MARKETING REPORT

MR-238
MMBI White Paper on Use of MPLS in LTE

Issue: 1
Issue Date: February 2010

Issue History

Issue umber	Issue Date	Issue Editor	Changes
1	February 2010	Bhaskara Chinni	Original

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1 Executive Summary

Mobile backhaul is a crucial part of the mobile network that links the Radio Access Network (RAN) and the mobile core network. Typically it consists of access and aggregation portions of a mobile network. Mobile backhaul traffic is expected to explode with the growing consumer interest in smartphones, dongles, and netbooks that demand high data bandwidth. Increasing numbers of mobile subscribers, irrespective of economic conditions, is another major contributing factor.

Service providers, driven by growing bandwidth demand and marginal overall growth in average revenue per user (ARPU), are quickly moving to next-generation mobile technologies such as Long Term Evolution (LTE) and increasingly adopting Ethernet services to implement mobile backhauling. LTE offers a significant drop in cost of bandwidth, improves service provisioning, enables flexible use of frequency bands, and simplifies the network architecture. Ethernet in the backhaul delivers increased capacity per connection at a lower cost per bit thereby offering total-cost-of-ownership benefits to the service providers.

LTE supports an all-IP RAN architecture, and IP technology with Multiprotocol Label Switching (MPLS) can offer Ethernet services for mobile backhaul with the same quality of service (QoS) characteristics as traditional SONET/SDH or ATM/TDM technologies. Many service provider deployments use MPLS to ensure connection availability between two endpoints with QoS guaranteed by a service-level agreement (SLA). Furthermore, a majority of the mobile backhaul networks will be multiprotocol dominated at least for the next five to ten years. MPLS is a mature technology that unifies various types of backhaul traffic and offers several migration choices to service providers, enabling them to follow the course that best suits their needs and operating environment.

The Broadband Forum, through its MPLS in Mobile Backhaul Initiative (MMBI), aims to define reference architectures and technical specifications for mobile backhaul deployments in collaboration with vendors and service providers. The initiative motivates vendors to offer products and services on a commonly agreed framework and enables service providers to offer new services with reduced risk and improved time to market.

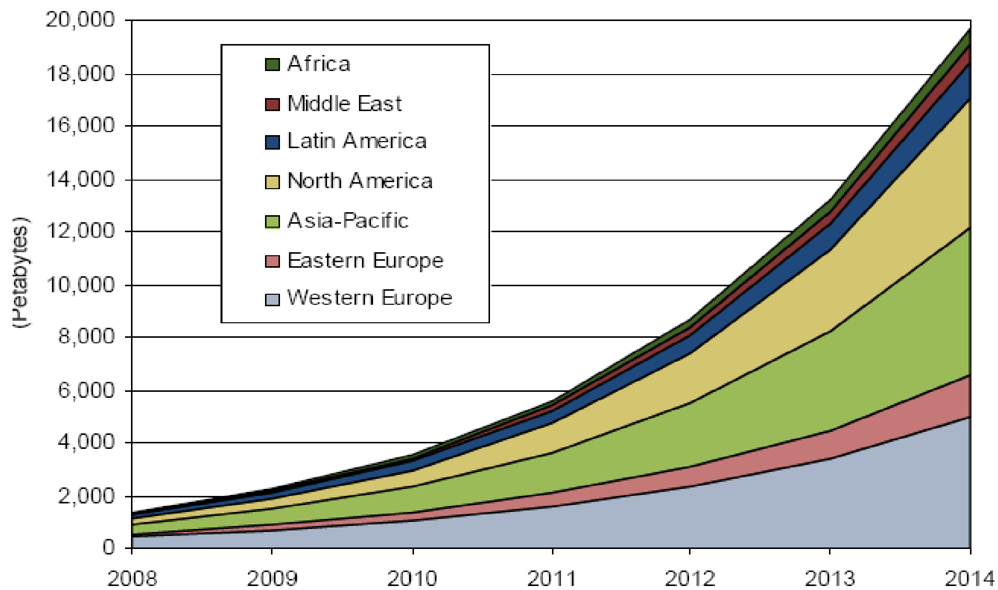
This paper targets vendors and service providers that are in various stages of planning for mobile backhaul for LTE.

2 Market Trends and Challenges

Increasing consumer interest in smartphones and cellular data modems is the primary driving factor behind the penetration of mobile broadband. According to an ABI Research report (source: “Mobile Data Traffic Analysis”, ABI Research, 3Q 2009), “Global mobile data traffic surpassed 1.3 exabytes (EB) sent and received during 2008. By 2014, an average of 1.6 EB of mobile data will be sent and received each month.” The global market for LTE handsets is expected to grow from 50,000 units (2010) to 82 million by 2014. Similar growth is expected in other LTE consumer segments such as netbooks (source: ABI report on LTE – 2Q 2009). Responding to increasing demand for bandwidth, service providers are quickly adopting LTE in the RAN.

With LTE, operators will have a powerful platform to deliver ubiquitous mobile broadband services, with a much improved business proposition compared to older technologies. LTE offers high data rates at a reduced price per bit, better spectrum efficiency, and reduced latency.

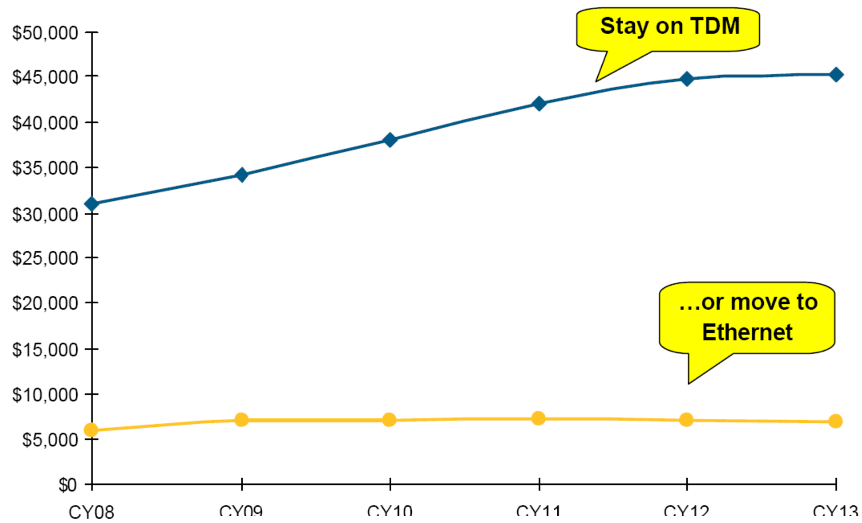
With expected throughput in the range of 100 Mbps and latency lower than 10 ms, LTE will provide a rich user experience comparable to what users have at home today with xDSL and cable connections, and with mobility being an added advantage. LTE will enable new business models around new services such as real-time online gaming, high-definition video streaming, video blogging, and peer-to-peer file exchange.



Source: “Mobile Data Traffic Analysis”, ABI Research, 3Q 2009

Figure 1 Mobile Data Traffic Growth

Mobile data traffic (see Figure 1) has recently surpassed voice traffic, and data traffic is growing exponentially while voice traffic is declining. Mobile data presents an exciting opportunity for operators, but the cost of providing this service is significant. This is a prime reason why mobile data is still relatively expensive compared to fixed-line broadband. Operational expenses for most of the older backhaul technologies go up linearly with traffic, but the ARPU a service provider can get is slow growing at best. These market trends are forcing service providers to Ethernet-based packet backhaul. Ethernet interfaces offer high data capacity at a much lower cost per bit as shown in Figure 2.

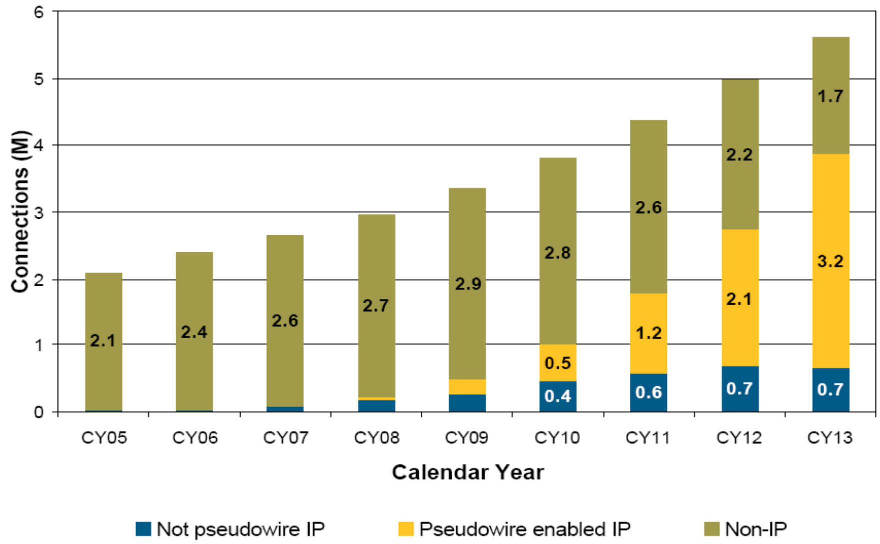


Source: Mobile Backhaul Equipment and Services, Infonetics, July 16th 2009

Figure 2 Mobile Backhaul Service Charges per Connection

Service providers require that the quality of their voice services are assured during the transition to packet-based backhaul, and hence a majority of current packet backhaul deployments use a hybrid approach where voice traffic is carried over TDM and data over packet. The hybrid approach is expected to dominate packet backhaul deployments for many years to come as it also enables service providers to make the most out of their existing infrastructure.

MPLS pseudowires provide the ability to aggregate TDM voice and packet data over a common network infrastructure. They are widely deployed in the aggregation parts of mobile backhaul networks as a traffic unifying technology for various RAN types. Pseudowire technology is expected to grow quickly through 2013, as shown in Figure 3.



Source: Mobile Backhaul Equipment and Services, Infonetics, July 16th 2009

Figure 3 IP and Pseudowire Connections

Mobile backhaul is increasingly becoming a strategic investment for service providers (source: "World Mobile Backhaul Infrastructure Market", Frost & Sullivan, February 2009) and hence the need for flexibility is ever growing. It is crucial for mobile operators to consider high speed packet access evolution and LTE requirements together in the near term, to optimize backhaul investment and potentially avoid additional expensive upgrades in the medium-to-long term. MPLS offers several choices to service providers in migrating to a pure packet-based backhaul network and is considered "evolution friendly."

In self-built mobile networks, the majority of current packet backhaul deployments are using MPLS transport and services in the aggregation part of the mobile backhaul. In the access part (the "first mile") that interfaces with subscribers, traffic volumes are typically low and the focus on cost is high. Transporting Ethernet services natively is cheaper and fits well with this MPLS scenario. As transport networks converge to provide services to both fixed and mobile subscribers, MPLS is expected to move further into access networks, at least initially as a transport mechanism to deliver Ethernet services. Additional MPLS transport capabilities defined as part of MPLS-TP are expected to strengthen MPLS adoption in mobile backhaul access networks. The Metro Ethernet Forum defines Ethernet services, and Broadband Forum solutions and architectures complement these services in such deployment scenarios.

MPLS features such as pseudowires; fast reroute; operations, administration, and maintenance (OAM); and failure troubleshooting tools are widely supported by many vendors. However, lack of commonly agreed frameworks, architectures, and deployment scenarios often result in additional avoidable costs in deploying MPLS services. Broadband Forum's MMBI, an industrywide initiative, aims to provide a framework and requirements for the use of MPLS technology in mobile backhaul networks that reduce the risks related to interoperability. MMBI also offers a certification program for vendors that enables service providers to choose deployment-ready products for their backhaul solutions.

3 The MPLS in Mobile Backhaul Initiative

The Broadband Forum's MMBI proposes a framework for the transport of RAN backhaul traffic over packet-based access, aggregation, and core networks as shown in Figure 4. The framework describes possible deployment scenarios and provides recommendations on how to use MPLS in each of these scenarios. Creating such a reference guide allows vendors and operators to select the appropriate feature sets for their specific scenario.

Areas within the scope of the initiative include QoS considerations (for example, to support specific service types), resiliency capabilities, clocking and synchronization, OAM, and support for various transport network layers and LTE.

The Broadband Forum has already published the following technical specification:

- MPLS in Mobile Backhaul Networks Framework and Requirements Technical Specification

The Broadband Forum is currently working on the following technical specifications

- Mobile backhaul network for LTE
- Mobile backhaul network for 2G and 3G

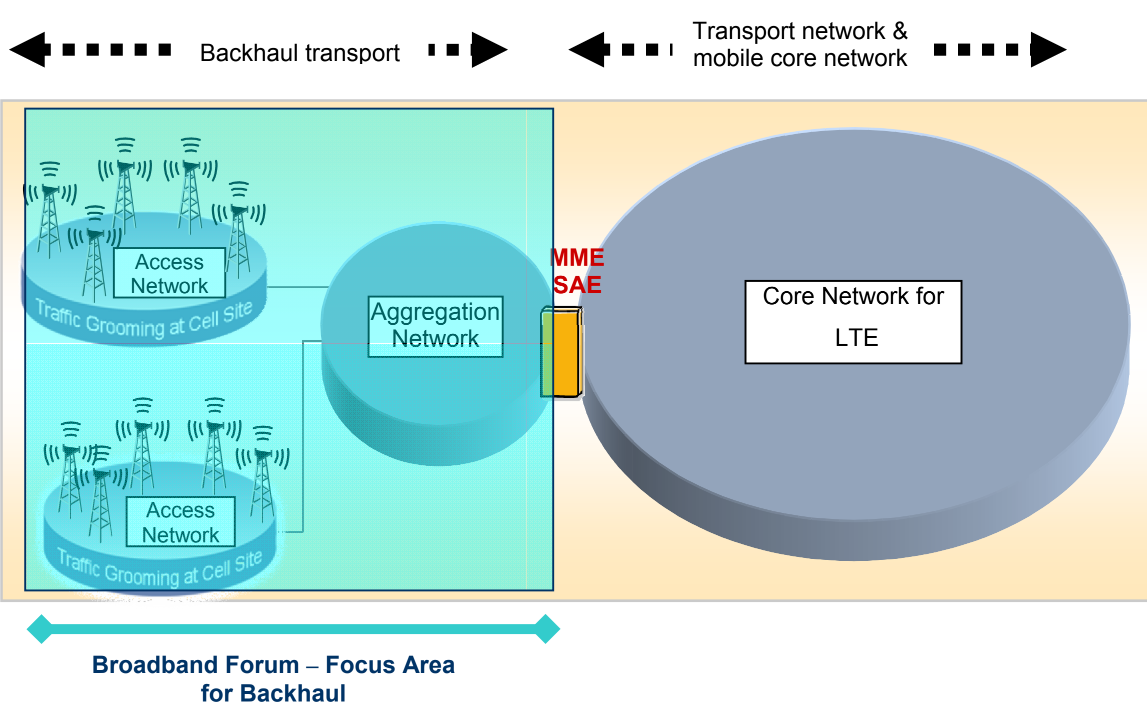


Figure 4 Scope of MMBI

3.1 Migration from 2G/3G to LTE

In a 2G/3G RAN, the base station handles the radio interface with the mobile station and the controller manages one or more base stations to provide control functions such as radio-channel setup, handovers, and so on. A hub-and-spoke topology enables communication from base station to controller and controller to base station as shown in Figure 5. In an LTE RAN, the base station itself consists of controller functionality and can communicate with another base station directly via any-to-any topology. An LTE base station communicates with a mobility management entity (MME) and a serving gateway (S-GW) via a star topology as shown in Figure 6.

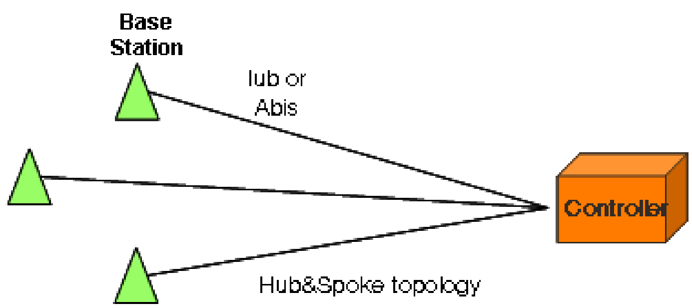


Figure 5 2G/3G RAN Topology

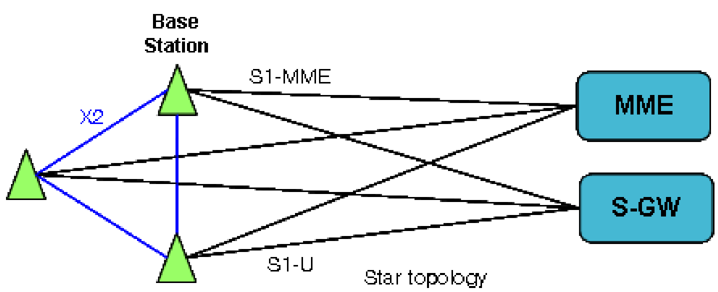


Figure 6 LTE RAN Topology

While Wideband Code Division Multiple Access (WCDMA) and high-speed packet access (HSPA) have made significant strides toward efficient mobile data and multimedia information exchange, LTE will provide extended network performance and reduced cost per byte that will allow it to deliver on the promise of broadband mobile.

Coexistence, interoperability, roaming, and handover between LTE and existing 2G/3G networks and services are inherent design goals, so that full mobility support can be confidently assumed. When introducing new network technologies, service providers expect that their existing investment will be protected and that deployed infrastructure can be reused to the greatest possible extent.

The main focus of the migration is thereby directed to topics representing a major part of a service provider's total cost of ownership:

- Deployment of LTE on existing sites and sharing of common infrastructure (such as antenna masts, site infrastructure such as power supply, air conditioning, feeder cables, and antennas)
- Sharing of backhaul equipment between LTE and other access network technologies provided at the same site. This means the same cell site gateway (CSG) deployed to connect a 2G base transceiver station (BTS) and 3G Node B to the packet-switched network could also be used to connect an LTE eNode B. CSG sharing to aggregate 2G/3G/LTE mobile traffic enables the use of the same fiber if only one fiber is available at the Node B site. The expected goal of service providers is to backhaul 2G/3G/LTE mobile traffic, together with fixed traffic issued from DSL, microwave, and FTTx access nodes, through a converged IP/MPLS core network for cost efficiency.
- Compatibility of transport solutions used for 2G, 3G, and LTE. For service providers it is important that the solutions used in the backhaul IP transport network layer (TNL) for 2G, 3G, and LTE be similar to use and unify operational tasks such as provisioning, monitoring, and OAM procedures. Indeed, 2G and 3G networks are already migrating to IP transport, but with LTE it will be mandatory as the 3GPP has specified IP transport as the sole TNL for LTE. Therefore, other than a hybrid approach with TDM and packet transport in parallel, service providers will need to renovate the backhaul network and add packet transport capabilities, typically using pseudowires to emulate the legacy interfaces (TDM pseudowire for 2G, ATM pseudowire for 3G).
- Common network management platforms

3.2 Layer 2/Layer 3 VPN

In LTE networks, IP is the only protocol used to support connectivity between the different mobile nodes as defined by 3GPP. Transport solutions based on Layer 2 VPN or Layer 3 VPN MPLS are convenient solutions to support IP connectivity between the mobile nodes, especially through the aggregation and core network. An overview of the use of L2VPN and L3VPN in LTE mobile backhaul with their respective strengths and weaknesses can be found in Table 1 below. In the description given above, *Cell Site Gateway (CSG)* and *Mobile Aggregation Site Gateway (MASG)* are equipment used to deliver traffic to the mobile nodes and are considered demarcation points between the transport network and mobile network.

Table 1 Layer 2 and Layer 3 VPNs in an Aggregation Network

	Layer 2 VPN VPLS	Layer 2 VPN VPWS	Layer 3 VPN
	Virtual Private LAN Service (VPLS) could be used in the aggregation network providing any-to-any connectivity between eNode Bs and security gateways in the regional area.	Virtual Private Wire Service (VPWS) could be used in the aggregation network especially when a security gateway is used to protect the mobile traffic (compare Case B or C of the security section).	L3VPN could be used in the aggregation network providing any-to-any connectivity between eNode Bs and security gateways in the regional area.
Pros	• The turning point for X2 is done as low as possible in the transport network reducing the delay on X2 • Provisioning of VLAN configuration is simplified on PE routers (EN in this example) • Provisioning to connect a new eNode B is simplified	• Simple point-to-point connectivity in the aggregation network	• The turning point for X2 is done as low as possible in the transport network reducing delay on X2 • Provisioning to connect a new eNode B is simplified • Potential scalability issues are solved
Cons	• No MPLS transport from end to end	• The turning point is done high in the backhaul network (for example, the security gateway) and delay for X2 is increased • VLAN configuration on the PE routers is complex (e.g. EN in the example)	• More complex to integrate in a wholesale offer • No MPLS transport from end-to-end

3.3 Synchronization

As in 2G and 3G networks, synchronization plays a vital role in LTE, helping maintain the requisite service quality and network performance. Figure 7 shows various synchronization techniques used to meet the LTE requirements. LTE air interface is designed for deployment in paired (frequency division duplex [FDD] mode) and unpaired (time division duplex [TDD] mode) spectrum bands:

- FDD LTE requires frequency synchronization similar to 2G/3G networks.
- Regardless of using FDD or TDD mode, LTE options such as Multimedia Broadcast and Multicast Service over Single Frequency Network require time/phase synchronization.

- TDD LTE requires phase/time synchronization in addition to frequency, as different time slots are used for upstream and downstream using the same frequency composition, and the transmission needs to be coordinated across the network.

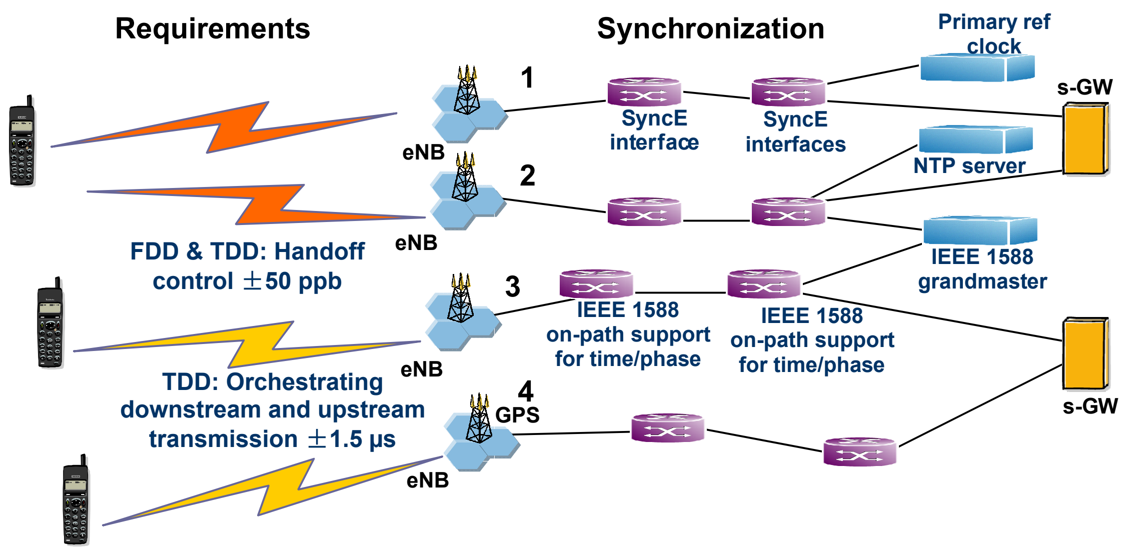


Figure 7 Frequency Synchronization: 1, Synchronous Ethernet; 2, IEEE 1588 or NTP Time/Phase Synchronization; 3, IEEE 1588; 4, GPS

Regarding frequency synchronization delivery in mobile backhaul, one option is Synchronous Ethernet (also called SyncE) as per ITU-T recommendations, which is an SDH-like mechanism for distributing frequency at the physical layer. Other ways of providing frequency synchronization include IEEE1588-2008 Precision Time Protocol (PTP) and Network Time Protocol (NTP). Both are packet based methods and therefore require careful QoS design throughout the packet transport network. ITU-T is concluding work on IEEE1588-2008 for a "telecom profile," including load balancing and protection switching among synchronization masters. The frequency synchronization can be distributed using a combination of different solutions listed above (such as IEEE1588 combined with Synchronous Ethernet).

For time/phase synchronization in existing networks, GPS is widely deployed and despite known drawbacks (need for a view of the sky and risk of interference), service providers with existing GPS-based synchronization infrastructure are expected to use it for packet backhaul networks as well. However, new networks may also make use of the time/phase telecom profile of IEEE 1588 as soon as the standardization is complete. The time/phase synchronization can be distributed using combinations of the solutions listed above.

3.4 Security

3.4.1 What are the security issues?

In a change from 2G/3G security specifications, 3GPP defined that for LTE all radio network layers between the user equipment (UE) and eNode B must be protected using the Packet Data Convergence Protocol (PDCP) layer terminated into the eNode B. However, the control plane between the eNode B and the MME and the user plane between the eNode B and the serving gateway are unprotected. Actually, only the control plane between the user equipment and the MME (NAS signaling) is protected. Due to this lack of protection on the mobile traffic going though the mobile backhaul network, 3GPP proposed an option to add protection to the S1 and X2 interfaces and the management plane using IPsec, especially when the eNode B is set up in untrusted locations. IPsec provides a comprehensive set of security features (data origin authentication, encryption, integrity protection) to address these security issues and is defined in the context of the 3GPP security architecture for LTE. Figure 8 below shows LTE network entities and mechanisms to secure interfaces between them.

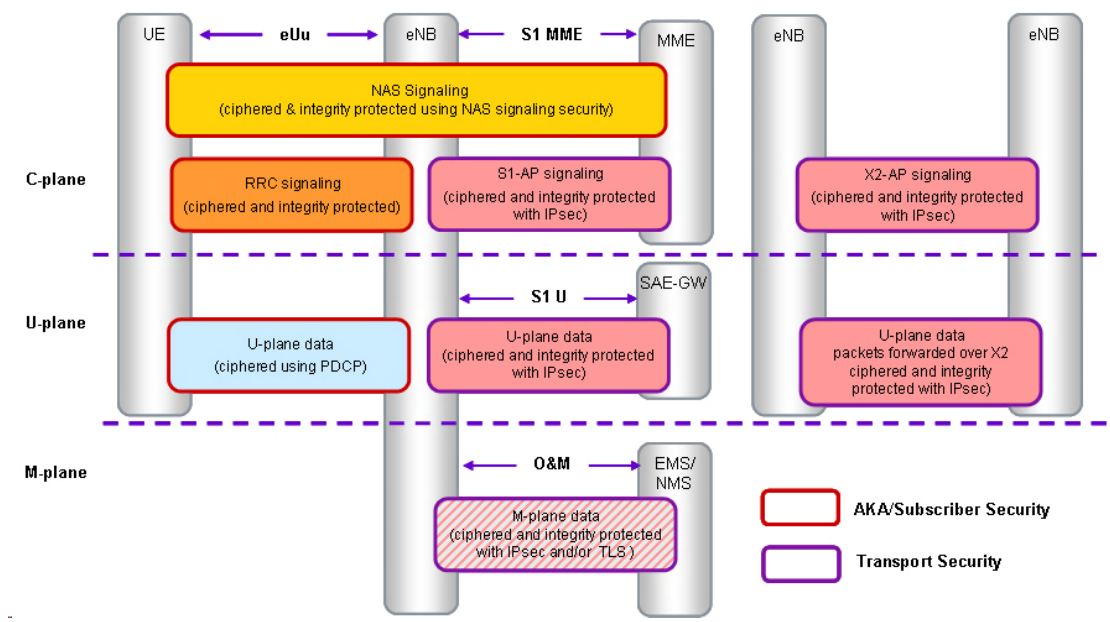


Figure 8 LTE Layered Security Approach

3.4.2 What are the security options?

It is up to the mobile network operator to decide if the mobile traffic has to be protected or not using IPsec. There are three different cases for mobile traffic protection in the mobile backhaul network:

- **Case A, no protection at all:** This case can be applied by operators that use their own mobile backhaul network and consider their eNode B sites trusted areas.

- **Case B, IPsec protection of the control plane:** This case can be applied by operators that want to ensure the integrity of the control plane traffic, especially when a wholesale offer is used in the mobile backhaul network or when the eNode B sites are in untrusted areas. The control plane protection prevents attacks against the operator's IP domains hosting the mobile core control nodes like MME and HSS. Nodes like Serving-Gateway (S-GW) located in the user plane IP domain stay unprotected. This case may generate complications from the point of view of addressing and transport design due to the differing treatment of control plane and user plane traffic.
- **Case C, IPsec protection of the control plane and the user plane:** This case ensures the confidentiality of user plane traffic in addition to case B, but requires more resources on the security gateway to encrypt/decrypt the traffic. The impacts of the approximately 15 percent overhead on the bandwidth due to IPsec headers may be an issue as well.

Cases B and C have some impacts and requirements on the mobile backhaul network as listed below:

- Security gateways are required in the mobile backhaul network to support IPsec
- The security gateway can be integrated into the EN or MASG or can be colocated with them if it is considered as a standalone node.
- The eNode B has to support security gateway features such as support of IPsec.
- At the eNode B side, the same IPsec tunnel may be shared to protect S1 and all its X2s (X2 star configuration) or the eNode B may be allowed to establish dedicated IPsec tunnels to each of its neighboring eNode Bs (X2 mesh configuration).
- The management plane is likely to be protected with IPsec as well, although OAM Transport Layer Security can alternatively be used to provide end-to-end security.

Furthermore, radio over fiber can be used to connect the remote radio unit to the base band unit through one fiber, using a specific protocol to carry the radio network layer. The information transported over this fiber is still protected by the PDCP radio layer of LTE so that there is no need to protect it in the last mile.

3.5 Service Quality Assurance

LTE promises the support of high throughput, low latency, plug and play, FDD, and TDD in the same platform. This will enable better and richer quality of experience for users and the ability to provide sophisticated services and applications such as VoIP, high-definition video streaming, mobile gaming, and peer-to-peer file exchange. The technology in the backhaul network must efficiently support these bandwidth-intensive services guaranteeing quality and adherence to per-service, end-to-end SLAs. The technology must support any service from any point to any point at any scale at the lowest cost per bit.

MPLS is a mature and ubiquitous technology that already plays an important role in packet networks and services. The IETF work on MPLS-TP extends the MPLS tool kit with additional mechanisms that ensure scalable, reliable, and high-quality transport. MPLS has mechanisms for cost-effective delivery of highly reliable differentiated transport services that include:

- Traffic Engineering capabilities to reliably address per-service traffic availability and performance requirements while efficiently utilizing network resources. Performance requirements are specified in terms such as throughput, delay, jitter, packet loss, and so on. Traffic Engineering mechanisms help ensure deterministic and predictable network behavior.
- Mechanisms to address the QoS requirements and enforce end-to-end bandwidth guarantees, controlled jitter, and delay.
- Flexible troubleshooting and carrier-grade OAM tools for fault management. IETF work on MPLS-TP extends the set of MPLS OAM tools to include more tools for fault management and performance monitoring (such as signal quality measurement). OAM has a significant role in carrier networks, providing methods in both the transport and the service layers to improve their ability to support services with guaranteed and strict SLAs while reducing operational costs.
- Comprehensive resiliency (protection and fast restoration) mechanisms capable of supporting even the most demanding services.
- Mechanisms to ensure secured networks and services.

The use of the MPLS toolkit in the backhaul network will enable service providers to migrate from 2/3G to LTE and rapidly deploy new services in an economical way.

3.5.1 Traffic Engineering and QoS

The MMBI defines ways to apply several IETF standards on Traffic Engineering capabilities, QoS mechanisms, and performance requirements to support transmission of differentiated services over the backhaul network while meeting SLAs. These mechanisms allow service providers to engineer the MPLS tunnel label-switched paths (LSPs) to optimize network bandwidth, directing traffic flow over specific core tunnels to maximize throughput, reduce congestion, and better utilize the resources in the backhaul network.

The paths of the MPLS tunnel LSPs can be calculated and provisioned with a control plane or an OSS-based solution using MPLS standard MIBs. The control plane includes tools (such as OSPF-TE and ISIS-TE) to distribute the information on the network topology and the actual utilization of the resources (providing information such as link bandwidth, link utilization, and priority). The control plane also includes tools (such as RSVP-TE) to signal the tunnel LSP and reserve resources and states along the paths according to the service specifications.

3.5.2 OAM

MPLS provides a wide range of troubleshooting and OAM tools for the underlying MPLS tunnel LSPs and the client services (pseudowires, IP) needed for a carrier-grade backhaul network. These tools provide mechanisms for proactive service continuity check and fault detection at the LSP level (such as MPLS BFD). They also provide proactive and on-demand network maintenance to quickly detect and localize a defect (such as LSP ping and LSP traceroute).

MPLS also provides mechanisms for end-to-end fault detection and diagnostics at the pseudowire level. Virtual Circuit Connection Verification (VCCV) provides a control channel associated with each pseudowire that allows sending OAM messages in-band with the traffic. VCCV supports tools such as ICMP ping, LSP ping, and BFD. Pseudowires also have OAM capabilities to propagate a client fault indication to the far-end peer, which detects a client-layer failure condition and notifies its client layer.

The ongoing work in the IETF on MPLS-TP extends the MPLS toolkit with more tools and capabilities, and shortly the toolkit will include a comprehensive set of carrier-grade OAM tools for fault management and performance monitoring. New tools such as Remote Defect Indication, Alarm Report, one-way or two-way Delay Measurement, Packet Loss measurement, and in-service Diagnostic Tests are currently being defined.

The MPLS extended OAM tools may be used to monitor the network infrastructure, to enhance its behavior and performance. MPLS allows seamless management of LSPs and pseudowires at different nested levels, that is, at the end-to-end level of a transport path, at a segment of a transport path, and at the MPLS-TP link level. This capability uses the existing MPLS construct of hierarchical, nested LSPs. The MPLS OAM messages can be transmitted in-band with the traffic.

The tools may also be used to monitor service levels offered to customers, allowing verification of their SLA parameters and enabling rapid response to failures or degradation. The OAM tools help speed troubleshooting (and therefore reduce operating expense) and help enable the delivery of high-margin premium services that require short restoration times. These tools are applicable for LTE mobile backhaul networks implemented using IP-based and Ethernet pseudowire-based solutions.

3.5.3 Resiliency

Network resiliency is the network's ability to restore traffic on failed or degraded links and nodes, which is a critical factor in delivering reliable services. The resiliency of an MPLS network can minimize the disruption to services in case of faults. The primary objective is to quickly reroute services around a failed facility.

Service interruption time is typically an explicit and clear measure. Service guarantees in the form of SLAs require a resilient network that can instantaneously detect link or node defects and restore network operation immediately.

MPLS provides a comprehensive set of protection and restoration capabilities for serving different faults that include global (centralized) and local (distributed) repair models. Traffic is redirected onto other parts of the network so that the service interruption time is unnoticeable or highly minimized. In general, protection actions are completed within tens of milliseconds, while automated restoration actions are normally completed in hundreds of milliseconds.

MPLS offers fast convergence and mechanisms for failure detection and recovery needed to maintain customer SLAs. Recovery actions may be triggered directly upon detection of a network failure, or they may be under the control of an operator. General MPLS mechanisms for recovery include alternate paths, bypass tunnels, and more. Recovery may be performed at multiple layers or across cascaded recovery domains. Enhancements to meet transport requirements extend the toolkit with mechanisms designed for specific topologies such as mesh networks and ring networks. These can be used to recover from defects in different pieces of the network: end-to-end path, a segment of a path, or an MPLS link.

MPLS provides the following levels of recovery:

- Dedicated protection, where resources are fully pre-allocated for use of the protected service (1+1 or 1:1)
- Shared protection, where resources are shared between several services (M:N)
- Restoration and repair, where resources may be pre-calculated and even but are allocated only when the recovery action starts

The level of recovery directly affects the service level (data loss and recovery time) provided to end users in the event of a network failure. There is a correlation between the level of recovery provided and the cost to the network.

Note that protection is basically a data-plane capability. The ongoing MPLS extension work for transport requirements ensures that it is possible to switch over independent of the way the network is configured and managed. The IETF is currently extending the MPLS toolkit with an in-band protocol element to coordinate the protection state between the edges of a protection domain in case of bidirectional protection switching. RSVP-TE already has mechanisms to communicate alarm information and coordinate the protection state. Work is being done to define MIBs to allow the configuration of the protection entities and functions.

MPLS also provides mechanisms for pseudowire redundancy. These are based on the actual attachment circuit through which the traffic enters the network and elements of coordination between the edges of the protection domain.

3.6 Synergies in the Mobile Backhaul Space

3.6.1 Synergy in Mobile Backhaul Standardization Efforts

The Metro Ethernet Forum (MEF) and the Broadband Forum are working on mobile backhaul services and mobile backhaul networks, respectively, and the two complementary efforts are tightly synchronized. The MEF focuses on Ethernet services and SLAs that clearly identify the behavior at the packet transport network external interfaces, and the Broadband Forum specifies the underlying packet transport network infrastructure, including its internal interfaces, IP/MPLS layers, and related signaling, to support those Ethernet services. In addition to the services and network architecture, ITU-T Q13/SG15 specifies methods to transport and deliver synchronization to LTE base stations. Together, Broadband Forum, MEF, and ITU-T Q13/SG15 provide the complete set of standards needed to build LTE backhaul solutions.

The Broadband Forum's union with the IP/MPLS Forum strengthened the focus on mobile backhaul network architectures. This synergy combines the service view and MPLS technology expertise of the IP/MPLS Forum with the work of the Broadband Forum on end-to-end multiservice broadband network architectures.

Figure 9 below shows Mobile Backhaul technologies and positioning of Broadband Forum's MBH activities. The following is a list of mobile backhaul network activities in the Broadband Forum:

- IP/MPLS-20.0.0: MPLS in Mobile Backhaul Networks Framework and Requirements Technical Specification
- IP/MPLS-23.0.0: Abstract test suite for testing TDMoMPLS CSG and MASG providing TDM service for connecting 2G base stations to BSC through MPLS network
- Abstract test suite for testing CSG and MASG providing ATM service for connecting 3G-R99 base stations to RNC through MPLS network
- MPLS in the mobile backhaul network for 2G/3G
- MPLS in the mobile backhaul network for LTE
- Multiservice broadband network functional modules and architecture

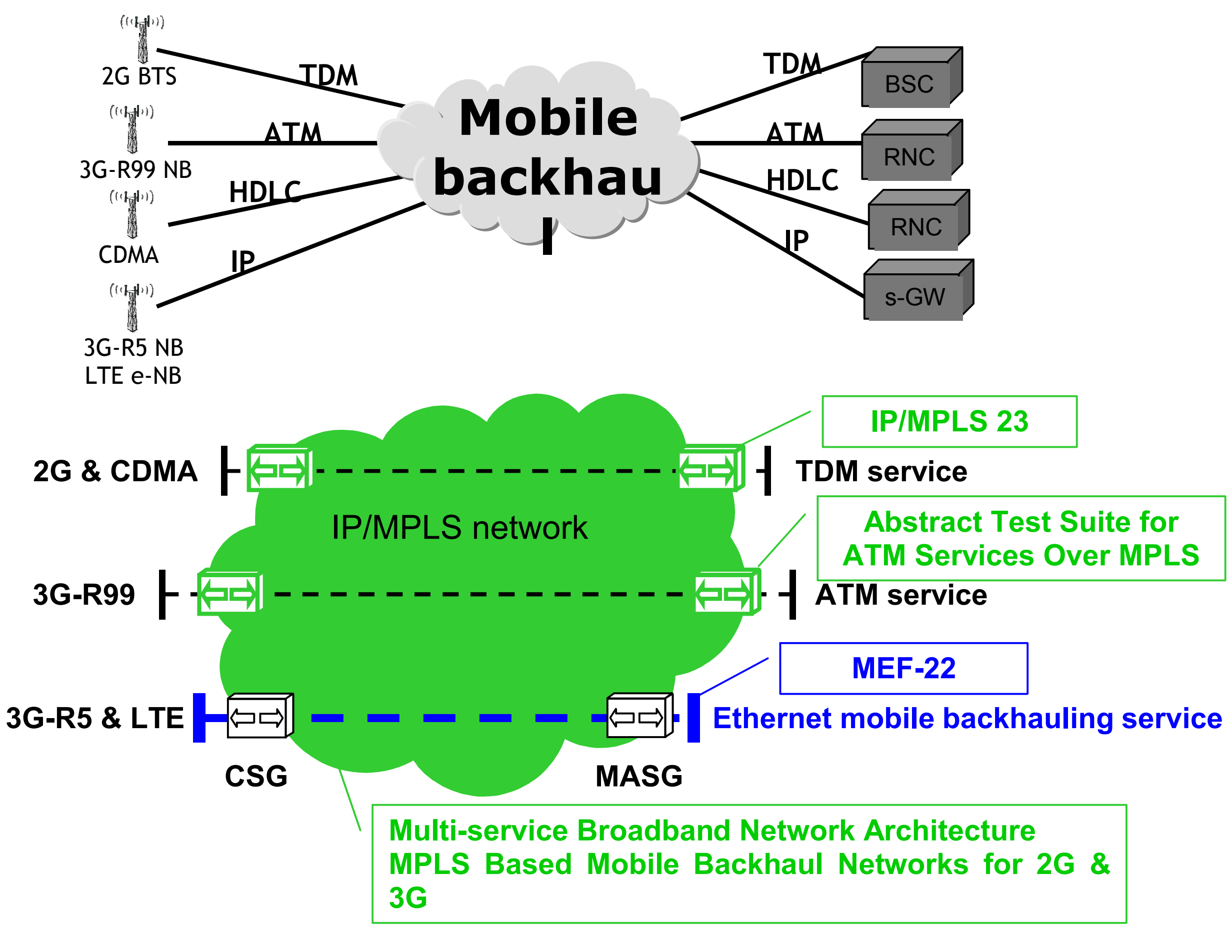


Figure 9 Standardization Efforts for Mobile Backhaul

3.6.2 Synergy with Next-Generation Broadband Network

LTE is a natural enabler of mobile broadband, and it will create an enhanced market that has the potential to transform how users receive, consume, and interact with information and content distribution. It adds mobility to the broadband experience already provided by fixed broadband access. Although broadband mobile appears to compete with residential broadband, there is much synergy between mobile backhaul for LTE and the next-generation broadband network.

First, LTE introduction must make use of existing networks for the best service velocity and return on assets. In particular, it may very well make use of packet-based and traditional transport infrastructures such as copper based (xDSL), fiber-based (GPON or Ethernet pt-to-pt), and microwave as backhaul as much as possible.

Second, the evolution from 2G and 3G to LTE allows mobile traffic to be aggregated and transported under similar requirements as fixed broadband traffic. Therefore, a multiservice network must enable proper QoS, security, scalability, and network reliability to efficiently converge fixed and mobile services. Furthermore, in such a converged environment, specific requirements of LTE comparable to those of broadband access, like synchronization and handover of traffic (X2 interface between eNode B's), can be properly ensured with network engineering.

The good news is that fixed and mobile networks will evolve to a synergetic environment that effectively enables seamless experience, which is perceived through end-to-end quality of delivery.

The Broadband Forum's work defining suitable reference architectures for multiservice broadband networks that cover this service delivery scenario is found in "Multiservice Broadband Network Functional Modules and Architecture."

4 Future

Mobile subscribers are growing rapidly around the world. According to a Portio Research report (source: Portio Research Mobile Factbook 2009), there will be an estimated 5.8 billion mobile subscribers worldwide by 2013. In addition, consumer devices such as set-top boxes and cars are becoming “connected.” Machine-to-machine communication is expected to rise significantly, and by 2020 the number of connections is expected to reach tens of billions. Mobile networks are going to be both more numerous and much larger than they are today. Future networks will need an end-to-end standards-based solution capable of transporting multiple services, with the ability to support the scalability needed and quick recovery mechanisms. Having a single end-to-end backhaul solution also simplifies provisioning of the network, thereby reducing operational complexity and costs. MPLS is a mature technology capable of transporting any service to anywhere, thereby offering greater returns on investment to service providers. With the continued commitment and investment from major vendors and service providers, MPLS is expected to further strengthen and enable the community to furnish innovative services at a lower price.

5 Conclusion

The world's first commercial LTE service was launched in December 2009, and more than dozen service providers around the world have plans to launch LTE services in 2010. Migration to LTE is expected to quicken in the next few years. Service providers are migrating to LTE-based RAN and Ethernet-based packet backhaul networks, gaining the ability to offer mobile data capacities comparable to fixed broadband technologies. The resulting 4G network will enable service providers to offer new data-intensive services at a low cost per bit. The service providers' goal is to deliver these new services while making optimal use of the network and guaranteeing SLAs from any one point in the network to another. The Broadband Forum specifies the architecture of the mobile backhaul network infrastructure and recommends how state-of-the-art technologies can be optimally employed to support that goal.

MPLS is a mature and ubiquitous technology which is already widely deployed and playing an important role in packet-based core networks solving similar problems. Mobile backhaul networks consist of access and aggregation segments. Ethernet technologies can be deployed in the access segment and can complement MPLS in the aggregation segment. Deployment of MPLS in the access segment is expected to strengthen in the near future. In converged deployments where both mobile and fixed subscribers share the same transport network, MPLS in both access and aggregation segments enables better and more cost-effective control of services end-to-end. The development of additional packet transport capabilities (MPLS-TP) will further strengthen the adoption of MPLS in new market segments.

The Broadband Forum, which is composed of leading vendors and service providers, defines the use of MPLS in LTE backhaul networks. The forum develops architecture and requirements that describe application of relevant standardized technologies in LTE backhaul networks. The Broadband Forum has also published a tutorial on MPLS use in LTE backhaul networks.

The Broadband Forum work in mobile backhaul complements other standard bodies like the Metro Ethernet Forum. MEF defines Ethernet services and the Broadband Forum complements this by focusing on implementation infrastructures that support these services. Broadband Forum, MEF, and ITU-T Q13/SG15, in conjunction with technologies from IETF and IEEE, provide a complete set of standards needed to build mobile backhaul solutions.

The Broadband Forum has launched a certification program to facilitate implementations of standards-based MPLS solutions and services. By having their products certified, vendors are able to demonstrate the quality of their products at a reduced cost. By choosing certified products, service providers are able to launch new services at a reduced time to market.

For more information please visit the Broadband Forum site at www.broadband-forum.org.

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