Solution Guide

LTE Backhaul: Meeting Operator Requirements

How Transport Providers Can Realize the Business Opportunity of LTE with SLA Assurance

RAD
data communications
The Access Company

Abstract

3GPP's (3rd Generation Partnership Project) LTE (Long Term Evolution) is widely accepted as the global 4G standard, however, transport providers face substantial challenges in realizing LTE's business and technological potential. Some of these challenges are also common to operators with self-built networks: Ensuring accurate timing and synchronization over packet networks; smartly managing traffic in LTE's flat architecture; providing adequate resiliency for 4G critical applications; and enabling backward compatibility to ensure service continuity for legacy 2G and 3G traffic are a few examples of the critical issues that need addressing. Nevertheless, backhaul providers need to address additional issues that are related to multi-operator colocation and customized backhaul SLAs.

This paper reviews the implications of LTE's "intelligence crunch" for backhaul providers and discusses how Carrier Ethernet can be used to smartly overcome migration hurdles.

Contents

1 LTE: The Global 4G Standard 2

2. New Challenges for Transport Providers: The LTE Backhaul Intelligence Crunch . 4

2.1 Disruptive Architecture 5

2.2 Service Capabilities 7

2.3 Synchronization and Clock Transfer 9

2.4 Backhaul Sharing 9

2.5 The LTE Voice Dilemma 10

3 Carrier Ethernet: Marrying Capacity with Intelligence 11

3.1 L2 VPN Topologies in LTE Backhaul 11

3.2 Service Delivery, SLA Assurance and Shared Backhaul 13

3.3 Synchronization and Timing over Packet in LTE Backhaul 16

3.4 Redundancy and Resiliency for Service Protection 17

Conclusion: How Transport Providers Can Realize Business Opportunities from LTE Backhaul 18

1 LTE: The Global 4G Standard

The telecom world seems to be in agreement concerning the role of 3GPP's Long Term Evolution as the next evolutionary phase in mobile broadband. Commercial rollouts of LTE services are expected to begin as early as 2010, with an impressive number of leading Tier-1 operators already expressing their commitments to the technology, including Orange, T-Mobile, TeliaSonera, Verizon Wireless, NTT DoCOMo, and China Mobile. While most operators and transport providers agree on LTE as the end-goal, they are likely to employ different migration strategies, depending on their current infrastructure, spectrum assets and local regulatory environment. For example, many UMTS operators have indicated their intention to exhaust HSPA upgrades before moving to LTE, while some who have previously embraced CDMA-2000 and EV-DO are among those with the most aggressive LTE migration schedules.

Regardless of how the transition will be executed, Infonetics Research predicts that operators will be serving over 72 million LTE subscribers by 2013[1]. New applications and their reciprocal impact on emerging communications trends will drive LTE uptake in the consumer and business sectors, helping operators to mitigate the steady decline in ARPU (average revenue per user) from traditional 2G voice and 3G data services. The primary attributes that make LTE an enabler for a revolutionary, revenue-generating user experience are its high capacity and speed, together with low latency and the ability to serve more users per cell/sector. As can be seen in Figures 1 and 2, these attributes result in superior performance compared to previous technologies and facilitate the introduction of interactive, multi-user and multimedia mobile services, as well as mobile commerce and new machine-to-machine (M2M) applications.

---

[1] Infonetics Research: LTE Infrastructure and Subscribers Biannual Worldwide and Regional Market Size and Forecasts, 2009.

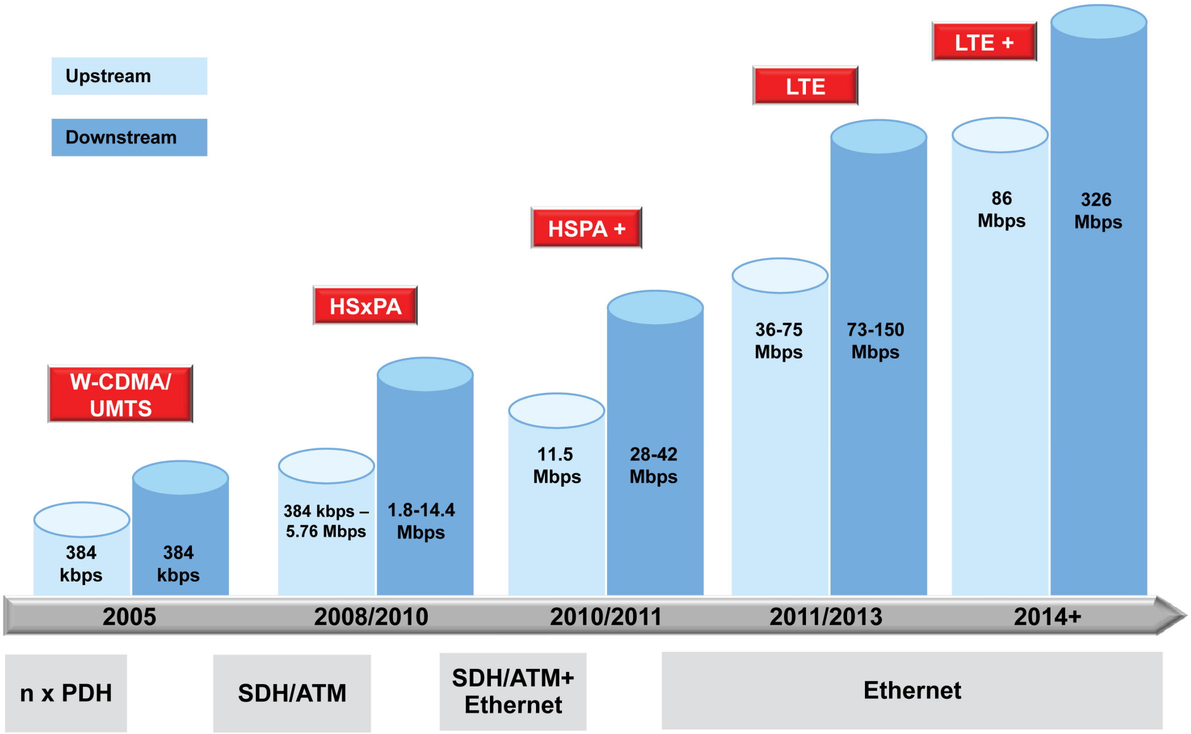

Figure 1: Evolution of bandwidth capacity[2] in mobile generations and corresponding transport technologies

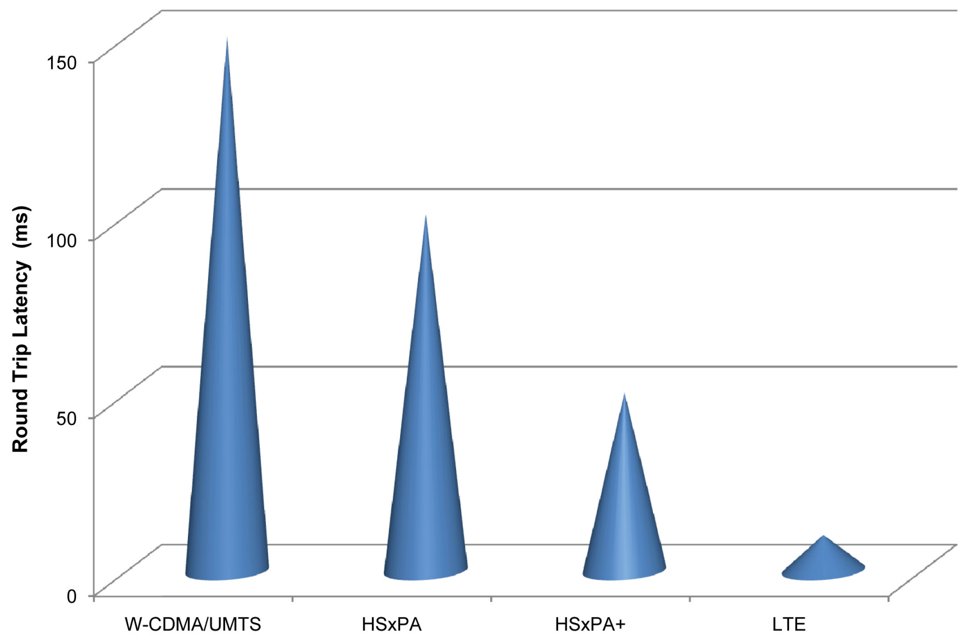

Figure 2: Comparison of round-trip latency for different mobile technologies

---

[2] Peak data rates.

LTE also brings substantial gains to radio performance, among which are the following:

- ✓ Enhanced spectral efficiency, including channel bandwidth scalability from 1.25 MHz to 20 MHz with OFDMA (Orthogonal Frequency Division Multiple Access) modulation, which boosts throughput, optimizes the use of available bandwidth and improves service coverage.

- ✓ High spectrum availability, allowing operators increased flexibility in planning rollouts with a wide range of frequency/channel combinations, including the reallocation of existing spectrum holdings.

In addition, LTE's flat IP architecture and self-optimizing features are designed to increase simplicity in network operations and management with lower cost per Mbps.

In order to realize LTE's cost and performance advantages, however, transport providers, wholesale backhaul suppliers and fixed-line carriers offering mobile backhaul services must prepare their networks to efficiently accommodate the expected surge in traffic rates and to meet the challenges brought on by the new technology's more innovative aspects.

2. New Challenges for Transport Providers: The LTE Backhaul Intelligence Crunch

The introduction of 3G and HSPA was met by market conditions that dictated the decoupling of data traffic increase from flattening revenues, as illustrated in Figure 3. This resulted in the need to separate backhaul costs from capacity so that booming traffic rates can be delivered economically. LTE addresses this issue by specifying cost-effective packet switching as the native transport technology. Nevertheless, high-volume "IP pipes" are not enough for backhaul providers to lower their TCO (total cost of ownership) in the access network and to meet operators' requirements for tight SLAs with guaranteed reliability and service quality. The need for intelligence in LTE backhaul is much greater than that of earlier generations, encompassing matters of architecture, network service functionalities, backhaul sharing, and voice traffic delivery. The following sections discuss the implications of these challenges.

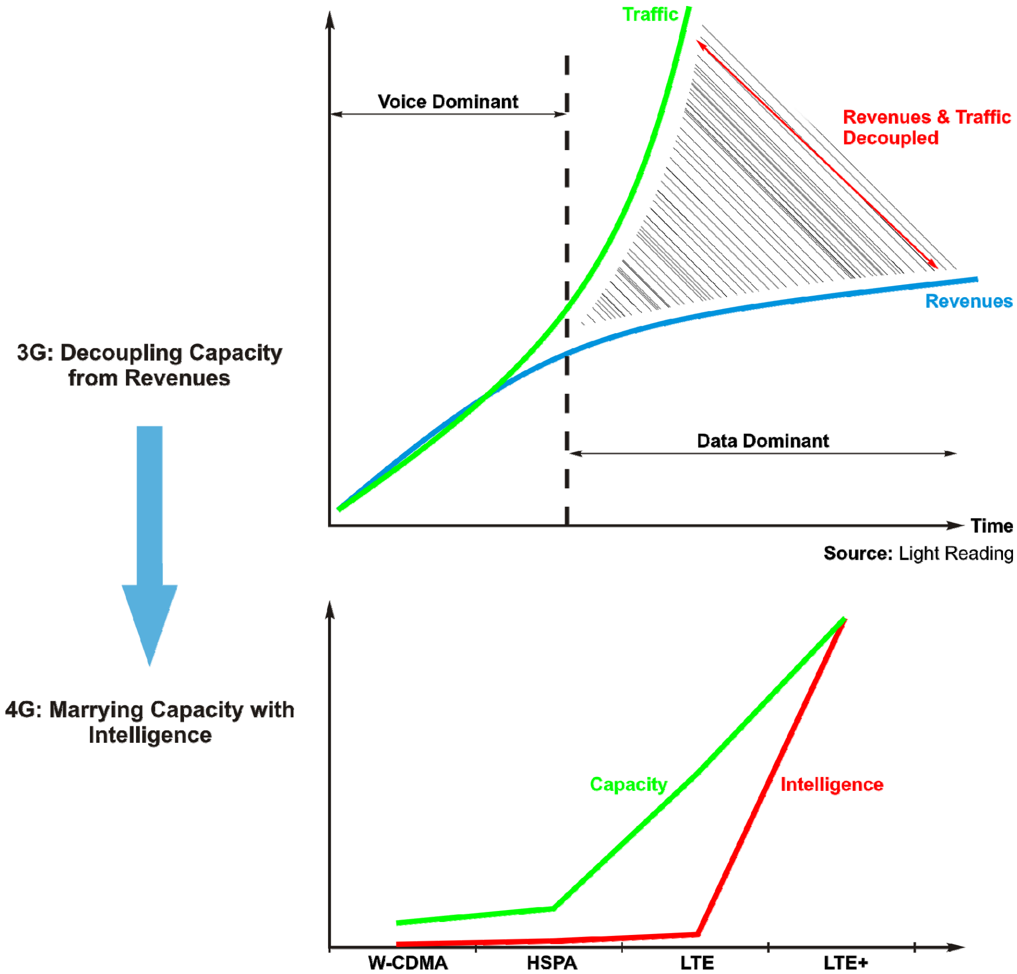

Figure 3: The story of a new generation – marrying capacity with intelligence in 4G LTE backhaul

2.1 Disruptive Architecture

LTE architecture's flat topology represents a departure from the hierarchical networks of earlier generations. As seen in Figure 4, LTE's semi-autonomous eNodeBs result in a smaller number of network node types.

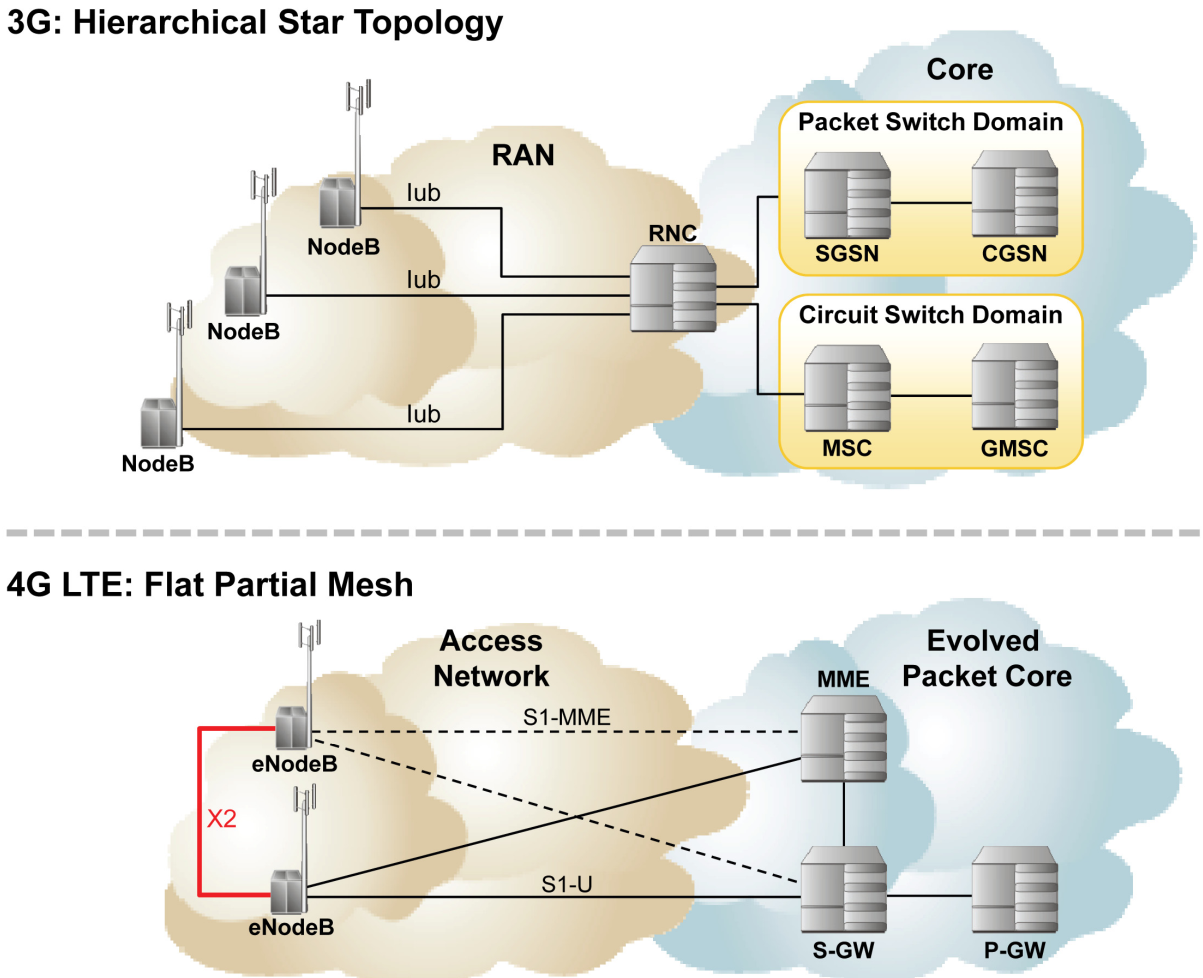

Figure 4: LTE's disruptive architecture

While easier to manage and operate, such architecture requires careful planning to ensure effective and scalable inter-eNodeB communications with constrained delay in a partially meshed network where each eNodeB can connect to up to 32 of its neighbors. Figure 5 illustrates the backhaul complexity caused by the "X2 factor," whereby the X2 interface is used in direct connections between base stations for handoff and signaling, as well as for local switching in later stages. Without base station controllers (e.g. RNCs) to manage the flow of traffic, transport providers servicing operators with eNodeBs of different make and capabilities are faced with the task of efficiently provisioning and maintaining a multitude of connections over diverse infrastructure.

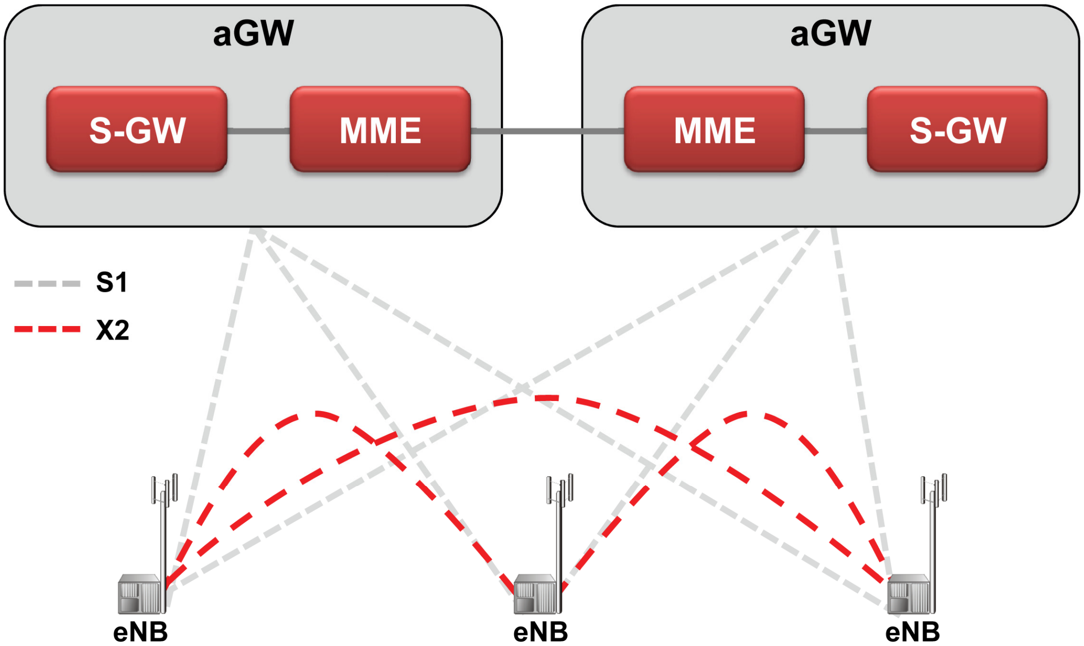

Figure 5: Inter-eNodeB communications

2.2 Service Capabilities

Mobile operators expect differentiated backhaul services with hard QoS (quality of service) that meet performance criteria, such as packet loss, delay, jitter, and availability. These, together with traffic security, service resiliency and protection with sub-50ms failover, clocking accuracy and OAM diagnostics, are mandatory for operators who wish to offer mobile users rich content and other value-added applications over packet-based transport. Such transport network and service capabilities should also be consistent regardless of the access technology or physical infrastructure.

The various service attributes that wholesale backhaul providers must be prepared to offer to their mobile operator customers are summarized in Figure 6:

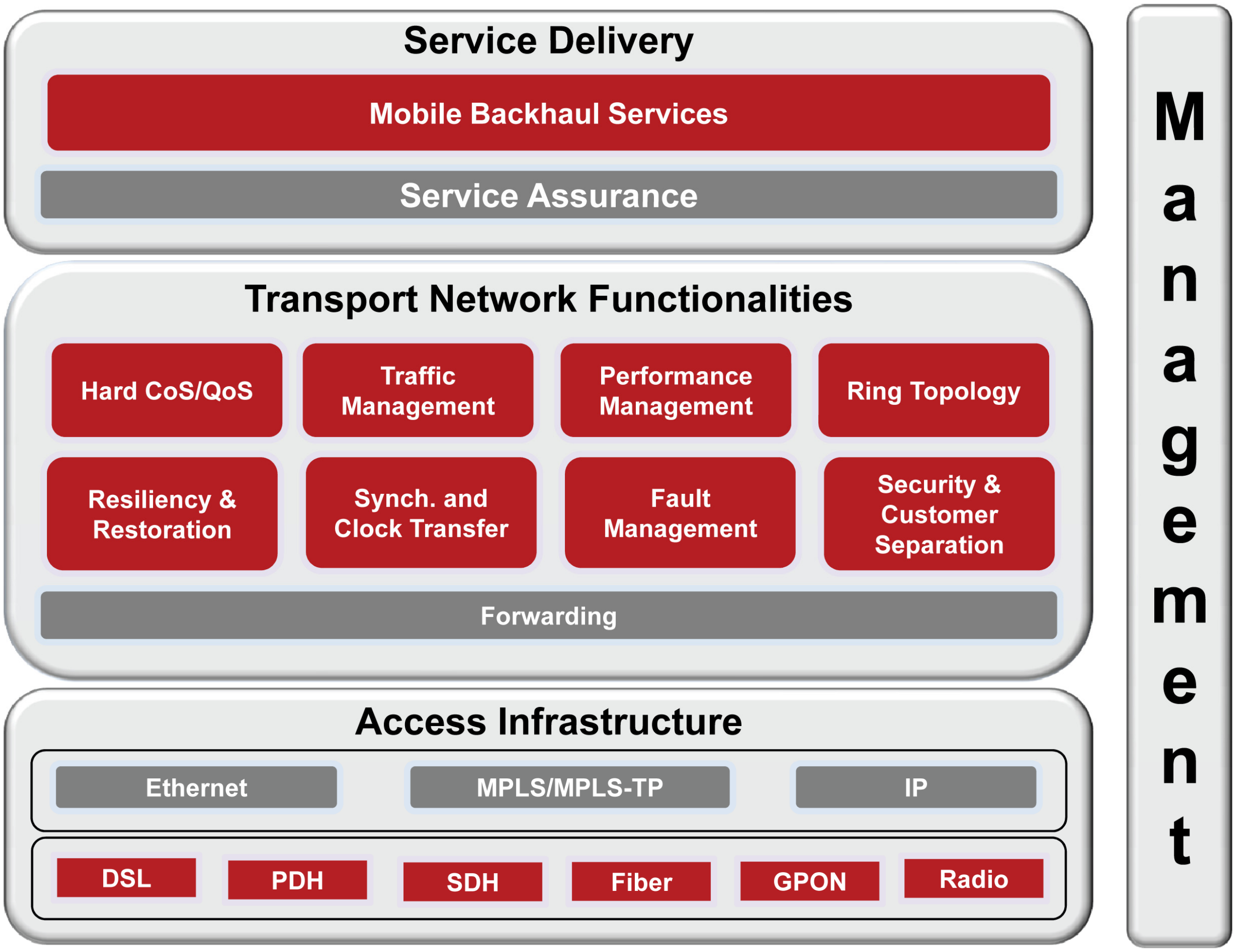

Figure 6: Essential transport network and service functionalities in LTE backhaul

Since LTE network deployments involve substantial investments, a considerable proportion of which are dedicated to the backhaul segment alone, transport providers must drive down their CapEx with an intelligent use of network resources to minimize equipment needed for timing and demarcation. Moreover, capacity planning is required to efficiently accommodate mobile broadband usage trends and to offset the huge discrepancy between peak and average data rates. The latter is affected by various factors, such as the number of users connecting to the cell site, number of sectors in a cell, etc, and cannot be economically resolved by over-dimensioning the network. Instead, providers can achieve bandwidth gains to meet demand and lower their OpEx by implementing backhaul aggregation and statistical multiplexing, which further increase the need for sophisticated network service delivery functionalities.

2.3 Synchronization and Clock Transfer

The need for synchronization and timing over packet (ToP) solutions is widely recognized as one of LTE's major challenges. This is because clocking data, which is transmitted natively in TDM networks, requires special attention in new packet switched networks (PSNs), as these are asynchronous by nature and introduce packet delay variation (PDV) and packet loss. As far as mobile operators are concerned, the backhaul network must meet "SDH/SONET or better" performance levels to eliminate the risk of service disruptions, impaired cell hand-offs and excessive dropped calls. LTE therefore requires robust clock distribution to all network elements to ensure accurate handover. This includes frequency as well as phase and time synchronization, not only for TDD (time-division duplex) networks, but also for those utilizing FDD (frequency-division duplex); MBMS (multimedia broadcast multicast system) applications and radio interference between base stations are two of the reasons phase accuracy is expected to be mandatory in FDD LTE.

2.4 Backhaul Sharing

Because of mobile backhaul's significant share of operators' operating and capital expenses, many of them are attempting to reduce their costs by outsourcing some or all of their backhaul services to fixed-line transport providers or by consolidating their networks with other operators. This trend, which has gained momentum in recent years, is likely to grow with LTE's expected rollout investments, estimated by mobile network consultancy Aircom to reach US$ 1.78 billion per operator in the US and US$ 232 million in Asia Pacific in the first year alone[3].

While backhaul sharing presents a lucrative business opportunity for wholesale transport providers, it also compounds the challenges relating to network service delivery that were discussed in the previous section. The need to support multiple operators with differentiated SLAs while keeping access rate fairness among operators requires SLA assurance, performance monitoring and diagnostic capabilities in a multi-domain environment. Another key requirement is highly accurate, simultaneous clock transfer for multiple clock domains to ensure each operator receives timing data from their own clock source.

In addition, as different operators use different base station versions/generations from various vendors, backhaul providers must find an economical solution to meet the above requirements while reconciling equipment dissimilarities.

[3] Refers to CapEx investments for radio site additions, backhaul infrastructure upgrades and core network enhancements. Source: Aircom International LTE cost calculator, 2009.

2.5 The LTE Voice Dilemma

There is no argument that LTE offers the best solution for mobile broadband data services. Things are somewhat different, however, for voice services; these still account for 69% of operator revenues on a global basis, according to a recent market study by telecom market analysis consultants Ovum[4]. In addition, SMS support has been absent from the LTE framework altogether, an oversight that may not only affect a major revenue generating service but also eliminate an important operational communication channel that operators use to manage subscriber devices.

The 3GPP endorses mobile VoIP using an IP Multimedia Subsystem (IMS) platform for supporting telephony services in LTE networks. The technology, however, is lagging behind planned 4G rollouts, its implementation is costly and doesn't yet offer an adequate solution for SMS. Until, or indeed, if IMS takes hold as the prevalent architecture, operators and transport providers face the following alternative routes for handling voice (and SMS) over LTE:

- CS Fallback – where voice calls are diverted to 2G/3G networks. While using existing network resources, this method offers far from optimal user experience. Long call setup times, lack of simultaneous voice and data support and roaming interruptions are hardly the kind of features that help sell new customers on the promise of LTE.

- VoLGA (Voice over LTE via Generic Access) – which tunnels CS traffic over the LTE network, using the 3GPP's GAN (generic access network) specifications. This initiative is presented as the least disruptive migration path to IMS but currently enjoys limited support among mobile operators.

- Proprietary solutions by network equipment vendors.

Without a clear industry consensus, the voice over LTE conundrum has grave ramifications on service coverage, equipment interoperability, handset design/cost, and continued support for operators' "bread and butter" services. It also dictates LTE rollout schedule, although almost all early deployments will offer data-only services initially.

[4] Ovum: Mobile voice and data forecast 2009-14, 2009

3 Carrier Ethernet: Marrying Capacity with Intelligence

The use of Carrier Ethernet at the transport layer presents a perfect fit for LTE backhaul, as it offers simplicity, scalability and cost-effectiveness in resolving the issues described above. It does, however, mandate the use of smart gateways to connect LTE elements with the backhaul network. Such gateways must support a flexible selection of topologies and allow distributed intelligence at cell site and aggregation switches to efficiently handle tens of thousands of backhaul connections in LTE's flat architecture, while optimizing network resources. In addition, such gateways must enable cost-effective backhaul sharing with customized SLAs and differentiated QoS. Below are examples of the various ways Carrier Ethernet gateways can optimize LTE backhaul.

3.1 L2 VPN Topologies in LTE Backhaul

Some examples of backhaul topologies using Carrier Ethernet are featured in Figures 7 through 9. The network in all these scenarios can be based on IEEE 802.1ad Provider Bridges (Q-in-Q), IEEE 802.1ah Provider Backbone Bridges (MAC-in-MAC) or MPLS-TP. An EVPL service (Ethernet Virtual Private Line, Figure 7) is used to transport S1 and X2 traffic. As an EVPL service allows more than a single point-to-point EVC (Ethernet Virtual Connection) to be supported at the same UNI, enabling resource optimization through statistical multiplexing. Traffic is separated by VLAN-IDs or other criteria, while switching is performed by an aggregation gateway.

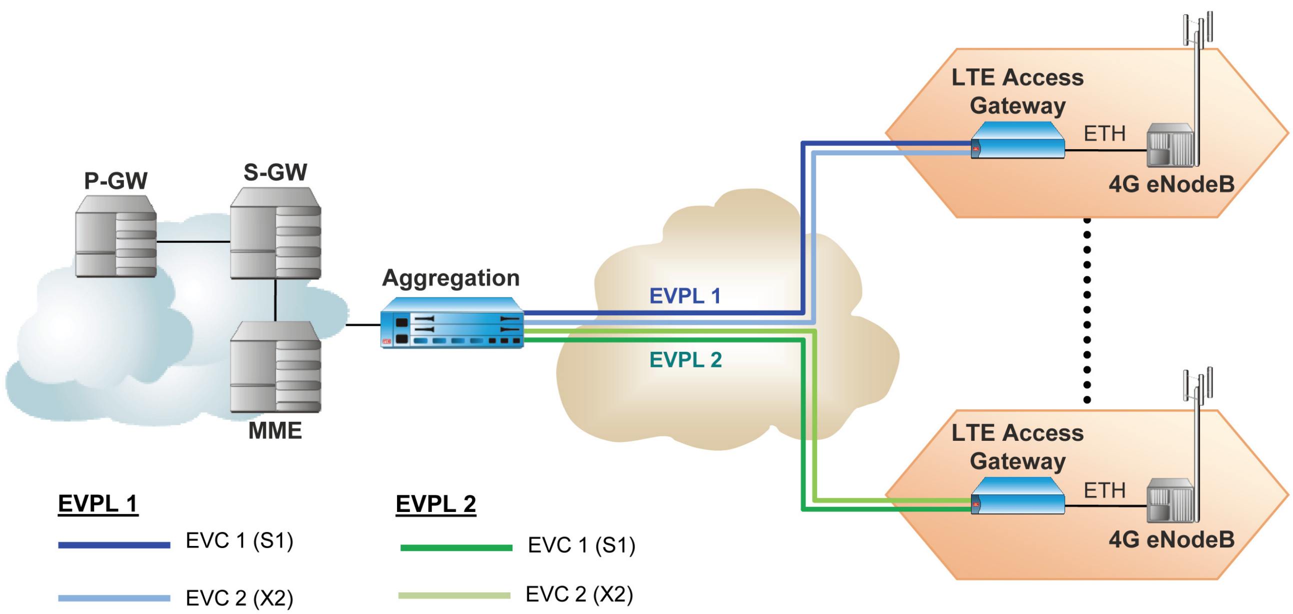

Figure 7: EVPL topology in LTE backhaul

A combination of E-Line and E-LAN (Ethernet Local Area Network) services, illustrated in Figure 8, uses EVPL to deliver S1 traffic via an aggregation gateway, while X2 traffic is delivered over the EVPLAN (Ethernet Virtual Private LAN) to facilitate inter-eNodeB communications. With its any-to-any connectivity attributes, EVPLAN is better suited than EVPL for network scale-ups, allowing easy addition of new sites without extensive efforts for configuration and set up at each location.

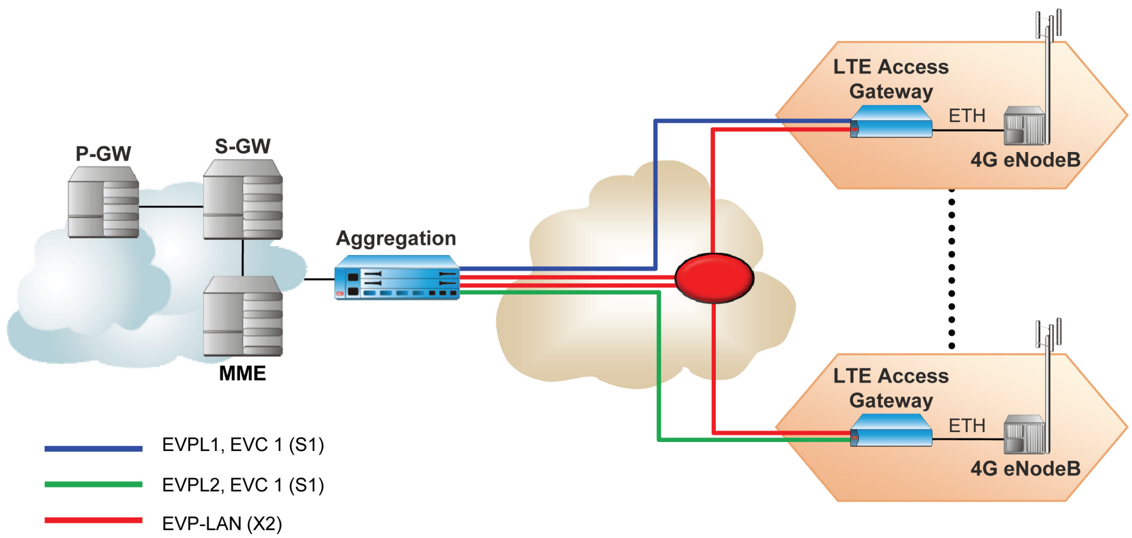

Figure 8: EVP-LAN and EVPL combination in LTE backhaul

The following table lists various implementation considerations that should be taken into account when evaluating the respective advantages of EVPL and EVPLAN services:

Implementation Considerations	EVPL	EVPLAN
Multipoint connectivity	Complex, not scalable	Native, simple
QoS guarantees	Based on relatively simple resource allocation approaches	Requires complex resource allocation due to lack of information on the traffic matrix
OAM	KPI measurements per connection	Aggregate/worst-case KPI measurements
N+ redundancy	Requires a high number of connections	Built-in support

Another alternative combines E-LAN and E-Tree, whereby S1 traffic is transported over a rooted multipoint E-tree and X2 transmissions are carried over an E-LAN, as can be seen in Figure 9. The use of E-Tree topology fits the nature of S1 communications while enabling efficient scalability as new cell-sites are added. It also fits multicast/unicast clock distribution from a central location, where no communications are required between the eNodeBs.

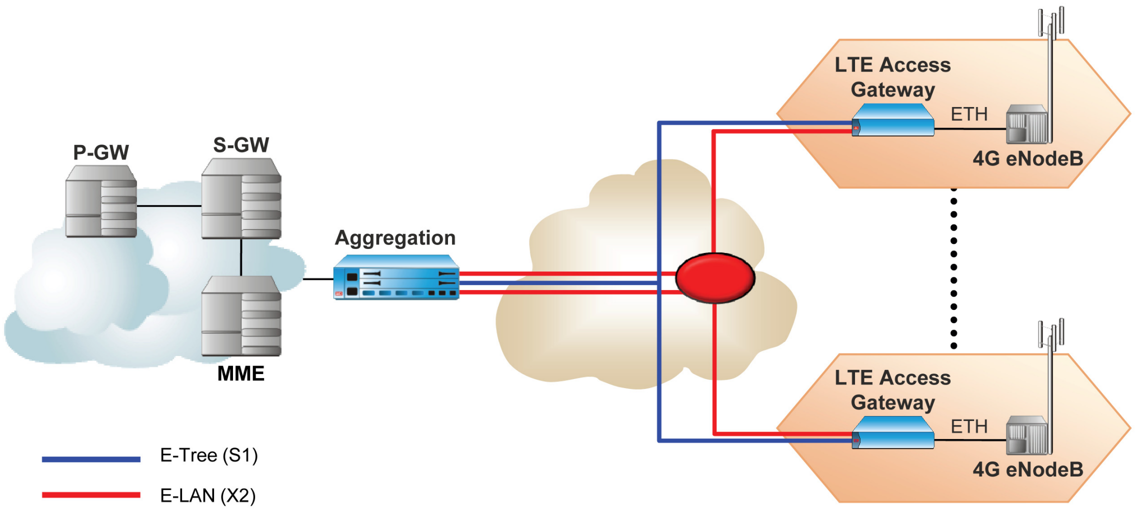

Figure 9: E-LAN and E-Tree topology in LTE backhaul

Note: Although the illustrative diagrams in this section show a single SGW at the core, each eNodeB will most likely be connected to multiple SGWs for N:1 redundancy. This connectivity can be based on an EVP-LAN service, whereby control plane and data plane traffic is separated by different EVCs.

3.2 Service Delivery, SLA Assurance and Shared Backhaul

Supporting multi-operator colocation with customized Ethernet backhaul SLAs requires sophisticated service handling functionalities. By implementing these functionalities at cell-sites and aggregation sites, transport providers are better equipped to harness LTE's low latency, efficiency and cost benefits in meeting operator expectations. An optimal set of service delivery and SLA assurance capabilities will typically include the following:

- GbE access rates from the cell-site
- High EVC/flow count to support service differentiation without increasing port count
- L2/L3 classification and hierarchical QoS per flow/service
- Shaping and CIR/EIR policing functionalities for intelligent traffic management
- Color-sensitive P-bit re-marking to ensure metering continuity in color-blind networks, as well as in color-aware networks with no "discard eligible" support
- Complete set of Ethernet OAM standards, including connectivity verification, fault management and service monitoring
- L1, L2 and L3, in-service and out-of-service loopbacks
- Real-time performance monitoring based on live traffic

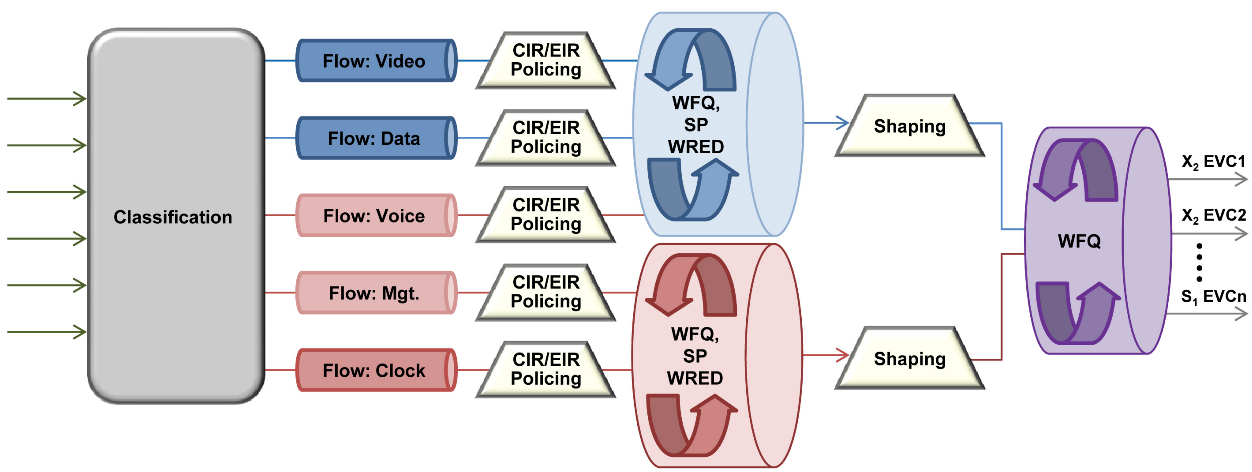

Figure 10: Carrier Ethernet service delivery functionalities in LTE backhaul

Note: For more information on SLA management capabilities, please refer to RAD's application guide: Carrier Ethernet SLA Support Tools.

In addition to supporting differentiated SLAs for multiple operators in colocated towers, the above-listed feature set helps providers increase their revenues per Mbps with smart oversubscription, while lowering MTTR (mean time to repair) with remote provisioning, monitoring and traffic management. Furthermore, it enables sophisticated service assurance over operators' and transport providers' domains with end-to-end OAM and performance management, as illustrated in Figure 11.

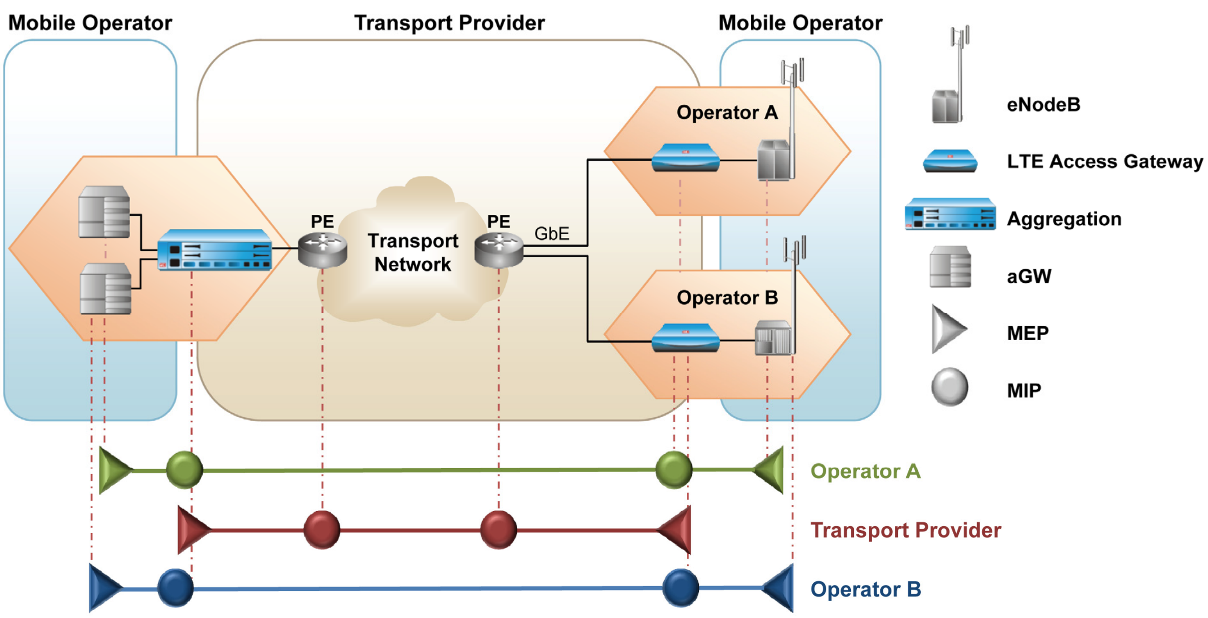

Figure 11: End-to-end backhaul service management in shared LTE backhaul

Specifically, advanced OAM and performance monitoring capabilities from the cell-site allow transport providers to accurately measure SLA KPIs, such as one-way delays, which are better suited for asynchronous packet networks. Furthermore, statistics analysis enables effective resource planning to overcome the "peak to mean" gap, such that bandwidth is added only when needed based on actual usage trends.

3.3 Synchronization and Timing over Packet in LTE Backhaul

The most popular methods today for ensuring synchronization in all-IP backhaul are based on the ITU-T Synchronous Ethernet (Sync-E) methodology, which uses the Ethernet physical layer to accurately distribute frequency, and on the IEEE 1588-2008 standard, which involves timestamp information exchange in a master-slave hierarchy to deliver frequency, phase and TOD information. LTE backhaul gateways that support clock transfer enable substantive cost savings, as they eliminate the need for costly dedicated hardware or GPS installations. The truly advanced gateways facilitate further savings by bridging different timing and synchronization technologies, for example, by employing 1588-2008 to receive the clock from the network then distributing it to the cell-site using Sync-E. Such devices provide backhaul suppliers with the ability to match different clocking technologies used by the transport network and the base stations, as well as help them avoid complete network upgrades with new hardware to support Sync-E end-to-end. Figures 12 and 13 show the different methodologies and their combination.

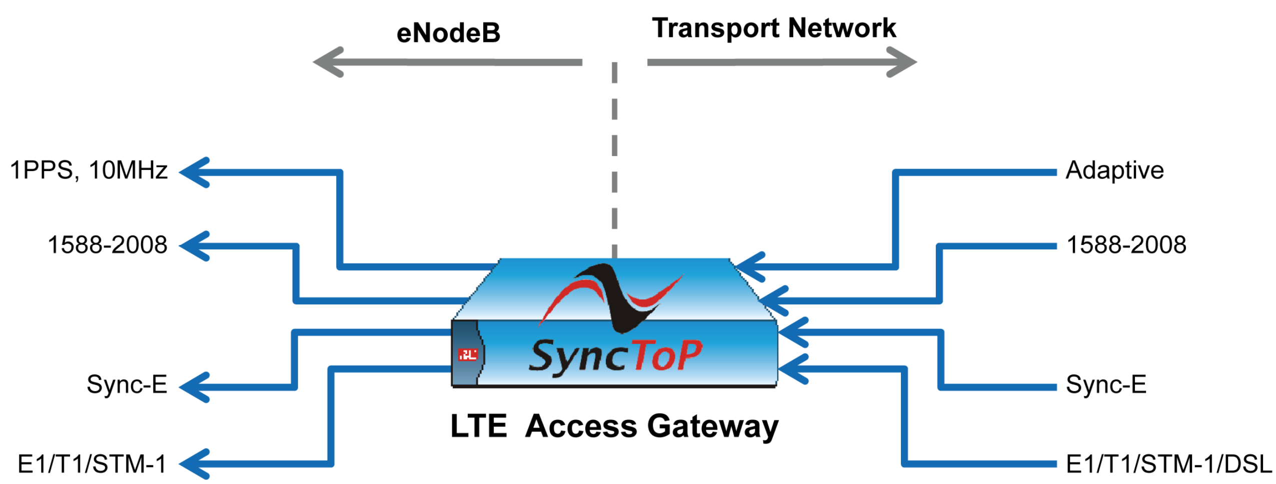

Figure 12: Multiple synchronization and Timing over Packet methodologies by a single LTE access gateway

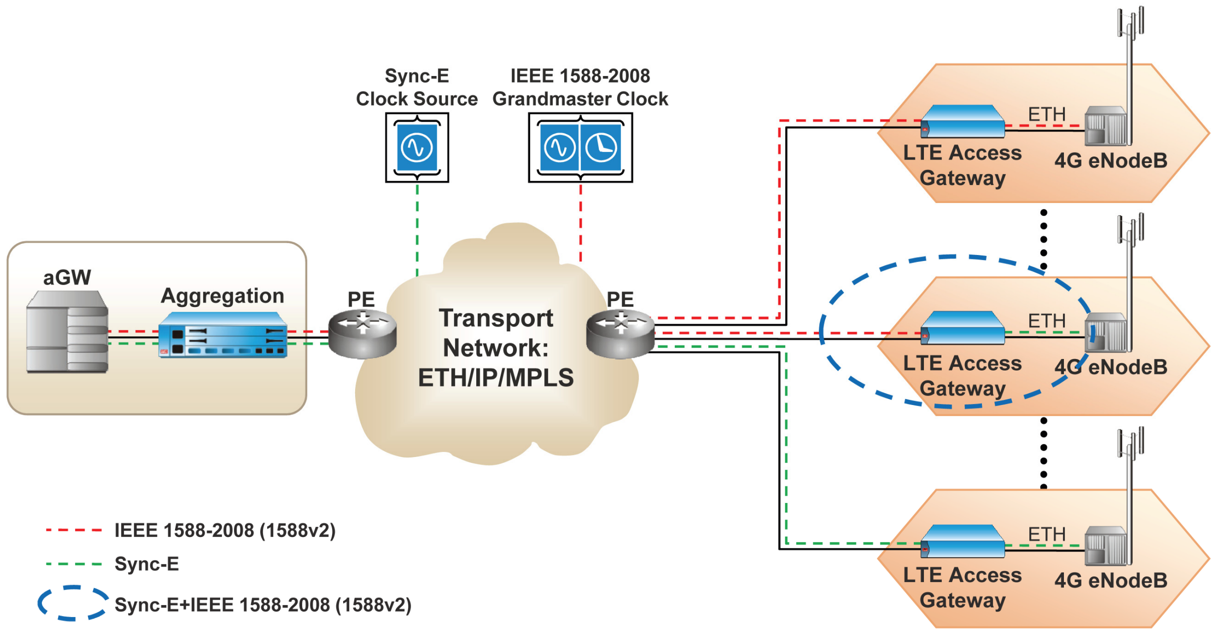

Figure 13: Synchronization and Timing over Packet in LTE backhaul

Transport providers offering clock distribution as a backhaul service stand to benefit greatly from gateways that combine timing and synchronization with demarcation capabilities. Aside from their equipment consolidation benefits, such gateways help providers navigate through the intricacies of multi-operator clocking SLAs, including QoS, resource management, OAM, and security for the different entities located at the same site.

3.4 Redundancy and Resiliency for Service Protection

Service protection and resiliency are additional critical factors for mobile operators, who expect Five Nines (99.999%) availability and speedy restoration in the event of network outages. Without proper redundancy for link and path protection, even brief failures may result in compromised QoE (quality of experience) for the user, due to retransmissions or even loss of service altogether. Transport providers are therefore required to ensure carrier-grade levels of service resiliency and continuity with dual homing redundancy, link aggregation (802.3ad LACP) and Ethernet linear path protection (G.8031), as well as with Ethernet Rings Protection Switching (ERPS), using ring topology to ensure sub-50ms service convergence without the risk of Ethernet loops upon restoration. The different methodologies for service protection are illustrated in Figure 14.

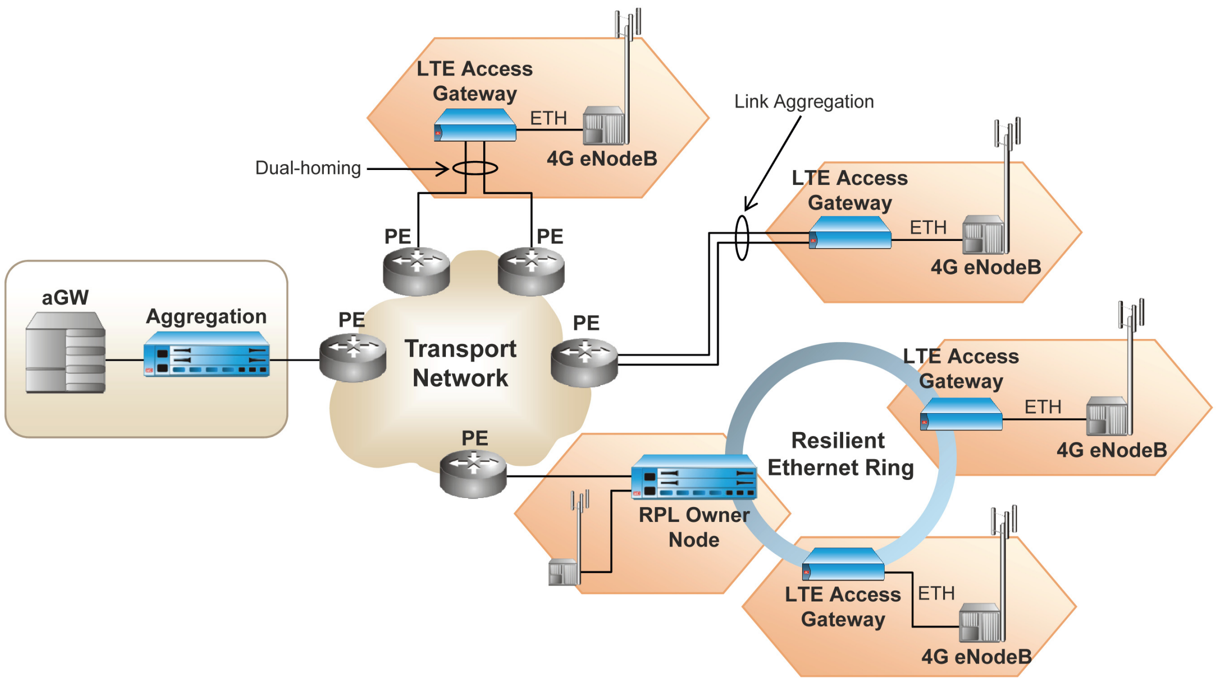

Figure 14: Service protection in LTE backhaul

Conclusion: How Transport Providers Can Realize Business Opportunities from LTE Backhaul

As wholesale transport providers around the world are preparing for new LTE rollouts, there is a clear need for effective strategies that reconcile the business and technology implications of 4G mobile broadband networks with operators' exacting requirements for backhaul services. These strategies must include solutions that add backhaul intelligence to LTE's abundant capacity, while lowering TCO to make such deployments economically viable. LTE's "intelligence crunch" is of critical importance as unresolved technological issues, such as voice traffic delivery, are likely to impact service coverage and equipment interoperability.

RAD's LTE backhaul solutions are specifically designed to meet these early deployment challenges head-on, by providing affordable intelligence with a future-ready migration path. With multiservice, multi-generation support, RAD's cell-site gateways and aggregation switches feature advanced backhaul sharing capabilities to allow transport providers to optimize LTE bandwidth while ensuring customized QoS and SLA performance. Such capabilities include the following:

- ✓ Sophisticated service functionalities, including smart traffic handling, SLA assurance and service resiliency
- ✓ Extensive support for various Layer 2 topologies to maximize backhaul efficiency in LTE's partial mesh architecture
- ✓ Clocking accuracy with the SyncToP™ suite of synchronization and Timing over Packet technologies, including the simultaneous use of Sync-E and 1588-2008
- ✓ Simplified management of LTE's backhaul network with traffic engineering, including load balancing, fault detection and alarm monitoring
- ✓ Backward-compatibility for 2G and 3G traffic delivery

In addition, RAD's LTE backhaul gateways allow transport providers high flexibility in choosing their preferred methodology for handling voice and SMS traffic over LTE. Such a wide range of carrier-grade capabilities in single, economically-sized devices make RAD's backhaul gateways an ideal solution to meet transport providers' migration needs and help them realize the LTE opportunity.

www.rad.com

International Headquarters
RAD Data Communications Ltd.
24 Raoul Wallenberg St.
Tel Aviv 69719 Israel
Tel: 972-3-6458181
Fax: 972-3-6498250
E-mail: market@rad.com
www.rad.com

North America Headquarters
RAD Data Communications Inc.
900 Corporate Drive
Mahwah, NJ 07430 USA
Tel: (201) 529-1100,
Toll free: 1-800-444-7234
Fax: (201) 529-5777
E-mail: market@radusa.com
www.radusa.com

data communications

The Access Company

 Catalog no. 802443 Version 11/2009