Scenarios and business models for 4G in Europe

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Abstract

This paper investigates the main trends and uncertainties that will define fourth generation mobile systems and services (4G) in Europe. It outlines two divergent visions on 4G: the so-called "immediate" 4G vision, consisting of wireless local area networks (WLANs) combined with other wireless access technologies, competing with 3G in the short term, and the so-called "linear" 4G vision, in which the 3G standard is not replaced until the end of its life cycle by an ultra-high speed broadband wireless network. Which of these visions will materialise, and what this means for the competitiveness of the main 4G stakeholders in Europe, will be to a large extent determined by which business models are feasible for 4G.

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In this paper, a business model is defined (following Hawkins (2003)) as a description of how a company or a set of companies intend to create and capture value with a product or service by linking new technological environments to business strategies.

Some of the main uncertainties related to 4G in Europe concern potentially viable business models which exist for both the "immediate" and the "linear" 4G vision, which stakeholders may be expected to play a dominant role in these models, and the timeframe of 4G developments. This paper addresses these uncertainties in three stages:

(1) The first stage is to analyse current and emerging third generation (3G) and wireless local area network (WLAN) offerings in Europe in terms of the main actors and markets concerned, the service portfolio, the business roles involved and the resulting business models. This results in a set of scenarios outlining the potential influence of WLAN on 3G, and how this relates to the "immediate" 4G vision.

(2) The second stage is to present an overview of different and competing long-term visions and strategies regarding 4G of the main stakeholders in Europe and other regions. This results in a set of scenarios for the "linear" 4G vision.

(3) The third stage is to assess the relative position of Europe with respect to the USA and Asia for both the "immediate" and "linear" scenarios.

1. Current and emerging business models for mobile services

1.1. 3G mobile networks

Based on the successful, Europe-led, standardisation cycle of GSM, the

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telecommunications world has taken to planning an interval of approximately ten years between each new generation of mobile systems. Following this timeframe, universal mobile telecommunication systems (UMTS) systems and services were supposed to come on the market by 2002/2003. They were supposed to mark the transition from the voice-centric 2G to the data-centric 3G world. Meanwhile, GPRS, as an upgrade from GSM, and subsequently labelled 2.5G, offered the first real market experience with mobile data services, at least in Europe. However, the "mobile internet" concept based on the wireless application protocol (WAP) largely failed. In contrast, the messaging service SMS proved to be a success. Following the success of i-mode services in Japan, a new generation of mobile data services in Europe (exemplified by the i-mode and Vodafone Live services) does appear to be able to raise ARPU, but only to a limited extent. In any case, growing doubts over the market potential of mobile data and mobile multimedia have depressed the expectations for 3G.

Major problems associated with 3G in Europe are (see, e.g. Wallage, 2003):

- Deployment is stalling because of the changed investment climate due to high license costs and high infrastructure costs.
- 2.5G seems to be adequate for mobile services at the moment. There are still doubts if there is a mass market for mobile multimedia.
- Latency is too high for voice over IP; data speeds are, at least initially, less than predicted.
- Vendors still struggle with basic problems such as interoperability, availability of devices, network performance and reliability.
- Battery life of terminals is a bottleneck.

As a result of these problems, a number of major European mobile operators have already written off the cost of their 3G licenses. The massive roll-out of 3G has been delayed, and the linear, phased approach to new mobile generations seems to be under pressure. However, for the time being, 3G deployment is still announced to go forward, even though launch dates have been pushed back considerably. The following paragraphs assess the influence of current developments on potential business models for 3G in Europe.

Actors and markets

In Europe, 2.5G systems and services are widely in operation. Meanwhile, Japan has taken the lead world wide in the introduction of 3G. NTT DoCoMo introduced commercial 3G services in Japan in October 2001 and had over 1 million subscribers by October 2003. The second operator to employ 3G services based on the WCDMA standard (i.e. part of the GSM-family) in Japan (December 2002) was J-Phone (owned by the Vodafone Group), which claimed 65,800 subscribers by July 2003. Also, South Korean SK Telekom and Japanese KDDI have started offering 2.5G/3G services based on standards belonging to the competing CDMA family.

The first introduction of 3G in Europe was in Italy. Hong Kong-based company Hutchison Whampoa first introduced 3G services through its subsidiary "3" in Italy and the UK. By March 2003, the company reported 50,000 subscribers in Italy and 10,000 subscribers in the UK. By June 2003, the company had approximately 520,000 3G subscribers world wide (i.e. in Italy, Austria, Sweden, UK and Australia). At the end of August 2003, the number of subscribers had risen to 155,000 in the UK, and 300,000 in Italy. In February 2004, Vodafone launched a limited 3G data service in Germany, The Netherlands, Sweden and the UK. Meanwhile, Telefonica, Telestet and T-Mobile have also launched 3G services in Spain, Greece and Austria respectively. The geographical coverage of the 3G service offerings is still often quite restricted.

A number of other European mobile operators have announced the launch of 3G before the end of 2004. These include T-Mobile UK and T-Mobile Germany, TIM, TeliaSonera Finland and TeliaSonera Sweden, O2 Germany and O2 UK, E-Plus, Orange France and KPN Mobile. However, it is still uncertain what date these companies are aiming for exactly, and to which extent services and networks will be available.

Services

In Japan, multimedia services offered with 3G technology were already accessible in 2G on handsets equipped with large colour screens and built-in digital cameras that can take photographs or videos (notably with the sha-mail and movie-mail services). Mobile subscribers there can download screensavers and polyphonic ringtones. DoCoMo's FOMA services do not presently provide additional generic innovations besides bitrates and video telephony. It appears that the dissemination and adoption of these services has been gradual, and not marked a break with existing services.

In the European Union (EU), the situation has been somewhat different (see also Manero, 2003). 3G services were introduced in the UK and Italy as bundles of a wide range of services, with considerable emphasis on video. Because of disappointing take-up, the operator cut its rates considerably, particularly for voice calls, and was then accused by its rivals of having instigated an aggressive price war. This latter strategy is in line with the argument (see, e.g. Odlyzko, 2001) that the investments being made in 3G may not be

necessary, as 2.5G would have been sufficient to relieve network congestion, but that, once made, they will provide much greater voice capacity and thus an incentive to charge substantially lower rates for voice calls. As the intensity of usage of mobile phones is still way below the intensity of fixed phone usage, there seems to be ample room for stimulating a quantum change in customer behaviour.

Other features beside video clips, video messaging and cheap voice calls, which have been emphasised as part of the 3G service portfolio are information services, gaming, and the simultaneous use of voice and data. Also, a number of applications tailored specifically to the business market are envisaged, such as high speed access to company networks (e.g. intranet, sales and service information). For instance, the recent Vodafone 3G launches are targeted at corporate users, offering 3G data cards for laptop PC users. In general, however, such applications are emphasised less, because of the higher requirements posed by the corporate market, and the identification, since a few years, of the youth market as the main driver of innovation in the mobile market.

Of course, the above observations are only based on a limited amount of evidence as they currently reflect only a few operators' strategies. However, they already provide a number of indications as to the nature of 3G business models and service offerings that may be expected. Next to video applications as an attractive novelty, 3G will likely be just as much about relieving congestion, so as to be able to support and/or combine better existing applications and services, and offer cheap mobile voice calls.

In terms of the value proposition, a divergence is apparent between positioning 3G as a complement, or rather as a substitute for 2.5G. The demand for mobile broadband services seems to be one of the main factors influencing the eventual outcome of these divergent strategies. If a strong uptake of mobile broadband services (such as video services) is expected or experienced, 3G will be more likely to be positioned as complementary to 2.5G. If this uptake is not expected or perceived to be strong, 3G will be more likely to be positioned as a substitute of 2.5G, e.g. offering cheaper voice calls.

Roles

As the success of Japanese i-mode services has been attributed largely to i-mode's supposedly superior business model, the particularities of this model and the roles constituting the i-mode value network have been well documented (see, e.g. Bohlin *et al.*, 2003). However, as far as the whole field of mobile services is concerned, a systematic taxonomy and comparison of mobile business models on the value network level is still lacking. This constitutes an important challenge for any research into current and future wireless business models.

The most striking difference between the 2.5G/3G value network and the traditional mobile value chain is that the latter is characterised by linear sequential dependencies, while the former is organised in the form of parallel, but interlinked, tracks of different chains and systems. The Yankee Group (2000) describes a mobile value network existing of five major value chains. They refer to:

(1) *Network transport*. Network operators have traditionally integrated the whole network operating value chain, consisting of spectrum brokerage, mobile network transport, and mobile service provisioning. They are often labelled as gatekeepers, both in terms of customer ownership and in terms of ownership of limited resources such as spectrum and operating licenses. With the subdivision of telecom groups into fixed and wireless operators, and the advent of so-called mobile virtual network operators (MVNOs), some fragmentation of this value chain can be expected.

(2) *Applications operation*. The application environment includes application developers, systems integrators, and applications operators. Companies that bundle these activities are also labelled wireless application service providers (WASPs). WASPs may develop and host applications for end-users, but they may also concentrate on providing solutions for mobile network operators. This means that there are strong links with middleware/platform providers (see below).

(3) *Content provisioning*. This value chain consists of content providers, content aggregators and portals. Portals also serve as wireless internet service providers (WISPs), as they become the gateway to internet content.

(4) *Payment processing*. Traditionally, network operators have had the only billing relationship with the client. With the possible advent of mobile commerce, requiring a number of mobile financial services, other parties, such as banks, specialised billing companies, and mobile commerce platform vendors, have opportunities to get involved in this activity.

(5) *Providing device solutions*. Handset vendors are a well-established part of the mobile value system. As they provide hardware as well as software solutions, they not only have access to the user because of the direct buying relationship, but they can also preset the operating and browser systems running on the handsets to their own advantage.

In addition, there are two "enabling" value chains involved:

(1) *Network equipment provisioning*. Companies providing network equipment are, e.g. Ericsson, Nokia, Motorola, Alcatel, Nortel. Traditionally, infrastructure vendors provided a relatively standardised product. However, this is changing as new applications and middleware (see (2) below) are being developed by these companies.

(2) *Middleware/platform provisioning*. This is becoming an ever more important part of the wireless value system. Examples are WAP gateways, SMS gateways, mobile portal platforms, mobile commerce platforms, and other applications platforms.

A lot of speculation has been put forward about the precise configuration of these interdependent chains in the 3G wireless value network. In general, it can be argued that business models for mobile services have traditionally been characterised by an important dependency on the underlying technological infrastructure, resulting in a rather closed model with a central "gatekeeping" role for the mobile network operator. Recent research (Ballon *et al.*, 2002; Fransman, 2002; Wehn de Montalvo *et al.*, 2002) shows that this constellation is, in general terms, still valid with the advent of new services over 2.5G/3G systems, although there are a number of profound underlying changes which are becoming visible:

- The increased centrality of handset and network vendors in the core value network, even more so as they are providing more and more of the platform and middleware functionality.
- The billing relationship with the customer is still largely held by the mobile operator, although it is no longer restricted to this role.
- There is no well-defined content provisioning model yet, with the i-mode model and the messaging model being the most successful ones at this stage.
- There is a large and growing gap between the high R&D expenditure of handset and network manufacturers and the continuously decreasing R&D expenditures of network operators.
- There is increased attention to the active role of users in the process of value creation.

Business models

The UMTS Forum (2002) has put forward three potential generic business models for 3G. These business models are differentiated according to which role acts as the main service provider (i.e. the point of enquiry for service requests and problems, typically also incorporating the billing and collections provider role) to the customer. These business models are labelled as follows:

- *Network operator centric service provider*. In this model, the customer has a direct relationship with the network operator. The network operator sets the prices of the services and handles the payments. Content is normally acquired wholesale from content providers or is "home-made" by the operator itself. The network operator effectively bundles the content aggregator role. Services are in many cases offered as bundled packages as part of subscriptions. Network operators will use this model to increase ARPU and to retain their customers.
- *Content aggregator/m-portal centric service provider*. This model is not limited to providing physical access to services through a mobile portal, but rather includes a range of value added services. Added value that might be offered on top of access and transport services could include authentication, security, simplicity and payment aggregation. In this model, the customer has an agreement with the content aggregator, but may still also have a relationship with the network operator. Content charges and access charges might thus be separated.
- *Content provider centric service provider*. This model is similar to the content aggregator model. The difference is that the content provider has a considerable portfolio of its own and wants to align itself with a network operator, and thus take up the content aggregator role. The customer may have a relationship with many content providers in this model. The diversity of service offerings is likely to be very high, while the number of transactions per buyer-seller combination is probably rather low.

The business model typology described by the UMTS Forum effectively points at the dilemma of so-called walled garden versus open models, which has occupied a central role in the debate over mobile internet business models since its very beginning. However, it can be argued that this typology is biased towards third party content services with the neglect of peer-to-peer services, and that it focuses too much on the operator-content provider dichotomy, thereby neglecting the increasingly decisive role of both handset vendors and platform providers, two "enabling" roles that, as was described above, have moved into the core of the mobile value network.

Therefore, this paper adopts another typology of potential 3G business models, which does take

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into account these decisive shifts. It distinguishes three typical "approaches" or models to new mobile services, service architectures, and network concepts, depending on the prominence of specific roles within the value network, functional characteristics, and dominant application types (apart from voice telephony). Adapting from Tee (2003), these may be labelled service-centric models, protocol-centric models and platform-centric models:

- *Service-centric models*. These models are driven by mobile operators, following the example of the Japanese i-mode service. The dominant, or at least most characteristic application type is third party content, provided by subsidiaries or partners of the mobile operator, or by independent content providers adapting their content to the operator's platform. In these models, the operator acts as a co-ordinator in terms of the standardisation of service design, protocols and billing models. The operator also plays a defining role in the branding of the service package. This goes contrary to the European tradition of vendors being able to innovate around a number of voice and open standard protocols, and to the tradition of branding of handsets, rather than of services, which has prevailed in the EU.

  Recently, the most notable examples of service-based models in the EU have been i-mode (Telefonica, E-plus, KPN), Vodafone's Live services and T-zones (T-Mobile). Vendors have been clearly reticent to support these services, as can be shown from the initial refusal of Nokia to build handsets supporting i-mode. Vodafone, having a larger scale on the EU market, has found it easier to convince handset makers to support Vodafone Live specifications. This has in turn led T-Mobile, TIM and Telefonica to bundle a number of their handset activities as a way to increase their bargaining power *vis-à-vis* the vendors.
- *Protocol-centric models*. These models are driven by mobile phone manufacturers. They are based on more or less open protocols such as WAP, SMS and MMS, which are in principle agnostic of operators, but may differ slightly between handset vendors. The dominant application type in these models is messaging (SMS, MMS). Since Vodafone Live and increasingly also i-mode supports MMS, it may seem as if these models have converged. Still, MMS is partly complementary, but also partly in competition with the service-based models, as it may form in itself an alternative to many i-mode and Live functionality. It is publicised as a peer-to-peer medium rather than a content driven medium such as the service-based models. But of course it can be used for multimedia versions of today's SMS third party content services. It has no portal structure, so users must know the address of these third party content providers, as is the case with SMS third party content services. Finally, it is branded as a feature of phones, rather than of operator's networks. The Open Mobile Alliance (OMA), to which the crucial player Nokia has pledged its allegiance, is currently attempting to push forward MMS and to enlarge the scope of open standards such as MMS.
- *Platform-centric models*. These models are driven by platform providers such as Microsoft and the Symbian group. They are based on a new generation of mobile handsets that run on powerful operating systems which have the ability to provide strong links with the fixed internet, intranet and extranet. The most characteristic application types in these models are mobile office applications. The O2 XDA and the Orange SPV Smartphone, both running on Microsoft operating systems, have initiated this approach.

  As it risks reducing device manufacturers to the role of white branded hardware producers, selling an increasingly commoditised product, an alliance of mobile handset manufacturers has teamed up under the name of Symbian to counter this strategy. With the goal of creating a joint, open mobile platform, the Symbian alliance was set up and headed up by Nokia as early as 1998, when it became clear that Microsoft was increasingly targeting mobile devices with its OS Pocket PC. In 2002, the first open Symbian platform was released, which is the Series 60 developed by Nokia. This has been licensed to most major handset makers. Its link with the manufacturers also ensures that the Symbian software is compatible with telecommunications operators' back-end equipment. Also, the Symbian Series allows customisation so that each vendor's cell phone is unique. The use of wireless Java (J2ME) on top of the operating system creates the possibility to change the upper layers of the platform substantially.

  Still, Symbian is not undisputed because of its strong Nokia ties. For instance, Motorola has announced that it will equip 80 per cent of its handsets with the license-free Linux operating system. This is motivated by the expectation that as prices of colour screens go down, the operating system will account for a major portion of the cost of a phone. As of

late, the Symbian coalition seems to be crumbling further, as both Samsung and Motorola have announced the release of a Microsoft-powered phone by the end of 2003. Moreover, mobile operator Vodafone has announced that it will work closely with Microsoft in the area of its Office applications and mobile web services standards, but that it has no plans at present to use the MS wireless operating system.

While protocol-centric models dominate for the time being, the competition between these models is still open and is not expected to be settled within a short timeframe. In the short term, the protocol-centric, and to a lesser extent the service-centric models, are expected to remain the most important models for 3G on the European market. Recent market forecasts on smartphones suggest that platform-centric models are not expected to gain any significant market share in the short-to-medium term. This means that 3G innovation will most likely be driven by "traditional" mobile (cellular) players. The transition from 2G to 2.5G and to 3G will be marked by evolutionary change in business models, but also by potentially disruptive developments caused by technological, strategic and demand factors. The uptake of WLAN might be one of those disruptive phenomena.

1.2. WLAN

WLAN has emerged as a family of standards from the IT- and internet-community. Based on IEEE standards (i.e. IEEE 802.11), it operates in unlicensed spectrum. As Lehr and McKnight (2002) point out, while 3G offers a vertically-integrated, top-down, service-provider approach to delivering wireless internet access, WLAN offers, at least potentially, an end-user centric, decentralised approach to service provisioning. WLAN offers wireless access characterised by high data rates at low cost. This is possible because the infrastructure cost of WLAN is only a small percentage of the cost of 3G infrastructure. Also, it does not require a massive, centralised roll-out. As it is possible for anyone to set up a single WLAN "hotspot", WLAN can be rolled out much more gradually and/or by many more actors. All of these characteristics have led WLAN to become hyped as the "immediate 4G" option.

However, there are also a number of problems associated with WLAN. Major bottlenecks for WLAN business models are (see, for example, Liddel, 2003; Briere and Bacco, 2003; Pau and Oremus, 2003):

- *Security*. WEP encryption is generally used, but has been reported to be flawed. A lot of public attention has been dedicated to this aspect of WLANs. User authentication is a similar problem.
- *Backhaul*. One of the major flaws in the "independent" hotspot business model is that the hotspot operator must lease a terrestrial circuit from an incumbent network operator to provide connectivity between the hotspot and their network operations centre. The cost of these backhaul circuits (T-1 or even simply DSL connections) represents a fixed cost that significantly outweighs current hotspot revenues. In addition, as usage increases, hotspot operators are entirely reliant on the incumbent network operator to dimension these circuits in a timely and cost-effective manner. Solutions that combine the WLAN access point and a wireless backhaul solution in a single unit are not yet effectively realised.
- *Coverage*. Traditionally, to receive coverage from an 802.11b access point a user must be within 50 metres and often within line-of-sight. This means that users have to "schedule" their visit to a hotspot, which significantly lowers the utility of the WLAN service. Roaming across hotspots is also an issue.
- *Batteries and devices*. IP Talk (Mitsubishi) has announced a WLAN phone designed for hotspots which also offers web browsing and e-mail. Other producers such as Cisco, NEC and Samsung are also working on WLAN phones. However, as a recent Forrester study has pointed out, it is unlikely that mainstream mobile phones will be WLAN-enabled in the short to mid-term future. The huge demands of WLANs on battery power even render it practically unworkable to incorporate WLAN-capabilities into anything else but laptops, which constitute only a small part of all mobile devices. On top of this, there is uncertainty over the market demand for public WLAN access via laptops outside of a limited number of prime locations such as airports;
- *Different owners*. Besides the positive points of spreading risks and costs, this also creates problems of non-ubiquity, large administrative and transaction costs, and technological heterogeneity.
- *Potential congestion*. WLAN access points compete with each other for space within the 2.4Ghz range. On top of this, even a single WLAN access point may congest the connecting T-1 line if it is used intensively.

From this short overview it may already be concluded that WLAN presents both major advantages as well as disadvantages compared to 3G. The following paragraphs assess to which extent these technologies and the associated

business models will overlap and influence each other.

Actors and markets

WLAN has entered the EU market in the form of office and private home solutions and public hotspots. Hotspots are locations such as hotels, airports and restaurants where users may wirelessly connect to the internet, their e-mail account or their corporate network. This access can be offered either as a paid or as a free service.

Owing to the lack of transparency in this market, it is impossible to assess the precise development of WLAN hotspots world-wide (see also Stone, 2003). According to some sources, there were over 50.000 hotspots world-wide by July 2003. Other estimates are as low as 10.000 or 20.000. In any case, it can be said that the amount of hotspots is small, but growing quite rapidly. According to most analysts, there were little over 1.000 hotspots in Europe at the end of 2002. As of September 2003, this number has grown to an estimated number of just over 2.750 public hotspots in the EU, most of which are operated by Telia Homerun and Swisscom Europort. Another major player is BTOpenZone, which has announced the opening of about 1,700 hotspots within a short time frame. Estimations for the future vary considerably as well. Some market forecasts predict that Europe will have 32,500 hotspot locations by 2007. Other estimations claim that there will be up to 100,000 hotspots in Europe alone by 2005.

World-wide, a conservative estimate shows that in September 2003, the US counted over 4,500 hotspots, about half of which were provided by T-Mobile. In total, Asia counted over 11,000 hotspots, of which more than 50 per cent were located in South Korea. The major driver behind the WLAN "success story" in South Korea is fixed incumbent Korea Telecom, offering public WLAN access bundled with the popular ADSL subscription, requiring users to pay a relatively small amount (about €8) on top of the monthly subscription fee. Currently, it is reported that there are over 150,000 WLAN users in South Korea.

As far as other countries are concerned, however, the number of users and the profitability of WLAN is low (see, for example, Gneitig, 2003; Rafer, 2003). It has been estimated that between one and two percent of hotel clients use WLAN access when it is offered. The typical usage of a current commercial WLAN hotspot is between 0 and 1 users per day. Even at standard commercial rates for WLAN access of between €4 and €8 per hour, this does not cover the estimated daily operating expense (mainly associated with billing and support functions) of over €25 for a single commercial WLAN access point. Even free WLAN offerings attract only limited amounts of users. As an example, a recent experiment with free WLAN access in the Paris underground resulted in only 1,700 users in three months.

Public commercial hotspots in Europe are in general not very user friendly according to recent research. They are characterised by high tariffs, difficult registration and charging procedures, an unclear overview of operators, exclusivity deals between operators and locations, a lack of roaming agreements and so on. Comparisons indicate that prices for WLAN access in Europe are considerably higher than those in the USA or Asia. The companies initially driving the WLAN public hotspots offer in Europe were specialised WLAN operators and the associated WISPs. There are already some consolidation tendencies among specialised WLAN providers. One of the reasons seems to be the entry of fixed and mobile telecommunications operators in this market. For instance, in The Netherlands, the commercial WLAN access market is more or less split between national telecommuications incumbent KPN and Swiss telecom operator Swisscom, after the acquisitions, in 2003, of the formerly independent WLAN providers HubHop (by KPN), and Aervik and Megabeam (by Swisscom). Swisscom followed the same strategy to enter the German and UK markets, by acquiring, respectively, British Megabeam and German WLAN AG in March 2003.

Public free WLAN has a very limited scope in the EU. A small number of cities are said to have plans to offer public free WLAN access. The Freenet movement, consisting of individuals offering free WLAN access, is also limited in Europe. There are as yet very few so-called hospitality providers (i.e. hotels, cafés or camping sites) offering free WLAN access as part of their ordinary service offering.

Private WLAN solutions consist of an in-house or in-company solution, which is generally restricted to teleworkers or smaller companies. The typical service offering is wireless internet/intranet access. Hardware manufacturers and fixed operators and other DSL providers are driving this offering.

The WLAN options mentioned above are aimed at providing wireless services, but not mobile services. The type of access can be characterised as "nomadic" or "serially stationary" rather than mobile. The remaining option is to integrate WLAN into a 2.5G/3G network, or even to construct an entire "mobile" network using WLAN technology.

In order to use WLAN for broadband services that are really mobile, it appears that WLAN hotspots need to be integrated into a cellular network. However, such an integrated WLAN/

cellular network is only a feasible option if a number of major caching and synchronisation problems can be solved. Currently, no real integration (for instance in terms of roaming, or even billing) between WLAN and cellular networks has been realised (see also the next section on services). As a future option, however, this will be addressed in the section on future visions for 4G systems.

There are only very rare examples of cellular networks based solely on WLAN. In New Zealand, the company RoamAD has deployed a WLAN-only demonstration network, consisting of 47 access points and covering 3 square kilometres. It has announced a commercial 100 square kilometre roll-out soon. The University of Twente in The Netherlands operates a large hotspot network on its campus consisting of 650 access points. However, most observers agree that a complete WLAN "cellular" network offering mobile services is not commercially feasible. To connect WLAN hotspots owned by a single operator to form a cellular network is hardly feasible because of, for example, the huge number of access points required, synchronisation and interference problems, and high operating expenses. In addition, to connect WLAN hotspots owned by different owners creates high transaction and co-ordination costs, which would probably outweigh the cost of transmission-based solutions.

Some future visions point to so-called mesh networks (i.e. networks consisting of WLAN-access points or WLAN-enabled terminals working together in an *ad hoc* fashion) as an alternative means of creating entirely WLAN-based networks. In this vision, network components would be fully distributed and individually owned, interactions between the nodes being "regulated" by tacit or explicit conventions between all participants. However, the long-term commercial feasibility of such solutions is quite problematic, for example, because of the well-known "Tragedy of the Commons" problem affecting shared public resources. A potentially more viable version of this vision, involving the possibility for each user to become a commercial service and/or network provider, is still very futuristic. The section on future 4G visions will come back to this option.

Services

The previous paragraphs already outlined the main forms in which WLAN access is offered and how it may be used. Currently, WLANs are used by laptop or PC owners for either internet access in public spaces or as a substitute to fixed LANs. In addition, WLAN might operate as (part of) a mobile broadband network in the future.

At this moment, predominant WLAN services are internet access, intra-/extranet access, and to connect to other in-house devices. In addition, services (to be) offered are shared internet access, multiplayer gaming, voice telephony (VoIP), SMS and MMS-WLAN-services.

The growing interest of telecommunications operators in the provision of public WLAN access seems to indicate that some sort of convergence between public WLAN and telecommunications networks is on the agenda. More futuristic cases will be dealt with in the next section. On a short-to-medium-term timescale, two types of WLAN offerings by telecom operators are in place or emerging:

(1) Telecommunications operators, including mobile operators, that have taken over public WLANs from specialised WLAN operators, have in general "inherited" a strategy in which WLAN access is positioned as a specific service, separate from and parallel to 2.5G services, and in which the WLAN market is treated as a separate market from other wireless data markets. However, there are clear signs that this strategy is being modified. First of all, the previous situation in Europe, in which there were no roaming agreements among WLAN providers, is being turned around. A number of operators have already signed roaming agreements so that WLAN users may use one another's networks. EU market leaders Telia Homerun and Swisscom have been among them, announcing a European-wide roaming agreement in October 2003. Second, joint GPRS and WLAN mobile data service are being announced and/or launched by, for instance, T-Mobile, Vodafone and KPN. These services typically do not include roaming between the cellular network and the WLAN hotspot or integrated billing yet, but such a convergence is clearly intended (Boogert, 2003; Kewney, 2003a). While remaining open to subscribers of other mobile networks, T-Mobile USA is now offering its WLAN service for a reduced tariff to its own mobile phone subscribers as a bundled option on their monthly wireless voice and data bill. South Korean KT is working on a single-password service that enables advanced mobile phones and PDAs to access seamlessly either its cellular infrastructure or its WLAN hotspots.

(2) In addition, fixed operators might be further driving public WLANs in Europe, as may be witnessed from the plans by a number of fixed incumbents to equip public payphones, where the fixed infrastructure is in place already, with WLAN access points. For instance, BT has announced that it will offer wholesale access to

its public wireless broadband network. BT Openzone will market the wholesale service to mobile operators, ISPs, fixed line operators and even "virtual mobile operators". The company plans to put BT Openzone Wi-Fi access points in many of the thousands of payphones across Britain.

In sum, WLAN is at this point still positioned as a specific service, separated from other wireless data services, or as a complement to fixed networks (whose business case is not threatened by, but rather strengthened by WLAN). The question of whether these public WLANs might operate as substitutes to 3G access is still unclear.

Private WLANs act mainly as a complement to fixed (often DSL) lines, and may be substitutes to short range wireless technologies such as Bluetooth. In the case of public WLAN being integrated into cellular networks, WLAN is used as a complement to mobile cellular networks (2.5G or 3G), and might be a substitute to 3G access in the case of being combined with 2.5G.

Roles

In terms of the value network, five business roles can be distinguished in the provision of WLAN access:

(1) *Location owners*. These are owners of attractive locations.
(2) *Operators*. They manage a number of hotspots.
(3) *Aggregators*. They link "networks" of hotspots together and provide access for the customer.
(4) *Service providers*. They formulate a proposition for the client, of which WLAN access may be only a part.
(5) *Vendors*. WLAN equipment producers and vendors constitute an enabling role, but are nevertheless very important in driving the market. In the case of private WLAN solutions, they constitute, together with the retailers and the users themselves, the core of the WLAN value network.

In the case of public WLAN, actors within each of the four primary business roles, i.e. location owners, operators, aggregators and service providers, are experimenting and moving downstream or upstream to integrate other roles. Actors originating from any of these roles have integrated the service provisioning role and thus the customer relationship. However, telecommunications operators, having the resources, the experience and the customer base to sustain the customer relationship, are becoming increasingly predominant in this area. Notwithstanding the fact that some telecommunications operators may become WLAN operators without retailing the service themselves (see the example of BT in the previous paragraph), telecommunications operators are, as a rule, entering this market as service providers and/or aggregators of WLAN services.

In the specific case of mobile operators, various strategies can be observed in the market as to which other roles they are integrating. Some mobile operators only act as service providers, relying on specialised WLAN operators and aggregators; others have integrated these roles, typically by acquiring WLAN operators as subsidiaries. Operators such as Telia and T-Mobile are even becoming location owners, by installing WLAN access points in their stores. Integration of roles seems to be positively related to ambitious WLAN expansion strategies.

As a rule, mobile operators try to close exclusivity deals with location owners. However, prime locations such as airports usually adopt a multi-service provider model. Other location owners are even offering WLAN access themselves, independently of any specific operator. The German rail company Deutsche Bahn, for instance, is planning to offer "rail&mail" WLAN access in most train station lounges and in its first-class carriages.

According to a study by the BroadGroup, new roaming and billing platform structure players may be expected in Europe by 2004, and will start to displace the role of aggregators. In Germany, the clearinghouse Eco-Forum already offers a roaming platform between different public WLAN operators and takes care of the charging between them.

Business models

In general, three potentially viable WLAN business models can be distinguished in the short-to-medium term:

(1) *Private WLAN model*. In this case, WLAN is positioned as complementary to ADSL, and as a substitute to short-range wireless technologies such as Bluetooth. Hardware manufacturers and ADSL providers (including fixed operators) drive this offering. The use of WLANs as a strictly private home or in-company solution is generally restricted to teleworkers or smaller companies. The typical service offering is wireless internet/intranet access. Next to the fixed internet subscription, there is only a hardware sale, of which the costs are relatively small.
(2) *WLAN hotspot model*. In this case, WLAN is positioned as complementary to fixed networks, and perhaps as a substitute to mobile networks. It has been argued earlier in this paper that free hotspots, which are operated by (networks of) individuals, have a limited long-term potential, in spite of the large amount of publicity that the free access phenomenon has received. Free hotspots

operated by public authorities, or by hospitality providers, are still very limited in numbers. Commercial hotspots are operated by fixed operators, mobile operators, specialised WLAN operators or service providers, or even by location owners themselves. In general, high rates are charged for access to these hotspots, in order to cover operating expenses or, as might be the case for mobile operators, not to cannibalise other services. These high rates limit the use of hotspots to the business market (which in turn limits the number of attractive locations) or as a "last resort" option. Generally, public WLAN access is positioned as a separate offering, even though there are signs of bundling the service with other services such as ADSL (e.g. in the KT case) or with GPRS.

(3) *Integrated WLAN-cellular model*. This model may be seen as a potential evolution of the WLAN hotspot model. In this case, WLAN is positioned as a complement to 2.5G/3G, and potentially a substitute to 3G access points, as it might make it unnecessary to upgrade from 2.5G to 3G, at least in some locations. Mobile operators will drive this model. The first signs of integrating WLAN into cellular networks can already be witnessed today. However, full integration is still a futuristic option, which will be dealt with in the next chapter on future 4G visions.

1.3 Conclusions: current and emerging business models and the "immediate" 4G vision

The previous paragraphs have reviewed potentially viable value propositions and value network configurations defining current and emerging 3G and WLAN business models in Europe. In order to outline potential scenarios for what was labelled the "immediate" 4G vision, some of the main factors which were identified as defining the emerging 3G and WLAN business models have been brought together. These were:

- whether there will be high or low demand for mobile broadband services; and
- whether WLAN will be positioned and experienced as complementary to mobile networks, or rather as a substitute.

An assessment of the cross-impact of these factors, in line with the trends and developments described earlier in this chapter, results in four scenarios of the potential interdependence of WLAN and 3G, which in turn determines the potential of the "immediate" 4G vision. These scenarios are outlined in Table I.

2. 4G visions and strategies

The previous section outlined potential cross-impacts of business models for 3G and WLAN and the resulting scenarios for the "immediate" 4G vision. Regarding the "linear", long-term 4G vision, developments are not sufficiently far to be able to assess potential business models involved. Instead, this section examines the visions and public statements on strategies of the main European stakeholders relating to long-term 4G developments. It will concentrate on telecom operators, telecommunications vendors and IT companies, as these have been identified previously as potential drivers of future mobile business models.

Data were gathered from official statements, vision documents and R&D white papers, from individual players as well as from research fora, standards organisations and interest bodies. Naturally, it is difficult or even impossible to select truly representative visions, as there are a multitude of players and organisations involved. Also, it is problematic to assess real strategies from vision documents. Therefore, this analysis should be seen as indicative rather than representative, and is only meant to give a general view of divergent visions and of strategic potential relating to long-term 4G developments.

The introduction to this paper already stated that the "linear" 4G vision was originally considered to sequentially follow 3G and to emerge in the 2010-2015 time period as an ultra-high speed broadband wireless network. The objective of this section is to see if this vision still holds for the different stakeholders involved, to assess the drivers in business terms attributed to 4G by the stakeholders, and their view on the time-path towards 4G. The result is a set of scenarios for the "linear" 4G vision and an assessment of the position of Europe with respect to the USA and Asia.

2.1. Visions of 4G-related organisations

At a world-wide level, the International Telecommunications Union (ITU) has taken the initiative to start working on a general 4G vision and reference model. It has also put forward a general timeframe for 4G, in the sense that it has stated that it does not see a need for 4G as a new wireless access technology until 2010. One of the considerations for this is the need to ensure that the operators and developers of 3G have enough time to make a return on their investments in 3G.

Besides the ITU, a whole range of existing and emerging, world-wide and regional, general and sectoral, standardisation organisations and research fora are dealing with 4G-related topics.

Table I Four scenarios for "immediate" 4G

	Low demand for mobile broadband services	High demand for mobile broadband services
WLAN substitute to cellular networks	*Scenario EU (A).* In this scenario, there is low demand for mobile and wireless broadband services in general. WLAN is attractive for private and limited public use. If 3G is introduced at all, it is used for relieving congestion in the 2G and 2.5G networks. In this case, "immediate" 4G remains a niche solution for mostly private use	*Scenario EU (B).* In this scenario, demand for mobile broadband is high and 3G is a success as a result. WLAN is either eclipsed or serves as a niche solution in selected prime locations. In this case, "immediate" 4G is insignificant or establishes itself as a niche market in prime locations
WLAN complementary to cellular networks	*Scenario EU (C).* In this scenario, WLAN is integrated into 2.5G networks. It satisfies the demand for wireless data in selected locations. UMTS roll-out is delayed or even put off. In this case, "immediate" 4G has severely diminished the value of 3G	*Scenario EU (D).* In this scenario, UMTS is introduced successfully, but is not able to satisfy all market demands in terms of bandwidth and speed. Heterogeneous networks consisting of UMTS combined with WLAN hotspots are rapidly introduced. In this case, "immediate" 4G has almost instantaneously succeeded 3G in the form of 3.5G

The following review of vision documents concentrates on organisations with a European emphasis. These include ETSI, Eurescom, UMTSForum, WWRF and WSI. As neither ETSI or the UMTS Forum have released major vision documents relating to 4G, the review will limit itself to Eurescom, WSI and WWRF. Vision documents and statements of other regional fora such as mITF have been analysed for comparative reasons only.

Eurescom: the operators' vision on 4G

As was stated before, European network operators are generally characterised by low R&D expenditures. Most long-term innovation activities are executed by other actors in the telecommunications' value network. Operators rather invest in short-to-medium term research related to network management, business and service modelling, markets and users, etc. Still, network operators participate in different research organisations and other bodies with a more long-term horizon, notably Eurescom. Eurescom, the European Institute for Research and Strategic Studies in Telecommunications, was founded in 1991 by major European network operators and service providers. Members include Deutsche Telekom, France Telecom, British Telecom, Telefonica, Telenor and Swisscom. Eurescom provides research management services related to large-scale innovation trajectories in the telecommunications industry. In 2001, Eurescom published a study on the research challenges connected to 4G for operators. The results were elaborated in a follow-up project outlining the operators' vision on systems and services beyond 3G (see Eskedal, 2003; Eurescom, 2003; Kellerer, 2002, 2003). The terminological shift from 4G to "beyond 3G" may be regarded as indicative of operators' anxiousness to present this future vision as in no way a disruptive alternative to 3G, but rather as a natural and incremental migration path.

Eurescom's main vision of systems beyond 3G (B3G) consists of systems encompassing heterogeneous access networks to provide the highest availability of mobile connectivity. These systems are not only expected to integrate several network platforms, but will also encourage richness of services and applications on a global scale. Services and applications which are envisaged include using the mobile phone as an authentication and security centre within a user's distributed device network, enabling open wireless access to the fixed network, and creating personalised value-added service packages. Eurescom identified four main drivers of B3G mobile systems:

(1) *Personalisation*. The increasing heterogeneity of devices will drive the need for service personalisation, i.e. seamless service usage across communication environments and applications that are adaptable to individual users' contexts. The requirements on the architecture go beyond storage and access of digital content via traditional database systems, implying an extensive personalisation architecture enabling information exchange between system components in all layers.
(2) *Seamless access*. This concept extends the concept of roaming to a wide range of access technologies and access networks with minimal input from the user. This entails requirements such as universal authentication (most operators see this as SIM-card related) and network integration based on IP.
(3) *Quality of service (QoS)*. In a heterogeneous network environment, end-to-end QoS becomes a major issue. The lack of robustness (particularly when using unlicensed

spectrum) and intrinsically limited capacity (due to the finite radio spectrum) of the access network is identified as one of the biggest bottlenecks. It is noted that there is a trade-off between quality and price which has to be balanced and may vary between users and contexts.

(4) *Intelligent billing*. For operators, billing is one of the most crucial aspects determining their relationship with the customer. The need for more intelligence in billing systems will be driven by, for example, the variety of access modes, the increasing popularity of non-time based services, more complex value chains and the evolution towards an IP-based infrastructure. It also implies a return from pre-paid to subscription models.

In terms of the business models supporting B3G systems and services, the Eurescom studies envisage building on the operators' existing strength, i.e. the customer relationship in terms of access provisioning, billing and branding. Drivers such as personalisation and intelligent billing should serve to strengthen the link between operators and users, and to ensure the orchestration role for operators in the B3G value network.

According to the Eurescom reports, the most important roles in the B3G value network will be the access network provider, with wireless access being predominant, and the service provider, hiding the complexity of the networks. The operator will be forced to move away from competition on geographical coverage and price, towards competition on services. As the operator is in an advantageous position to act as a trusted point for payment for transport and service provisioning, he/she is advised to take care of providing personalised service packages. An increasing involvement in service provisioning also implies (renewed) co-operation between operators and content providers, for instance through partnership and venture activities.

Despite their assets in terms of customer relationship and access networks, it is foreseen that existing operators will face tough competition from numerous new service providers entering the market, from unlicensed wireless access providers, and because of regulators insisting on network operators to open their access networks to competitors. As a result, market players will be more cautious to invest in expensive new infrastructures without carefully investigating the market shift of services, regulations, upcoming network technologies, etc. For most types of investments, the return on investments will have a shorter time scale. This is again supportive of the operators' view of 4G as a slow and incremental process.

The most pressing requirements on operators identified by Eurescom include optimisation of resources through flexible network configuration and access type selection, efficient and flexible QoS, charging and security handling with single authentication, smooth service migration from existing systems to B3G, and a reduction of cost of terminals and network equipment based on global economies of scale.

It is striking that the operators' vision, as put forward in the Eurescom studies, hardly mentions any needs for greater data rates, or for any new access infrastructures. Rather, their long-term 4G (or B3G) vision is concerned with solutions for coping with different existing access networks, and strengthening the ties between the service provider, access network provider and the user of mobile or wireless services by service integration and personalisation. In terms of timing, Eurescom sketches a migration path adding functionality to 3G from 2005 onwards, with a move to a B3G system after 2008/2010.

Wireless Strategic Initiative and Wireless World Research Forum

The Wireless Strategic Initiative (WSI) was an R&D project sponsored by the European Commission under the 5th Framework Programme (IST) 2000-2003. Its aim was to provide a focus for the conceptual work of future wireless systems and to open up a range of advanced research prototypes and testbeds from other research projects with a wireless component. WSI comprised the four major European telecommunications manufacturers (Ericsson, Alcatel, Siemens and Nokia) and four European academic partners.

In 2001, the WSI founded the Wireless World Research Forum (WWRF) as an open forum for discussion and research between academics and industry researchers on 4G. Since then, the WWRF has grown to about 150 members, mostly in Europe, but also in the USA and Asia. At the end of 2001, the WWRF *Book of Visions* (WWRF, 2001) was published, with the objective to set the agenda for 4G research in Europe and abroad. In 2002 and 2003, a number of leading members of the WWRF, including the WSI-partners, created the Wireless World Initiative (WWI), which has initiated a series of research proposals for the European 6th Framework Programme. In the same period, WWRF working groups have started to produce a series of white papers, indicating a further implicit shift of the forum towards a pre-standardisation organisation.

As indicated by the labelling of 4G as "wireless world", the 4G vision of both WWRF and WSI

(WWRF, 2001; Arbanowski *et al.*, 2002; Mössner *et al.*, 2002) puts an emphasis on heterogeneity of networks and new service paradigms, rather than on increased bandwidth *per se*. It identifies nine building blocks of future 4G systems:

(1) *Augmented reality/cyberworld*. This refers to new types of user interactions, such as wearables, deviceless communication, avatars and augmented reality.
(2) *Semantic aware services*. 4G services should be aware of users' preferences, profiles, history, context and, accordingly, be able to anticipate in an intelligent fashion.
(3) *Peer discovery*. This refers to addressing schemes that work across network boundaries, and service discovery mechanisms put in place.
(4) *End-to-end security and privacy*. Transactions via mobile devices imply the provision of universal, easy-to-use, secure and cheap payment services across the system.
(5) *Co-operative networks and terminals*. This refers to a continuous service area ensuring seamless use of heterogeneous networks and terminals. An all-IP architecture could be the common basis for co-operation.
(6) *Heterogeneous* ad-hoc *networking*. Additional *ad hoc* communication links such as WLAN, but also *ad hoc* networks between terminals themselves, are also part of the WWRF/WSI 4G vision.
(7) *4G radio interfaces*. This includes mechanisms for spectrum sharing, new air interfaces, and so on.
(8) *Smart antennas and basestations*. This refers to technological innovations such as high altitude platforms and smart antennas.
(9) *Software defined radio*. This refers to reconfigurable, downloadable protocol stacks of mobile stations, thus ensuring that network architectures are future proof.

The WWRF (2001) *Book of Visions 2001* outlines a broad array of research topics connected to these 4G building blocks, including research on future service and business models. As a reference for this work, it introduces a multisphere model, consisting of a number of concentric spheres around the individual user. At the first level sits the personal area network (PAN), or even body area network, a concept which is already feasible today, but is not well integrated within the overall wireless and mobile systems yet. The second level consists of the immediate or ambient environment surrounding the individual, which is expected to react to and interact with users in an intelligent way on a much larger scale than today. At the third level instant partners are situated, i.e. close-by people or close-by complex technological systems such as cars. Easy and rich interaction, or just relaying information through them, are scenarios envisaged within this sphere. The fourth level consists of radio accesses, referring to current as well as new mobile communication infrastructures. The fifth level refers to interconnectivity, meaning the ability to wirelessly and universally connect to any other device, as in today's mobile internet core networks. The sixth and final level is called the cyberworld, indicating the sphere most remote from our immediate real world, i.e. self-created service or gaming spheres with virtual presence and semantic agents.

The most particular features of this multisphere model are the integration of a multitude of heterogeneous and until now separated communication environments into a single system concept, and the fact that it is centred around the individual ("I-centric" in the terminology of the WWRF). This means that there is ample room for ad-hoc and peer-to-peer elements (following the philosophy that all network nodes are equal - there are no client or server nodes, and there is no central element of control) within the WWRF's 4G vision. In this view, open, distributed service platforms need to be put into place to manage the device and network heterogeneity.

This comprehensive, long-term vision, including very innovative approaches to wireless systems architectures is in contrast with the more short-term, network management-oriented view expressed by operator-driven organisations such as Eurescom. Furthermore, other than in the Eurescom reports, the predominance of manufacturers and academics involved in technical research within the WSI and the WWRF has created an emphasis on technical R&D issues, mainly related to networks and radio interfaces, rather than on service or business-related issues. In terms of timing, the WWRF and WSI have put forward a timeline and roadmap for 4G, aiming at a first agreement on specifications by 2004, followed by major R&D trajectories running until approximately 2007, an integration phase resulting in prototypes by 2009, followed by enhancements and finally the commercial introduction expected in 2011/2012.

Non-Europe-based organisations

This section provides a succinct overview of 4G visions of non-European based, i.e. Asian or US-based organisations. Relating to Asia, it briefly reviews the visions and approaches of a number of national research fora. Relating to the USA, it is harder to identify 4G initiatives gathering most of the potentially involved stakeholders. Instead, vision documents or statements from a number of selected companies, along with the IEEE, are reviewed.

In Asia, three countries are taking on a proactive role *vis-à-vis* 4G: Japan, South Korea, and China. Each of these countries has its own 4G co-ordination initiative, which in turn collaborate in the CJK 4G Project (Yabusaki, 2003). Another common characteristic is the active involvement of the national governments of these countries, which are pushing this research with the objective to set early 4G proprietary standards.

In China, the Future Technologies for Universal Radio Environment (FuTURE) project was established in 2001 within the National High Technology Research and Development Program. It focuses on the wireless transmission technology for B3G/4G, self- organisation mobile network technology, and technology in the multi-antenna wireless telecommunication environment. One of its aims is to establish core patents relating to B3G/4G systems early on in the development stage (You, 2003).

In South Korea, the 4G VISION Studies Committee, founded in February, 2002, unites 30 mostly domestic experts with the aim of guiding the national 4G R&D efforts. It emphasises Broadband Cellular (100 + Mbps access) next to ubiquitous access, all-IP networks and reconfigurability as the major building blocks for 4G (Han, 2002; TTA, 2003).

In Japan, the government established its "e-Japan" strategy in January 2001, which sets the objective to realise "the most advanced high speed wireless internet-connection in which the wireless access network will be efficiently connected with the internet (IPv6)". A 2001 report on future mobile communications systems, drafted by the ministry in charge of telecommunications, estimated the size of the markets to be created by 4G mobile systems and the development of services at 42 trillion yen. The Japanese Government's IT policy guidelines for 2003 have confirmed 4G mobile communications as one of the nation's most important areas of strategic research. The ministry in charge of telecommunications is co-funding the development of key 4G technologies, scheduled by 2005, aiming at commercial deployment in around 2010. In a report entitled *Future Prospects for New-Generation Mobile-Telecommunications Systems*, it has outlined faster speed and seamlessness as the major objectives of a new 4G system (Fujisawa, 2002; Miyashita, 2002). The Japanese telecommunications and IT industry, from its part, established the Mobile IT Forum (mITF) in June 2001, which published its own 4G vision document in 2003 (mITF, 2003). In this document, ten application scenarios are presented (e.g. rich voice applications, remote patient monitoring, real-time video, and advanced mobile commerce applications), for which the user acceptance factors, business model characteristics and technical requirements are outlined. Finally, four major research domains are listed: high-speed and large-capacity wireless transmission technologies (e.g. frequency refarming, multiplexing techniques), network constructional technologies (e.g. radio access networking techniques, ad hoc networks), high-performance and advanced function terminal technologies (e.g. circuit and device technologies, software defined radio), and mobile system technologies (e.g. mobile multicast techniques, security techniques).

The Asian 4G visions as reviewed here have many points in common with the European visions, but as a whole, they tend to be more in line with the original "linear" vision of 4G. The 4G visions developed in China, Korea and Japan focus more on a large increase of the data rates of mobile systems, and on developing new systems or system components, and less on seamless use of existing systems, even though this latter element tends to be more and more included as the visions are further developed. Also, the governments' active role in driving the domestic manufacturers to set early 4G standards is a typical element in the Asian 4G "ideology".

The US situation tells a completely different story. Owing to the US tradition of competing standards, and the variety of potentially interested companies and sectors, there is no representative body expressing any "US vision" on 4G. Considering statements of individual US IT companies, US telecommuncations operators and standards organisations with a US emphasis, three observations can be made:

(1) Some US mobile operators, such as Nextel, who are "trailing behind" in the development towards 3G, are said to consider 4G as a way of "leapfrogging" to next-generation mobile networks. AT&T is also working on a so-called 4G solution, combining 2.5G EDGE technology with advanced multiplexing techniques (i.e. orthogonal frequency division multiplexing (OFDM)). As a whole, there is no clear picture as to what is considered as 4G in the US telecommunications market, or as to which approach to standardisation is followed.

(2) A number of US-based IT vendors, such as IBM, Oracle, Sun and Microsoft, as well as a number of start-ups, have explicitly identified the mobile market as a strategic target market (Kewney, 2003b). As middleware platforms become increasingly important in a vision of heterogeneous networks and devices, converging standards mean that mainstream IT-vendors can increasingly sell to operators, without necessarily having to support a multitude of telco-specific standards and technologies. Also, operators may fear that a

further reliance on vendor-owned device platforms will further commoditise the role of the network, and of the network operator. The 4G visions of US IT companies, besides pushing WLAN equipment sales, therefore generally emphasise the need to overcome problems associated with the increasing heterogeneity of networks and devices by implementing integrated middleware platforms.

(3) Some standards organisations, such as the IEEE, have been active in the field of 4G. The IEEE has published a number of special issues on 4G and is involved in the 4G Mobile Forum conferences. IEEE is working on its own standards to accommodate "cellular-like" mobility (i.e. the IEEE 802.20 standard, which aims at providing data rates of up to 4 Mbps, and mobile users supported at up to 250 km/h). However, the structure of IEEE as a collection of individuals leads in general to slow decision making. Also, this structure makes it less suited to be an organisation actively promoting specific 4G concepts or visions.

2.2. Individual players' 4G strategies

This paragraph reviews a number of individual stakeholders' strategies relating to 4G as they are publicly known today. World-wide, the most concrete plans towards 4G have been announced by Asian mobile operators and manufacturers. Japanese operator NTT DoCoMo in particular has proclaimed itself as the world's leading operator in terms of 4G development, in line with its successful piloting of the i-mode service and its 3G FOMA service which has been running since October 2001.

NTT DoCoMo has been working on 4G since 1998. In December 2000, it started a joint research effort with Hewlett-Packard aimed at developing a multimedia architecture for 4G wireless broadband networks called MOTO-Media. In October 2002, NTT DoCoMo announced that it had successfully conducted a 100 Mbps-downlink and 20 Mbps-uplink transmission experiment indoors, using a 4G mobile system. In May 2003, NTT DoCoMo started a series of outdoor experiments of this system, merging OFDM (used by WLANs) and 3G technologies. DoCoMo also announced the opening of a 4G research and development laboratory later in 2003 in Beijing, China. This is to become DoCoMo's second laboratory to focus on such research after the company's main research and development laboratory in Japan.

It has also been repeatedly stated that the company is moving its commercial launch of a 4G system, delivering maximum data speeds of 20 to 30 Mbps, to 2006 instead of the widely targeted 2010 starting date, aiming to set the de facto international standard. However, it is not clear whether this is the official NTT DoCoMo viewpoint.

In South Korea, there have also been talks of introducing 4G well before 2010, as fixed operators and mobile operators are competing against each other for mobile and wireless broadband users. WLAN technologies play an important role in these strategies. Korean manufacturer Samsung has set up 4G research laboratories in Korea and the UK, as well as hosting the Samsung 4G Forum and announcing the development of powerful cell phones capable of 4G video downloads.

In Europe, individual companies have been far more reticent to announce long-term 4G plans. Mobile operators in particular have been silent about 4G; no EU operator has publicly announced any plans towards 4G. As was already mentioned in the previous chapter, most EU operators are in the middle of rolling out 3G. A number of operators are, in addition, building up an additional WLAN offering and are slowly recognising the need to integrate this with the current offering, mostly in commercial rather than in technical terms.

European telecommuinications vendors have taken a more proactive stance towards 4G, as may already be witnessed from their involvement in, for example, the WSI, WWRF and WWI initiatives and subsequent research activities. One of the aims of these activities is to position the EU vendors at the forefront of mobile and wireless innovation. Besides these efforts, a number of them have also announced co-operation deals for joint 4G R&D with other stakeholders, seemingly recognising that 4G will not be driven by the EU manufacturers and the EU markets alone. In April 2003, Nokia and Samsung established a co-operative tie aimed at developing a 4G standard capable of using both the WCDMA and CDMA2000 standards. Some observers have interpreted this move as a sign that Nokia is forced to acknowledge the importance of the CDMA standard, which is mostly used in parts of Asia and the USA. Ericsson, for its part, which has been conducting research into 4G since the late 1990s, has founded a 4G research centre in May 2003 along with Microsoft and Swedish operator Telia. Both short-term and long-term research related to 4G is being conducted by the EU vendors, but all have presented 4G as a solution which will not be commercialised before 2010/2012.

2.3. Conclusion: 4G visions and strategies

In conclusion, it can be said that the distinction made in this paper between the "immediate" and the "linear" vision is, while being still useful

conceptually, becoming increasingly blurred in worldwide discourse relating to 4G. Most or all "linear", long-term 4G visions now also include heterogeneity of networks and interoperability or even integration between WLAN and cellular networks. This indicates that these "linear" 4G visions have started to converge with some of the scenarios for the "immediate" 4G vision (i.e. the scenarios in which WLAN is regarded as a complement to cellular networks). However, "linear", long-term 4G visions of stakeholders in different regions of the world are still not the same. They diverge as to the emphasis they place on 4G as a new architecture connecting existing networks, *vis-à-vis* on 4G as a completely new system, with very high bandwidth and data speeds and so on.

This also means that there is no coherent long-term 4G vision yet. It may be argued that 4G consists at this point merely of a set of technology wish lists (McKay, 2002) for technologies left out of 3G or for 3G promises that have not come true, such as broadband-like data rates, Mobile Voice over IP, always-best-connected capabilities, software defined radio, the integration of WLAN, etc. It is clear that the different "wish lists" and the associated timeframes are indicative of divergent commercial interests. In general, four scenarios for "linear", long-term 4G can be distinguished. These are summarised in Table II.

3. Implications for Europe

By means of a final conclusion, the question inevitably arises what the implications of these scenarios for Europe's relative position are. The potential European scenarios for both the "immediate" 4G vision (i.e. scenarios EU (A), EU (B), EU (C) and EU (D) - see previous section) and the "linear" 4G vision (i.e. scenarios EU (I) and EU (II) – see above) have been plotted on a timeline and compared to the long-term views and developments in Asia and the US. This has resulted in Figures 1 and 2.

Figure 1 shows estimated timelines for the "immediate" 4G scenarios based on the data gathered for this paper. In line with the arguments presented earlier, it indicates that WLAN developments in the USA, if quite uncertain still, may lead to early integration with mobile networks, or, alternatively, might be dominated by strong WLAN deployment. Similarly, the projected timeline for Asia (in this case for forerunner South Korea) shows early convergence (and competition) between WLAN and mobile networks. The alternative timelines for Europe all indicate that developments are expected to take longer, for example, because of the slower uptake of WLAN.

Figure 2 shows projected timelines for the "linear" 4G scenarios. It indicates that Asia is moving faster towards 3G, and that in the most likely case this will also mean that it will be faster to deploy new 4G systems. The EU telecommunications vendors' scenario has a similar timeline compared to the Asian one, but with some delay. The estimated timeline for the EU operators' scenario is of a more gradual and slow conversion to 3.5G. The potential US timeline shows a slow launch of 3G systems, but includes the possibility of US telecom operators "leapfrogging" to 3.5G or 4G. In sum, these

Table II Scenarios for the "Linear" 4G vision

	Long-term 4G scenarios
EU-operators	Scenario EU (I): European mobile operators are still predominantly occupied with making 2.5G a success, and with the planned roll-out of 3G. In the European operators' scenario, there is no large-scale integration between cellular networks and other networks before 2008/2010. 4G, or rather Beyond 3G (or 3.5G) is mainly an architecture managing heterogeneity (i.e. fixed-mobile networks together) and providing personalised services to the user
EU-vendors	Scenario EU (II): European telecommunications vendors have set ambitious research goals regarding 4G. In their scenario, 4G is characterised by large-scale heterogeneity of networks and devices, user centric services, distribution of intelligence, etc. The timeframe for this scenario consists of pre-standardisation activities until 2005, standardisation activities from 2005 onwards, and commercialisation in 2011/2012
Asia	The Asian 4G scenario focuses on a large increase of the data rates of mobile systems, and on developing new systems or system components linking heterogeneous networks. The aim of companies and governments involved is to set early proprietary 4G standards. The timeframe for commercialisation is 2010, although there have been talks of an even earlier launch, e.g. in the case of South Korea, where the "linear" and the "immediate" vision overlap quite strongly
US	The US scenario is one of heterogeneous networks, of competition between market-defined *de facto* standards, and an emphasis on WLAN technologies. Main stakeholders are US telecommunications operators, some of which consider WLAN technologies as a way of "leapfrogging" to 4G, and IT companies developing WLAN equipment and integrated middleware platforms

Figure 1 Potential timelines for the "immediate" 4G scenarios

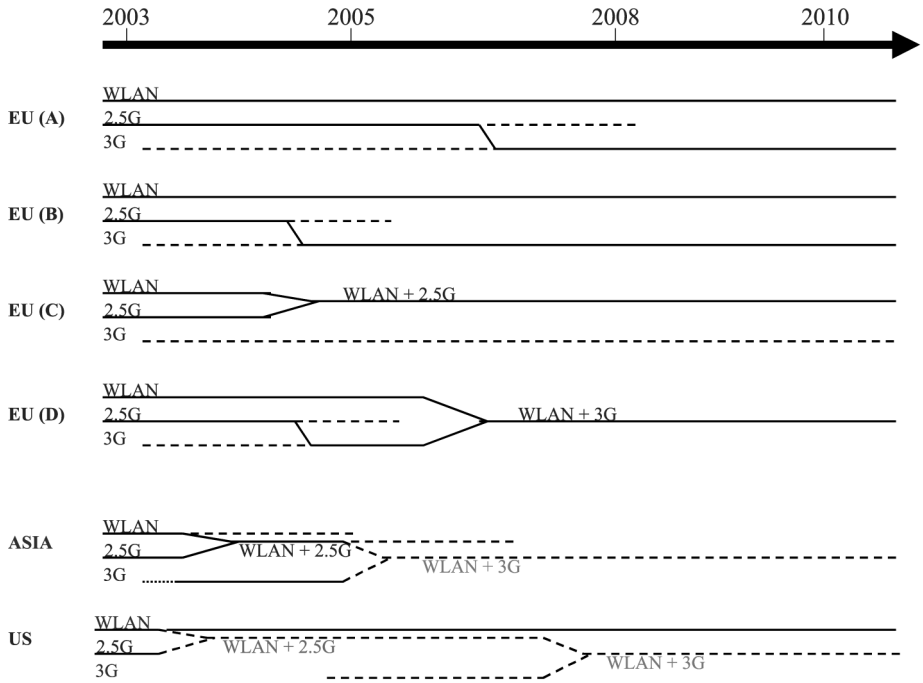
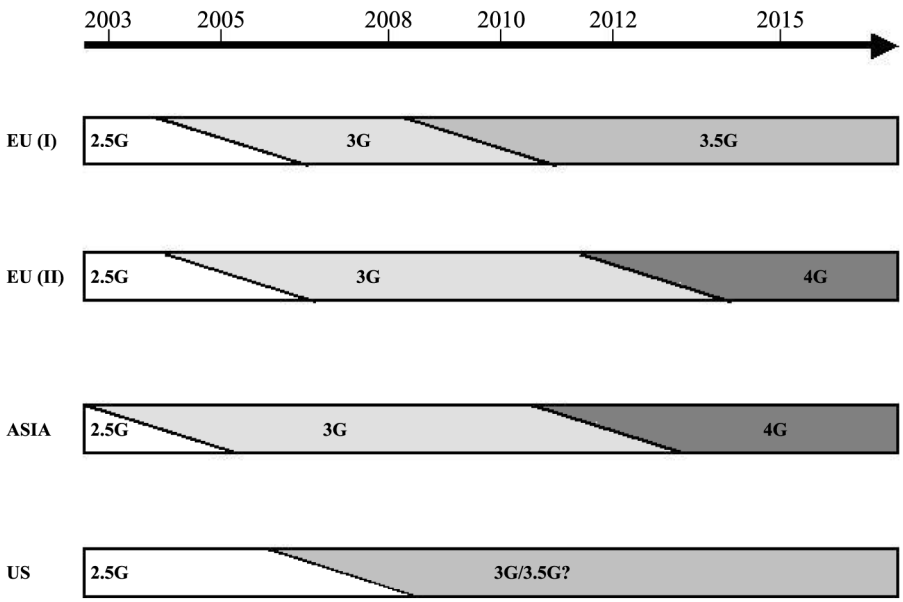


Figure 2 Potential timelines for the "linear" 4G scenarios



projected timelines indicate that Europe risks losing momentum *vis-à-vis* both the "linear" and the "immediate" 4G visions and developments.

Taking these time-paths into account, how may the position of Europe regarding 4G be characterised in terms of strengths, weaknesses, opportunities and threats? First of all, as stated earlier 4G is not a uniform concept, but often still rather a "technology wish list" and a term used for strategic reasons. As was amply demonstrated, there are different 4G trajectories imaginable. This chapter has shown that even within the "immediate" and the "linear" 4G visions, a number of diverging scenarios are possible. However, it also became clear that mobile data, under whichever term it is presented, has developed its largest user base in Asia (i.e. Japan and South Korea), through successful introductions of 2.5G, 3G and WLAN access and services. This seems to demonstrate the

continuing success of co-ordinated and integrated approaches in stimulating uptake of mobile communications. Also, the large Asian user base for mobile data is likely to stimulate further innovations in this field at a more rapid pace than in other continents.

Regarding the European position relating to the "immediate" 4G vision, this chapter investigated a number of potential substitutes and hindering factors for 3G. An analysis of current 2.5G and 3G offerings showed that 3G services may be positioned either as add-ons to 2.5G services or as a completely new set of services, according to whether the demand for mobile broadband services is perceived as low or as high. It was discussed to which extent this will influence, and possibly delay, the speed of 3G roll-out in Europe. Three potential business models for 3G in Europe were outlined and assessed. These models lead to the conclusion that 3G in Europe will be driven by "traditional" telecommunications players, i.e. mobile operators and telecommunications vendors. However, a growing divergence between these stakeholders may be expected. In addition, evidence on WLAN developments in Europe was scrutinised. This chapter discussed three potential business models for WLAN and four scenarios for the cross-impact of WLAN and cellular networks. It was concluded that at this point, WLAN is mainly complementary to fixed networks, i.e. in the form of private in-house WLAN, or public hotspots for "nomadic" internet/intranet access via laptops. It was argued that these kinds of WLAN offerings may only marginally substitute 3G. However, WLAN is also increasingly integrated with cellular networks, and being positioned as a complement to 2.5G mobile telecommunications networks. In this case, WLAN does have the ability to function as a substitute for 3G access. It may be said that WLAN may be a threat to 3G under certain circumstances, but is not likely to be a real threat to mobile operators except as a niche solution.

Regarding the European position relating to the "long-term" 4G vision (i.e. 4G as a successor to 3G), it was stated that it is still too early to analyse potential business models. Instead, the visions and strategies of 4G-related collective bodies as well as a number of individual stakeholders, the drivers in business terms attributed to 4G, and the different views on the time-path towards "long-term" 4G were identified. It was concluded that in the typical European operators' 4G vision, there is hardly any need for greater data rates, or for any new access infrastructures. Rather, their "long-term" 4G scenario is concerned with coping with different existing access networks, and strengthening the ties between the service provider, access provider and user by service integration and personalisation. The typical European telecommunications vendors' 4G scenario has a more ambitious scope, and envisages 4G as a very heterogeneous, all-encompassing and user-centric wireless world. The Asian 4G scenarios as reviewed in this paper focus on a large increase of data rates and on setting early proprietary 4G standards. They are also characterised by active industrial policies and a high degree of coordination. In contrast, the US "long-term" 4G scenario emphasises WLAN technologies and competition between market-defined standards. It is at this moment still unclear whether users will favour broadband capabilities, which are emphasised in the Asian 4G vision, or seamlessness across heterogeneous networks, which is stressed in the European vision, or WLAN functionality, which is emphasised in some of the US visions. Each of these strategies may be considered as an opportunity at this moment. In any case, this paper has pointed to potential benefits arising from the European evolutionary approach, e.g. allowing better recuperation of past investments and opportunities for evolved 3G systems. However, it also pointed to the risk of lagging behind inherent to such a cautious approach. Table III summarises these points in the form of a strengths, weaknesses, opportunities, threats (SWOT) analysis of Europe's position regarding 4G.

This summary of strengths, weaknesses, opportunities and threats to Europe's position indicates that the current European approach, which emphasises 3G evolution and the integration of heterogeneous networks, constitutes a definite opportunity and a potential strength. However, it also indicates that the slow speed of developments in Europe leads to a risk of

Table III SWOT analysis of Europe's position regarding 4G

	SWOT analysis of Europe's position regarding 4G
Strengths	4G visions take into account installed base and past investments Strong position of European telecommunications vendors expected in 3G
Weaknesses	No large user community for advanced mobile data applications yet Growing divergence between telecommunications vendors and operators
Opportunities	Evolutionary approach may yield opportunities for evolved 3G Emphasis on heterogeneous networks capitalises on past investments
Threats	Faster rate of developments in other continents Strong policy support in Asian countries

losing momentum regarding both the "immediate" and "long-term" 4G. Also, the growing divergence between operators and vendors, and the resulting lack of coordination and integration, may harm the competitiveness of the Europe telecommunications sector *vis-à-vis* other regions.

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Erratum

info, Vol. 6 No. 5

Owing to an error in the production of the Rearview feature "The battle for the Latin American mobile space", in the above issue, several errors – the omission of the footnotes, and misalignment of some columns – were published in Table I.

The table is reproduced correctly below.

Table I Gross/proportionate subscribers: Telefónica and BellSouth, 31 December 2003

Telefónica Móviles				BellSouth		
Total subscribers	**% ownership[a]**	**Proportionate subscribers**	**Country**	**Total subscribers**	**% ownership**	**Proportionate subscribers**
1,824,000	97.9	1,786,000	Argentina	1,487,000	65.0[d]	967,000
20,660,000	Various[b]	5,714,000	Brazil			
2,270,000	43.6	[990,000]	Chile	1,301.000	100.0	1,301,000
			Colombia	1,920,000	66.0	1,267,000
			Ecuador	816,000	89.4	730,000
248,000	90.3	224,000	El Salvador			
157,00	100.0	157,000	Guatemala	252,000	60.0	151,000
3,454,000	92.0	3,178,000	Mexico			
			Nicaragua	229,000	89.0	204,000
			Panama	420,000	43.7	184,000
1,507,000	98.0	1,477,000	Peru	642,000	97.4	625,000
175,000	49.9[c]	[87,000]	Puerto Rico			
			Uruguay	146,000	46.0	67,000
[2,681,000]	6.9	[185,000]	Venezuela	3,107,000	78.2	2,430,000
30,295,000 [32,976,000]		12,536,000 [12,845,000]	Total	10,320,000		7,926,000

Notes: [a] The main totals strictly relate to where the assets are held by Telefónica Móviles, and the Latin American totals in brackets are accordingly not counted as these are owned by parent Telefónica – via CANTV in Venezuela while Móviles manages the networks in Chile (which it has offered to buy) and Puerto Rico. Parent Telefónica owns 92.4 per cent of Móviles, so the first total in brackets comprises 92.4 per cent of the assets owned by Móviles plus those owned directly by Telefónica. The second total in brackets adds to this 92.4 per cent of the total for Morocco and Spain. However, Telefónica also owned 4.7 per cent of Portugal Telecom at the end of 2003, subsequently raised to 8.17 per cent in April 2004; [b] The economic interest in Vivo is 50 per cent, but the proportionate subscribers need to be calculated on a network by network basis and represent much less than 50 per cent of the gross figure. Thus we have Cellular CRT (25.3 per cent), Global Telecom (32.6 per cent), Telesp Celular (32.6 per cent), Tele Centro Oeste (9.5 per cent), Tele Leste Celular (13.9 per cent) and Tele Sudeste Celular (41.9 per cent); [c] Telefónica obtained a licence in Uruguay in May 2004; [d] During 2003, BellSouth sold its controlling interest in BCP in Brazil to América Móvil

The Production Department sincerely apologises to the author and readers for these errors.