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Beyond 3G

4G Strategies for Operators in Europe

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1 Abstract

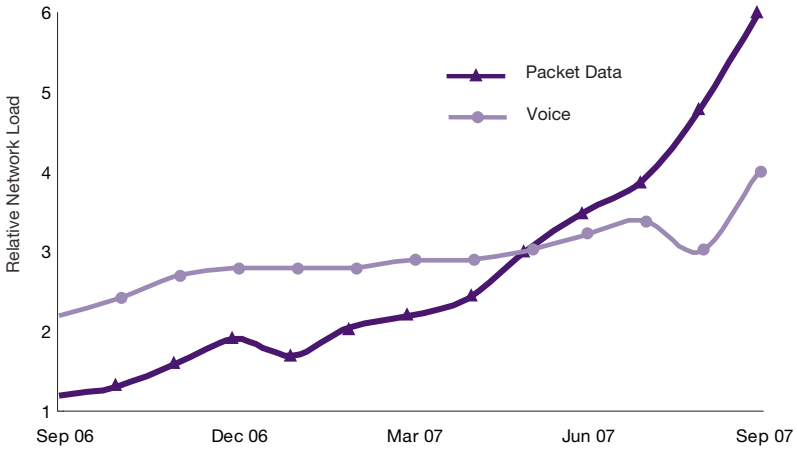
Recent increase in mobile data traffic is being driven by the growing popularity of mobile broadband-enabled embedded devices, increasing consumer interest in data-intensive applications, and flat-rate pricing of mobile data. This usage growth is likely to continue, and will exert significant pressure on mobile network performance, compelling operators to consider the deployment of 4G access technologies. The improved network characteristics of 4G technologies promise to solve network congestion issues and facilitate the rollout of new services and applications through higher access speeds. Of the 4G standards, LTE[1] is the most likely to achieve widespread operator deployment in Europe and other developed mobile markets. Capgemini anticipates that LTE's chief competitor, mobile WiMAX, will find some adoption as a complementary platform to LTE, albeit only in niche market provisions. Our assessment of the economic viability of 4G deployments indicates that operators will struggle to find a business rationale for deployment in rural and suburban areas, and should instead focus on urban areas which promise sufficient monetizable data traffic.

1 LTE: Long Term Evolution.

2 Introduction

During 2007, an inflection point was reached on WCDMA networks as volume of data traffic exceeded that of voice traffic for the first time, as exhibited in Figure 1. Driven by data usage, further rise in traffic volumes are anticipated; estimates of Compound Annual Growth Rate (CAGR) of mobile data traffic between 2007 and 2012 vary from 40% to 65%[2]. While this increased adoption of data services is encouraging (as operators need to realize returns on their existing network investment), uncertainty surrounds the ability of operators to meet future capacity demands.

Figure 1: Relative Voice and Data Traffic in WCDMA Networks Worldwide[a]



Source: Ericsson, "Long Term Evolution (LTE): an Introduction," October 2007; Capgemini Analysis

With an eye on keeping up with this increased capacity requirement, operators have started looking at upgrading their networks using 4G technologies. Offering superior spectral efficiency and hence higher capacity, 4G promises to provide significantly greater download speeds. With spectrum auctions scheduled in some key European markets soon[3], operators need to have a clearly defined vision for their transition toward 4G.

Yet, observers are questioning whether operators should be considering the massive investment necessary for the proposed transition to 4G (Capgemini estimates indicate a CAPEX of almost €100 million for a city the size of London[4]), especially given the history of poor returns on capacity investments. The poor adoption of 3G services, which even by February 2008 (after five years of their launch) had reached a penetration level of only 24.2% in the UK and 25.5% in

2 ABN-AMRO: "Mobile CAPEX Trends—Slowing Down", January 2008; Informa Telecom and Media, "Mobile Networks Forecasts: Future Mobile Traffic, Base Stations & Revenues" June 2008; Cisco, "Approaching the Zettabyte Era" June 2008.
3 UK and German auctions are likely to occur in 2009.
4 CAPEX for active components such as base stations and core network components; assumes reuse of passive infrastructure.

USA[5], is often cited to support this argument. However, the fact that such a small percentage of the total users have been able to generate such large volumes of traffic has made operators examine their network capacity plans as they try to further increase the adoption of data services.

In this paper, we review the developments compelling operators to consider the transition to 4G and assess the merits of the various 4G technologies available. Following an analysis of the business case for 4G deployments, recommendations are made for operator strategies.

5 eMarketer, "3G and Smartphone Penetration (% of mobile subscribers) in the US and Select Countries in Western Europe in February 2008", April 2008·

3 The Case for 4G

Operators need to carefully evaluate the case for deploying 4G, in light of demand from consumers as well as the benefits which might accrue to them in terms of better spectrum utilization and higher ARPUs. In this section, we discuss the factors operators must examine to understand how strong the case really is for 4G.

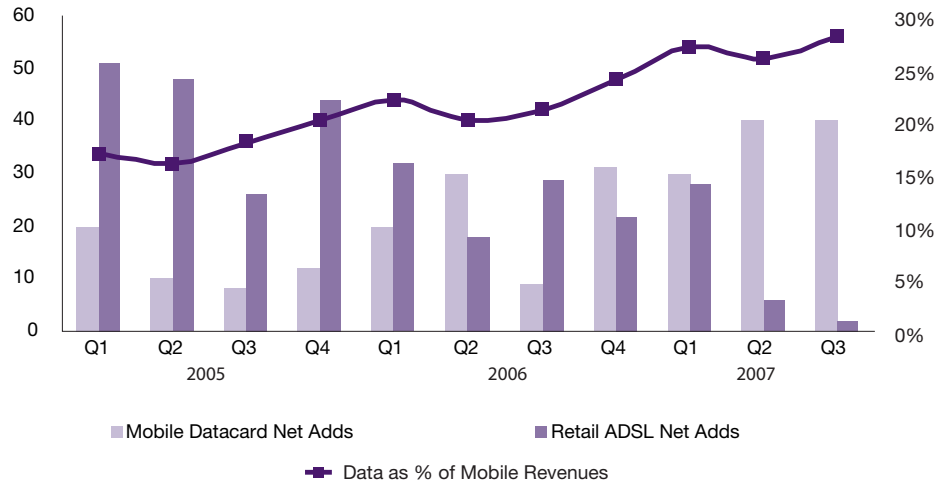
Demand-Side Factors

There are a series of industry trends that are driving higher data usage on mobile networks, with profound impacts on network planning.

Proliferation of Mobile Broadband for PCs

The popularity of mobile broadband devices such as 3G data cards and USB dongles continues to drive consumers from traditional connections (WiFi, DSL, etc.) to 3G networks. In Austria for example, mobile broadband subscriptions accounted for more than 75% of new broadband additions in Q2 and Q3 2007 (see Figure 2), and in Q2 2008, about 30% of all broadband subscribers in the country used mobile devices to access broadband[6].

Figure 2: Mobile Datacard and ADSL Net Additions in Austria, ('000), Q1 2005 – Q3 2007



Source: Analysys Report for Ofcom, "Assessment of the UK Mobile Sector," August 2008

The popularity of these devices has been aided by recent HSDPA/HSUPA network upgrades, and pricing which is increasingly comparable to fixed broadband[7]. In Europe, sales of mobile broadband-enabled notebooks are forecasted to grow strongly, from 8.9 million units in 2007 to 49 million units in 2013[8].

6 Deutsche Bank, "Mobile Broadband", October 2008.
7 Capgemini Analysis.
8 Berg Insight, "HSPA Broadband Europe" as cited in press release, June 18 2008.

There is a case for deploying of 4G networks in dense urban markets

Available data indicates that mobile Internet access through PCs already constitutes the bulk of mobile data traffic; in Finland, traffic from these devices grew at 1300% from 2006 to 2007, accounting for 92% of the total traffic on the network[9]. Similarly, data card-induced traffic has caused the load on H3G UK's network to increase from under 50,000 GB in October 2007 to 500,000 GB in June 2008[10]. This suggests that once the user base for this access technology broadens, it will be the largest contributor to network traffic, resulting in a capacity demand which will make the transition to 4G networks an imperative.

Increased Consumption of Bandwidth-Intensive Applications

The growing popularity and usage of bandwidth-intensive mobile applications is likely to create a case for deployment of 4G. For example, in April 2008, approximately 31% of UK mobile users had shared video or photographs through their mobile phones, while almost 10% watched video clips[11]. The popularity of such data-intensive applications has contributed heavily to the growing traffic on mobile networks. Estimates indicate that while only 9% of the total traffic in 2007 was generated by videos, the share is likely to grow to 23% by 2012[12]. Survey results also show that of the top ten data applications that consumers are interested in, four are of bandwidth-intensive nature[13]. It is anticipated that further uptake of applications such as Mobile TV, Location-Based Services and Multiplayer Gaming will continue to increase data traffic in future.

A key usage driver for mobile data services in the last couple of years has been the evolution of price plans—European consumers are now paying much lesser per Mb of data. For example, in the UK, Vodafone customers paid 0.07€/Mb in 2005-2006, which has reduced to 0.01€/Mb in 2008[14]. In addition, a significant usage barrier was removed when plans switched to flat-rate "all you can eat" pricing, especially as mobile data had earlier been perceived to be expensive. Further, the proliferation of smartphones and handsets with enhanced features, has underpinned increased consumer interest in data services. The success of the iPhone demonstrates this—it is estimated that almost 60% of iPhone users access Web-search, compared to only 6.1% of total mobile users[15].

The increasing popularity of mobile broadband through USB dongles and PC cards, as well as the growing consumption of bandwidth-intensive applications through smartphones are resulting in an exponential increase in mobile data traffic. This traffic is expected to continue growing at a rapid pace, leading to an imminent capacity shortage on mobile networks in the medium term (see Figure 3).

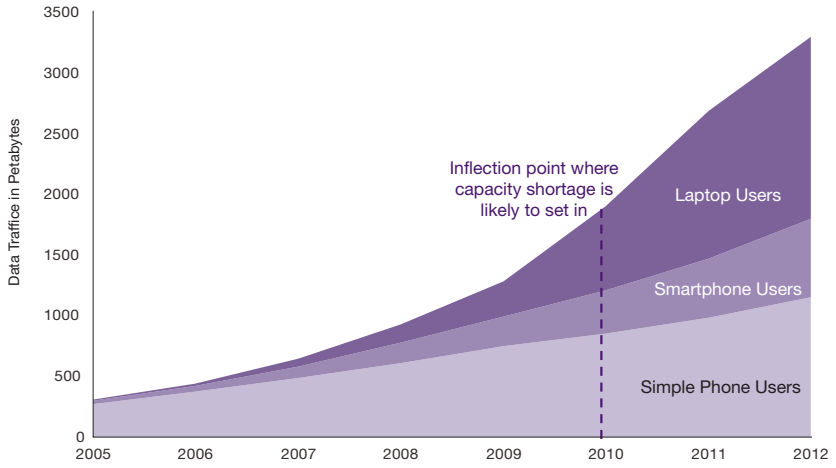
Supply-Side Factors

Network Performance

Much interest in 4G stems from the opportunity these technologies present to improve access network performance. Improved spectral efficiency will allow networks to carry a greater amount of data over a given amount of spectrum, and improved voice efficiency will allow networks to carry a greater number of active voice users for each cell (see Figure 4). This will allow the operators to upgrade their network capacity without having to invest further in new base stations.

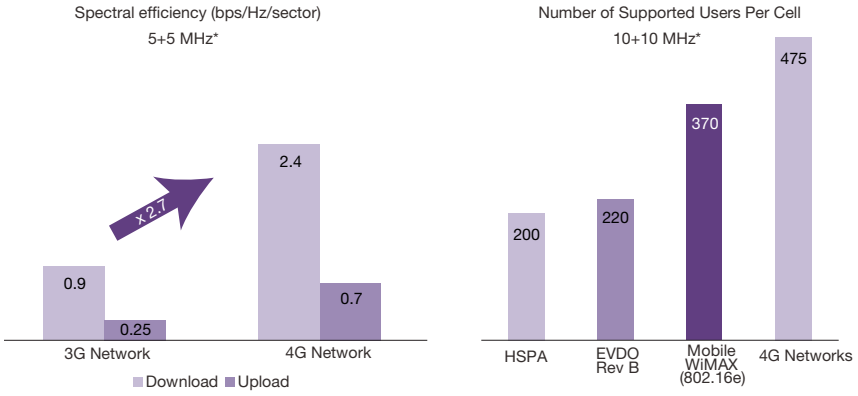
9 Antero Kivi, Helsinki University of technology, "Mobile Data Service Usage Measurements, Results-2005-2007", August 2008.
10 Enders Analysis, "H3G H1 2008 results and data economics", September 2008.
11 eMarketer, "Mobile Content and Application Activities of Mobile Subscribers in the US and Select Western European Countries, April 2008".
12 Informa Telecoms and Media, "Mobile Networks Forecast", 2008.
13 European Technographics Online Consumer Technology Survey, Q4 2007.
14 Capgemini Analysis; Company Websites; Enders Analysis, "Vodafone UK data pricing: free for £5 a month ", May 2008.
15 M:Metrics, as quoted in a press release on March 18, 2008.

Figure 3: Worldwide Mobile Data Traffic and Installed Capacity



Source: Capgemini Analysis; ABN AMRO, "Mobile CAPEX Trends-Slowing Down", January 2008; JP Morgan, "The Power of Mobile Broadband", May 2008

Figure 4: Comparison of Spectral Efficiency and Number of Users Supported per Cell for 3G and 4G Networks[a]



4G Networks includes LTE, Mobile (802.16m) and UMB

(a) Spectral efficiency expressed in bits per second per Hertz per sector. * Indicates spectrum allocated to upload and download streams.

Source: 3GPP TR25.913-V7.3.0; "Reduced HS-SCCH-DL VoIP Capacity Gain"; September 2007 Raysavy Research and 3G Americas "EDGE, HSPA, LTE: The Mobile Broadband Advantage" September 2007

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Applications like High Definition TV, which requires 5 to 8 Mbps, and Video Presence, which requires around 10 Mbps, are currently constrained by insufficient end-user access speeds. 4G networks promise greatly improved access speeds, with expected end-user speeds up to 17Mbps[16]. These new access speeds enable the launch of a host of services which operators hope to monetize in the coming years.

Competitive Pressure

Beyond the industry fundamentals discussed in previous sections, operators must also consider how 4G will change the competitive dynamic in their markets. For example, should a competitor pursue an aggressive early rollout, the incumbent operator faces a risk of subscriber churn that must be carefully considered. Accordingly, some players in the market might need to look at 4G technologies as a defensive approach to hold on to their existing customers.

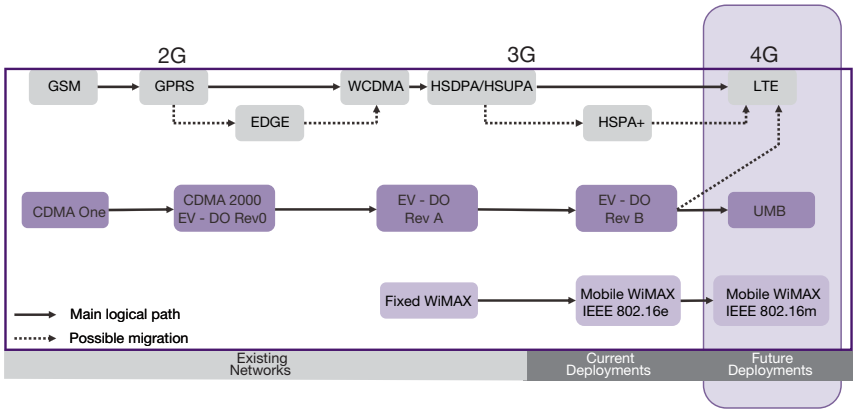
16 Vodafone, "Challenges in Future Wireless Broadband Access networks", February 2008.

4 Assessment of 4G Standards

A critical decision for operators as they formulate their strategy for 4G networks is the technology they decide to adopt for their network. Earlier, upgrade decisions were straightforward and constrained by whether the operator had a GSM or a CDMA network. However, since 4G requires core network as well as radio network upgrades from 3G, operators can consider all possible technology platforms as migration options. LTE, Mobile WiMAX 802.16m and UMB[17] are the three standards vying for adoption in the 4G space.

As illustrated in Figure 5, LTE and UMB are natural evolution paths of established GSM and CDMA platforms, while the WiMAX standard 802.16m is distinct in being an evolution from a fixed wireless broadband standard. The current deployments of mobile WiMAX are on 802.16e standard, which precedes upcoming 4G standards.

Figure 5: Migration Path to 4G for Various Wireless Access Technology Standards



Source: Capgemini TME Strategy Lab Analysis; Company Websites

As evident from Figure 6, the three standards provide similar theoretical performance. As a result, it is likely that other commercial and operational attributes will define technology choice for operators. LTE is likely to be the overwhelming favorite amongst mobile operators as the technology choice for 4G, with WiMAX finding some adoption for rolling out broadband services, especially in under-served markets.

In this section, we evaluate the three evolution paths towards 4G, and assess which is the most likely path for European operators to adopt.

17 LTE: Long Term Evolution; WiMAX: Worldwide Interoperability for Microwave Access; UMB: Ultra Mobile Broadband.

LTE is the most likely 4G standard to achieve widespread deployment

Figure 6: Comparison of LTE, WiMAX and UMB Standards

	LTE	WiMAX (802.16m)	UMB
Frequency Band of Operation (in MHz)	700, 850, 900,1800 1900, 2100, 2500	Under 6GHz	450, 700, 850, 900, 1700 1900, 2100, 2500
Spectral Efficiency	~2.4 bps/Hz/Sector (5+5 MHz, 4x4 MIMO)	~2.4 bps/Hz/Sector (5+5 MHz, 4x4 MIMO)	~2.4 bps/Hz/Sector (5+5 MHz, 4x4 MIMO)
Channel Throughput (Theoretical)	DL: 277 Mbps UL: 75 Mbps (20MHZ bandwidth, 4x4 MIMO)	DL: > 350 Mbps (4x4 MIMO) UL: > 200 Mbps (2x4 MIMO)	DL: 288 Mbps UL: 50 Mbps (20MHZ bandwidth, 4x4 MIMO)
Latency	~10ms	~10ms	~14.3ms
Backward Interoperability	Interoperable with UMTS	No Interoperability with existing networks	Interoperable with CDMA networks
Network Equipment Availability	2009	2010	2009
Affordable Handset Availability	2011	2012	Post 2013

Weakness Strength

Source: Capgemini TME Strategy Lab Analysis; Websites of the WiMAX Forum, Qualcomm and IEEE; Various Analyst Reports

LTE (Long Term Evolution)

We believe that LTE is the most likely 4G evolution standard for existing mobile operators in Europe who have WCDMA and HSDPA-based networks. It provides a natural evolution path for GSM operators via interim HSDPA/HSPA networks. Once finalized, LTE is expected to be backward interoperable with the existing UMTS[18] networks, which is the dominant platform in Europe, giving it a huge advantage vis-à-vis other standards.

LTE has been able to successfully build up a strong ecosystem of chipset and equipment vendors committed toward supporting the standard. These includes prominent equipment vendors like Ericsson, Alcatel-Lucent, Motorola and Nokia-Siemens Networks. More importantly, the significant operator commitment this technology will provide is the biggest impetus to this standard. Three of the top ten operators in the world by number of subscribers—namely China Mobile, Vodafone and T-Mobile—have already committed to the standard, with a number of others engaged in pilots. Additionally, there are also some operators with the CDMA technology platform who have indicated a preference for LTE. The strong operator ecosystem is likely to translate into economies of scale in the future, prompting other operators to back this standard.

WiMAX 802.16m

The WiMAX 802.16m standard is still being finalized and is not likely to be ready for commercial deployment before 2010. The standard faces the serious challenge of not being interoperable with any of the existing mobile operator networks. However, a number of 802.16e networks are being deployed worldwide, albeit primarily for mobile broadband access and not for mobile phone communication. It is expected that current 802.16e deployment by operators would pave the way for eventual 802.16m WiMAX deployments.

Operators are increasingly weighing the benefits of 802.16e deployments vis-à-vis HSPA deployments. With the gradual maturing of the HSPA ecosystem, the time-to-market advantage for WiMAX is diminishing rapidly. This has influenced equipment manufacturers like Nortel to re-evaluate their WiMAX strategy and devote more resources toward building their LTE portfolio. However, WiMAX is likely to continue to see deployments in under-served regions for broadband services[19].

18 UMTS: Universal Mobile Telecommunications System.
19 FierceWireless, "Nortel teams with Alvarion on WiMAX, Focus Moves to LTE", June 11 2008.

UMB (Ultra Mobile Broadband)
UMB is the third contender in the standards race for 4G. However, it has not been able to gain any significant traction in the market. Verizon, Alltel and MetroPCS, CDMA operators from the US, have indicated that they would abandon their natural migration path towards UMB and deploy LTE instead.

The vendor and chipset ecosystem for this standard is weak, with Qualcomm as the only major vendor to support it. Part of the apprehension regarding the standard is a result of Qualcomm being its major proponent owning significant intellectual property rights. Qualcomm's track record of legal challenges over intellectual property rights makes operators nervous about any standard being promoted by it. As a result, Capgemini does not foresee UMB gaining any traction in the 4G market.

5 LTE Deployment Economics

The time-to-market advantage for wimax is diminishing rapidly

In our assessment of the economic viability of 4G deployments, we have modelled the deployment of services in the Western European market. As the most likely 4G technology, LTE was considered for deployment in three different types of markets—urban, suburban and rural[20].

Adoption rate for the technology

Capgemini's has modelled three different uptake scenarios for 4G services amongst the total user base of mobile operators—pessimistic, moderate and optimistic. The adoption rates in the moderate and optimistic scenarios, given in Figure 7, have been modelled to ramp up more quickly as well as become higher than what has been achieved for 3G technologies. Capgemini believes that a more mature 4G ecosystem, greater user awareness of mobile data services, greater content availability and more compelling end-user devices will result in this scenario in the Western European market.

Figure 7: Estimated Adoption Rate of LTE Services in Western Europe (% of Total Mobile Subscriptions)

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Comments:
Pessimistic Scenario	0%	2%	3%	5%	9%	15%	24%	65% YoY growth from second year onwards
Moderate Scenario	0%	3%	5%	9%	16%	28%	49%	75% YoY growth from second year onwards
Optimistic Scenario	0%	4%	7%	13%	23%	40%	71%	78% YoY growth from second year onwards
3G Penetration Levels in UK	0%	0.4%	4%	7%	11%	22%	....	

Capgemini TME Strategy Lab Analysis; Ofcom; M:Metrics, Inc.

Network dimensions based on projected network traffic

Capgemini's estimation of network traffic considers a mean average of 50% CAGR in network traffic over the six-year time frame, based on analyst estimates which estimate CAGR of 40% to 65% between 2008 and 2012 for mobile traffic. In our estimates, the number of base stations required to cater to the increased traffic load has been modelled to be similar to that of earlier 3G networks[21].

Cost of Network Deployment and Operations

We have estimated the CAPEX and OPEX of LTE deployments based on the assumption that the rollout of the network will be completed by the third year of operation. As no new base stations would need to be constructed, operators are assumed to reuse their existing base station sites. The other major CAPEX cost

20 Rural: Population density of 31 per square km; Suburban: Population density of 400 per square km; Urban: Population density of 4800 per square km.
21 ABN-AMRO: "Mobile CAPEX Trends-Slowing Down", January 2008; Informa Telecom and Media, "Mobile Networks Forecasts: Future Mobile Traffic, Base Stations & Revenues"; Cisco, " Approaching the Zettabyte Era" June 2008.

components include core network cost and spectrum cost. Subscriber acquisition costs, backhaul costs and customer support costs are the largest OPEX cost components.

Revenue accruing to the network

In this analysis, Capgemini considered both mobile data and voice services revenues. Additionally, we included revenues from broadband Internet services through devices like USB dongles, data cards, etc.

The time-to-market advantage for wimax is diminishing rapidly

Capgemini forecasts voice ARPU to steadily decline at around 8% CAGR and data revenues to grow at around 10% CAGR (see Figure 8). The rise of data ARPU is attributed to revenues from new services enabled by these networks, such as high-definition video, multiplayer gaming and video presence. Results indicate that revenues from broadband access itself will be significant, contributing up to 20% of the total revenues (see Figure 8).

Figure 8: Estimated ARPU for 4G Mobile Services, (€)

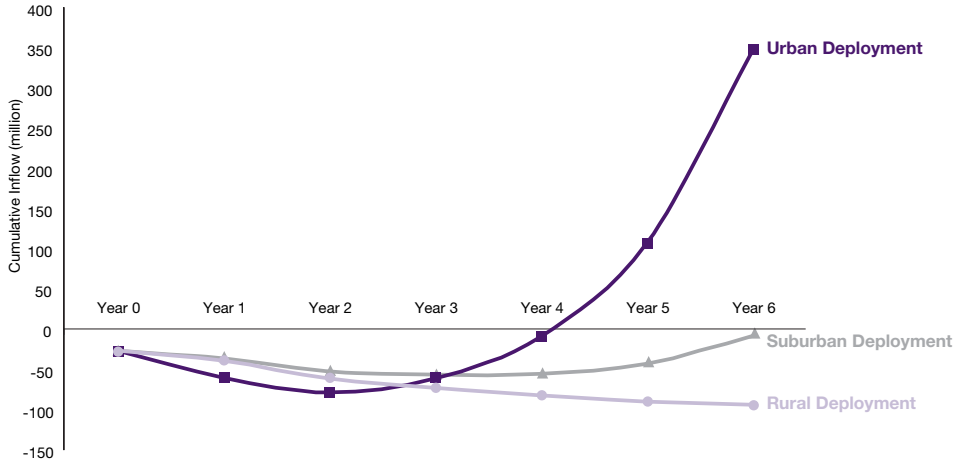
ARPU Estimation	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Voice (€)	0.00	21.00	19.50	18.12	16.83	15.64	14.53
Data (€)	0.00	11.80	12.90	12.90	15.40	16.84	18.40
Total ARPU (€)	0.00	32.80	32.40	32.40	32.24	32.48	32.93

Source: Capgemini TME Strategy Lab Analysis

Payback period and conclusions from the business case

In the scenarios outlined, our model indicates that the payback period for LTE deployments in urban areas is just over four years for moderate levels of service uptake (see Figure 9).

Figure 9: Cumulative Profit/Loss for Deployments Under Moderate Uptake (€m)



Source: Capgemini TME Strategy Lab Analysis

In 2007, volume of data traffic exceeded that of voice traffic on WCDMA networks

By comparison, the business case for deployments in suburban and rural areas appears a lot weaker, with operators unable to break-even within the first six years of operations. Even with an optimistic prediction of technology adoption, suburban areas take nearly the entire six-year period, while rural areas take even longer. This is primarily a result of the fact that the CAPEX spreads amongst a larger user base in the case of urban areas.

These conclusions indicate that operators are unlikely to have a business rationale for nationwide rollout of 4G services in the near future. While Capgemini anticipates 4G rollouts in denser urban areas, the less expensive option of 3/3.5G network upgrades is more viable for other regions.

6 Recommendations for Operators

Skipping 3.5G networks for a radical transition to 4G would be ill-advised

There is no one-size-fits-all strategy for operators. Decisions on the timing of network upgrades, rollout strategies and technology selection are heavily dependant on market circumstances.

First-Tier Operators in Developed Markets
Capgemini recommends that first-tier operators consider 4G as an opportunity to differentiate from competitors. As LTE spectrum auctions do not generally carry rollout obligations, a targeted approach can easily be adopted, providing services to only profitable areas. The high CAPEX requirement and perceived risks in the business case will limit the ability of smaller operators to respond.

Second or Third-Tier Operators in Developed Markets
For smaller operators, 4G can either present an opportunity to make a play at becoming more significant in the market, or can be used to carve out a market niche. Smaller players should consider the potential of 4G to target particular market segments such as SMEs; by carefully targeting propositions, 4G could help a small player differentiate towards particular market segments.

Technology Migration
Operators are advised to migrate to 4G networks in a phased manner, so as to gradually transition to an all-IP environment. A radical transition to 4G skipping the 3.5G networks would be ill-advised, especially since the movement from 3G to 3.5G is a much simpler software upgrade. Operators are advised to implement the interim 3.5G networks to cater to their immediate capacity requirements.

Early adopters too appear to be taking an evolutionary approach to 4G. AT&T, Verizon and Vodafone are the earliest to announce their 4G strategies and have chosen to migrate to 4G LTE via interim 3.5G networks.

In conclusion, Capgemini believes that there is a case for the deployment of 4G networks in urban and suburban markets in developed geographies, although the case for universal deployment of 4G networks is poor. The evolution to new network technologies is likely to be phased, both at a country and a global level. In general, we anticipate a cautious approach to future network investments, with accurate predictions of future network demands being a serious challenge for operators.

Interestingly, the movement to 4G will have strategic repercussions beyond the availability of higher network speeds. With LTE taking precedence over other 4G technologies, groups such as Vodafone and T-Mobile which are divided between GSM and CDMA standards, have an opportunity to harmonize their technology paths. This is of huge significance, as economies of scale can then be leveraged across all operations.

About the Authors

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