FTTH: The solution for Mobile Broadband

Focus on APAC

Interim report

Study on behalf of the FTTH Council Europe and FTTH Council APAC

12077 – August, 2nd, 2012

Roland MONTAGNE
+33 (0)4 67 14 44 26
r.montagne@idate.org

www.idate.org

DIGIWORLD by IDATE

IDATE creates the DigiWorld Institute

Founded in 1977, IDATE has gained a reputation as a leader in tracking telecom, Internet and media markets, thanks to the skills of its teams of specialized analysts. Now, with the support of close to 40 member companies – which include many of the digital economy's most influential players – the newly rebranded DigiWorld Institute has entered into a new stage of its development, structured around three main areas of activity:

- **IDATE Research, an independent observatory** whose task is to keep a close and continual watch on digital world industries, collect relevant data and provide benchmark analyses on market developments and innovations in the telecom, Internet and media sectors – through its comprehensive collection of market reports and market watch services.
- **IDATE Consulting,** time-tested analysis and consultancy solutions: Our multi-disciplinary teams of economists and engineers established their credibility and independence through the hundreds of research and consulting assignments they perform every year on behalf of top industry players and public authorities.
- **DigiWorld Institute, a European forum open on the world:** The DigiWorld Institute will take existing IDATE initiatives, such as the DigiWorld Summit, the DigiWorld Yearbook and the monthly clubs in Paris, London and Brussels, to the next level. Members have the opportunity to participate in think tanks on the core issues that will shape the industry's future, drawing on the knowledge of outside experts and our own teams.

Table of Contents

Tables

***

Figures

1. Backhaul as a priority for telcos

1.1. Dramatic growth of data traffic

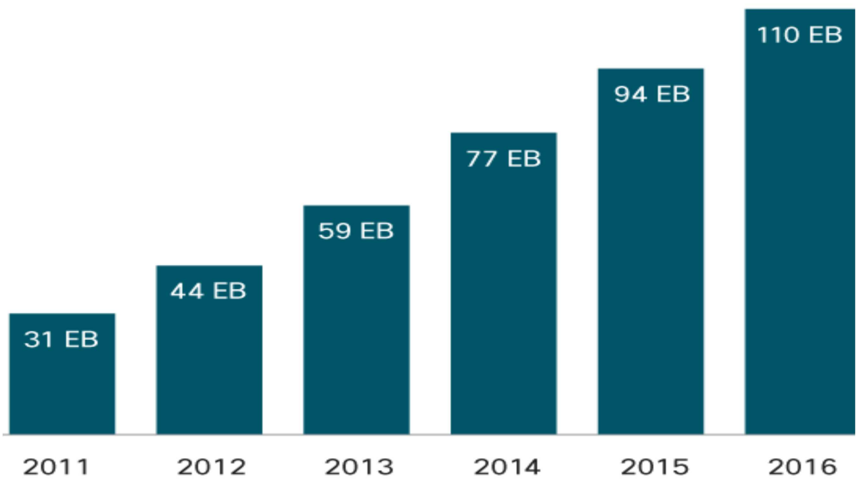
1.1.1. Global data traffic will quadruple by 2014

It is well known that overall traffic is soaring, notably due to the changing pattern of network usage. Utilisation rates are increasing as people spend ever more time on the Internet using bandwidth-hungry applications such as video streaming, file sharing and gaming applications. This significant increase of data consumption has been allowed by the deployment of broadband networks, both in fixed and mobile sectors.

According to Cisco, globally, mobile data traffic will increase 18-fold between 2011 and 2016. Mobile data traffic will grow at a CAGR of 78 percent between 2011 and 2016, reaching 10.8 EB[1] per month by 2016.

Global mobile data traffic will grow three times faster than fixed IP traffic from 2011 to 2016. Global mobile data traffic was 2 percent of total IP traffic in 2011, and will be 10 percent of total IP traffic in 2016.

Figure 1: Global IP traffic trends, 2011-2016
(Exabytes per Month)



Source: Cisco VNI, 2012

1.1.2. Current data growth driven by mobile usage

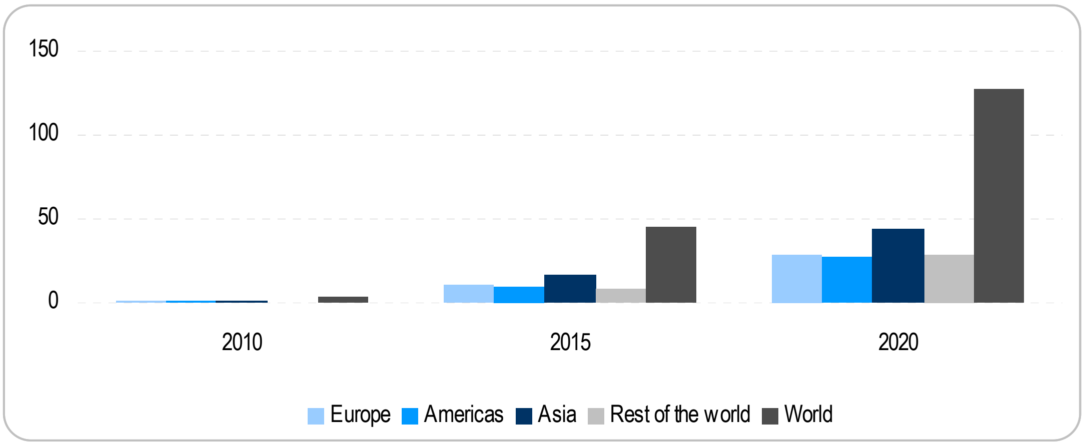
The availability of video content in particular has been the driver of this growth of data traffic, with fast-expanding consumption. This is especially true for mobile users, given the growing number of mobile devices such as smartphones, tablets or dongles, as well as over development of mobile broadband networks.

Indeed, laptops with dongles now generate 450 times more traffic than traditional devices.

IDATE estimates that mobile traffic will reach more than 127 EB in 2020, an increase of 33-fold compared with 2010 levels.

[1] 1 Exabyte = 1,000,000 Terabytes

Figure 2: Annual mobile traffic 2010-2020, EB



Source: IDATE

Streaming and file sharing are today the heaviest traffic usages, being more than 50% of traffic in 2009 in Western Europe and generating the highest growth rates – close to 100% in the case of HTTP streaming. Mobile viewing content on such sites as YouTube has grown grew remarkably and this surge will likely continue in coming years. IDATE estimates a CAGR exceeding 100% between 2009 and 2014 for video traffic.

1.2. Telcos still cautious with network spends

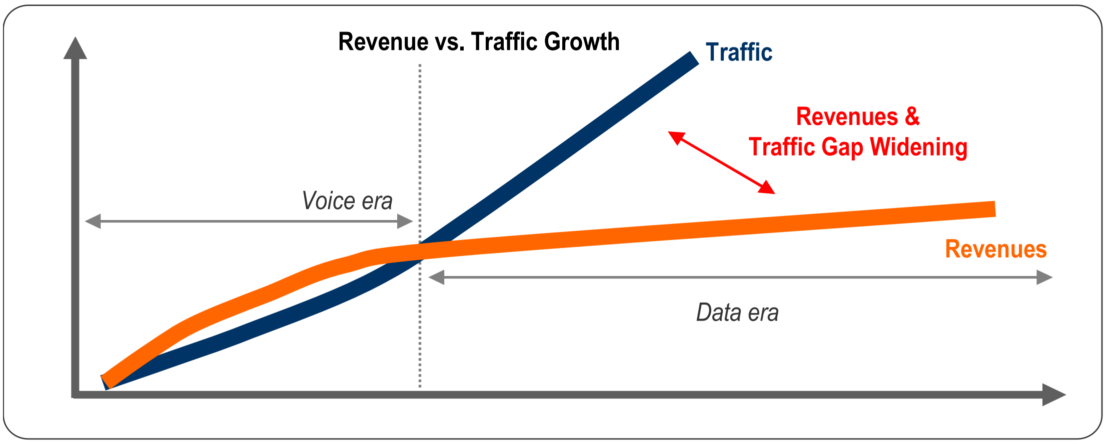
1.2.1. No additional capex foreseen by telcos

Capex under pressure

Following the first mobile network deployments, mobile operators invested largely in their infrastructures up to 2008. It can thus be expected that most incumbent mobile operators will be able to deploy LTE networks without any significant increase in their capex. This will be significantly different from the unprecedented and excessively-high capital costs associated with 3G network deployments.

The emphasis today is on the fact that data traffic is growing exponentially, but not so operator revenues! Operators need to develop their network without requiring large amounts of investment.

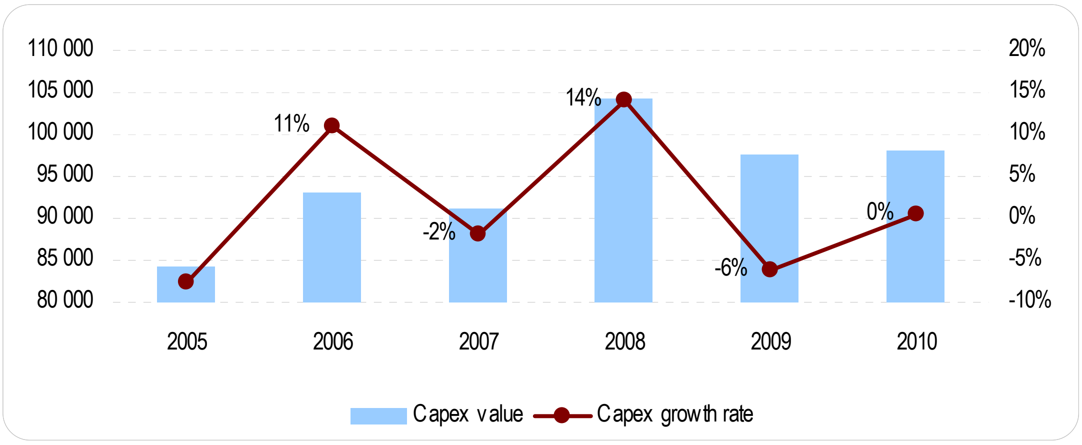
Figure 3: Gap between revenues and traffic growth – Y axe representing Volume and X axe representing Time



Source: Continuous Computing

In 2009, in line with the economic crisis, capex contracted noticeably by 6%. The following year, investment increased slightly again thanks to a few players investing in mobile spectrum and networks. Examples include AT&T investing massively (+50% of capex in one year!) in HSPA and LTE infrastructures, as well as Verizon (+18%) and Sprint (+24%).

Figure 4: MNO [2]capex in value and growth rates, 2005-2010
(million EUR)



Source: IDATE

Table 1: MNO capex growth rate between 2009 and 2010

Mobile operator	Capex growth rate 2009-2010
AT&T	+50%
Verizon Wireless	+18%
Sprint	+24%
Orange France	+10%
Telefonica Moviles Spain	+8%
NTT-DoCoMo	-1%

Source: IDATE

1.2.2. Operator investments in legacy mobile backhaul are not sustainable

Wireless capacity requirements on the increase

Mobile operators are now facing a significant rise in bandwidth demand in the backhaul due to the proliferation of such rapacious services as video and the emergence of very high broadband mobile access networks (LTE and 4G with LTE Advanced to come).

The shift to 4G is increasing the data rates and capacity that have a significant impact on the mobile backhaul network. As seen in the table below from Fujitsu, 2G GSM-based networks require an average bandwidth of 1.3 Mbps for a 3-sector site; 3G needs 6 Mbps and LTE craves for up to 80 Mbps. This demonstrates how the current backhaul infrastructure is not sustainable when coming to HSPA+ technologies and beyond.

[2] MNO for Mobile Network Operator is a player owning and operating his mobile network in opposition with MVNO for Mobile Virtual Network Operator.

Table 2: Mobile capacity requirements

	Voice spectrum (MHz)	Data spectrum (MHz)	Voice Spectral Efficiency (bit/s/Hz)	Data efficiency (bit/s/Hz)	# Sectors	Traffic Eng % Peak	Total Bandwidth (Mbps)	#T1s
GSM 2G	1.2		0.52		3	70%	1.3	1
GSM / Edge 2.75G	1.2	2.3	0.52	1	3	70%	6.1	4
HSDPA 3G		5	0	2	3	70%	21.0	14
LTE 4G		**5**	**0**	**3.8**	**3**	**70%**	**39.9**	**n.a.**
LTE 4G		**10**	**0**	**3.8**	**3**	**70%**	**79.8**	**n.a.**

Source: Fujitsu/4G impacts

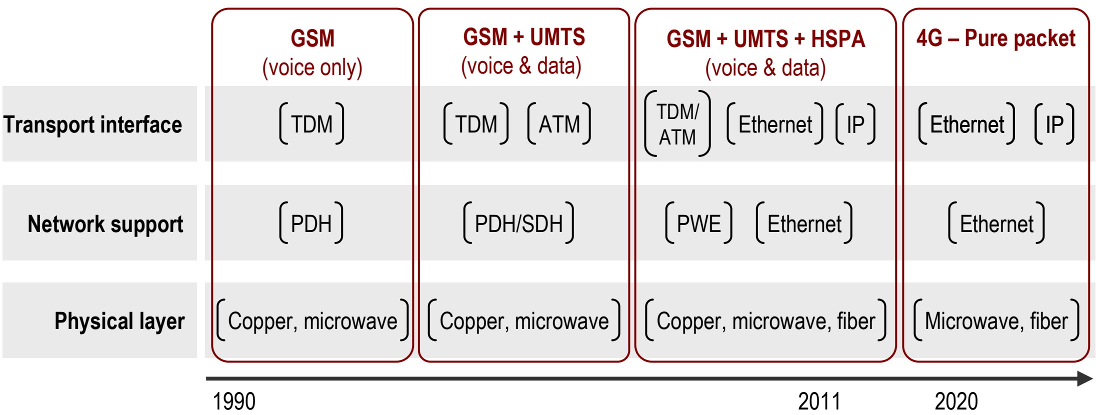
Operators having to transform their backhaul network

Traditionally, the main backhaul technology used by operators was T1/E1 leased lines, where the T1 rate is equivalent to 1.544 Mbps and E1 to 2.048 Mbps. For many years, operators kept on expanding their 2G and 3G networks using more and more T1/E1 to provide the extra capacity. Bandwidth demand was primarily linked to voice services but the escalating demand for mobile data services, explained above, is significantly increasing bandwidth demand at present.

The use of T1/E1 leased lines is no longer sufficient to support higher amounts of bandwidth and it is expensive to scale up. In recent years, operators have been reporting increased backhaul expenditures of 15-25% to be able to carry traffic adequately to their base stations.

In addition, operators have to transport both legacy and newer mobile technologies, including packet-based traffic, as they are not willing to build separate backhaul networks. More precisely, the GSM network is supporting services based on Time Division Multiplexing (TMD) while UMTS infrastructures rely on services based on Asynchronous Transfer Mode (ATM). Nowadays, operators are orienting themselves towards packet-based Ethernet technology which promises to extend infrastructure in a cost-efficient way.

Figure 5: Protocol stacks in mobile backhaul



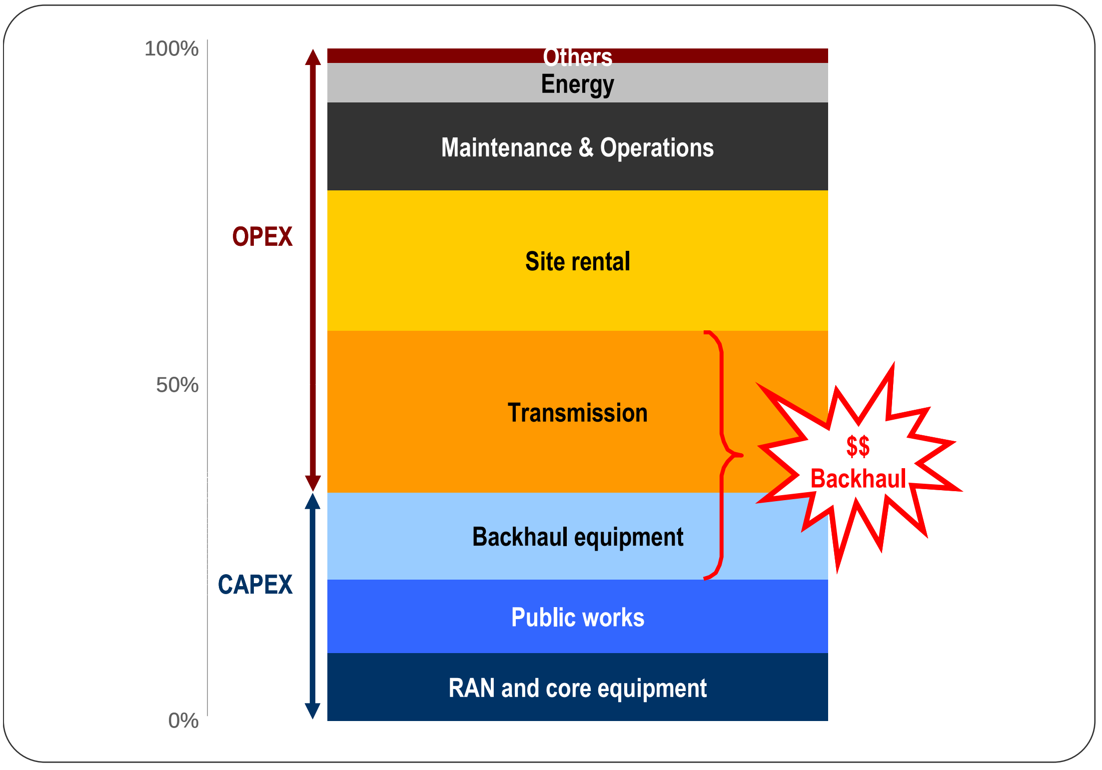
Source: IDATE

Backhaul portion of network weighs heavily in mobile network operator costs

It is estimated today that 20-40% of annual mobile network capex is dedicated to backhaul due to high equipment costs. In addition, backhaul costs account for anywhere between 30 and 40% of network operational costs, notably on leased links. With the huge increase of data traffic driven by mobile services, the traditional model is not sustainable.

Indeed, network costs are expected to grow sharply in the years ahead with increased demand for capacity. In order to avoid upwardly-spiralling capex and opex whilst being obliged all the same to develop their backhaul network, mobile operators have had to look for alternative solutions.

Figure 6: Typical network costs breakdown



Source: IDATE

2. The access revolution: small cells and femtocells

With the arrival of LTE the architecture of the access network will evolve drastically. Deployment of small cells in the outside plans and femtocells at home will be massive and this will have a major impact on backhaul needs.

2.1. Small cells are seen as the inevitable complementary network infrastructures to macro-cells to meet the mobile broadband capacity crunch

The heterogeneous network will be the mainstream for mobile access infrastructure and especially for LTE deployment. This involves a network composed of macro-cells plus a range of small cell solutions such as pico cells, micro cells, femtocells and WiFi hotspots. The main interest here is to increase network density by increasing capacity and lightening the traffic load from the clogged macro-cell at a lower cost.

Typically used in urban areas, small cells are characterised by a coverage range of a few dozen metres; they are mainly used indoors and, more recently, have been introduced in aircraft. The key advantages of small cells for lower associated MNO expenditures are:

- ***Lower capex***: Small-cell products cost far less than macro-cells and can be deployed in a matter of days or weeks, whereby carriers can deploy them with a build-as-you-grow strategy. In the LTE case, one can start out by covering the urban part where the concentration of early 4G adopters will be higher and then move on from there as demand grows.
- ***Lower opex***: Small base stations do not require the expensive real estate of macro-cells; they use far less power, and those deployed indoors will require very little maintenance. To reduce travel time for service technicians, carriers can also use Distributed Antenna Systems (DAS) technology to extend signals out from centrally-located base station hotels.

2.2. Network equipment provider pushes small cells

The Japanese equipment manufacturer NEC has an advanced approach regarding small cells for LTE. Indeed, the company regards small cells as the main infrastructure for operators' LTE deployment, thus skipping macro-cells. They claim that small cells can serve the equivalent coverage and capacity needs at a cheaper TCO, with up to 60% savings compared to macro-cells (in terms of cost per bit per square kilometre). Moreover, in late August 2011, NEC and Cisco concluded a partner agreement which allows each company to raise its market share in LTE deals. Through this cooperation, NEC and Cisco will provide an end-to-end LTE offering with the NEC radio portfolio and Cisco mobile core platforms.

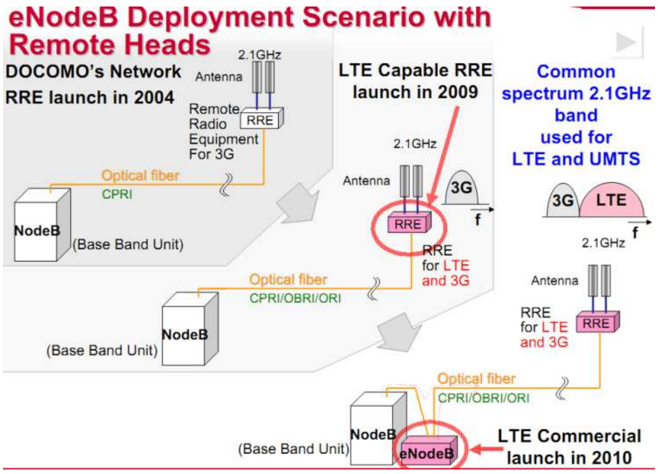
Clearly, from the perspective of the equipment vendor, the move to small cells deployment is inevitable in the years ahead and particularly for LTE deployments. Alcatel-Lucent, Ericsson, Huawei, Nokia-Siemens Networks, and ZTE have all been promoting their new compact stations composed of Remote Radio Head and a separate Base Band Unit since the beginning of 2011. They are all positioning themselves for the eagerly anticipated explosion in LTE small cell deployments, whether in the form of picocells, femtocells, or WiFi.

Figure 7: The Alcatel-Lucent LightRadio

Source: Alcatel Lucent

As a trail blazer, NTT DOCOMO is especially keen on deploying remote radio equipment as new base stations for its LTE network. The company has committed heavily in deploying such equipment: half of initial base stations were Remote Radio Equipment in 2010.

Figure 8: NTT DOCOMO RAN architecture evolution with Remote Radio Head



Source: NTT DOCOMO

2.3. The migration from macro-cells to small cells is under way

Until now, early LTE adopters have launched their LTE network deployments by rolling out macrocells in order to expand coverage. Given the economic constraints and the ever-increasing demand for bandwidth, mobile operators are considering a move from traditional macro base stations to smaller compact sites. The deployments of small cells are thus awaited for increasing capacity. Today, the uptake of small LTE cells is still negligible but major operators have already shown their interest.

- In late 2010, Telecom Italia trialled LTE small cells with Alcatel-Lucent in order to experiment with small cell performance in indoor coverage applications.
- According to Orange, small cells represent a major evolution path for the radio network and a massive deployment of compact base stations for LTE in 2015 can be expected.

There is no doubt that small cells definitely represent a major path for the evolution of the radio network. According to IDATE forecasts, up to 75% of base stations shipped in 2015 will be small cells, meaning a significant shrinkage in the share of the macro-cell.

Table 3: Base station shipments estimates

Base stations shipments worldwide (estimates)	2011	2015
Base stations shipments	800,000	5,000,000
Share of small base stations	30-40%	75-85%

Source: IDATE

2.4. Femtocells will be a critical part of LTE network deployments

Femtocells are small, low-cost, low-power personal base stations, usually designed for use in residential or business environments. The main advantage of the femtocell is improvement in the indoor signal. Given the issues in urban areas and the poor indoor penetration of high frequency LTE (2.6 GHz), LTE femtocells can improve the performance of service provider macro networks.

Beyond the indoor coverage, LTE femtocells can be an acceptable complement to the LTE macro network in high-traffic zones (principally city centres) where the deployment of femto allows a higher wireless capacity. Moreover, by using customer wireline connection broadband as backhaul, the femtocell can provide voice and data services in the same way as a regular (macro) base station and thus off-load the mobile macro network.

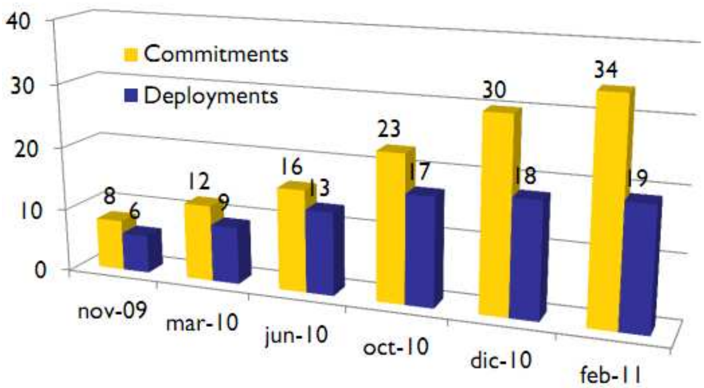
Deploying femtocells has the benefits of easy installation at a low unit cost and stronger mobile phone coverage at home. Typically, the cost of femtocells is lower than picocells particularly due the cost of maintenance and installation which must be undertaken by the operator in the case of other small cell types.

Current designs generally support up to four mobile phones in a residential setting using the provider's own licensed spectrum to operate. The femtocell incorporates the functionality of a typical base station but extends it to allow a simpler, self-contained deployment.

For the femtocell, the main challenge in gaining traction has been due to regulatory reasons as well as the unclear value perceived by end-users and operators. However, in October 2010, the Femto Forum published a set of APIs intended to facilitate the interoperability of LTE femtocell semiconductors from different vendors. Within the industry, the chip maker PicoChip has come out in support of this announcement, which will help operators to quickly and easily extend LTE wireless cellular (and at a lower cost).

At present, 3G femtocells have already been adopted by many major operators, including AT&T, Verizon, Vodafone, Telefonica and China Unicom. The Femto Forum reported a growing trend of operators committed to deploying femtocells, with a level of 34 commitments and 19 deployments by April 2011.

Figure 9: Femtocells operator commitments and deployments



Source: Femto Forum

Several mobile operators have also expressed an interest in deploying femtocells along with their LTE deployment:

- NTT DOCOMO has been looking into deploying femtocells alongside its LTE macro network deployment. The Japanese telco may envisage femto to ensure coverage and capacity performance on its 4G networks but LTE femto availability is not certain. NEC is one of the equipment manufacturers working on this aspect and expects to be ready for trials at the end of 2011 and for commercial products in 2012.
- SK Telecom is already using 3G femtocells to improve voice and data quality. It is now considering LTE femtocells as well as WiFi hotspots to enhance indoor coverage and to increase the capacity of its LTE networks particularly in high data traffic areas such as business parks or shopping malls. The idea is to rely on femto for offloading data from the macro network. SK Telecom has planned to roll out about 10,000 femtos in 2011.
- China Telecom is also showing interest in LTE femtocells.
- In the USA, both AT&T and T-Mobile are tapping WiFi hotspots and femto for LTE data offload. It is known that WiFi can handle heavy data traffic and is easy to install at a low cost.

3. Backhaul, the state of the art

3.1. Definition of backhaul

Re-defining backhaul frontier

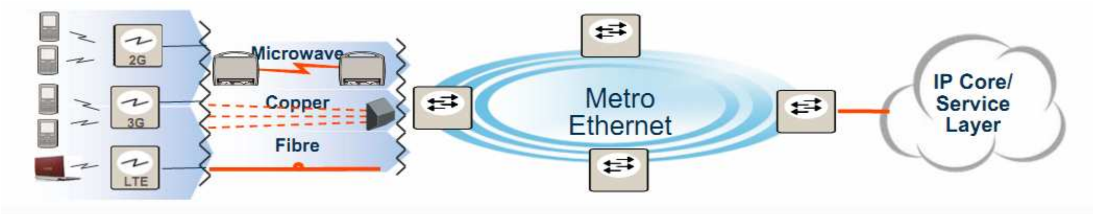
The 'backhaul' refers to the action of transmitting from a remote network to a central node.

Traditionally, in the mobile space, backhaul corresponded to the portion of the network between cell sites and their corresponding Radio Network Controller (RNC) which is dedicated to aggregate all the traffic from base stations.

As far as there are no more RNCs in LTE network architecture, the backhaul definition needs to be adapted and connected with the Evolved Packet Core (EPC), LTE core network.

A new, more contemporary definition could be that mobile backhaul role is to manage the connectivity between cell sites and the switching elements located deeper in the core of the network. In addition, the backhaul consists of any link transmission between the Radio Access Network and the core network.

Figure 10: Illustration of mobile backhaul



Source: Ericsson

3.2. Backhaul network elements and RAN requirements / constraints

The backhaul transport network has to meet additional specific requirements notably due to the upcoming LTE with its own technical demands. As a result, the backhaul must support multiple mobile generations, carrying different services with different needs in terms of capacity, QoS, latency and other factors.

3.2.1. Capacity, latency and jitter

Given the growing demand of mobile data, and their relative weight in the totality of global network traffic, the imperative is to increase capacity, and LTE performances promise to support the explosion of traffic.

With theoretical[3] downlink peak data rates of up to 300 Mbps or more, and uplink peak data rates of up to 75 Mbps or more, LTE requires much more capacity than previous technology. This is a significant increase over 2G and 3G systems and further reinforces the need to be able to scale transport capacity at lower cost and increase transport efficiency by migrating to packet backhaul.

[3] Referring to LTE Release 8

Beyond high demand for capacity, the LTE network also needs reduced latency[4] and low jitter[5]. Typically LTE requires latency below 10 ms. Voice and high quality mobile video are, by nature, sensitive to jitter, which should be 1 ms.

Table 4: Specific backhaul requirements, by mobile generation

	GSM	WCDMA	LTE
Capacity	1.5 Mbps	21 Mbps	80 Mbps+
Latency	Max: 40 ms Target: 10 ms	Max: 30 ms Target: 10 ms	Max: 20 ms Target: 10 ms
Jitter	Max: 10 ms Target: 5 ms	Max: 10 ms Target: 2 ms	Max: 2 ms Target: 1 ms

Source: IDATE

In reality, these figures are not being reached by current networks. In terms of data rates, for the time being, the highest data rates reached by mobile operators were 135 Mbps for both downlink and uplink, during the LTE trial by Telecom Italia.

Latency results obtained during trials are also encouraging with measured roundtrip delays of less than 20 ms, measured by Net4mobility – for its LTE network – at peak rates close to 100 Mbps at 20 MHz bandwidth (February 2010).

3.2.2. Quality of Service (QoS)

When coming to a packet-based network, the challenge is not only to deliver voice and data services but to transport different services with wildly different characteristic needs. The delivery of real-time, performance-sensitive services such as video or VoIP introduces stringent requirements for the transport layer in terms of QoS management. Offering suitable transmission for different service flows must be cost-efficient, especially at a time when demand for bandwidth is growing substantially.

Here the importance of fine and flexible differentiation in the QoS provisioning cannot be understated. It enables operators to release and monetise the value of differentiated bandwidth services based on policy QoS capabilities, as well as requiring the implementation of multiple SLAs.

The ATM and SDH backhaul protocols have allowed a great deal of traffic management and network control. As for the transport characteristics of a native Ethernet, it is less mature in attaining the same degree of quality on packet transport. That is why the mobile backhaul operators are looking for MPLS-TP or PBB (see later in Chapter 4.4) which can provide QoS and management capabilities to support mobile services.

3.2.3. Clock synchronisation

In order to manage inter-cell handoffs, mobile networks require highly accurate network synchronisation. This is especially the case in maintaining contact between base station and mobile devices, avoiding dropped calls and prevention any degradation of quality for the user.

In practice, all network equipment need to be synchronised with Primary Reference Clocks (PRCs). There are many ways to obtain the clock.

Typically, the two following methods are widely used to synchronise 2G and 3G networks:

- The clock reference used is provided by the network elements (BSC and RNC)
- Synchronisation can be acquired from an external source such as a GPS receiver.

[4] Definition: latency (a.k.a. delay) is an expression of how much time it takes for a packet of data to get from one designated point to another. For operators, latency is measured by sending a packet that is returned to the sender -- the round-trip time is considered as latency.

[5] Definition: jitter (a.k.a. Packet Delay Variation) is the variation in packet arrival times

On these networks, the clock reference is maintained while traffic is transported over the TDM network. A BITS clock should be a backup clock input.

When dealing, however, with a packet-based network which is supported by Ethernet, the clock reference is not transported transparently. Indeed, an Ethernet packet-based network is very lax in its timing requirements. To both ensure recovery of the clock reference and to keep delay and jitter to required levels, Ethernet networks are required to meet specific timing standards specified by the ITU-T in Recommendation G.8262.

One approach is to use the clock embedded in the physical transmission layer by extracting it from the synchronous data stream. The Synchronous Ethernet (SyncE) method has in particular been suggested by the ITU-T. It can be implemented in every physical layer used in backhaul, but its only requirement is that every network element is SyncE-enabled.

The other possibility is 1588v2, a Precision Time Protocol (PTP) based on specific packets transmitted by a master clock node. Set as the main clock for transmission via E1 or Ethernet interfaces, this PTP transfers both frequency and time-of-day information through the network. It can, in fact, convey with synchronous network element but as it relays with time packets, it does require a enforcement of QoS to ensure their delivery.

In general current mobile backhaul system vendors support both methods.

3.2.4. Management with Operations, Administration and Maintenance (OAM)

With the transition from circuit-based mobile backhaul to an all-packet Ethernet-based one, telcos need to guarantee network management, notably in ensuring service quality and SLA. As was emphasised earlier, Ethernet is less QoS-sensitive than TDM services, and thus the IEEE and ITU-T have defined service layer OAM standards. Both the 802.1ag and Recommendation Y.1731 were designed to assist operators in simplifying the management of Ethernet services with end-to-end service visibility, fault isolation, reporting and continuous performance monitoring.

In a nutshell, OAM provides efficient network management and monitoring capabilities to maintain QoS.

In addition, in case of failure, Ethernet-based mobile backhaul must support corrective action in order to manage redundancy and maintain the service (as previously included in TDM and ATM standards).

3.2.5. Supporting legacy and IP over new backhaul network

Circuit services emulated with pseudowires

Any new backhaul network must support the coexistence of different technologies whilst meeting capacity requirements.

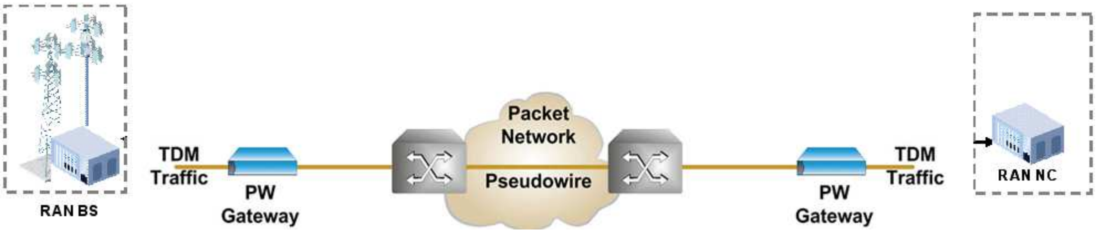
The 2G and 3G networks currently deployed will remain an integral part of the mobile infrastructure for the next 10 to 15 years. The native T1/E1 TDM transport will, therefore, be present for a long time to come until 2G and 3G base stations are decommissioned. In the meantime, during the migration to next generation networks, it is necessary that new backhaul networks incorporate implemented 2G and 3G backhaul networks with planned 4G as already outlined.

Indeed, a backhaul network needs to be scalable to transport TDM, ATM and Ethernet-based services for this migration period.

A TDM-based circuit can be emulated by pseudowires – these allow service providers to carry traditional services (such as voice) over any packet-based and physical layer network.

Concretely, the basic function of a pseudowire is to packetise and encapsulate native TDM circuit-based traffic before transmitting it over the packet network. On the receiving side, the packets are de-capsulated and converted into native transport streams.

Figure 11: Circuit emulation with pseudowires

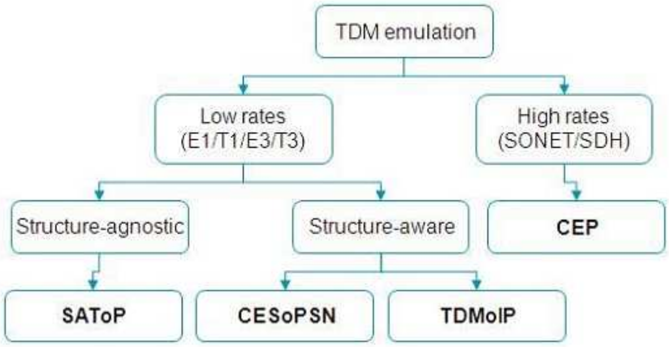


Source: RAD/MEF Forum

Many organisations have defined the encapsulation techniques for the transportation of the relevant standards in mobile backhaul networks, notably with the contributions of the IETF working group on Pseudo-wire Emulation Edge-to-Edge (PWE3).

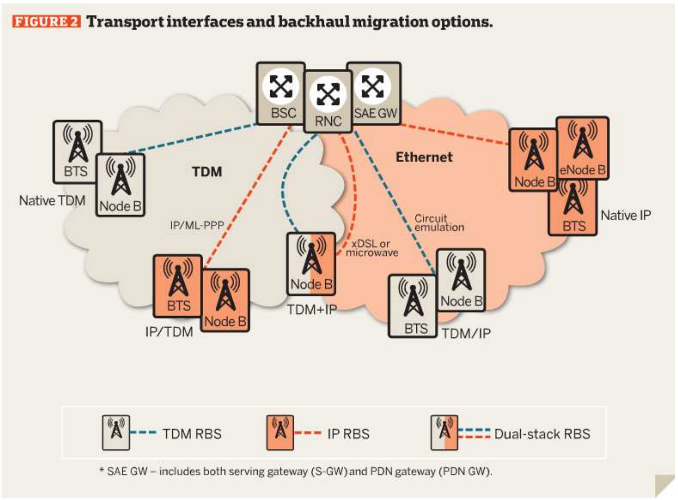
In a nutshell, the concepts of TDM emulation technologies are the same: they enable carriers to provide TDM connectivity and services over a packet network, by encapsulating TDM in an IP packet. Where there are differences, it is in the way each technology packetizes as well as in the structure of the packet.

Figure 12: TDM emulation technologies



Source: Orckit

Figure 13: Options to transport legacy over packet networks, and inversely



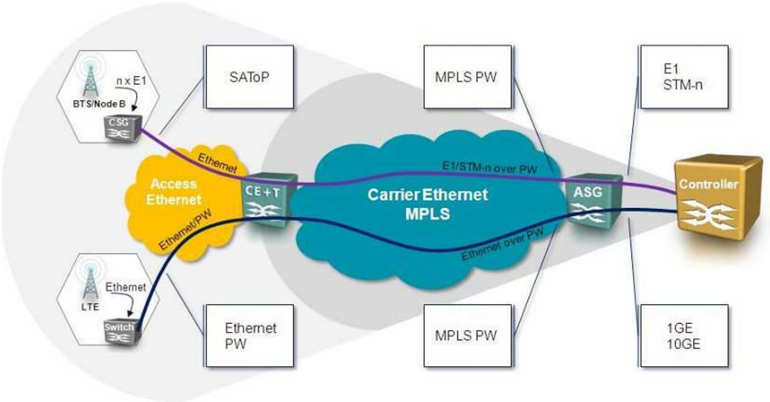
Source: Ericsson

Pseudowire technology provides a migration path

In reality, pseudowires allow operators to transport on a packet-based network without replacing legacy infrastructure and deploying a new one. Some new network elements do need to be implemented in current backhaul networks to take pseudowires into account. This is done by using an 'Interworking function' (IWF) element that interconnects legacy equipment to the packet-based Ethernet services. Pseudowires involve the use of MPLS LSPs, a kind of tunnel allowing the transport of traffic as a VPN service.

In this configuration, Cell Tower/Site Gateways are deployed at the cell tower/site with pseudowire functions included. This equipment is dedicated to receiving the traffic from the antennas and encapsulates the TDM services into Ethernet packets. From this point onwards, the data packets are transmitted using pseudowire emulation. At the other side of the mobile backhauling network, an 'Aggregate gateway' can be used to convert IP packages into TDM. Its role is to de-encapsulate traffic before sending it on to the core network.

Figure 14: Cell sites and Aggregate gateways



Source: Orckit

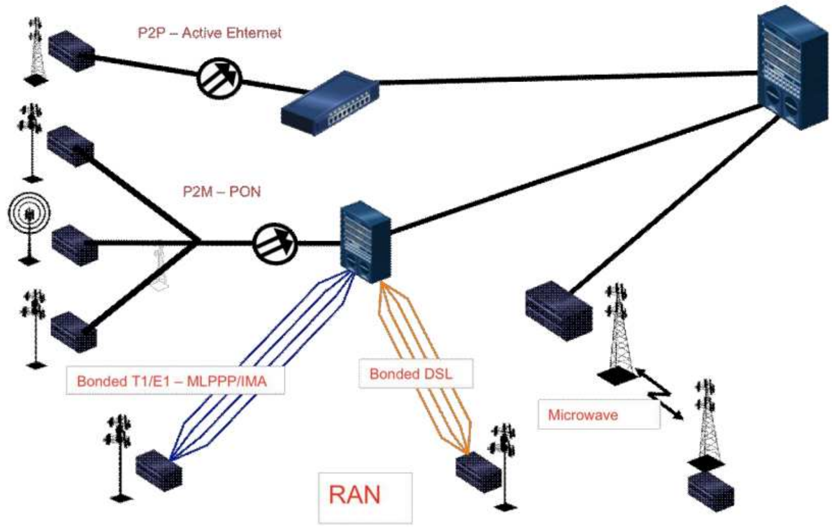
Moreover, operators can also carry multiple services over existing E1 lines using a MultiLink Point-to-Point Protocol (MLPPP). This allows the transport of high-speed traffic - Ethernet traffic over T1/E1 links - and provides users extra bandwidth to accommodate demand for high-speed applications. It is a technique used to derive larger bandwidth pipe by aggregating smaller bandwidth pipes from, for example, multiple T1/E1s. For obvious reasons of performance, MLPPP is a suitable solution as an interim choice for backhaul and it means that migration to Ethernet will not always be the inevitability that it sometimes seems.

3.3. Various technologies can support backhaul at Physical Layer…

There are today several possibilities for supporting the backhaul network, ranging from wireless technologies such as microwave, WiMAX and satellite to copper-based infrastructure like the traditional E1/T1 connection and xDSL, as well as more **recent FTTH networks.**

The choice of operator depends on a number of factors including the availability of equipment, spectrum and licence costs, the extent of existing copper and fibre resources and the geographical area in question. Satellite is, for instance, the favourite medium in emerging countries for connecting remote base stations. In North America, operators were historically using T1 copper-based leased lines but that is now changing; in Europe and in Asia, TDM-based microwave is presently the leading technology but the migration to Ethernet microwave is already underway. Generally speaking, **fibre is becoming a leading vector** for backhaul technologies with regard to current FTTx & FTTH deployments. In the future, Ethernet microwave and fibre will together take the lion's share.

Figure 15: Available backhaul support technologies



Source: Ethernity

3.4. Microwave

The prime features of microwave comprise:

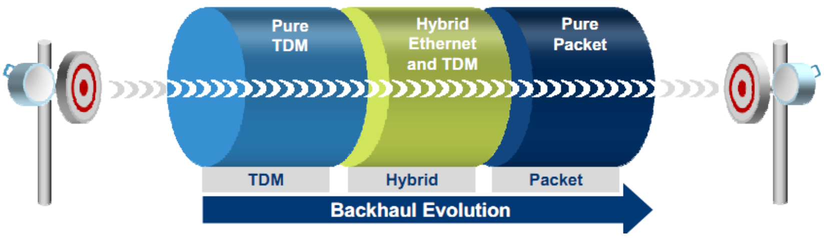
- Ability to meet high data bandwidth requirements. New microwave technologies are significantly expanding the capacity limits
- Requiring the availability of radio spectrum, including any eventual license costs
- Line-of-sight (LOS) technology which suffers from reduced capacity during severe weather conditions
- Being the pre-dominant solution in backhaul, widely used in Europe and in Asia amongst the range of vectors providing large-scale capacity
- Appropriate for areas where it is not possible to lay cables, such as densely-populated or hilly regions

Microwave characteristics

Description

The majority of cell sites today are backhauled exclusively using TDM microwave. Over the long term, backhaul will be served exclusively by Ethernet, supporting packet-based services. In the meantime, during the current phase of migration, hybrid links support both TDM and Ethernet over microwave.

Figure 16: TDM and Ethernet evolution over microwave

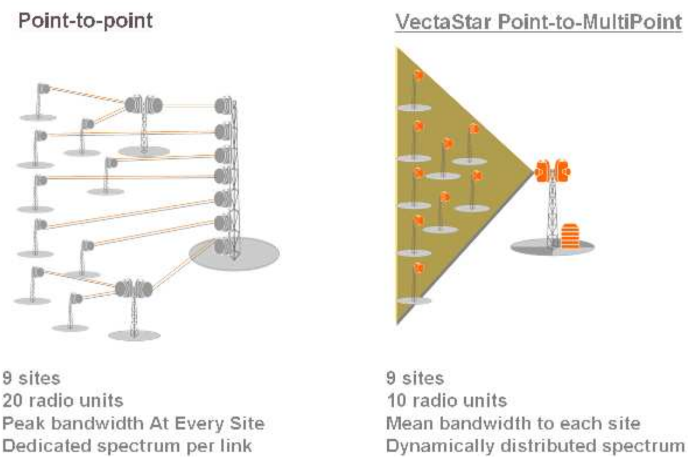


Source: ECI

Two possible configurations:

- The standard configuration, with one emitting and one receiving antenna;
- The broadcast network configuration in which one central antenna broadcasts to several receiving antennae

Figure 17: Different architectures: Point-to-point and Point-to-multipoint



Source: Cambridge Broadband Networks

This technology requires radio spectrum use included in the 6-38 GHz bands.

Typically, spectrum used for backhaul can be under license, or non-licensed

- Licensed: 6 GHz, 11 GHz, 18 GHz, and 23 GHz
- Unlicensed: 5.3 GHz, 4.9 GHz, 5.4 GHz, 5.8 GHz, and 24 GHz

24 GHz is an unlicensed frequency that is recently used for point-to-point backhaul providing up to 720 Mbps (using 256-QAM modulation)

In addition, spectrum suitable for PTMP are 3.5 GHz, 10.5 GHz and 26 GHz.

However, licensed spectrum ensures QoS unlike unlicensed.

Capacity

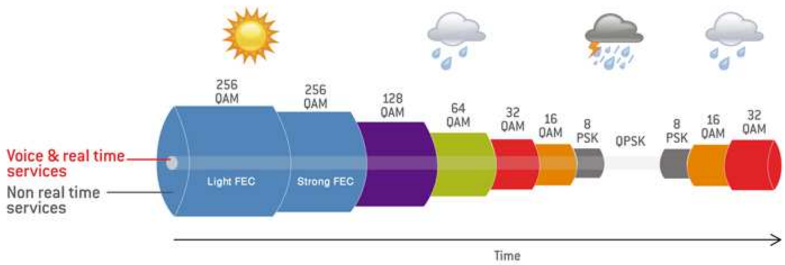
Theoretical capacity max: up to 1 Gbps depending of the configuration (aggregation of the multiple radios)

However, today operators are deploying 100-200 Mbps to backhaul their cell sites with microwave links.

Range reaches up to 80 km (adapted for rural areas)

Since it can be influenced by climate, ‘Adaptive Coding and Modulation’ can serve to mitigate weather conditions and optimise the link capacity.

Figure 18: Adaptive Coding and Modulation



Source: Ceragon

Recently, a new band in the Extreme High Frequency (EHF) band included the 60-90 GHz frequency range called ‘E-band’ has come into use. This licensed frequency band can be used in a point-to-point microwave backhaul configuration. The use of a high frequency band implies a higher link capacity (up to several Gbps), a shorter range (typically just a few kilometres) and being suitable for urban connections. High frequencies are also very vulnerable to rain, resulting in limited range during heavy downpours. This technology is being trialled increasingly by such operators as Clearwire in the USA. This operator is now deploying E-band in the 80 GHz range and regards the technology as the cheapest and fastest.

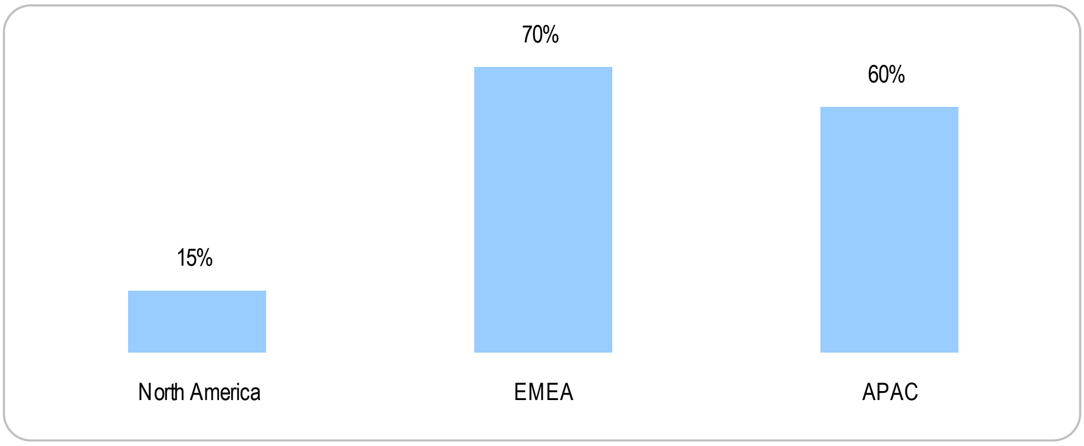
Maturity

It is the pre-dominant technology in the world today.

Historically, operators had the choice between leased lines and TDM-based microwave technologies. Those avoiding the reliance on leased line providers – generally, these were the incumbent – opted for microwave. Today, many operators are considering an upgrade of their microwave assets to Ethernet-based backhaul infrastructure. This is especially the case in Europe where Vodafone relies on microwave in several of its countries of operation, including Germany, Italy and Spain. In France, SFR in France is currently using microwave for 60% of their cell site connections. In Asia, Hong Kong CSL uses microwave for its LTE backhaul, delivering 100-170 Mbps per site.

In the USA, microwave connections are used as short-term solutions given to its rapid installation and its suitability for places where laying fibre is prohibitively expensive – this is the practice of AT&T, Verizon Wireless, Sprint and MetroPCS. Alternative carriers provide US operators with backhaul capacity. FiberTower is one Verizon Wireless provider using microwave as a complement to fibre in order to maximise coverage. As a result, Verizon Wireless has the means to scale capacity up to 100 Mbps and beyond.

Figure 19: Relative weight of microwave among backhaul support technologies in 2010



Source: IDATE

Costs

Relatively high capex is directly linked to the acquisition and installation of new equipment, although it should be noted that fewer antennae are required for the point-to-multipoint configuration)

Opex is related to the space and rental fee as well as maintenance cost

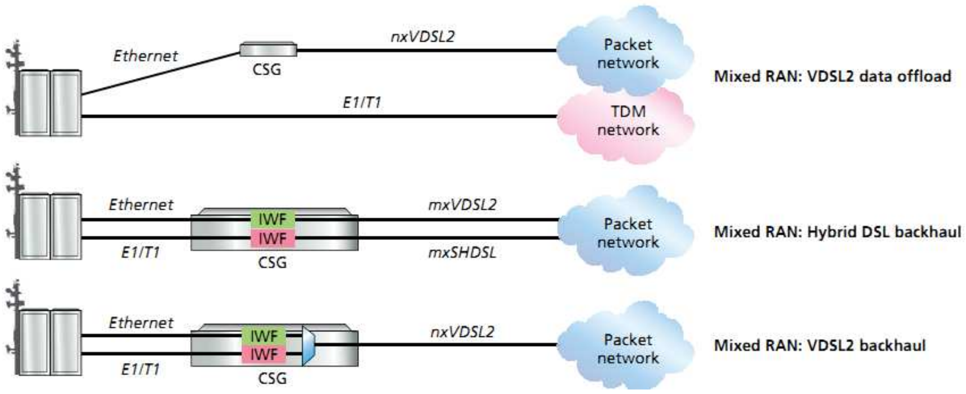
Reduced level of opex as there is no leasing of transmission capacity from fixed operators

3.4.1. Copper

The major features of copper are:

- Being a traditional media used for mobile backhauling
- Ability for E1/T1 lines to support TDM, although the technology becomes cost-prohibitive in meeting current MNO requirements in terms of bandwidth and scalability
- Possibility to leverage the existing xDSL asset by allowing a stretch to higher capacity and, in particular, by using pair bonding (two or more pairs combined to increase the bandwidth capacity)

Figure 20: Several options to use xDSL as mobile backhaul



m, n being the number of xDSL pair bonding, CSG: Cell site Gateway; IWF: InterWorking Function

Source: Alcatel-Lucent

Legacy copper

Description

Operators used to support the TDM network via E1/T1 PDH circuits, using copper-based twisted pair cable. Generally, the lines are leased from the incumbent fixed carrier.

The limitation of this technology is the reliance on another operator, the high related costs and capacity. The way to increase bandwidth – using bonded E1/T1 lines – involves higher expenses.

Capacity

E1/T1 provides 1.544 Mbps and 2.048 Mbps respectively (E1 corresponds to the European standard while T1 is the standard in the USA and Japan) for a distance above a few hundred metres.

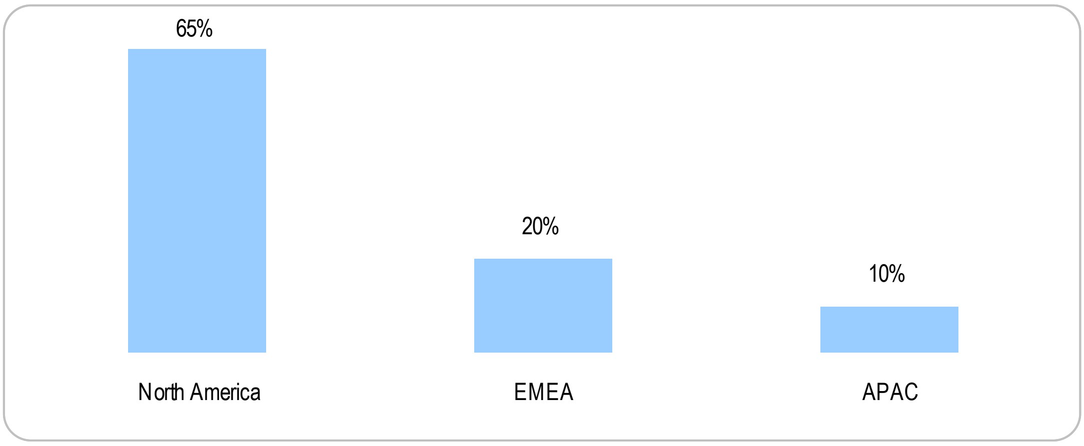
<u>Other specifications:</u>

- Frequency synchronisation is natively supported by TDM over E1/T1
- Very low latency (< 100 µs) and jitter (<3.2 µs) assured

Maturity

Deployed in particular in North America, 65% of cell sites are connected using T1 circuits. This contrasts with Europe where a copper E1 connection provides 20% of backhaul connections. In Asia, copper represents 10% of connections.

Figure 21: Relative weight of copper among backhaul support technologies in 2010



Source: IDATE

Costs

The costs of additional E1 lines are becoming prohibitive because line prices increase linearly with capacity

Associated maintenance costs also increase linearly.

DSL

Description

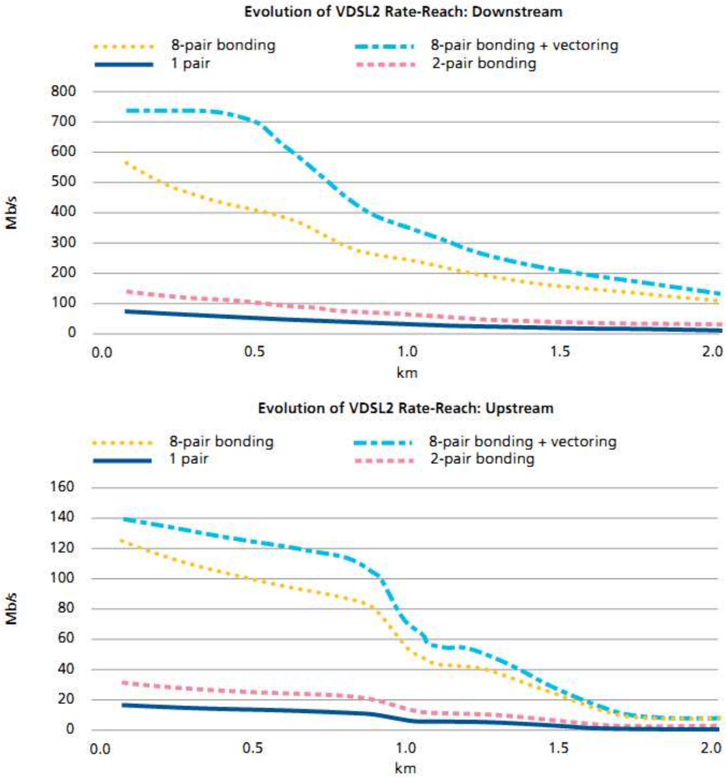
Copper-based DSL is an attractive solution for the mobile backhauling. This technology completely relies on the existing infrastructure of the operator. De facto, xDSL is particularly suited in urban and suburban areas where DSL has been widely deployed.

Capacity

The interest of using DSL for mobile backhaul is its ability to raise its native capacity by using multi-pair bonding:

- 2-pair ADSL2+ bonding can support 10 Mbps downstream. This is a short-term solution and not relevant to future backhaul requirements.
- 8-pair VDSL2 bonding will enable 400 Mbps downstream and 80 Mbps upstream at a distance of 1 km

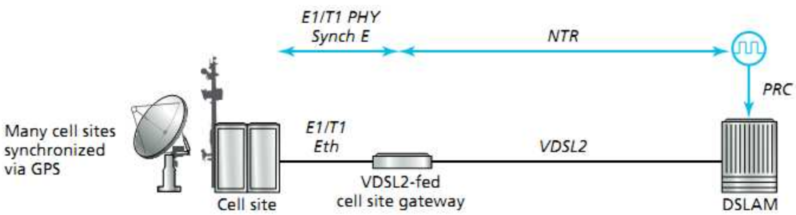
Figure 22: Evolution of VDSL2 rate-reach curves for downstream and upstream traffic



Source: Alcatel-Lucent

Beyond concerns of bandwidth capacity, VDSL2 raises a number of interesting issues related to current and future requirements for mobile backhaul:

- Network Timing Reference (NTR) is defined in the VDSL2 standard



Source: Alcatel-Lucent

- SLA are taken into account in bonding protocol (in case of failure)
- The latency managed by VDSL2 with a current one-way delay is 8 ms (future improvements will reduce this to 2.5 ms)

It is possible to select the best copper pairs in order to avoid transmission impairments such as crosstalk and noise.

Maturity

ADSL2+ as a mobile backhaul technology is used by some operators keen to leverage their fixed broadband assets by taking advantage of the wide-scale deployment of this technology.

In France, Orange has connected the majority of its cell sites stations with DSL.

T-Mobile in Germany is also migrating to ADSL2+, on lines supplied by the Deutsche Telekom fixed-line business from its traditional leased lines or microwave backhaul.

VDSL2 bonding is not totally stabilised today (ITU G.998.2 and BBF WT-273 close to final).

VDSL2 Vectoring is now also close to standardisation (G.993.5 and BBF WT-249 on-going work) and can allow reaching up to 200 Mbps (on certain conditions).

Costs

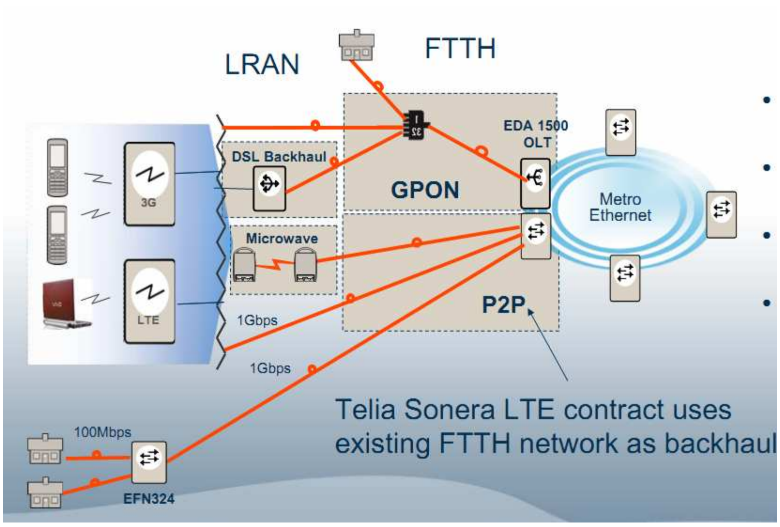
Low acquisition cost, thanks to existing access nodes (DSLAMs or MSANs), with this option requiring only the installation of CSG gateways

3.4.2. Fibre

The key features of fibre are:

- Being a physical medium being increasingly considered as a technology for mobile broadband backhaul thanks to the very high bandwidth capacity it can provide (taking over DSL and being future proof)
- Opening up the opportunity to leverage on current FTTx & FTTH networks deployment, especially available in urban and suburban areas
- Being used by mobile operators to support their LTE mobile backhaul; these include for example Verizon in the USA and TeliaSonera in Sweden and Norway
- It is also widely deployed by China Mobile, with 95% of its cell sites being fibre-fed

Figure 23: FTTH network adapted for LTE backhaul



Source: Ericsson

Description

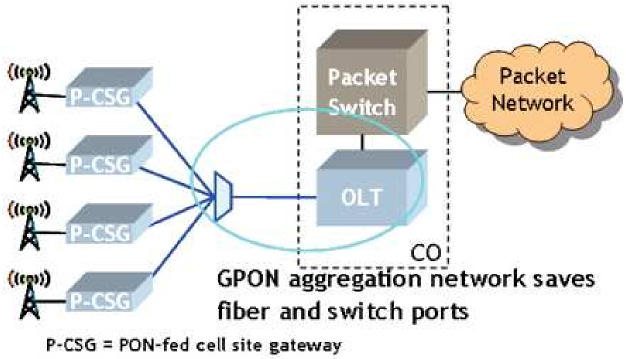
Optical fibre plays a key role in mobile backhaul. Operators (especially in Asia) used to deploy Sonet/SDH in order to support 2G voice and early 3G services. Basically, SDH equipment aggregates traffic from TDM-based equipment in cell towers and feeds it over optical fibres into the core network.

Today, however, optical fibre needs to be upgraded to support packet-based connections. Of special interest now is the use of the currently deployed FTTH network to transport packet data from cell sites to the core network.

Indeed, given the high potential of capacity that can be handled by optical fibre, using FTTH appears to be one of the best technical solutions for mobile backhaul.

Various Fibre technologies are available, such as GPON, EPON and Point-to-Point. Today operators are tending to choose GPON as it is the configuration delivering higher bandwidth.

Figure 24: GPON as mobile backhaul



Source: Alcatel-Lucent

Depending on the topology of the network, OLT (equipment traditionally on network side) plays the role of Aggregate gateway while ONT (on premise side) is used as the Cell gateway directly linked to the base stations or eNodeBs.

Capacity

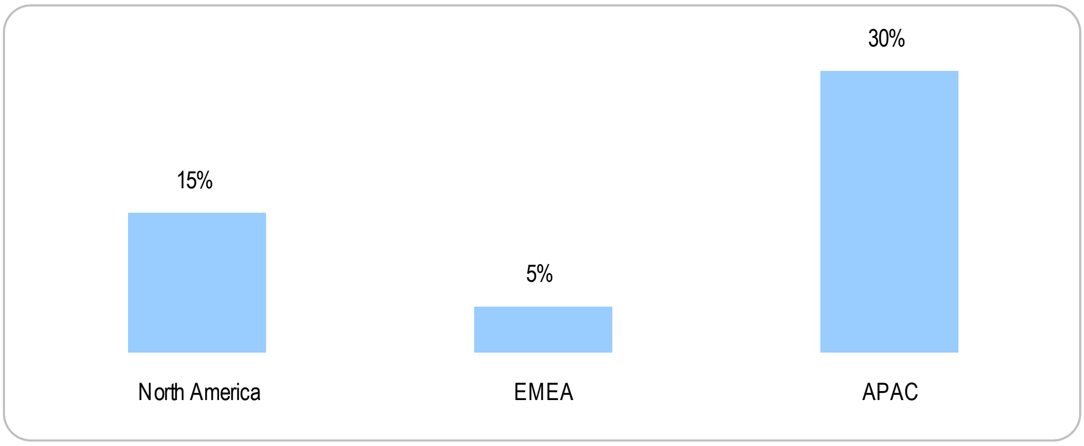
- Capacity is virtually unlimited, with 10G GPON today providing up to 10 Gbps downstream and 2.5 Gbps downstream
- In reality, operators are using a capacity link of 100-150 Mbps per site
- Suited for urban and suburban areas, where infrastructure is already deployed for residential service
- GPON uses 8 kHz clock PRC protocols

Maturity

FTTx & FTTH networks are currently deployed by significant carriers such as AT&T, Verizon, Cox and TeliaSonera for their LTE network backhaul.

In Asia, the majority of cell sites are fibre-fed in metropolitan areas in China, Japan and Korea. Indeed NTT DoCoMo and China Mobile are deploying fibre massively to backhaul their sites.

Figure 25: Relative weight of fibre among backhaul support technologies in 2010



Source: IDATE

Costs

There is no upselling investment in the case of reusing existing infrastructure

In the case of non-existing infrastructure, strong up-front investment is required, given the high volumes of fibre to be laid, and the network could be long to implement

High capex due to the public works required (for trenching) and with fibre costs increasing linearly by the metre.

But there's a rationale in sharing capex spending deploying FTTH for final access and backhaul at the same time.

4. APAC Case studies

4.1. Australia

Key figures at end 2011		
Number of Households		8 558 400
Population		21 766 711
Number of subscribers		**% in total HH**
FTTH/B	37 000	0.43%
		% in the population
3G	18 002 000	83%
LTE	100 000	0.5%

Source: IDATE

4.1.1. Telstra

Telstra is Australia's former fixed line monopoly operator. The Telstra Broadband and Media unit was established in 2003 and is the main broadband provider in Australia with more than 50% of market share.

Table 5: Key Telstra Figures at end 2011

Key figures at end 2011	
FTTx figures	
FTTH subscribers	23 000
FTTH Homes passed	26 500
FTTLA subscribers	na
FTTLA Homes passed	1 000 000
Mobile subscribers	
3G subscribers	8 275 000
LTE subscribers	100 000

Source: IDATE

Telco key markets

FTTx:

Telstra started its FTTH test in 2004 targeting greenfields areas. The operator also upgraded its cable infrastructure to DOCSIS 3.0.

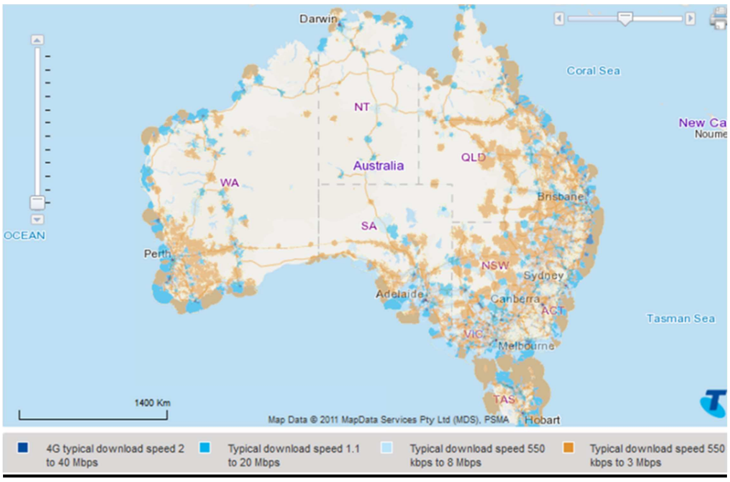
Then in May 2010, it launched a FTTH trial in Point Cook, the first roll out of fibre optic broadband in an existing estate. But during the summer 2011, it signed a deal with the Australian government in order to participate in the government plan. Indeed, Telstra will allow NBN Co access to its infrastructure and it will migrate its voice and broadband traffic from its copper and cable networks to the NBN Company's network.

Mobile Broadband and LTE strategies:

2G and 3G:

Telstra is deploying 2G and 3G network across the country. Currently, the mobile broadband networks are located in big cities.

Figure 26: Mobile Broadband coverage



Source: Telstra

LTE

Telstra is trialling LTE in hotspots in Australia, more precisely, in urban areas in May 2010. Telstra and Huawei are trialling LTE technology in Victoria.

In February 2011, the operator announced its willingness to deploy LTE technology in in the central business districts of all Australian capital cities and selected regional centres by end of this year. Under this plan, it aims to propose dual mode LTE/HSPA+ mobile broadband devices.

Then the LTE mobile network launching occurred in September 2011 using the 1800 MHz band. The customers firstly concerned were located all eight state capitals and 30 regional centres across Australia. Indeed, it has switched on its first LTE-enabled base stations, activating equipment at sites in Sydney, Melbourne, Perth and Brisbane. This is the first test call on an integrated network using the 1800MHz spectrum.

After these successful trials, Telstra decided in April 2012 to deploy its LTE network in a number of new suburbs in Newcastle over the next few months.

As of today, the Australian actor provides LTE services in more than 100 regional and metropolitan centres across Australia, including central business districts in eight major cities

On the LTE services side, Telstra used the 1800 MHz and 2600 MHz for trial but it thinks that the 700 MHz seems to be better to provide 4G services.

The 4G services launching started very recently, in September 2011 and first LTE smartphone HTC Velocity 4G were marketed in January 2012. Two months later, first LTE mobile Wi-Fi device were available.

Mobile Broadband traffic

Mobile Performances:

3G: Maximum downlink: 20 Mbps

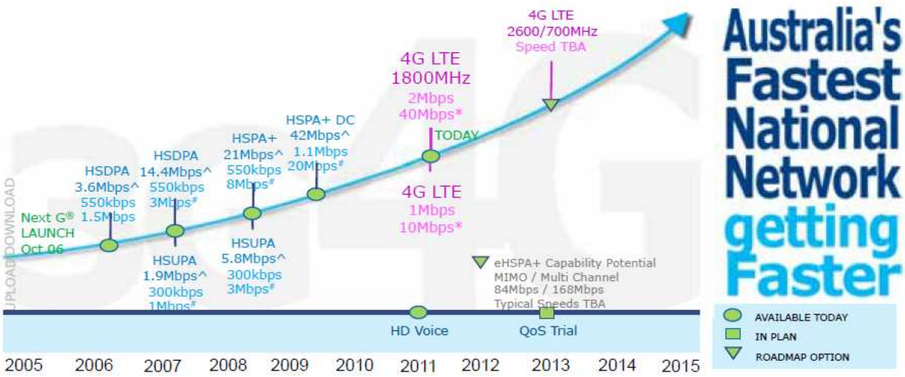
LTE: Maximum downlink: 40 Mbps/uplink: 10 Mbps

Telstra made several LTE tests in June 2010 with NSN. As a result, the operator showed that average speeds are 88.1 Mbps for downlink and 29.6 Mbps for uplink

The Australian operator is involved in the mobile broadband market since October 2006 with the launch of its HSDPA network with maximum speeds of 3.6 Mbps. Then it has implemented a plan in order to be able to provide an increasing speed. It expects to offer very high speeds through its LTE network deployed in the 2600/700 MHz.

So if we compare the capacity and the performance from the beginning of its mobile broadband involvement to today, the maximum speeds increased from 3.6 Mbps to 40 Mbps.

Figure 27: Telstra's Capacity and performance plan



Source: Telstra

Backhaul strategy

Telstra is deploying fibre-based backhaul to meet LTE requirements. The increasing investment made by Telstra in fibre for the FTTH network will provide backhaul to mobile networks.

Today Telstra believes that LTE will clearly work alongside NBN in order to carry the large amounts of expected traffic. In the long term, Telstra envisages a seamless connection with home and mobile devices.

LTE equipment providers

Several Providers have contracted an agreement with Telstra. Regarding core network, Nokia Siemens Networks has been selected. Radio Access Network is provided by Ericsson, Huawei and Nokia Siemens Networks. And Sierra Wireless is developing the dual mode mobile broadband devices.

FTTH for Backhaul

The increasing investment made by Telstra in fibre for the FTTH network will provide backhaul to mobile networks.

4.1.2. Vodafone Hutchinson Australia

Vodafone Hutchinson Australia is a mobile telecommunications operator. It is a joint venture founded in Jun 2009 and owned by Hutchinson Telecommunications Australia and by Vodafone Group.

Table 6: Key VHA figures at end 2011

Key figures at end 2011	
FTTx figures	
No FTTx involvement	
Mobile subscribers	
3G subscribers	3 487 000
LTE subscribers	0

Telco key markets

FTTx:

VHA is a purely mobile operator. So it is not involved in the FTTx market and more generally in the fixed sector.

Mobile Broadband and LTE strategies:

2G and 3G:

Initially, Vodafone operated on the 2G and 3G networks as a single network in the 2100/900 MHZ. And next to this network, it has the Three network. But after the joint venture creation, the 2G network was available for Three customers in areas that had limited 3G coverage.

Then the objective is to consolidate the two kinds of networks in order to be able to compete with main competitor Telstra. So VHA decided to expand the UTS 900/2100 MHz coverage in 900 metropolitan sites and 500 other sites in the country. It wanted also to extend the 3GIS network and the 1400 UMTS-850 base stations - 850 MHz.

Currently, it is deploying its new 850 MHz network for 3G representing now two thirds complete including 1,000 sites for 850MHz.

Indeed, the operator has contracted with Huawei to replace base station equipment at 5,800 sites installing SingleRAN base stations and radio network controllers. This method will deliver 2G, 3G and 4G services from a single base station with theoretical downlink speeds of up to 42Mbps.

Figure 28: Mobile Broadband Plan

Source: VHA

LTE

On the 4G side, its plan is to move its 3G network to LTE.

VHA started to be involved in the LTE rollout in October 2010 through a pilot initiated near Newcastle, north of Sydney, using 10MHz of spectrum in the 1800MHz band. The vendor partner for this LTE trial was Huawei. As a result, maximum downlink speeds of 74.3Mbps were achieved averaging an uplink throughput of 5.6Mbps. The first LTE services should be launched end 2011.

In October 2011, the operator has increased its 1800 MHz mobile broadband spectrum in which it expects to deploy LTE services. In the same time, it announced that it expects to rollout Huawei-supplied radio network controllers in Sydney Brisbane, Adelaide and Perth with the final objective to implement LTE services. Indeed, several months later VHA confirmed that it wants to provide "4G like speeds using HSPA". So it is the main reason why, currently, VHA is focussed on the HSPA extension. As a result, it would be able to provide speeds from 21 Mbps to 42 Mbps using HSPA+.

In February 2012, the Australian joint venture concluded an agreement with rail authorities in New South Wales, Victoria and South Australia in order to secure 1800 MHz spectrum allocation. As a result, it used blocks of 22.5MHz of spectrum in Adelaide, 17.5MHz in Melbourne and 12.5MHz in Sydney. But the 1800 MHz spectrum allocations will expire between 2013 and 2015.

As of mid-2012, no LTE network launched massively. Indeed, the operator prefers to concentrate its efforts on the HSPA side.

Mobile Broadband traffic

Mobile Performances:

3G: Maximum downlink: 20 Mbps

LTE: Maximum downlink: 74.3 Mbps/uplink: 5.6 Mbps

The maximum speeds of 74.3Mbps occurred during a LTE test. This amount represents a very big difference compared to the 3G speeds. But, VHA has not really implemented its LTE network and it has not launched any LTE services. Indeed, it prefers to extend its HSPA network. So the only available mobile performances which we can observe are provided through initial networks.

Backhaul strategy

The plan of VHA is to implement LTE network moving 3G to 4G. Indeed, it is updating 5800 2G base stations with 3G equipment that can eventually be upgraded to LTE.

The operator has selected Huawei in order to work on over 2200 new VHA base stations by the end of 2012. Initially, base stations are linked with Microwave. But, once the LTE project launched, fibre will be used.

But as of May 2012, no massive LTE network rollout

LTE equipment providers

Huawei is the main partner selected for the 4G LTE project

FTTH for Backhaul

NBN Co FTTP network should be used for mobile towers

4.1.3. Optus

Optus is a wholly owned Singapore Telecom (SingTel).

The operator is involved in both fixed and mobile sectors. More precisely, Singtel Optus (Optus) operates in the wireless market through its subsidiary named Optus Mobile.

Table 7: Key Optus figures at end 2011

Key figures at end 2011	
FTTx figures	
FTTLA subscribers	na
FTTLA Homes passed	na
Mobile subscribers	
3G subscribers	6 240 000
LTE subscribers	0

Telco key markets

FTTx:

Optus is upgrading its HFC cable network to DOCSIS 3.0 network in Brisbane, Melbourne and Sydney where its Supersonic broadband services are available. But, it has concluded an agreement with NBN Co to be one of its retail services providers on the NBN Co network.

In this same line, during the summer 2011, the operator announced its new agreement with NBN which consist in migrating around 500,000 hybrid fibre-coaxial customers to the NBN infrastructure. Under this agreement, Optus will receive a total of 800 million AUD. This migration project should begin in 2014. And it is expected that this process take up to four years to be completed across Optus' entire HFC footprint. Optus will continue to provide its services over its own cable network until the complete migration.

Mobile Broadband and LTE strategies:

2G and 3G:

Optus was involved in the 3G network rollout in 2001. Three years later, it signed an agreement with VHA in order to share network. As a result, they build a common W-CDMA network in Sydney, Melbourne and Canberra. The following year, 3G services were extended to the central business districts of Adelaide and Perth and some surrounding areas.

Then, the operator announced in 2007 its willingness to deploy a new 3G network replacing its 2G coverage in 2100 MHz. After several different objectives announced with the new 3G network rollout evolution, it decided to fix its goal to 98% of the population by mid-2008. It planned to install a further 750 base stations operating on the 900MHz band nationwide. This new plan included also to increase theoretical downlink speeds to 28Mbps by mid-2010.

In the speed increasing line, the operator concluded a deal with Qualcomm to acquire 10MHz of 2100MHz spectrum in order to meet the data services demand. Then, in July 2010, it obtained further spectrum in the 2100 MHz band in order to cover 972 sites among which Bendigo in Victoria; Bundaberg, Hervey Bay and Port Macquarie in New South Wales.

LTE

Optus announced in November 2009 its willingness to deploy a LTE pilot in Australia in the 2100MHz band. We can note that the group wants also rollout a LTE trial in Indonesia, the

Philippines and Singapore. The trial started a few months later with NSN. As a result, the LTE trial succeeded in July 2010 with peak downlink rates of 50Mbps in Gordon and Pymble.

Then the second phase of the LTE trials started in December 2010 in Sydney in the 1800 MHz band.

Initially, Optus expected to deploy LTE network in October 2011 and to provide 4G services in Newcastle, Port Stephens, the Hunter Valley and Lake Macquarie areas in April 2012.

Indeed, in September 2011, it obtained the licence to trial LTE services in the 700 MHz spectrum band in Bendigo, Victoria. This trial was also succeeded in November 2011 with Huawei as vendor.

Then, it acquired local WiMax operator Vividwireless in February 2012 in order to build-out a metropolitan 4G network based on TD-LTE technology in the 2.3 GHz band.

Second LTE network was launched using the 1800 MHz band in April 2012 offering free services and devices to select customers in greater Newcastle, Maitland, Port Stephens and areas in the Hunter Valley. The LTE offers will be available to 1 000 business and residential customers for free with the only condition to get their feedback. The aim of this project is to optimize the LTE rollout which will be deployed in large metropolitan areas of Sydney, Melbourne and Perth from mid-2012. Then, the operator expects to extend its network to Brisbane and Adelaide from 2013.

In May 2012, Vodafone Hutchison Australia (VHA) and Optus are set to expand their network joint venture. The two operators want to provide improved 3G and 4G in Australia. But as of today, it is only a project because it required to be approved by Authorities.

Mobile Broadband traffic

Mobile Performances:

3G: maximum data is 7.2 Mbps

LTE: maximum downlink speeds: 70 Mbps and uplink speeds: 32 Mbps

The maximum LTE speeds occurred during trials. Nevertheless, the LTE marketing would start in April 2012. So no information is as of today available regarding speeds available.

Backhaul strategy

Optus backhaul LTE strategy is focused on implementing trial in different spectrum band. The first LTE trial was conduct in July 2010 with a peak downlink rate of 50 Mbps in Gordon and Pymble. Several trials were then deployed and LTE marketing began in April 2012.

Regarding the architecture strategy retained, the operator prefers to use fibre backhaul. Indeed, over 80% of its sites in metro are connected to fibre at end 2011.

LTE equipment providers

The main vendor chosen by Optus are NSN and Huawei.

FTTH for Backhaul

As the NBN intends to deploy a FTTP network, this architecture could be used for LTE.

But as of today, no announcement was made by the operator regarding FTTH to be used for backhauling.

4.2. China

Key figures at end 2011			
Number of Households			393 019 573
Population			1 336 718 015
Number of subscribers		**% in total HH**	
FTTH/B	21 300 000		5.42%
FTTx+LAN	124 500 000		31.68%
		% in the population	
3G	127 521 000		10%
LTE	0		0.0%

Source: IDATE

4.2.1. China Mobile

China Mobile was created in 1997 and merged with China TieTong in 2009. China Mobile is a Chinese state-owned telecommunications company providing mobile voice and multimedia services through its nationwide mobile telecommunications network.

Table 8: Key China Mobile figures at end 2011

Key figures at end 2011	
FTTx figures	
FTTH/B subcribers	300 000
FTTH/B Homes passed	5 000 000
FTTLx+LAN subscribers	3 000 000
FTTLx+LAN Homes passed	na
Mobile subscribers	
3G subscribers	51 212 000
LTE subscribers	0

Source: IDATE

Telco key markets

FTTx:

China Mobile is involved in the FTTx market since 2008-2009. Firstly, the operator decided to deploy FTTx trial in the provinces of Jiangsu and Guangdong. Then it decided to extend its FTTx coverage to all the country.

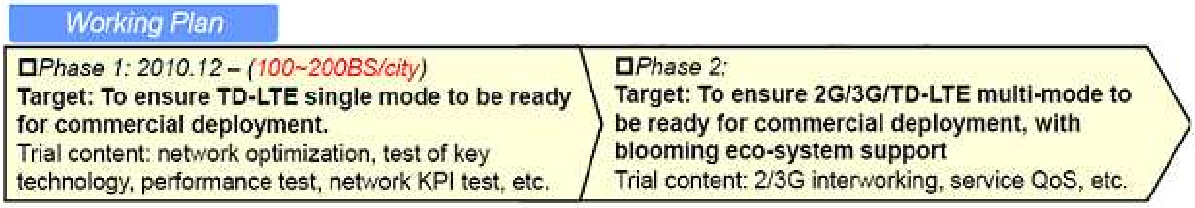
In July 2009, Alcatel Lucent was chosen Alcatel Lucent for the FTTH deployment in 10 cities across the provinces of Guangdong and Anhui. In the same time, China Mobile has starting to roll out its own FTTH-based network in 20 provinces.

One year later, Alcatel Lucent is one more time selected to deploy its FTTH/B network based on GPON across 14 provinces.

Next to the FTTH/B architecture deployment, China Mobile is also involved in the FTTx+LAN rollout.

Mobile Broadband and LTE strategies:

Figure 29: Mobile Broadband plan of China Mobile



2G and 3G:

China Mobile is operating in both 2G and 3G market in China. More precisely, it operates in a 2G network based on the GSM standard and a 3G platform based on TD-SCDMA.

Before to deploy a national 3G network, it rolled out a pilot network with 14,300 base stations. This trial was achieved at end of 2007. And the following year, in April, China Mobile decided to implement commercial trials in Beijing, Shanghai, Tianjin, Shenyang, Guangzhou, Shenzhen, Xiamen and Qinhuangdao. Over 20 000 residential customers were chosen to benefit to TD-SCDMA handsets for free. Those services has been also marketed for a further 40 000 users but with discounted fees. China mobile 3G services test has been a success. As a result, it obtained its TD-SCDMA network licence in January 2009.

The operator has acquired a total of 40MHz of spectrum among which the 900 MHz band is used for transmission and 1800 MHz for reception. And regarding 3G services, the operator used the 35 MHz spectrum and the 50 MHz.

China Mobile is operating a TD-SCDMA network (3G) which can be upgraded seamlessly to support TD-LTE.

LTE

China Mobile announced in 2008 that it wanted to roll out LTE with FDD and TD-LTE.

Indeed, three experimental TD-LTE networks in Qingdao, Xiamen and Zhuhai were established during the second half of 2010. Initially, it planned to launch its commercial services in 2012 even if the Minister of Industry says commercial LTE will not roll out on any wide scale until 2014.

Nevertheless, after different succeeded pilots to test interoperability began in January 2010, China Mobile and Alcatel Lucent start to deploy the LTE pilot in Shanghai during the spring 2011. This network was then extended to 6 big cities including Shanghai, Hangzhou, Nanjing, Guangzhou, Shenzhen and Xiamen. LTE trials were made in the 2.3 GHz and 2.6 GHz band.

The next phase of the LTE plan is to extend the test to nine cities including Beijing, Tianjin and Qingdao during 2012. So to meet its objectives, the operator is working closely with key TD-LTE operators within the Global TD-LTE Initiative.

As a result, in September 2011, China Mobile and Clearwire announced their willingness to collaborate to speed up the development of TD-LTE devices. And the two operators launched test specifications and joint interoperability testing for TDD-LTE devices in 2.3 and 2.7 GHz band.

More recently, China Mobile launched its 4G offers with Nokia Siemens Network in Hong Kong with expected peak download/upload speeds of up to 100Mbps/35Mbps.

Figure 30: LTE plan for China Mobile

Source: China Mobile

Mobile Broadband traffic

Mobile Performances:

3G: downlink speed of 2.8Mbps

LTE: Downlink peak rate of over 80 Mbps in test in a 20 MHz band. But China Mobile announced 100 Mbps for DL and 35 Mbps for UL.

Backhaul strategy

China Mobile has firstly deployed a TD-CDMA backhaul network which it reuses now for its TD-LTE network. Moreover, it has selected fibre for its cell sites connection. As a result, 96% of its bases stations are linked with fibre.

We can note that its 4G services marketing will need to rely on fibre to handle the amount of traffic and to upgrade its legacy fibre-based backhaul.

LTE equipment providers

China Mobile has selected several vendors to deploy its LTE network. ZTE was in charge of an IP multimedia subsystem core network deployment in China. Then three partners have been selected to deploy trial TD-LTE in 2010 for the Shanghai exposition including ZTE, Motorola and Alcatel-Lucent.

The following year, Alcatel-Lucent was chosen to deploy end-to-end LTE solution for LTE trials in Shanghai, Hangzhou, Nanjing, Shenzhen, Xiamen and Beijing. Regarding these trials, Nokia Siemens Network and Huawei are the two others equipment providers.

FTTH for Backhaul

China Mobile is involved in the FTTH rollout but only in the fixed market. So the backhaul upgrading with FTTH can be envisaged. But no announcement has been made as ofmid-2012.

4.3. Japan

Key figures at end 2011		
Number of Households	52 366 499	
Population	127 469 543	
Number of subscribers		**% in total HH**
FTTH/B	22 045 000	42.10%
		% in the population
3G	122 078 000	96%
LTE	727 000	0.6%

Source: IDATE

4.3.1. Softbank

Softbank Mobile is a mobile operator founded in 1981. Initially, the company was a Vodafone subsidiary. But in March 2006, Vodafone Group sold Softbank Mobile which is now owned by Softbank Corp. The initial objective of Softbank is to become a real competitor to NTT Docomo and KDDI thanks to big investments.

Table 9: Key Softbank figures at end 2011

Key figures at end 2011	
FTTx figures	
No FTTx involvement	
Mobile subscribers	
3G subscribers	27 835 300
LTE subscribers	0

Telco key markets

FTTx:

Softbank is only a mobile operator and it is not involved in the fixed broadband market.

Mobile Broadband and LTE strategies:

2G and 3G:

Even if Softbank was initially involved in the 2G market through its initial parent group, it changed its mobile strategy in March 2008. Indeed, its new mobile strategy is to migrate to 3G and to stop progressively to provide 2G mobile services. This method is in part due to the decreasing of the 2G subscribers. As a result, it is massively rolling out 3G base stations with the backhaul solution from Alcatel-Lucent since 2008.

LTE

Softbank obtained a licence of experimental wireless station for a wideband mobile wireless access technology in the beginning of 2009. And the following year, it acquired Willcom which owned the 2.5 GHz band spectrum. To Softbank is a strategic acquisition because it wants to launch a 4G service using the Advanced XGP standard which is a derivative of the old Willcom PHS (Personal Handyphone Service) network and is highly compatible with TD-LTE.

The LTE network will be built in the 900 MHz frequency band. The objective announced in November 2011 is to deploy 12,000 base stations in 2012. Then it plans to install a total of 30 000 units by end 2013. The LTE network began to be rolled out in February 2012 with its services marketed under the brand name "Softbank 4G". The LTE project should represent a total investment of JPY 100 billion (~1.03 billion EUR). First areas concerned are the main big cities including Tokyo, Osaka and Nagoya.

As a result, it announced in May 2012 to have attract 30 000 LTE subscribers. The next step is to increase its LTE subscriber base and to reach 1 million LTE customers by end of 2012 and to cover 90% of Japanese population by end 2013.

Mobile Broadband traffic

Mobile Performances:

3G: Maximum download is 7 Mbps

LTE: Maximum download is 76 Mbps with a maximum Upload is 10 Mbps. The average rate is over 20-30 Mbps.

Softbank expects to be able to provide 110 Mbps via its LTE network soon.

Backhaul strategy

Softbank's backhaul strategy is based on very high speed network reusing. Indeed, its base stations are connected to its core network via optical fibre network. If no fibre link is available, the operator uses ADSL for backhaul. And where area is victim to an earthquake, the satellite is a temporary solution for its backhaul.

LTE equipment providers

Several equipment providers have been selected by Softbank to build its LTE network and to meet its LTE objectives.

Alcatel-Lucent is the Core Network provider. Huawei, ZTE and Ericsson have been chosen to be the Radio Access Network providers. More recently, in April 2012, Softbank has selected Nokia Siemens Network to deploy its Flexi Multiradio Base station for both FDD LTE network and HSPA+ network expansion.

FTTH for Backhaul

No FTTH item has been announced by Softbank regarding its LTE project.

4.3.2. NTT

NTT, the Japanese Incumbent, is the largest broadband provider in the country. The company is partially owned by the government.

NTT is devised in several subsidiaries depending on the market.

Figure 31: NTT structure

Source: NTT

Table 10: Key NTT figures at end 2011

Key figures at end 2011	
FTTx figures	
FTTH/B subcribers	16 310 000
FTTH/B Homes passed	na
Mobile subscribers	
3G subscribers	523 000
LTE subscribers	1 139 000

Source: IDATE

Telco key markets

FTTx:

NTT was the first actor to implement FTTH in Japan in 1999. But it was also one the first to deploy FTTH network in Asia and more generally in Europe. The FTTx project from NTT targets residential and business users.

Most fibre deployments in the last drop part are aerial except for MDUs.

As of end 2011, it has 16.31 million FTTH subscribers and it should reach 18.014 million FTTH subscribers by March 2013. Indeed, it reviewed its initial target which was to reach 20 million FTTH subscribers by FY2010 (March 2011).

Regarding its FTTH services, NTT plans to achieve the profitability in 2012, more than 10 years after beginning its fibre deployment.

Figure 32: Fixed subscribers evolution for NTT

Source: NTT

Mobile Broadband and LTE strategies:

2G and 3G:

NTT was involved in the mobile market in 1987 through its subsidiary named Docomo with the launch of its analogue network. Then, the operator replaced this network by the 2G.

NTT launch its first 3G services in October 2001 under the brand name FOMA and the 3G networks covers now nearly the entire country. In August 2006, it started to deploy its new High Speed Download Packet Access (HSDPA) network marketing its first HSDPA-compatible handset. Initial areas concerned by this project were Central Tokyo and other major cities.

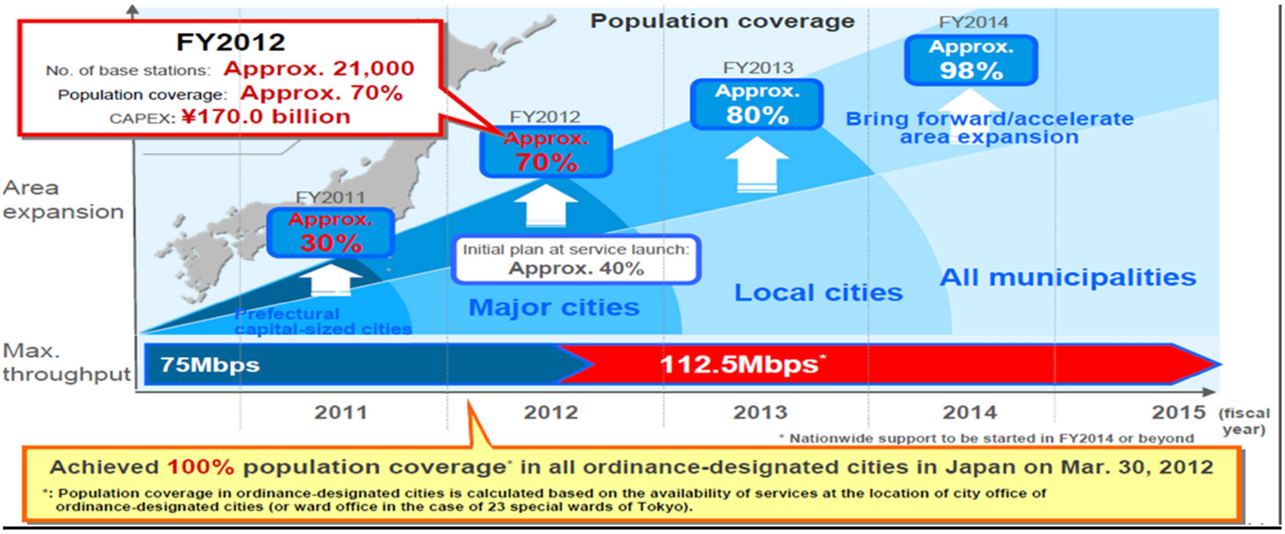
LTE

First NTT's LTE commercial service was launched in December 2010. And two months later, while it was pre-licensed by Japan's government it began to test a new data communications technology LTE-Advanced. As a result, it achieved speeds of 600 Mbps in downlink and 200 Mbps in uplink by applying 2x2 single-user MIMO technique.

Then, it invested in LTE Antenna Developer during spring 2011.

The NTT's LTE project is part of its larger project named “Shaping a Smart Life” which consists in offering innovative services and content in an open environment by FY 2015. More precisely, NTT plans to implement its LTE network across the country covering 80% of the population by FY 2013 (March 2014) and 98% by FY 2014 (March 2015). The LTE deployment started to be rolled out in prefectural and capital-sized cities. Then in a second phase the network was extended to major cities. And step by step, the Japanese operator aims to cover the entire country.

Figure 33: LTE rollout project of NTT



Source: NTT

The LTE plan has also a part including subscribers' objectives. Indeed, NTT aims to reach 30 million Xi customers by FY 2015. Xi is the brand name for LTE services. Like in the LTE coverage plan, the LTE subscribers plan is divided in several phases with an exponential growth.

As a result, while the LTE services were launched in December 2010, NTT reached 1 million Xi subscribers one year later and it had more than 2 million LTE subscribers in March 2012. The rapid growth is partially due to the introduction of the first Xi-compatible smartphones in November 2011. Currently, Xi customers are able to opt for a maximum downlink of 75 Mbps. The operator is continuing to introduce additional Xi-compatible smartphones, tablets and data-communication devices and mobile Wi-Fi routers. So the number of Xi subscribers should increase more and more achieving NTT LTE plan.

Figure 34: NTT's LTE subscribers' evolution (in million)

Source: NTT

Mobile Broadband traffic

Mobile Performances:

3G: maximum downlink is 128 Kbps/ uplink: 64 Kbps

LTE: maximum downlink is 37.5 Mbps (75 Mbps in some areas)/uplink is 12.5 Mbps

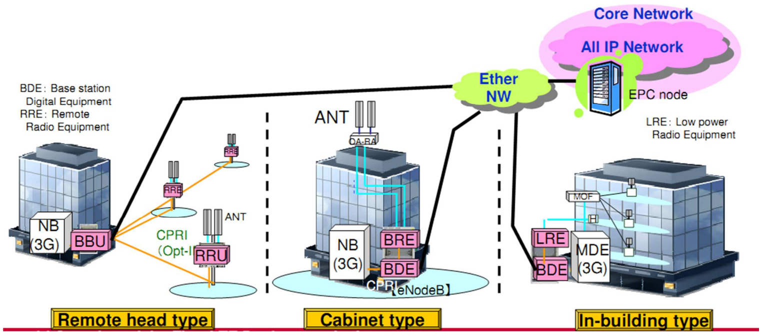
Backhaul strategy

In 2009, DoCoMo was considering building a separate backhaul infrastructure especially designed for LTE. That meant, at that time, that the operator did not expect to use existing facilities to transport its 2G and 3G traffic. In the end, for the LTE launch the new network was overlaid over existing 3G network. It has been installing LTE base station components on existing W-CDMA 3G base stations.

Base stations in the existing 3G network are thus already equipped with dual W-CDMA/LTE remote radio equipment which can be easily upgraded for LTE service with only the addition of LTE base station digital equipment.

In this way, DoCoMo is deploying a packet-based Ethernet backhaul using both fibre and microwave.

Besides backhaul, the operator is especially keen on deploying remote radio equipment as new base stations for the LTE network. DoCoMo invested heavily in deploying such equipment in order to be able to provide higher speeds and broad capacity.



Source: NTT

LTE equipment providers

Alcatel-Lucent and Nokia Siemens Networks have been selected to be the Core Network providers. And regarding the Radio Access Network providers, NTT has chosen Ericsson and Nokia Siemens Networks.

FTTH for Backhaul

NTT is rolling out its FTTH network used in the fixed market. But the architecture could be envisaged for the mobile backhaul.

4.3.3. KDDI

KDDI is a Japanese telecommunications operator on the market since October 2000.

Table 11: Key KDDI figures at end 2011

Key figures at end 2011	
FTTx figures	
FTTH/B subcribers	2 167 000
FTTH/B Homes passed	na
Mobile subscribers	
3G subscribers	32 481 000
LTE subscribers	0

Source: IDATE

Telco key markets

FTTx:

As of end 2011, KDDI is not the leader in the Japanese FTTH/B market but it is one of the ten main FTTH/B players in the world. Indeed, like its competitor it is a precursor in the Very High Speed Network with its first FTTH/B service launched in June 2006 under the brand name Hikari One. Currently its FTTH/B offers are available in Tokyo Metropolitan Area and seven prefectures in Japan’s Kanto region, in Miyagi Prefecture in the Tohoku region, in Hokkaido, in Ishikawa Prefecture in the Hokuriku region and more recently Niigata Prefecture.

Mobile Broadband and LTE strategies:

2G and 3G:

In November 2000, the KDDI's mobile firm named "au" was founded. It started to market its 2.5 G service using its 800 MHz in April 2002. And the following year, it launched its 3G CDMA2000 network. Then Hitachi was selected to provide 3.5G equipment and Motorola to deploy CDMA200 radio access network equipment in the 1900 MHz band. Airvana has been also selected to deliver its HubBub CDMA femtocell.

The operator wants to continue to use its CDMA200 network to provide voice communications.

LTE

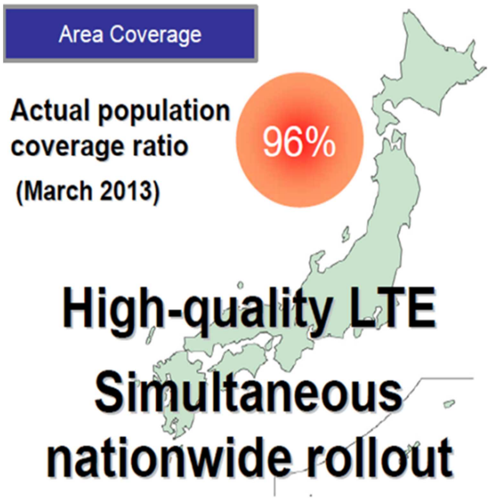
To build its LTE network, KDDI wants to overlay its CDMA mobile network to be able to provide very high speed connection to its customers. Its LTE project consists in covering 96.5% of the population from 30,000 base stations by March 2015. It plans to invest JPY 500 billion (~5.02 billion EUR) to meet its objectives.

It began to be involved in the LTE rollout mid-2010. Initial deployments were trials with the first which occurred in Nasu-Shiobara area in March-August 2010 and the LTE trial was extended to an urban environment with high density population in October 2010. To develop this network, KDDI uses its 1.5 GHz spectrum with the partner vendor named NEC. The 800 MHz band will be used for nationwide expansion. And the LTE service marketing is expected to be available by December 2012.

We can note that the Japanese operator doesn't want to rollout a unique technology to meet demand capacity. According to KDDI, mobile data traffic will grow 15-fold over the next five years, and the LTE network couldn't satisfy the demand. So, it intends to complete its LTE network with other technologies among which WIMAX and WIFI.

Regarding voice traffic, KDDI aims to integrate its LTE with its 2G/3G CDMA networks. In the same line, it aims to launch a 3G smartphone able to detect a WiMAX signal by mid-2012.

Figure 35: KDDI's LTE plan



Source: KDDI

Mobile Broadband traffic

Mobile Performances:

3G: -

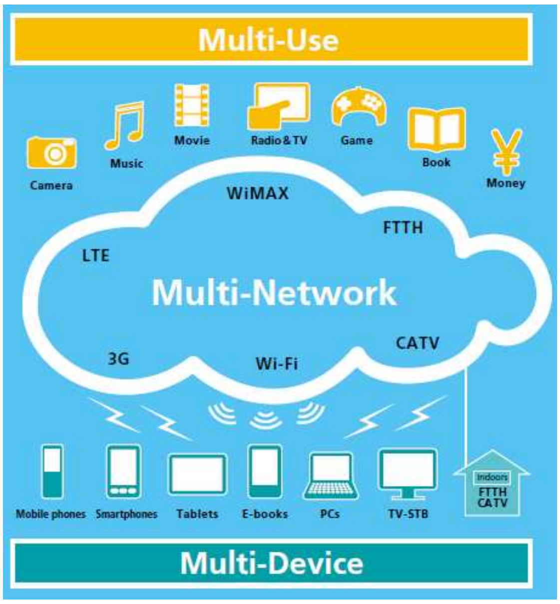
LTE: Maximum download speed is 75 Mbps

Backhaul strategy

The KDDI's LTE rollout started to be deployed in 2010 with trials deployment in a first phase.

The operator is using the "3M strategy" which consists in offloading data from mobile networks to the other networks that it operates, including WiMAX and fixed broadband.

Figure 36: 3M Strategy of KDDI



Source: KDDI

LTE equipment providers

KDDI has selected Hitachi which plans to work with Nortel as its partner in LTE development. NSN has provided the CDMA network, and is now supplying and deploying KDDI's LTE radio network. Samsung, NEC and Motorola will supply LTE network equipment. And on the Radio Access Network providers' side, KDDI has chosen Samsung, NEC Corporation and Motorola.

FTTH for Backhaul

KDDI is rolling out its FTTH/B network used in the fixed market. But through the 3M strategy of KDDI, more precisely the Multi-network item, FTTH could be envisaged for LTE.