The IEN Connectivity Model

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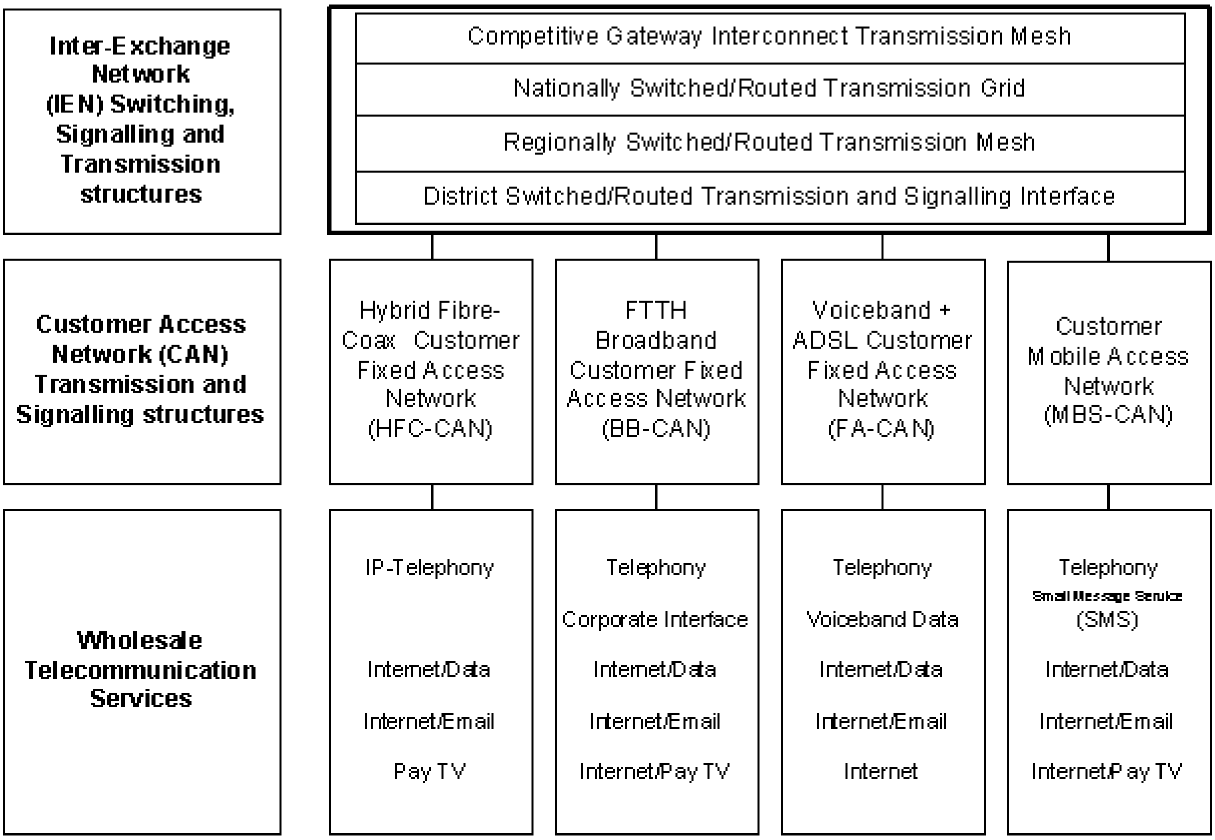
02-Nov-2005

(November 2005, July 2007, August 2007)

Introduction

The diagrammatic figure at the top of this Web page gave a visual appreciation of the Customer Premises / Business Equipment and how it connects through the CAN to the IEN, and back again through the CAN to other Customer Equipment (anywhere in the world).

The figure directly above showed diagrammatically how the IEN and CAN sits together to form a well-structured connection model between a wide range of commercial products. From this aspect is relatively easy for even the most inept business analyst to comprehend the IEN Connectivity Model as the diagram below.



The IEN Switch and Transmission Structures are a series of Signalling, Switching and Transmission infrastructure layers, where at the bottom level the District/Local switch levels interfaces to the CAN in various forms of simple transmission infrastructure that connects to Customer Premises, and provide a range of Retail Products and Services.

There are primarily four types of CAN infrastructures (Voiceband (usually copper pair), Broadband (usually xSDL on copper pair) or point-to-point radio) Multimedia/Wideband/Broadband (usually on Hybrid Fibre Coax or just Fibre) and Mobile (usually Wideband CDMA / 3G).

Most of this is pre-determined by the available IEN infrastructure - and the IEN infrastructure is highly geographically dependent on its traffic density throughput capabilities.

Fixed Access CAN is through Pair Cable, Coax Cable, and/or Optical Fibre, while Mobile Access CAN is Radio through a large number of Mobile Base Stations (which are part of the CAN). It is the available IEN infrastructure that determines what CAN interfaces are possible and together these two pre-determine what Wholesale services can be made available at any geographic location.

While it has been proven that it is extremely inefficient to unbundle CAN to provide competitive retail pricing, it is extremely efficient to resell Wholesale services to competitive telecommunications resellers to provide competitive retail pricing. Retail price bundling of wholesale products is a very common marketing tool that is highly acceptable to the public.

While the IEN is now largely homogenous, the CAN structure is not largely homogenous and the CAN interfaces in different ways to the IEN, depending on the technologies involved. The rational solution is to resolve where the CAN and IEN start and finish - in other words - their demarcation points, and this needs clarification.

Demarcation between CPN, CAN and IEN

In all cases, the CAN sits between the CPN and the IEN, so it is relatively easy to nominate the various CAN structures and then define the demarcation points to both the CPN and the IEN (in their various forms).

A mature call connects from customer premises equipment / network (CPN) to the customer access network (CAN) to the IEN / IDN / IPN (where the call is switched) to the distant CAN then finally to the distant CPN/ CPE.

It is the horizontal dashed line in the above picture that clearly shows where the CAN stops and the IEN starts - or vice-versa and the distinction very clear in a visual form. It is very obvious that virtually all switched connections that go beyond local switching site boundaries pass through the Inter-Exchange Network (which, by the way; functions far more efficiently as an Infrastructure Business - and is a very inefficient Competitive Business).

In technology terms that horizontal dashed line is not so simple to specify, and a little bit of history is necessary to get the basis of the understanding to explain where and how the line is drawn, and understand the need for a reference point to start with that then leads to rational Demarcation points to work with. Fortunately a little bit of history provides the necessary knowledge to create wisely defined boundaries:

The Exchange Reference Point

Historically, when telephone calls were manually connected by a Local Operator using a cord in a switchboard to establish a call, the prime interface was called the 'Feed Bridge", and this was the signalling interface point and the speech interface point. The determination then, (pre-1930) was that the exchange reference point (ERP) was in the middle of the Feed Bridge, and this hypothetical point was a common reference for all level measurements, and power feeding measurements, and signalling measurements.

For Step-by-Step equipment, this strategy then related to the Feed Bridge in the First Selector; so the Uni-Selector that came before the First Selector was therefore part of the CAN. Likewise, the Feed Bridge that was in the Final Selector was the secondary ERP - so part of the Final Selector circuitry was part of the CAN too!

This understanding should start to explain why part of the local exchange buildings in the picture above are part of the CAN and not in the IEN. Further - every switching technology has its' own ERP, and knowing where these are situated goes a long way to understanding where the demarcation points are between the IEN and the CAN.

For Crossbar Equipment, the Subscribers Line Switches (SLA, B, C and D) graded the currently active customer circuits into large groups where they then pass through Feed Bridges. If the call was local, then the ERP was in the SR (Subscribers Relay) interface, and if the call was not local then the call would be directed through the FUR (Outgoing) or FDR (Bothway) line interface equipment. All these interfaces had Feed (or Speech) Bridges in them and the same rule applied as this was the primary ERP. For Incoming calls, the FIR (Incoming) interface also had a speech bridge as the secondary ERP.

With the transmission changing from both-way (2 wire) in the CAN to unidirectional two-pair balanced in non-metropolitan IEN, the interface included a hybrid transformer, and the ERP in this case was in the middle of the hybrid transformer. The attenuation from the 2-wire terminals of the hybrid transformer to the ERP is about 0.1 dB and that aligns very closely with the earlier Feed Bridges.

From about 1980 until late 1994, Telecom Australia / Telstra replaced the entire Analogue Transmission Inter- Exchange Network (IEN) with a completely Digital Transmission IEN.

Along with this conversion Loop Signalling Multiplexer (Mux) equipment was initially connected after the Group Switching stages in Crossbar Equipment to make connection into the IEN. As the number of Loop Mux equipment increased, the Group Switching stages in Crossbar were replaced by digital (AXE) switches and the Loop Mux equipment was brought forward to become part of the SR/FIR/FUR/FDR interface relay set function, and the ERP moved into the Loop Mux Hybrid transformer.

This concept of the Speech Bridge location as the hypothetical ERP is a watershed and with developments, less switching remained between the ERP and the Exchange Main Distribution Frame (MDF); where CAN cables physically terminate in the Exchange building. This concept then translated directly into digital transmission and then to digital exchange switches as follows.

With early Ericsson AXE digital switches, the equivalent Crossbar Subscriber Grading Stages were electronic but used Reed Relay switches for grading customer circuits, with significantly reduced maintenance requirements. The next phase of Digital AXE equipment provided four customer line circuits per interface card; completely removing all physical switching and again significantly reducing maintenance requirements. So now the ERP was on the Line Interface Card about 0.1 dB in attenuation from the Equipment side of the MDF.

Alcatel System 12 and Nortel DMS 100 switches (and other switches used by other telecommunications businesses for 'domestic' switching), also has Line Interface

Cards, and the (hypothetical) ERP standardised on being in the Hybrid connecting the 2-wire CAN to the 4-wire digital streams, with a loss of about 0.1 dB from the card terminals, or in other words; about 0.2 dB from the Equipment side of the MDF.

Although this explanation might appear long-winded; it sets the scene to position physical demarcation points between the CAN and the IEN, and the CAN and the CPN at practical connection points as follows:

Network Inter-Connect Points

Fixed Access Telephony

For fixed access telephone services; the practical interconnection point between the CAN and the IEN is the Exchange Equipment side of the Main Distribution Frame (MDF). This means that from the local exchange switch, everything past the Exchange side wire jumper connection on the MDF that connects towards the customer is part of the CAN.

At the Customer Premises end of the CAN, the first terminal connection point of the lead-in is the interconnection point between the CAN and the Customer Premises Network. This could be a phone terminal block, or residential MDF at a home unit complex, or an MDF in a business premises.

From that initial connection point onwards towards and including the premises equipment, this is all Customer Premises Network (CPN).

Private Automatic Branch Exchange (PABX)

When Digitally (switched) Telephone Exchanges were in their maturation phase around the mid-late 1980's Private Automatic Branch Exchanges (PABX's) leapt into the fore as another office based productivity tool at customer business premises.

For Calls that are 'Outgoing' from the PABX - that is towards the IEN via the CAN, these circuits normally utilise Loop Disconnect signalling and therefore usually use physical pairs just like a non-commercial telephone service. ***The interconnection points for an 'Outgoing' connection are identical to a non-commercial telephone service.***

In some cases smaller PABXs utilise "Bothway" interfaces so that they can create an outgoing connection utilising Loop Disconnect line signalling (and Dual Tone Multi-Frequency in-band signalling) to create and establish connections through the IEN. The Bothway interface can also manage incoming calls with Ring-Down signalling to terminate and facilitate extension connections.

Again, the interconnection points for a 'Bothway' connection are identical to a non-commercial telephone service.

The big difference is the 'InDial' circuits that connect from the Exchange to the PABX for calls coming into the PABX from outside. These circuits usually connect with Primary Rate ISDN (Integrated Services Digital Network) over a 2 Mb/s bearer carrying 30 voice (B) channels at 64 kb/s with one LAP-D signalling circuit and the 32nd channel is for bearer synchronisation.

Local Exchanges do not switch at the 2 Mb/s interface, but they are parented by Group Switching Stages that connect at a 2 Mb/s interface; and this is where the ISDN connects.

To follow the convention, the IEN/CAN Interconnection Point for Primary Rate (2 Mb/s) ISDN is at the Equipment side of the Digital Distribution Frame (DDF) connecting to the CAN. Any line conditioning equipment past this point towards the customer is part of the CAN.

In line with Physical Telephony for PABXs alike, ***the Interconnection point between the CAN and the CPN is at the first terminal connection point of the lead-in.*** In this case it will be the line side of the MDF in a business premises.

Mobile Telephony

In a very similar vein to ISDN Indial circuits used in most PABX equipment, the CAN for Mobiles connect with Bothway circuits at a nominal 2 Mb/s or 8 Mb/s interface at a DDF into the Group Switching Stage and then connects through to a Mobile Base Station for transmission / reception via radio to the mobile phone. The interconnection points are better described backwards from the mobile phone to the IEN.

The Mobile Phone <u>antenna</u> (air interface) is the interconnection point between the Customer Access Network (CAN) and the CPN.

At the IEN end of the CAN, near the Group Switch ***the IEN side of the DDF is the interconnection point between the CAN and the IEN*** in the exchange. So the transmission (reception) links between the DDF and the Radio Base Station, and the Radio Base Station itself, and the near geographic radio limits from the Antenna's Mobile Base Station are all part of the CAN.

Dial-Up Internet

At the premises the telephone is replaced by the data modem and the call is established through the IEN via the CAN as per a standard telephone. ***At the Dial up Modem end of the call the interconnection points are exactly the same as for a telephone connecting to the IEN via the physical CAN.***

The Internet Service Provider (ISP) is usually connected to the IEN via a CAN in much the same style as a PABX InDial circuit - utilising Primary Rate ISDN based on 2 Mb/s links that directly connect to a bank of Digital Data Modems each working in 64 kb/s channels.

The IEN to CAN interconnection point from the ISDN connection is at the Equipment side of the DDF (just like the InDial circuit for the ISDN PABX). The CAN to CPN interconnection point is the first connection point from the CAN at the Customer Premises (again just like before).

At the ISP, the bank of Digital Data modems usually have an IP based interface to connect with ISP Servers and Firewalls which manage the Email and Web usage interface. From this point, the IP traffic passes through a transmission system back to the mainstream IP network (which is also part of the IEN).

The IP based CPN to CAN interconnection point is, as before, the first connection point from the CAN to the CPN, which would be the Premises MDF or ODF if it is an optical fibre CAN. The IP based IEN to CAN point would be the equipment side of the DDF of ODF (if it is an optical fibre CAN).

ADSL Internet

At the premises the ADSL Modem connects in parallel to the physical telephone service through an ADSL Splitting Filter (which is part of the CPN). The ADSL

Modem establishes a virtually permanent connection via the CAN to the ISP through the IEN. ***At the Customer Premises end of the session, the interconnection points are exactly the same as for a telephone connecting to the IEN via the physical CAN.***

Near the IEN end of the CAN, the physical pair is redirected from the MDF to a bank of Splitting Filters, and then there are two appearances on the MDF - one for the telephone and the other for the Digital Services Line Access Multiplexer (DSLAM). These Splitting Filters are part of the CAN, so ***the interconnection point is exactly the same as for a telephone connecting to the IEN via the physical CAN.***

The DSLAM is part of the CAN, and its IP interface is usually an Optical Fibre or Shielded Twisted Pair running ATM at 155 Mb/s (STM-1), or Cat 5E running 100BaseT. ***The interconnection point is the IEN Equipment side of the ODF, DDF or Data Panel connecting to the DSLAM.***

Cable Internet and Pay TV

At the premises the Cable Modem connects to the Coax cable either directly or via a splitter to provide additional Cable services for example Cable TV. Either way there is a connection box that is externally mounted that has a pair of connectors and/or a splitter if other services are connected. ***The CAN - CPN interconnection point is the first connection in that box of the cable from the street towards the customer premises equipment.*** The splitter is part of the CPN.

At the IEN end of the Hybrid Fibre-Coax (HFC) CAN it is a little more complex, as the HFC CAN leaves the multiple Headends it does do in Optical Fibre (OF) and some km from the headend, the bearer is changed to coax cable in a transceiver for distribution to premises.

Cable Internet this is essentially an Analogue Transmission system consisting of several TV Channels in the downstream direction and a number of upstream data channels, all created in a Universal Broadband Router (uBR) which is also part of the CAN. The downstream TV channels in the range about 500 MHz to 600 MHz are used for Internet and these are mixed at local exchanges in Broadband Multimedia Services (BMS) equipment before being fed into local Headends.

The IEN - CAN interconnection point for HFC Cable Internet and Pay TV is at the TV Aggregation Rack for Pay TV where the Network TV connects to the Headend. For Internet the IEN-CAN interconnection point is in the BMS Aggregation Rack where the Cat 6E or Optical Fibre feeds to the Universal Broadband Router (uBR) making the uBR and all the HCF Headend equipment part of the CAN.

Wideband Business / IP

This is bi-directional (and usually equal data rate in each direction) Broadband Connection that is usually constructed as Optical Fibre. At the Customers Premises, the CAN-CPN interconnection point is at the first interface connection point of the lead-in cable and this will usually be at the Optical Distribution Frame (ODF), or the optical terminal into the Customer Broadband Equipment. So the Customer Wideband Equipment is part of the CPN and not the CAN.

At the IEN end of the CAN, the IEN-CAN interconnection point is at the first interface connection point from the IEN that connects to the CAN transmission link (equipment) that then connects to the into the Optical Fibre Cable and this will usually be at the Optical Distribution Frame (ODF) feeding to that transmission equipment CAN OF cable. So the OF transmission (reception) equipment at the IEN end of the CAN is actually part of the CAN.

If the CAN connection is Twisted Pair cable or Coax Cable then the CPN-CAN interconnection point is at the first connector/joint from the customers lead-in cable into the customers premises.

The IEN-CAN interconnection point is at the first interface connection point of the cable and this will usually be at the Digital Distribution Frame (DDF) for twisted pair or coax cable. So the Twisted Pair / Coax Cable transmission (reception) equipment at the IEN end of the CAN is actually part of the CAN.

If the CAN connection is Radio / Wireless, then the CPN-CAN interconnection point is at the Antennae, which is also Customer Network first connector/joint from the customers lead-in cable into the customers premises.

The IEN-CAN interconnection point is at the first interface connection point of the cable and this will usually be at the digital distribution frame (DDF) for twisted pair or coax cable. So the Radio transmission (reception) equipment at the IEN end of the Radio-based CAN is actually part of the CAN.

These interconnection points very closely align with those for Mobile Radio and for Pay TV, and Cable IP.

IP Telephony

If the IP phone is a Fixed Access IP Phone, then this would follow the interconnect rules for a Fixed Access Telephone.

If the IP Phone is a Mobile Phone then it follows the Mobile Telephony rules.

If the IP Phone is part of a IP/PABX then it follows the Wideband Business / IP rules for both the CAN-CPN interconnection and the IEN-CAN interconnection rules.

Conclusion

This brief tutorial has identified the three prime networks: Customer Premises Network (CPN), Customer Access Network (CAN) and Inter-Exchange Network (IEN), and shown pictorially how a connection is made from Customer to Customer, through CPN-CAN and CAN-IEN interconnection points.

Since automated alternate route switching was implemented and became effective by about 1965, the terminology of the **Public Switched Telephone Network (PSTN) connectivity model became obsolete and has been replaced** with two diametrically different connectivity model network structures that interconnect: The **Customer Access Network (CAN)** and the **Inter-Exchange Network (IEN)** **and these form the IEN Connectivity Model**.

A very brief outline about Exchange Reference Points (ERPs) has shown that these hypothetical points are useful but unpractical as physical demarcation points, and from that, a set of network interconnection points have been identified to cover a wide range of technologies.

The two prime interconnection points IEN-CAN and CAN-CPN have been explicitly described over a wide range of transmission technologies and these interconnection points have been shown to be highly consistent and very practical.

The notion of Network Interconnection Points has been extended from fixed-line Telephony to include Mobile Phones, PABXs, ADSL Internet, Cable Internet, Pay TV, Customer Wideband / IP / Email / Website Servers; and this sets the framework for consistent legislation, and common-sense reporting; because this **IEN Connectivity Model very closely aligns with the Australian Telecommunications Infrastructure.**

Comments and Corrections are welcome