Backhaul technology in the IP era

As base station backhaul transforms to IP, transmission is switched from circuits to packets in order to efficiently carry multiple mobile broadband services and reduce operators’ OPEX ready for the IP era.

Backhaul goes IP

P-based multi-service applications are pervading mobile communications. Bottlenecks are created in SDH backhaul networks as broadband access become dominant in base station backhaul; SDH’s insufficient capacity, low efficiency, and costly data service interface are gradually becoming evident.

The transformation of base station backhaul to IP marks both network evolution and a technological revolution. The capacity and efficiency of base stations are greatly expanded and improved after IP bearer network access is achieved, and resulting costs are easily controllable. In this scenario, per shelf capacity ranges from 500G to 1T; network transmission is raised to 40GE, and statistical division multiplexing improves efficiency by 50%.

However, IP base station backhaul presents some risks, and minimizing these is a current industry priority. An IP network requires a free and open information structure, which threatens the immediacy, reliability, and manageability of base station backhaul.

One leading European operator decided to replace its legacy SDH/PDH networks with Huawei’s customized IP bearer network solution for base station access, as opposed to a pure Ethernet or router solution. The operator reasoned that IP transformation would deploy 300,000 base stations globally, and that these should fulfill a number of functions: improve efficiency; be future-oriented, and guarantee service provision, stability, and ease of management.

A detailed study of IP bearer network characteristics in terms of base station access reveals that unified bearer, hierarchical and multi-domain networking, and visual management are preconditions for the large scale deployment of IP bearer networks with mobile base station access. Compared with a DSLAM metropolitan broadband network, these characteristics are more important than the IP protocols used for multiple service provision. Nevertheless, many focus only on technical maturity and ignore the inherent attributes of mobile IP bearer networks. This does not help operators avoid risks in base station backhaul IP transformation.

MPLS hits the mainstream

IP/MPLS or Ethernet switching can be employed to realize IP transformation. MPLS, transport MPLS (TMPLS) and provider backbone transport (PBT) are major transport technologies that can be identified as PTN technologies. These technologies implement QoS management for base station backhaul, hierarchical and multi-domain networking, and visualized management.

Each technology has its own advantages and disadvantages. Commercial circumstances have restricted the development of TMPLS and PBT for IP bearer networks that deliver mobile base station access. MPLS is now the dominant technology thanks to its continuous technological and protocol optimization. Indeed, most operators currently deploy MPLS PTN devices for mobile backhaul networks.

PWE3 tunnel is adopted in the MPLS PTN to ensure that the bearer layer is unified and compatible with the TDM and ATM services of traditional mobile 2G/3G base stations. PWE3 transmits TDM, ATM, or Ethernet services in backhaul and simplifies base station access to IP bearer networks.

The PTN is structured in a similar way to the hierarchical rings of SDH networks, which reduces overall maintenance complexity. For services, the PTN utilizes star path planning with DiffServ technology to implement cross-service QoS between base stations. PTNs use the simple and reliable 1:1 LSP protection mode.

The PTN uses a hierarchical OAM design that covers Ethernet or POS links, MPLS tunnels, PWE3 tunnels, and Ethernet services, providing OAM information at each level of the entire network. The PTN supports future-oriented LTE, large-capacity packet convergence and IEEE 1588v2 clocks. For the X2 interfaces of the LTE eNB, PTN provides L2/L3 switching. Visualized end to end (E2E) network management enables rapid E2E service configuration and, with the OAM mechanism, the PTN can quickly locate board and port faults within minutes.

MPLS already transports packets on telecom networks due to improved telecom features. PTN is in fact an extension of MPLS at the base station access layer for...
large-scale networking in terms of hierarchical and multi-domain networks, visualized management, and clock systems. The PTN uses MPLS routers to meet the needs of IP bearer networks with mobile base station access, which eliminates mobile operators' concerns regarding IP transmission.

PTN devices are now the leading choice for customized IP bearer networks with mobile base station access. Xu Rong, a researcher for China Mobile, believes that PTN provides a variety of carrier-class network features and greatly reduces CAPEX and OPEX. Thus, PTN has emerged as the only option for the IP transportation of base station backhaul.

**Future transformation strategies**

The rapid development of mobile broadband services has encouraged many operators plan to deploy LTE networks, and some are already constructing FMC networks. In this sense, IP transformation of mobile base station backhaul must consider LTE and FMC development.

**LTE backhaul**

The centralized control of radio network controllers (RNCs) diminishes in the LTE phase and communication services exist between eNBs and access gateways (AGWs). Base station switchover can be performed between eNBs through X2 interfaces.

Some industry insiders maintain that LTE bandwidth inherits fixed DSLAM bandwidth to support mass P2P services, and that flat IP switching between eNBs transmits services through a large number of routing protocols instead of through carrier-class management. However, this is not entirely correct and is common misunderstanding of IP technological application in the telecom field.

The scale of the Internet and its access scope continue to grow rapidly. Service development demonstrates that MAN base station services are increasingly integrated to enter the Internet backbone network from MAN core nodes. This is also the major reason why LTE standards define that all voice, data, and video service flows enter the AGW with the S1 interface. The X2 interface is only responsible for switching traffic between base stations. Base station backhaul with flat P2P IP switching is not necessarily required for LTE. If P2P traffic is not considered, a two-level service model of star (S1 traffic) and mesh (X2 traffic) is formed.

The traffic of X2 interfaces features mesh distribution that is transmitted through L2 MAC or L3 IP switching. X2 interfaces have a logical mesh structure, but the service volume on the X2 interface is relatively low (3% to 5% of network bandwidth) due to the short duration of base station bandwidth switchover. In this case, the cost of independent network-wide L2 or L3 switching is quite high and the network is complex to be managed, leading to integrated L2/L3 switching as the preferred mechanism. In this case, L2/L3 switching usually occurs in the central nodes when X2 services have arrived through designated MPLS tunnels.

In a new backhaul network between base stations and AGWs, service tunnels are thus S1 and X2. L2/L3 switching is implemented in easily controlled convergence nodes that are less cost sensitive for operators. The mesh-structure traffic of X2 interfaces is realized through logical links. The star links and integrated L2/L3 switching solution ameliorate cost, management, and complex service flow issues in the mobile backhaul network.

T-Mobile has begun to build its LTE-oriented mobile IP backhaul network based on comprehensive research and analysis. The operator will deploy MPLS routers in the central nodes with L2/L3 switching, and deploy end-to-end VLL provisioning for base station access to simplify the backhaul network. This will help to reduce network costs, improve management, and ensure carrier-class control and future LTE development.

**FMC bearer network**

Numerous mobile operators have sought to increase their competitiveness in various ways; for example, by constructing large-scale Wi-Fi networks, acquiring small or medium broadband operators, or by applying for fixed licenses in the drive to become full service operators. Operators favor combining mobile bearer networks with broadband MANs to reduce the overall cost of bearer networks, but to do so requires that IP bearer networks with base station access can support future FMC service development, such as IPTV and IP VPN. This poses higher requirements on the traditional backhaul network of mobile base stations.

Notably, FMC bearer network in this situation does not refer to the FMC bearer network for each base station as each MAN incorporates many base stations. FMC bearer network generally refers to combined multi-play IP convergence bearer networks and IP backhaul networks (the PTNs) of base stations.

As PTNs focus too much on tunnel, stability, and management, current PTNs cannot bear multi-play services. Traditional MPLS routers are recommended to implement IP convergence centering on service provision. These convergence routers adopt dynamic or static multicast for IPTV services, implement L2 switching for Ethernet services from fixed networks, provide VPLS and IP VPN dedicated lines for commercial users, and evaluate base station backhaul services as VPN dedicated line services.

The number of base stations is about ten times greater than that found at convergence nodes. If MPLS routers are used for such a large-scale network maintained through command lines, the costs are high, reliability is not guaranteed, and management is complex. Thus, PTN technology is recommended based on service requirements. The entire network can be built with router-based IP aggregation layer and PTN-based mobile base station access, and be managed by a unified network management system (NMS).

By selecting optimum technologies based on services and unifying management, the most effective FMC bearer solution in an FMC MAN combines MPLS routers and the PTN. One leading European operator's Romanian and Belgian networks employ this solution. MPLS routers improve the IP metro aggregation network's multi-service provision capability. The IP transformation of base station backhaul enhances service provision, fortifies management, and facilitates low-cost base station expansion; mobile bandwidth competitiveness is thus greatly improved.

**Editor:** Xu Peng xupeng@huawei.com