Author: Tony Hill

Mobile Backhaul – The Next Telecoms Revolution

Foreword

Every once in a while the telecommunications industry experiences a technological and commercial revolution.

One such revolution took place in the mid 1990s when ISPs globally invested billions to satisfy the huge demand for dial-up access to the World-Wide Web. Another revolution took place in the late 1990s when ISPs deployed MPLS in their core networks to offer customers a plethora of new, more efficient and scalable VPN services. Widely available DSL was the next sea change within the industry. By the turn of the century, millions of business and domestic customers had upgraded their Internet connections from dial-up to DSL.

The development in recent years of next generation mobile hand-sets and applications has been the catalyst for what is widely regarded to be the next telecommunications revolution. Today's mobile users demand low cost, easy to access mobile broadband business and entertainment multimedia services that are of a similar quality to those offered by fixed-line operators.

Mobile operators had forecast an increase in demand for these bandwidth intensive services. However, the rapidity and extent of the growth in this demand has taken most of them by surprise.

Mobile operators must invest in new infrastructure as well as sweat their existing assets to satisfy this growth in world-wide demand for mobile broadband. The investment in first-mile mobile backhaul equipment alone is anticipated to increase from $4.6B in 2008 to $8.2B in 2010[1]. In addition to this spend on radio, microwave and packet-switching equipment there will also need to be investment in operations and business support systems and, of course, services to design and to build and deploy suitable backhaul solutions.

Mobile Data Services – The Demand

On June 16th 2009, the Government published the Digital Britain Report outlining its strategic vision for digital communications to underpin the nation's society and economy in the future. The conversion of existing radio and TV broadcasting from analogue to digital will free up transmission frequencies within the radio spectrum, some of which will be re-allocated to mobile operators to provide higher bandwidth mobile broadband services.

The report states:

"The exponential growth in mobile broadband services in the UK in the last 12-18 months has led to the possibility of Internet connection over relatively inexpensive devices such as pre-pay mobile. The Government's commitment to the earliest release of radio spectrum to support next generation wireless technology will further build the capability of this option for many people."

Mobile subscribers connect to the Internet via existing 3rd Generation (3G) mobile networks using their mobile handsets or by plugging a USB 'dongle' into their PCs or laptops. Mobile operators in

[1] Infonetics Research

the UK provided over two million new connections between February 2008 and February 2009[2] to satisfy the growth in subscriber demand for these mobile broadband services.

Figure-1 below shows current 3G services coverage across the UK for the Vodafone, Orange, O2, T-Mobile and 3 mobile networks.

Figure-1: Mobile Operator 3G Network Coverage in the UK

Author's note:
http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/broadband/cellular/3g/maps/3gmaps/

The mobile sector currently accounts for over 51% of the revenue that is generated with the UK's telecommunications market place. Approximately 92% of households in the UK have mobile subscribers and it is anticipated that more than half of all voice traffic will be based on mobile rather than fixed-line technologies by mid-2010[3]. It is inevitable that this continuation in the growth of mobile voice services will result in a corresponding growth in demand for mobile broadband services.

The number of mobile broadband subscribers grew world-wide by 125% between 2007 and 2008 to approximately 210 million. This number is expected to top the 1 billion mark by 2013[4] with the revenue from world-wide mobile broadband services alone expected to increase year-on-year from $49.8 billion in 2008.

[2] Source OFCOM – January 2009
[3] OFCOM Research
[4] Infonetics Research

Mobile Backhaul – The Background

The Third Generation Partnership Project (3GPP) formed in Denmark in 1998 to specify standards for the globalisation of mobile communications – the Universal Mobile Telecommunications System (UMTS). One of the principal aims of the 3GPP was to define the framework within which mobile operators could offer their subscribers higher bandwidth access to voice and other multimedia services. Better integration of the radio and packet-switched environments is seen as vital to achieve this aim. Work on the 3GPP standards and framework has been progressing steadily ever since.

The 3GPP introduced WCDMA in Release 99 (R99) networks as the radio access technology of choice to increase radio access speeds and to support higher numbers of subscribers. R99 and later 3GPP Releases specified that mobile networks should support the co-existence of the older Global System for Mobile (GSM) and newer UMTS architectures and the evolution of the former to the latter. These Releases also specified that IP/ATM rather than TDM should be the means of transporting voice and / or data traffic from the radio base stations in the field to the base station controller devices in the mobile network core.

Figure-2 shows the high-level architecture of a 3GPP R99 GSM/UMTS network.

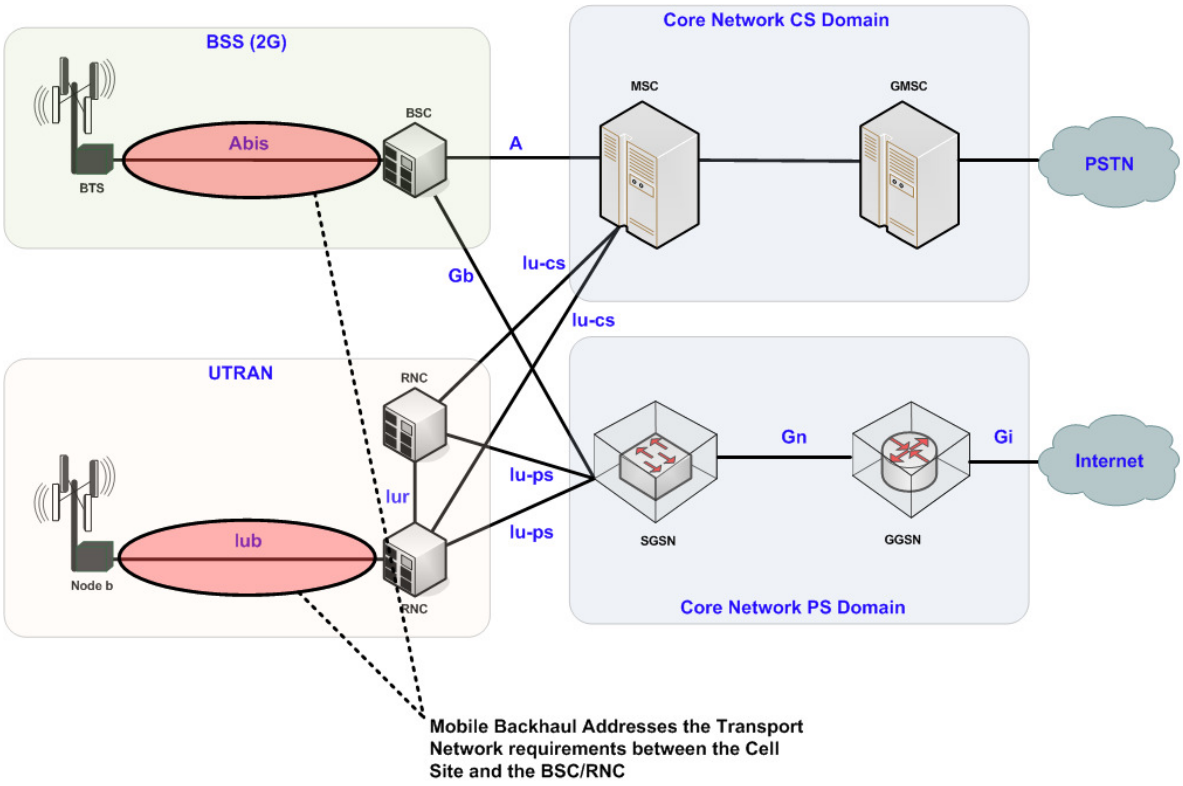

Figure-2: R99 GSM/UMTS Network Architecture

However, the majority of GSM base stations today are still connected to the Base Station Controllers using low-bandwidth E1/T1 TDM leased-line circuits and the UMTS Node B base stations are connected to the Radio Network Controllers using ATM over E1/T1 (IMA). These

native TDM and ATM over TDM leased-line connections are referred to as the mobile operators' "mobile backhaul" network.

Mobile Backhaul – The Case for Packet-Switching

The continued use of lease-line connections in mobile operators' backhaul networks poses enormous commercial and practical challenges to them. The cost of deploying and managing thousands of dedicated individual and aggregated leased-lines is not only prohibitive but also inefficient because any unused bandwidth that may exist in the network cannot be reclaimed and re-allocated dynamically.

The use of packet-switched connections in the mobile backhaul network addresses both of these issues. A packet-switched backhaul network is capable of providing much higher bandwidths with fewer infrastructure elements, and hence with much lower deployment and operational costs. It is also much more efficient because it consumes bandwidth dynamically on shared links only forwarding traffic over those links when it is necessary to do so.

Mobile Backhaul - Evolution

The case for packet-switched mobile backhaul networks is compelling and fits in very well with the 3GPP's plans for the future transport of all voice and data traffic between mobile network elements using native IP. This longer term goal of deploying IP in the Radio Access Network (RAN) is referred to as Long Term Evolution (LTE).

The Digital Britain Report states:
"The next revolution will be a technology that is able to achieve greater resilience at the edge of radio cells and work in much wider radio channels. The most likely such technology for national networks across Europe will be the Long Term Evolution (LTE) technology."

However, mobile operator networks today are extremely complex and consist of a variety of different types of technology and equipment from a multitude of different radio and packet-switching equipment vendors. In addition, the evolution to an all IP multimedia environment must support existing services during the migration of many thousands of legacy leased-line connections.

The majority of mobile operators are currently planning to phase the evolution of their backhaul networks as they progress towards LTE, as depicted in Figure-3:

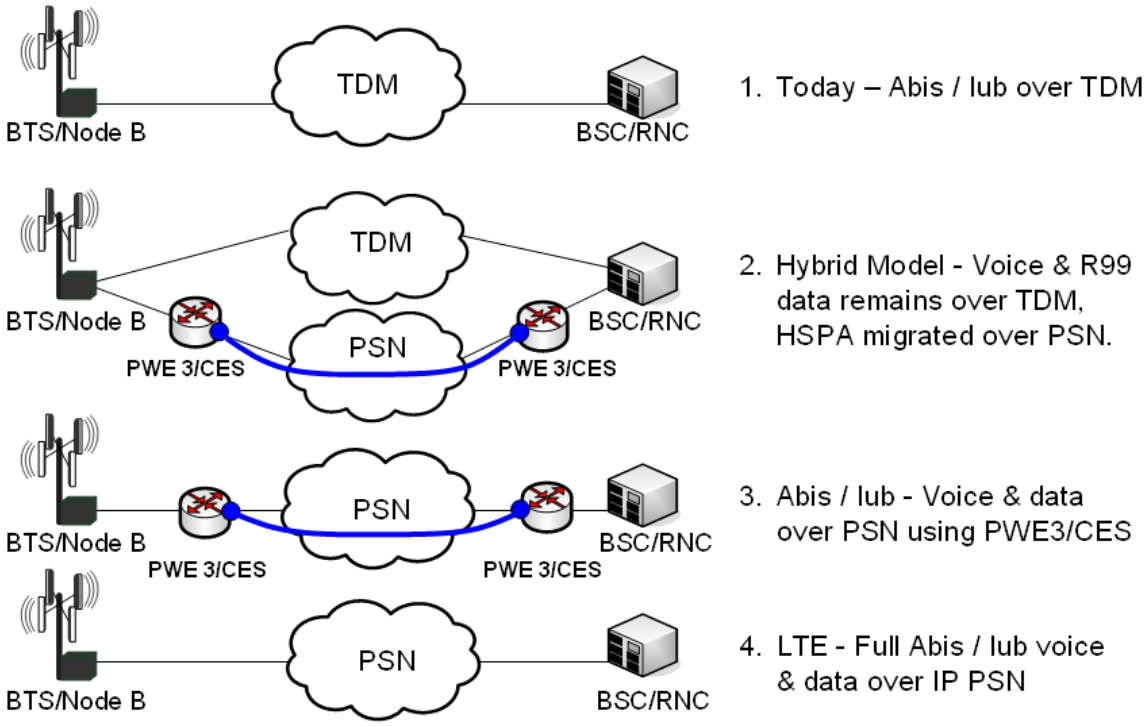

Figure-3: Evolution to LTE

The first step in the evolution is to continue to provide traditional mobile voice services across existing leased-line connections and to provide separate connections across a packet-switched network (PSN) for the data (mobile broadband) component of the services. The transport of this data component is referred to as High Speed Packet Access (HSPA).

HSPA entails connecting the data bearing leased-line connections at the base stations to intermediate routers and/or switches. The data is transported across an Ethernet and / or IP/MPLS PSN towards the Base Station Controllers / Radio Network Controllers using Layer 2 circuit emulation services (CES) and / or pseudo-wire end-to-end emulated (PWE3) connections.

The main advantages of this approach are:

- Offloading of the data component provides an immediate reduction in bandwidth consumption across the leased-line network infrastructure;
- The legacy leased-line environment continues to provide accurate frequency alignment between base stations when voice calls are hand-over from one base station to another.

Packet-switched connections are not subject to the same clock and frequency synchronisation constraints as voice calls. However, accurate synchronisation between base stations must be achieved across the PSN for successful migration of both voice and data services to a full packet-switched mobile backhaul solution that LTE mandates.

Mobile Backhaul - HSPA Architecture

So, of what will a mobile backhaul PSN consist and what will it look like? The answer is that it will consist of a myriad of technologies and connection types. Figure-4 shows a typical mix of base station to base station controller connections over a backhaul PSN:

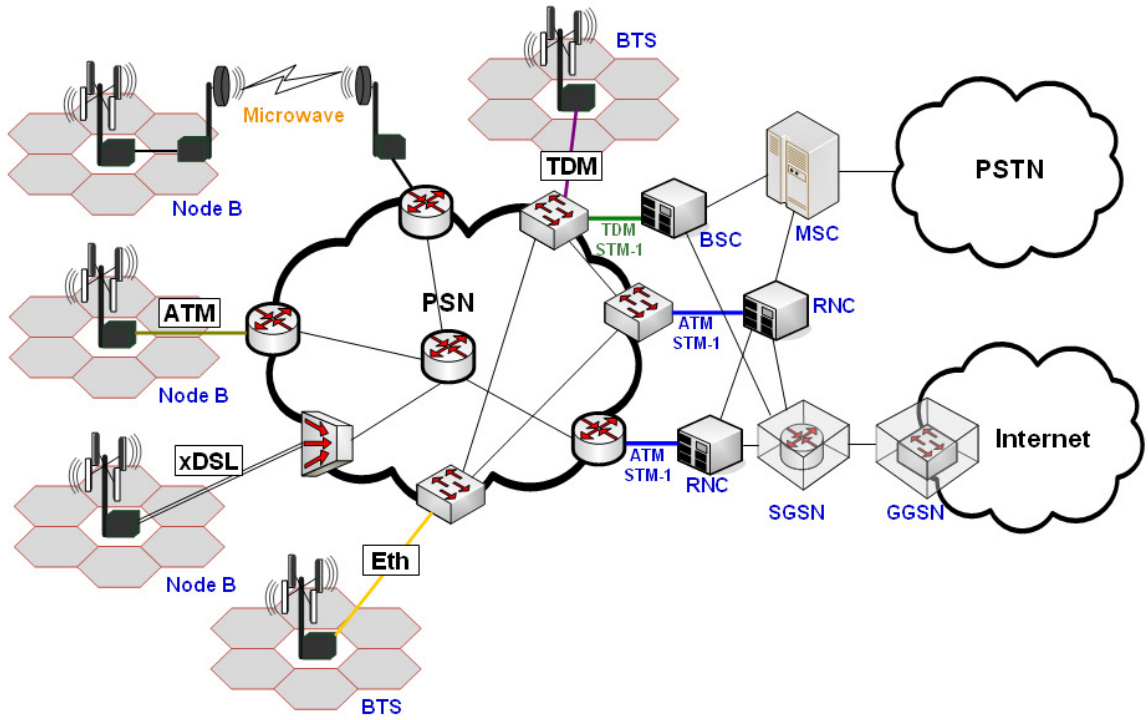

Figure-4: GSM/UMTS Mobile Backhaul PSN

Mobile Backhaul – Synchronisation (The Elephant in the Room)

When a mobile subscriber moves between the cells of one base station, or between the cells of different base stations, it is vital for the network to "know" within microsecond tolerances that the subscriber's connection has been handed over. Calls would be dropped if the base stations and their controllers were not able to track accurately the movements of subscribers and process call contexts during the hand-over between cells.

Accurate synchronisation of all mobile network elements to a single, reliable clock-source is fundamental to the successful operation of mobile networks. Figure-5 shows the tolerances within which GSM networks must align their Frequency Division Duplex (FDD) clocks, and UMTS/LTE networks must align their Time Division Duplex (TDD) clocks.

Providing this degree of frequency and phase alignment is extremely challenging for the deployment of packet-switched mobile networks.

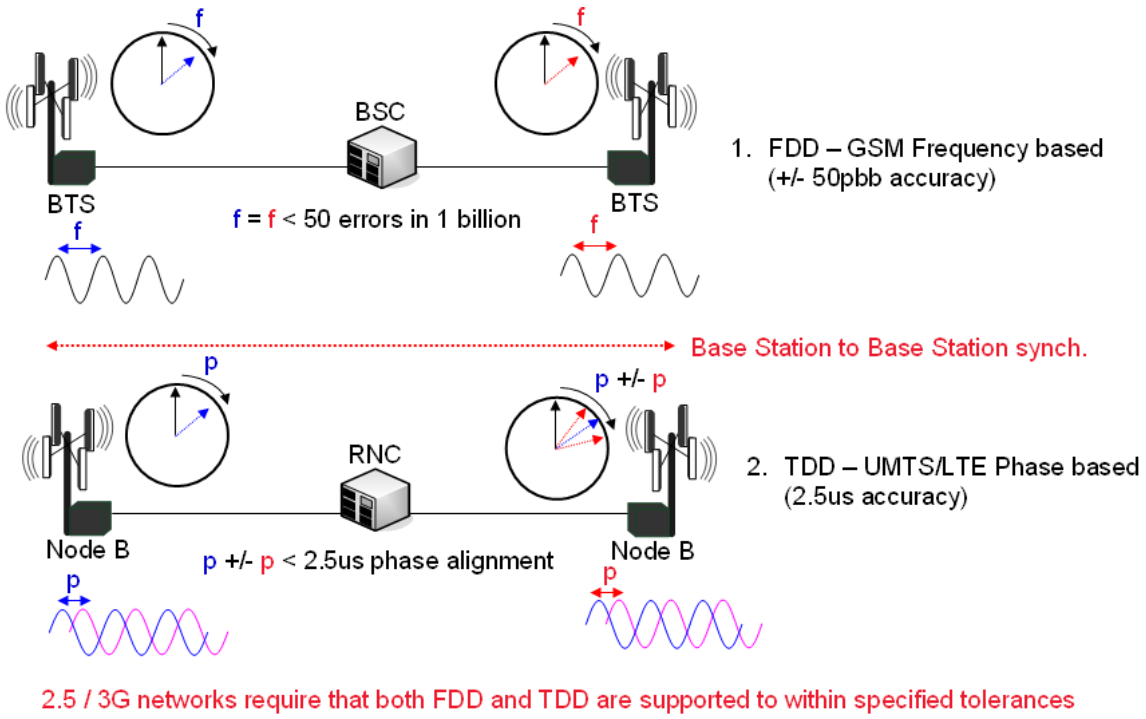

Figure-5: Frequency and Phase Alignment

For LTE, accurate synchronisation and time-of-day must be maintained on all network elements when voice and data services are migrated to, and transported across, the backhaul PSN. Mobile operators are currently considering a number of options for achieving this:

Synchronisation Method	FDD GSM (Frequency)	TDD UMTS (Phase)	Time of Day	Notes
GPS (NAVSTAR)	X	✓	✓	▪ Expensive ▪ Possible problematic reception indoors
IEEE-1588v2 (PTP)	X	✓	✓	▪ Requires network symmetry ▪ Hardware Assist ▪ Packet Delay Sensitive
Synch-Ethernet	✓	X	X	▪ Hardware support needed in adjacent network devices
TDM/SONET/SDH	✓	X	X	▪ Currently in use ▪ Use in conjunction with NTP / 1588v2 for Time of Day

Table-1: Synchronisation Options

None of the above options on its own satisfies all of the requirements for mixed GSM/UMTS environments. In practice, mobile operators will have to deploy network synchronisation solutions that consist of a combination of network time and timing mechanisms.

Mobile Backhaul - Summary

There is absolutely no doubt that mobile operators globally will make significant investments to upgrade their backhaul networks to packet-switched infrastructures to support the growth in

demand for mobile broadband. Doing nothing is not an option if a mobile operator wishes to retain its customers and remain competitive.

In the UK, the Digital Britain Report outlines the Government's vision of a minimum of 2Mbps broadband access to everyone by 2012:

"To ensure all can access and benefit from the network of today, we confirm our intention to deliver the Universal Service Broadband Commitment at 2Mbps by 2012. This can be delivered through upgrades to the existing copper and wireless networks."

A significant proportion of this access will need to be wireless broadband not only to cater for improved services on the move but also to allow access for those who do not live and work in urban areas.

The principal drivers for mobile operators to invest in mobile backhaul PSNs are:

- The explosion of wireless broadband services is already crippling existing leased-line based backhaul network infrastructures;
- Leased-line backhaul infrastructures suffer from the following drawbacks:
  - They are expensive to deploy, expand and maintain with a high Total Cost of Ownership;
  - They are not scalable to satisfy the anticipated future demand for mobile broadband access.

Mobile operators are looking at new and more cost effective technologies to replace existing, legacy E1/T1 ATM leased-line architectures. These include:

- Enhancements to Microwave;
- Ethernet;
- xDSL (Bonded G.SHDSL / ADSL2+ / V.HSDSL);
- Cable (DOCSIS).