The Internet Protocol Network (IPN)

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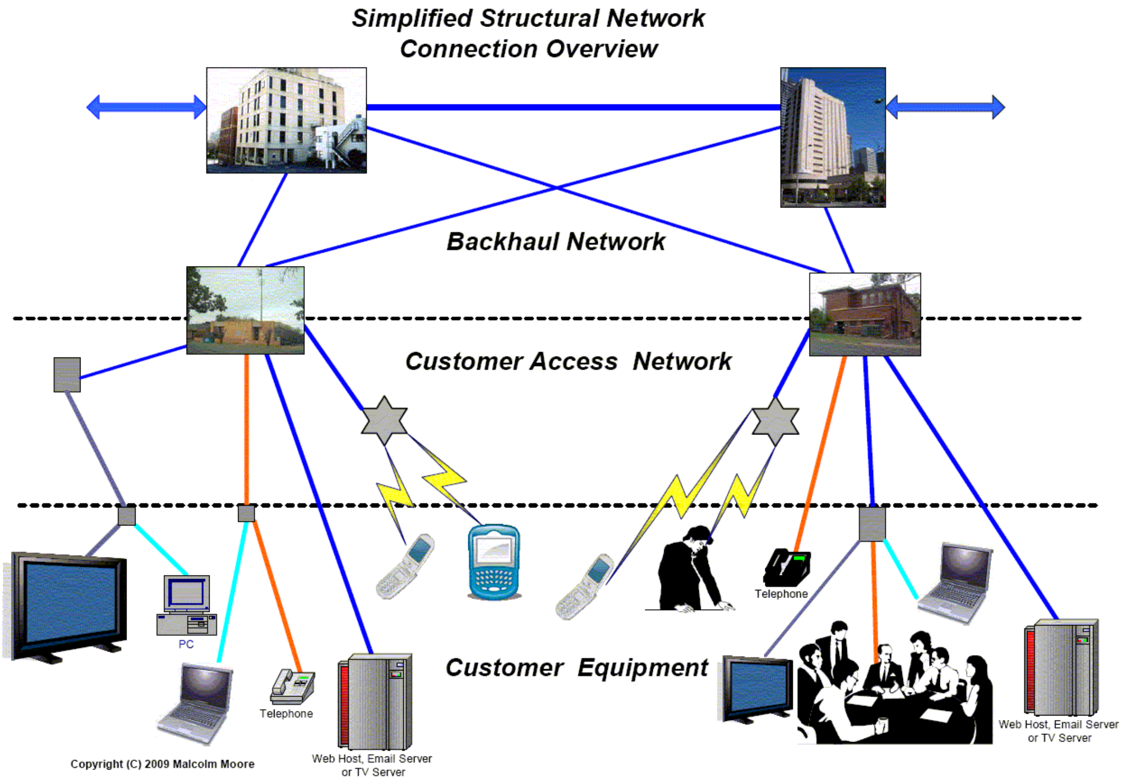
The Emergence of VoIP

From about 2000 with the predominance of Internet it is known that calls based on G.703 are bandwidth wasteful as most human conversations are simplex (that is; while one person is speaking, the other person is listening); and there are gaps between words and to take breaths.

By encoding the active speech into IP datagrams it is quite possible to have upwards of 70 bi-directional conversations on a 2 Mb/s stream that with G.710 would hold 30 conversations. The problem is that this IP needs to be high priority or there will be significant breaks in the conversation that will seriously degrade the speech Quality of Service (QOS).

With IP phone calls in mind, the Backhaul Network has gone through a dramatic change where local telephone exchanges are now fed into Node/District located "H Servers" that interface IP to G.710, (2 Mb/s).

The voice-based IP (VoIP) then continued through the Backhaul Network/IPN to the distant Node/District located "H Server" where the IP is converted back to G.710 (2 Mb/s) for its local switch to covert back to analogue for fixed access CAN or, remain digital to ISDN CAN, and Mobile Base Stations for cellular mobile phones in their CAN.



In cases where the distant end is an IP Phone, the VoIP will pass through the Backhaul Network/IPN to the distant Backhaul Network/IPN-CAN router/switch interface and continue in IP through the CAN to the Customer Premises Network (CPN), where it directly connects to an IP phone.

All these network switching scenarios fit very comfortably into the Connectivity Model described in Telecommunications 101, and the derivation of that connectivity model comes from a basic understanding on how calls connect. This simplified picture outlines the very basics of all call connections here:

It is imperative to comprehend that the PSTN connectivity model did not correlate with reality beyond the early technology of direct telephone connections between customers. Since about 1960, automated alternate network switching made the PSTN connectivity model obsolete (but some naive Business Analysts still cling on to it).

The Connectivity Model manages multiple CAN transmission and signalling protocols, multiple Backhaul Network transmission structures, multiple Backhaul Network signalling protocols, and multiple Backhaul Network switching structures and hierarchies. This Connectivity Model is the basis of the Business Model that Business Analysts should be using, if they want their modelling to mimic reality.

Since about 1990 there has been a concerted engineering effort to integrate the Internet Protocol with telephony traffic, (which uses CCS7 for its switching and control protocol) and Data traffic which inherently uses IP. The IPN has a very similar structure to the IDN with the names of various switches / routers changes slightly - but they all have generally similar locations and functions.

These two technologies can and do sit very comfortably beside and within each other. Voice and Vision on IP have to pass through priority switching so that the latency delays are minimised, and the sequence of packets at the distant end are kept in sequence. This priority restriction causes priority IP for these applications run to operate in less dense arrangements than is used with data to avoid latency issues.

At Local / Terminal exchange sites, "Edge Network" equipment; consisting of Router / Switches connect to the CAN via Digital Service Line Access Multiplexers (DSLAMs) for unconditioned twisted copper pair cable; and via Universal Broadband Routers (uBRs) for Hybrid Fibre Coax. These Router / Switches are the hop-off point for new CAN technologies like Fibre to the Home / Premises (FTTH / FTTP).

On the next page is a fairly typical Router / Switch (on the left hand side) that would usually be in a District / Node exchange site, connecting to business through Wideband Customer Systems, to DSLAMs and maybe Cable Internet. Each vertical slot would connect to four STM-1 (155 Mb/s) Optical Containers by pairs of yellow Optical Fibre Patch Cords, and these would connect to the "Edge Network" equipment in the CAN.

In this case there are four Router / Switches that would be in a 'Quad Mesh' for reliability and high throughput, and the dual Parents would probably feed this Local exchange Network IP switch via an STM-16 transmission system if non-capital city, or directly by Optical Fibre pairs if this network was located in a capital city (metropolitan) geographic arrangement.

The in non-metropolitan areas the transmission system would be a series of intersecting physical SDH rings that would connect to another two or three other District / Node exchange switches like this one, and the Dual Parent Regional or Main / Primary Router / Switches would connect to these Local exchange Router / Switches to form a 'Double Centred Star' Network - for reliability, redundancy and high data throughput.

The more central body of the Internet Protocol Network is termed the "Core Network" and this consists of banks of Router / Switches that automatically load share and network switch Internet based calls between major capital city centres. As this network grows in size and strength, the Regional layer will emerge, but the main problem is in providing the enormous bandwidth requirements for distance transmission of Internet Protocol traffic.

This is a typical suite of IP Routers / Switches that would form part of the Core Network (equivalent in Backhaul Network telephony switching terms as the Main / Primary switch).

These Router / Switches would connect with Optical Fibre (see the yellow patch cables over the racks) to either; cables connecting directly into Local exchanges Router / Switches in metropolitan areas, or through STM-16 Optical Fibre ring SDH networks that then connect to Local exchange Router / Switches in non-metropolitan Local exchange sites.

The Next Generation of Network Switches and Transmission systems will clock at 10 Gb/s, but these (at 2007) are in their infancy, but will be fully functional and highly effective in providing a very robust IP Network by about 2010.

Note the Purple cable: This is Cat 6E Ethernet cable capable of at least 1 Gb/s, and it has a special spacer in it to keep the four twisted pairs far enough apart from each other so that the crosstalk is minimised.

These systems do not run on thin air! They are fan forced cooled and you can see the thickness of the power cables (Blue and Red) feeding to the equipment.

In most metropolitan areas, distances rarely exceed 60 km and most are in the order of 10 km to 20 km, so it is possible to use Optical Fibre cables directly without any transmission systems - apart from the small profile Gigabit Interface Optical Transceiver (GBIX) that can be plugged into most Routers / Switches used for these purposes.

These interfaces provide a 1 Gb/s interface (and 10 Gb/s interface) and can operate up to 100 km depending on their specifications and the type of Optical Fibre (but the usual limit for network reliability is about 60 km).

Non-Metropolitan Networks

Beyond these distances it is necessary to use SDH transmission systems, but these are limited to the standards 155 Mb/s STM-1 Virtual Container as their base clock rate. Transmission systems that used to be bearers for telephony traffic and Internet traffic are now becoming too small at STM-4 size (625 Mb/s), and are being replaced with STM-16 (1.2 Gb/s) and STM-64 (10 Gb/s) transmission systems - and this replacement process takes several years to install and commission.

One of the beauties of the IPN is that it automatically load shares, so switches can be commissioned and activated and they will be fully operational in about 30 minutes.

On the other hand, it may take some years to manage the technology of multi-path switching at 10 Gb/s, and not have concurrent load sharing issues!

Protocols for High Capacity Networks

SDH is not the ideal transmission language for network Switches and Routers, as these talk and listen in short bursts of data where that data has a 'header' that tells what type of data it is, how important the data packet is and where it is destined to go.

The first version of high-speed data was Asynchronous Transfer Mode (ATM), which treated the STM-1 as a data path, and this worked rather well - even though a poor compromise was made on the standardised data packet (datagram) length of 55 bits. (Some companies wanted 48 bits and other companies wanted 64 bits - so an ITU “committee” compromise of 55 was declared.)

ATM was replaced in about five years by Multi Protocol Language Switching (MPLS), which solved both issues and allowed for a range of other data packet sizes. It also allowed Frame Relay to fit within itself, and a range of other data transmission protocols.

Telephony traffic is diametrically different is in that it is a long held link sometimes for hours, the call is essentially simplex (because we do not speak when we are listening). There are big efficiencies that can be grasped by merging these two technologies together and utilising and entire STM-1 Virtual Container as a data path and not an SDH telephony path.

A 2 Mb/s stream used for telephony can carry 30 Voiceband channels, while an equivalent 2 Mb/s stream using Voice in IP (VoIP) could carry about 60 to 70 Voiceband channels. This also suits MPLS, but the MPLS for this application has to avoid running into routers that are 'spraying' data into multi-paths to achieve throughput.

With telephony, the 64 kb/s data stream can be captured and stored (for a few milliseconds) and then this can be transmitted with a header to tell it where to go. At the distant receiving end, the datagram is received and stripped of its header and then sequentially passed on to the Node switch to the Local switch to the distant CAN. While this all sounds very simple - it is - but the priority of this Internet is very high, as minor delays cannot be afforded or the speech will be severely distorted. This is VoIP in a paragraph!

To all intents and purposes, the IPN is carrying all the telephony traffic above the Node hierarchical level as VoIP, and it is a dual network structure where the telephony traffic is separated from the Internet traffic, but as the Internet structure becomes much stronger (thicker pipes) by about 2010, these two networks will merge, and IP telephony will be the norm with analogue telephony being phased out.

Comments and Corrections are welcome