LTE requirements for bearer networks

As increasing numbers of leading operators unveil their LTE plans, the high requirements for LTE are shaping the development of bearer network technology. Notably, bearer networks must consistently deliver a carrier-class performance that caters to all scenarios and is underpinned by simplified and cost-effective O&M.

Full scenario

PWE3/MPLS: 2G, 3G, and LTE coexistence

Over 90% of wireless sites will be reused during the 2G/3G transition to LTE. However, transition does not mean “replacement”, and the three technologies will coexist over the long term. This situation will force transport networks to adapt to the varied requirements that arise in the different stages of wireless technology evolution.

The cost of wireless sites, including equipment room construction and rent, accounts for almost half of total wireless network CAPEX, while wireless base stations and the transport network incur 40% and 10% respectively. Comparing with the heavy cost of renovating their existing 2G/3G base stations, most operators choose to offer multi-service capabilities on their newly-built IP transport networks.

Only MSTP and PWE3/MPLS-based packet transport technologies can currently carry TDM, ATM, and Ethernet services. As transport networks evolve toward IP telephony, PWE3/MPLS technologies have emerged as a vital feature of the mobile bearer area.

IEEE 1588v2: low cost synchronization and full coverage

GPS or IEEE 1588v2 achieves the time synchronization that TD-SCDMA, CDMA, WiMAX, and LTE (including LTE TDD and LTE FDD) all require.

Frequency limitations mean that LTE provides less coverage than 2G and 3G; CAPEX is increased due to the necessary increase in base stations and the provision of network-wide GSP. However, IEEE 1588v2 technology reduces GPS costs and fortifies the telecom infrastructure by maintaining synchronization should GPS fail.

Wireless broadband is widely used in indoor applications. As GPS cannot penetrate roofs, time information from indoor base stations must be synchronized by the transport network, in which case GPON, Ethernet and others need to integrate IEEE 1588v2 capabilities.

OTN/WDM: high speeds and low OPEX

The current mainstream solutions for LTE-based high-speed railway applications provide network coverage through distributed BTSs, with multiple remote radio units (RRUs) located in the same cell. This solution reduces the number of cell handovers across base band units (BBUs) by enabling handover to occur within a single BBU. Doing so significantly enhances the broadband service experience as call drop rates are reduced during high-speed motion.

As the bandwidth of common public radio interface (CPRI) between a BBU and an RRU can reach 1Gbps and as base stations located on a rail system complicate maintenance and are prone to theft, compact optical transport network (OTN) and wavelength division multiplexing (WDM) devices are favored for the CPRI bearer. This solution lowers overall maintenance costs by reducing fibers, centralizing BBU management, deploying remote and
distributed RRUs, and easing equipment room acquisition. Moreover, it is advisable to protect investment by deploying an IP bearer network that can evolve to incorporate OTN and WDM capabilities.

**Carrier-class performance**

**LTE bearer: a connection-oriented entity**

An LTE bearer network provides two interfaces: S1 to connect a base station to the core network gateway and X2 to realize logical inter-base station connections.

The S1 interface is topologically similar to the 2G Abis and 3G Iub interfaces and requires Flex capability for disaster recovery. Similar requirements would apply to the Abis and Iub interfaces as 2G and 3G networks become IP compatible, but this has not been realized yet. Protection extends beyond technology to involve a number of factors such as network topology, transmission directions, network construction costs, and requirements. The service gateway (SGW) only necessitates dual-homing protection, given that SGW would be relocated in the radio network controller (RNC) room. The network core must provide Flex protection as the mobility management entity (MME) is located in the central equipment room.

As LTE networks are designed to serve the general public, the X2 interface is obligated to comply with a given nation’s rules and policies, including requirements for legal monitoring. All traffic must be monitored through the gateway to prevent mobile subscribers from accessing each other without authorization. Operators currently only use the X2 interface to enhance adjacent base station handover, after which services still need to be transmitted through the S1 interface.

As handover is confined to neighboring base stations, leading operators require the X2 interface to logically connect adjacent base stations so as to prevent the failure of a single base station extending to others by blocking full-mesh connectivity.

Connections in this way can only be established through static configuration due to complex coverage between base stations. Creating a suitably connective link is unfeasible given the high requirements of the X2 and S1 interfaces for low delays coupled with strong protection capabilities. The connections, protection mechanism, and QoS features of the two interfaces must be pre-configured before services are launched over the LTE bearer network. This type of connection is immune from both aging and automatic changes, which in turn positions the LTE bearer network as essentially a connection-oriented entity.

**Lower delay guarantees service experience**

LTE is designed to enable the same capabilities as fixed broadband. Traditional 3G/HSDPA architecture handles services over four layers from subscription to service, causing lengthy delays and high costs. LTE’s flat structure considerably reduces delay to markedly improve the performance of broadband services.

LTE bearer networks require much lower delays than legacy fixed broadband bearer networks to achieve the same end-to-end (E2E) performance indices. However, the coding of wireless air interfaces creates long transmission delays, which lowers system throughput and potentially erodes the spectrum efficiency of wireless air interface. In this scenario, greater number of wireless carriers increases costs to guarantee sufficient coverage. Consequently, transmission delays must be minimized to achieve viable costs.

Traditional switches and routers generate discrete transmission delays, which occasionally causes interruptions exceeding 1ms in single sites. As signal transmission generally passes through 10 to 20 sites, LTE bearer networks are unable to guarantee stable E2E transmission with low delays. As a result, operators opt for packet transmission equipment with fixed-length packet forwarding to deliver LTE bearer capability. For lower E2E delays, L3 handling procedures and the number of hops must be minimized.

**H-QoS ensures base stations are always online**

The LTE wireless layer realizes E2E service QoS control by controlling signals and reserving resources. However, increasing IP-based bearer network architecture stimulates a number of problems that degrade QoS across the LTE service layer, including network congestion, packet loss, jitter, and delays. Since All-IP bearer networks may suffer from congestion, a mechanism for guaranteeing QoS under congested conditions must be implemented.

The QoS mechanism for the LTE base station transport network must meet two key requirements: first, prioritized service forwarding that mirrors traditional differentiated services; second, service guarantees at crucial base stations, for example, those at government buildings, hospitals, and schools, to ensure seamless service provision in the event of major congestion or a disaster. This requires hierarchical QoS (H-QoS) processing on the bearer network to schedule queues across different base stations and services to maintain the functionality of priority base stations and vital services.

**Easy maintenance**

**LTE transport focuses on S1 not X2**

LTE’s new logical interface X2 is intended for handover. The interface features a complicated logical mesh connection that challenges legacy point-to-point transmission network architecture. Further analysis reveals that the X2 interface needs little bandwidth—a maximum of 3% of the amount required by the S1 interface. The E2E transmission delays must range from 50 to 100ms on the X2 service plane, 10 to 20ms on the signaling plane, but considerably under 5ms on the S1 user plane.

The time delay on the X2 interface has to adapt to mobility requirements while delays on the S1 interface must meet service and throughput requirements. The X2 time delay requirement is negligible if the bearer network accommodates the S1 interface delay requirement. Thus, X2 logical handover can also be performed on the bearer network or access gateway (AGW) convergence point. Notably, the
Bearer network is required to support X2 logical interconnection, which may increase demands on maintenance and equipment functions, such as L3 VPN.

In addition, preventing unauthorized connections between adjacent base stations requires a security control policy, though this can increase the bearer network CAPEX by over 30%. Is it worthwhile to increase investment by 30% simply to cover 3% of the traffic but degrade the QoS and maintenance for 97% of S1 services?

The experience of fixed network operators shows that VPN PE routers can be located in the core metro equipment room to support low-traffic L3 VPN services over the broadband network. In terms of configuration and management, this model accommodates requirements that are similar to those of the X2 bearer and fixed network L3 VPN: low traffic, configuration needs, and frequent adjustments. Centrally configured VPN provider edge (PE) routers can represent the optimal X2 bearer solution if the time delay index is achieved.

**Unified management ensures smooth evolution**

LTE services are currently transported in two ways. The first reflects concerns regarding new technology by delivering 2G and 3G services over MSTP, and LTE services through a separate PTN. The second method aims to protect future investment by transmitting both 3G and LTE services over a PTN and migrating existing 2G services from the MSTP to the network.

Both solutions must address the small size of base station rooms. As transport equipment is located in the base station cabinet, which provides 2U-3U space. However, the base station can smoothly evolve from 3G to LTE, with 2G and 3G coexistence occurring over the long term. Therefore, each solution has to provide unified end access through an equipment box.

Traditionally, one MSTP maintenance team is sufficient for wireless network maintenance. A specialized maintenance team is usually necessary for wireless and transport networks as the former requires operators to frequently adjust bandwidth, add carriers, and relocate sites. Otherwise, cross-departmental communication will increase maintenance cost and weaken troubleshooting efficiency. Thus, the unified maintenance and management of LTE and 2G/3G backhaul networks is vital for a smooth evolution process.

**IP NMS visualization reduces OPEX**

LTE deployment on a massive scale is inhibited by the challenge of rising OPEX. The Organisation for Economic Co-operation and Development’s (OECD’s) analysis of wireless broadband reveals that initial wireless broadband construction accounts for the bulk of expenditure, but that OPEX burdens operators during the latter stages. See Fig.1.

Therefore, the bearer network must prioritize easy maintenance and availability. This promotes the advantages of legacy SDH networks, which operators can refer to as models of reliability and maintainability.

Legacy SDH networks provide a rich set of alarm and performance monitoring capabilities based on hierarchical overheads and maintenance information. To support visualized E2E IP-based network management system (NMS) configuration and rapid troubleshooting, PTN equipment must also provide hierarchical OAM capabilities in the same way as SDH equipment, and send comprehensive maintenance information to the NMS.

Compared with traditional IP equipment that supports single-site command line configurations, the visualized IP-based NMS increases configuration efficiency by 95%. Moreover, the system greatly improves fault detection efficiency, which eases maintenance complexity, and may significantly curtail OPEX in the context of massive-scale deployment.

**A customer-focused, expedient approach underpins the robust and sustainable development of bearer networks.** With a focus on key mobile bearer requirements, Huawei has launched its multi-service platform based on PTN products. Geared to mobile operators’ broadband and All-IP transition requirements, the platform currently serves the world’s top 10 global operators, including China Mobile, Vodafone, Orange, and Telefonica O2.

Based on a unified platform, Huawei’s IPTime solution (IP infrastructure for Multi-Play experience) significantly simplifies maintenance by facilitating access via microwave, copper wire, and fiber lines. Huawei has incorporated E2E IEEE 1588v2 capability into its full product series, including PTN, GPON and routers. Oriented to operators’ key LTE bearer requirements and incorporating hierarchical SDH network maintenance and management, the Huawei IPTime solution has considerably enhanced the PTN in terms of holistic adaptability, carrier-class performance, and maintainability. Thus, it can assist operators to provide 2G and 3G systems with full service LTE bearer capabilities.

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