIN E., BALLON P., BJÖRKDAHL J., BURGELMAN J-C., LINDMARK S., RODRIGUEZ CASAL C., WEBER A. & WINGERT B. (2004): "UMTS integration and framework program priorities", Paper submitted to the IST Mobile and Wireless Communications Summit 2004.

CHRISTENSEN C. (1997): *The innovator's dilemma: When new technologies cause great firms to fail*, Boston, Massachusetts: Harvard Business School Press.

FRANSMAN M. (2003): "Knowledge and industry evolution: The mobile communications industry evolved largely by getting things wrong", paper presented at the DRUID summer conference, 2003.

LINDMARK S. & BOHLIN E. (2003): "The i-mode Success Story – Towards a System Explanation", in *COMMUNICATIONS & STRATEGIES*, 52, pp. 193-213.

LEHR W. & MCKNIGHT L. (2002): "Wireless Internet access: 3G vs. WiFi?". Paper prepared for ITS Regional European Conference, Madrid, September 2002.

RODRIGUEZ CASAL C., BURGELMAN J-C. & BOHLIN E. (2004): "Prospects beyond 3G", paper submitted to the IST Mobile and Wireless Communications Summit 2004.

SAVIOTTI P. (2001): "Variety, growth and demand", in *Journal of Evolutionary Economics,* 11, pp. 119-142.

SJÖLANDER S. & MAGNUSSON M. (2002): "Entrepreneurial discovery, resource transformation and the growth of the firm", Working paper.

THOMSSON K. (2002): *Large scale deployment of public wireless LANs*, Master thesis, Royal Institute of Technology, Stockholm.

WEBER A., BOHLIN E., LINDMARK S. & WINGERT, B. (2004): "4G-developments and European policy", paper submitted to the IST Mobile and Wireless Communications Summit 2004.