As the broadband revolution continues to intensify, technologies – both wireless and wireline – have been undergoing continuous evolution to meet the increasing requirements for bandwidth-intensive applications that have resulted in a strong demand for higher broadband bandwidth provisioning.

Increasingly high-bandwidth applications and services such as VOIP, IPTV, video-on-demand, file sharing, user-generated content, online gaming and social networking have been exerting great pressure on the core network and operators are facing serious problems in coping with this issue. Current assessments of traffic in the carrier backbone reveal that bandwidth requirements are doubling every 12-18 months and this rate of growth is expected to continue in the near future.

While powerful smartphones, fast networks, compelling applications and user awareness have led to a dramatic surge in the use of mobile broadband (with wireless data now experiencing mass-market adoption), wireline broadband technologies have not only continued to hold their own but have also witnessed growth and undergone significant technological developments. They have become faster, with technologies such as fibre-to-the-home (FTTH) and next-generation cable-modem technologies providing throughput rates of tens of megabits per second, enabling applications such as high definition (HD) video over the internet, which were previously not possible.

Broadband technologies

Two kinds of networks – core/backbone network and access network – are required to offer any kind of service, whether narrowband or broadband. The core network, having a high speed and high capacity, supports all traffic that is routed to/from customers connected to the access network. The core network of each operator is connected to the core and/or access networks (wireless operators are mostly connected to the core network via leased lines) of other operators as well as with the international backbone network to provide internet services.

On the access front, broadband technologies can be divided into two camps – wireline and wireless.

Wireline broadband technologies

The main wireline broadband technologies include digital subscriber line (DSL), fibre and cable modem. A key advantage of these technologies is their ability to concurrently deliver the highest data rates to many subscribers. This paves the way for several new services such as IPTV and HDTV. The broadband packet network enables business customers to enjoy virtual private networks as well as peer-to-peer file sharing.

Among these, DSL, the dominant broadband technology, is delivered over a twisted copper pair used for voice and can reach speeds of over 2 Mbps. Incumbent wireline operators traditionally leverage their legacy copper installations to offer broadband services with DSL to consumers. While there are various flavours of this technology such as asymmetric DSL (ADSL), symmetric DSL and very high bit DSL that are distinguished by data rates, reach and application, the ADSL family (ADSL, ADSL2+, ADSL2++) is the most commonly deployed DSL technology, with up to 20 Mbps downstream capacity and a peak upstream capacity of between 1 Mbps and 3 Mbps. The downstream-to-upstream performance ratio of 10:1 is perfect for IPTV services with high downstream data rates and high speed internet browsing.

In fact, operators are now bundling IPTV with fixed line broadband services to retain customers and have witnessed an increase in their revenues. For instance, Canada's largest communication company Bell Canada witnessed an increase in its wireline operating income in the January-March 2010 quarter, driven primarily by its broadband and IPTV services.

However, with the focus shifting from voice to multimedia services and a growing end-user bandwidth demand, fibre deployment has gained considerable momentum in the industry. Only the optical fibre access network's virtually unlimited bandwidth can cater to the emerging needs both for wired and wireless connectivity. Using fibre in place of copper boosts data rates and extends reach many times over. Fibre may be deployed in point-to-point connections from a central access switch or an optical line termination to the subscriber's premises or to a subtended DSL access multiplexer. Also, several subscribers may share fibre in passive optical networks.

The various fibre solutions are fibre-to-the-curb and fibre-to-the-building, with FTTH being the ultimate fibre access solution where each subscriber is connected to a fibre. Worldwide, FTTH rollouts surpassed 30 million users earlier this year and are continuing to grow at a rapid clip.

There are two important types of systems that make FTTH broadband connections possible. These are active optical networks and passive optical networks (PONs). Each offers ways to separate data and route it to the proper place, and each has its own set of advantages and disadvantages. However, PONs have been considered the most promising technology for delivering various FTTx solutions. Next-generation PONs, which outreach DSL many times over, are expected to deliver new and legacy services, both analog and digital, in a single converged conduit.

These networks use passive optical components that may be buried in cable ducts and need no dedicated power supplies, thereby reducing network complexity and life-cycle costs. Comprising optical line terminals (OLTs) deployed at the central office and optical network terminals (ONTs) at the customer premises, these networks are designed for residential and business applications and exploit fibre's ability to deliver the highest data rates to subscribers.

PON systems vary in performance. The different variations of the technology include ATM-based PON (APON), Ethernet-based PON (EPON) and gigabit-based PON (GPON). Among these, EPON and GPON technologies are the most innovative options that provide more bandwidth per subscriber. For instance, EPON, which can deliver data streams of up to 1 Gbps and operates at a distance of up to 20 km between the OLT and ONT, is quite popular in Japan and its uptake is increasing rapidly in other Asian countries including China and Korea.

These systems allow operators to share a single fibre access line among a cluster of buildings using passive splitters to distribute traffic to individual homes (each optic fibre strand can serve up to 32 users). Fixed network and exchange costs are shared among all subscribers, thereby reducing the key cost per subscriber metric.

The other FTTH architecture is the all-optical Ethernet network, a point-to-point network that uses electrically powered switching equipment, such as a router or a switch aggregator, to manage signal distribution and direct signals to specific customers. This switch opens and closes in various ways to direct incoming and outgoing signals to the proper place. In such a system, customers may have a dedicated fibre running to their house that provides a dedicated line of connection to the operator for each subscriber. This enables these systems to have an edge over PONs as the dedicated lines facilitate higher subscriber bandwidth with improved traffic security as well as a simple provision of symmetric services.

Mobile broadband

Mobile broadband technologies include 3G/wideband, CDMA/universal mobile telecommunications system (UMTS), evolution data optimised (EVDO), high speed packet access (HSPA), Wi-Max and long term evolution (LTE). Apart from phones, internet and network access using these technologies is increasingly being incorporated into laptops, automobiles and public transportation.

In the GSM segment, EDGE/HSPA/ LTE is a robust portfolio of mobile broadband technologies and is an optimum framework for realising the potential of the wireless data market. The HSPA mobile broadband equipment, already available in the market, supports peak rates of 14 Mbps downlink and 5.8 Mbps uplink, capabilities that are typically added to existing networks using a simple software-only upgrade, which can be downloaded remotely to the UMTS radio network controller and Node B. Most of the existing UMTS networks have already been upgraded to support HSPA.

EVDO is the leading 3G mobile broadband technology in the CDMA space. The widely deployed EVDO Rev. A offers 3.1 Mbps peak downlink data rates and 1.8 Mbps on the uplink for users of smartphones and portable computers with wireless data cards. Successive generations of EVDO technology will provide plenty of headroom for networks to offer higher speed services and greater spectrum efficiency without disrupting their subscribers or infrastructure.

Another technology that provides mobile broadband is Wi-Max. Fixed Wi-Max, standardised as IEEE 802.16-2004, has been playing a key role in the field of fixed wireless broadband access and is an alternative to wireline ADSL in areas where ADSL is not available and carriers are unable to deliver wireline broadband cost efficiently. Driven by economies of scale and interoperability between vendors, the technology has evolved from the fixed version to support mobility with the mobile Wi-Max 802.16e. In addition to mobility, the mobile Wi-Max supports features that increase spectrum efficiency. This technology is the best-positioned time division duplex (TDD) technology for fixed nomadic and mobile access aimed at the 2.3 GHz, 2.5 GHz and 3.5 GHz bands, and offers 40 Mbps peak bit rates with 10 MHz bandwidth, and up to 80 Mbps peak bit rates with 20 MHz bandwidth. Originally designed as a wireless backhaul technology and especially well suited for that task, it is being used as an ideal wireless backhaul technology for bandwidth-intensive applications such as wireless video surveillance and traffic synchronisation. It will be used as the backhaul technology for wireless voice and data networks as well.

With the introduction of new content and services on the web, there is an increasing need for a more advanced network. LTE is the latest standard in the mobile network technology tree that previously realised the GSM/EDGE and UMTS/HSPA network technologies. The technology supports both frequency division duplex and TDD as well as flexible carrier bandwidths from below 5 MHz up to 20 MHz. LTE also enables speeds of over 200 Mbps. For instance, technology behemoth Ericsson has demonstrated LTE peak rates of about 150 Mbps. Furthermore, radio access network (RAN) round-trip times are less than 10 milliseconds.

LTE is currently competing with mobile Wi-Max for the pole position as the preferred future (4G) mobile broadband technology with the promise of speed, higher capacity and cost efficiency. Both technologies use the same fundamental wireless standard known as orthogonal frequency division multiplexing.

The intense rivalry between the technology heavyweights and global operators notwithstanding, it seems that both technologies will become viable 4G access technologies, with Wi-Max maintaining its position as an ideal backhaul technology as well. So, as LTE networks begin to roll out, it is quite likely that Wi-Max will also be used as the wireless backhaul for those networks while LTE provides the access.

Clearly, both the existing and future wireless technologies will work together as there are significant, varied and non-exclusive market opportunities for both Wi-Max and LTE.

Converging wireless and wireline networks

As services grow richer and more varied, bandwidth consumption and user expectations for quality rise accordingly. Consumers want the convenience of being able to access them freely, anywhere and anytime. Only by converging fixed access with broadband wireless access technologies can service providers hope to offer always-on broadband services on a continuous basis. The movement towards building converged networks that provide the bandwidth pipes and mobility to deliver content and applications has gained traction as operators try to minimise costs and offer consumers ubiquitous broadband connectivity.

While the evolution to a unified core network that supports existing access technologies in both the fixed and mobile domains is likely to take time, it will be key to an operator's ability to reduce opex in the long term as well as increase competitiveness and profitability.

Wireline versus wireless

Wireless networks have a major advantage over wireless networks – they offer personal broadband access regardless of the user's location. That spells total mobility for nomadic and fully mobile use cases. In addition, if a region lacks wireline infrastructure, wireless technologies can provide low-cost broadband coverage at far lower costs as compared to new wireline installations. This becomes particularly relevant in emerging markets like India where wireless broadband access is an attractive alternative for the densely populated urban and sparsely populated rural areas. However, these networks inherently have a far lower capacity than wireline networks. One fibre optic cable has greater data capacity than the entire radio frequency spectrum. A shared, inherently unreliable medium like radio simply cannot match what wire can offer. As a result, only a small number of mobile users with bandwidth-intensive applications can consume the available wireless network capacity.

To cater to this exponentially growing demand (especially since it will take five years or more for new spectrum allocations), operators are using multiple strategies such as building new cell sites (an expensive and time-consuming process) and spectrum reuse, which is accomplished through the use of the same frequencies over and over again in different cells and is, in fact, the greatest determinant of overall network capacity. Offloading data onto other networks such as Wi-Fi is another option that is being aggressively pursued. Femto cells could also eventually offload data to buildings, but the market for these cells is yet to pick up.

Clearly, both mobile and fixed line broadband have advantages and issues. Though with the strong demand for ubiquitous connectivity, wireline broadband will face some erosion from wireless technologies, it will continue to be more resilient to competition from wireless transmission than telephony has been.

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