# The Customer Access Network

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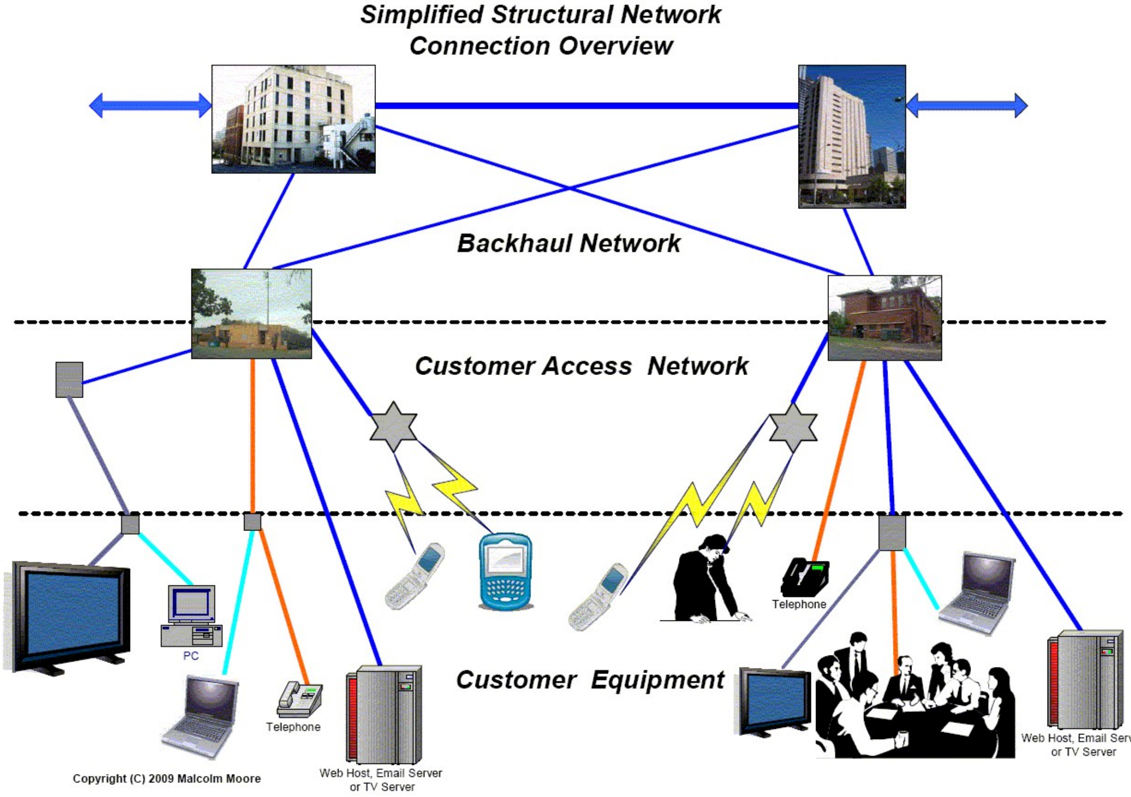
23-Mar-2003

(2003, 2005, 2007, 2012, Jun 2013)

## Introduction

The pre-requisite reference[1] and Telecommunications 101[2] showed that the CAN sits between the Customer Premises Network (CPN) and the Inter-Exchange Network (IEN), otherwise also known as the Backhaul Network (BN) or in some circumstances the Core Network. Every CPN has CAN attached to it, and the other end of the CAN attaches to the Inter-Exchange Network / Backhaul Network.




This document specifically covers pair copper lines as the CAN. Other documents in this group about the CAN cover "conditioned" physical lines and the use of Radio as well as Single Mode Optical Fibre (SMOF) used in a variety of ways either by itself or with Radio Base Stations, Point-to-Point Radio, and also as hybrid with Coaxial Cable (HFC) for connectivity between the (non) premises and the nearest telecomms infrastructure connecting to the Backhaul Network.

Technology advances in the last 50 years (since about 1960) have caused considerable changes to the Backhaul Network and these technology advances are now flowing through to the CAN. As these technologies mature - the wide variations

[1] http://www.moore.org.au/comms001.htm
[2] http://www.moore.org.au/comms/01/20051102%20Telecommunications%20101.pdf

of CAN implementations are considerably narrowing. These converging technologies were briefly addressed in the document Converging Network Technologies[3].

The CAN is engineered in several different physical forms, depending on the population density, distance to the nearest Local Telephone Exchange site (which is part of the CAN and Backhaul Network), and geographic restrictions.

Compared to the Backhaul / Inter-Exchange Network, the footprints for Customer Access Networks are usually relatively small, but every Local Exchange has a Customer Access Network. In Australia there are over 5000 Local Exchange sites each having one or more different technology Customer Access Network structures, depending on the connectivity requirements to Local Customer Premises or Personal Equipment.

## *CAN Components*

### Analogue CAN - Digital CAN

The term **Analogue CAN** is really a misnomer as this really refers to the transmission mode that is employed to connect the Local Exchange site with the Customer Premises Equipment or Personal device.

With an Analogue CAN the speech / signal is passed through as an analogue signal.

With a **Digital CAN** the speech / Internet / Video / Signal is a digital transmission, where the analogue signal is digitally encoded into quantum (pre-determined) levels / values and this coding is transmitted and later decoded to reconstruct the analogue signal.

The main advantage of digital transmission is that the coding can be self-repairing and can be regenerated with virtually no degradation, but digital transmission is an inherently complex technology.

## Transmission Bearers

In “engineering land” the term “bearer” is used to describe the family of technologies used to transmit signals through a physical medium – such as a Customer Access Network.

The prime transmission bearers for CAN usage are: Insulated Copper Twisted Pair (in a cable), Coaxial Cable, Single Mode Optical Fibre (in a cable), and Radio. In many cases the CAN is constructed with a combination of bearer technologies; such as Hybrid Fibre Coax (HFC) for TV and Broadband Internet, GSM (3G, 4G) Radio which is typically SMOF to a Radio Base Station and radio to the personal devices; Satellite, which is SMOF from the Exchange site to the Earth Station, then Radio to the Satellite and Radio to the Home Transceiver.

[3] http://www.moore.org.au/comms/02/20051126%20Australias%20Converging%20Telecomms%20Networks.pdf

## Open Wire Lines

Historically, before pair copper cables were common, telegraphy and telephony were carried on open wire lines.

Open wires as shown on the right are simply bare (cadmium) copper, the cadmium is included to make the wire much stiffer and far less susceptible to stretch under its own weight.

These wires are in pairs but it is not hard to realise that the electromagnetic interaction between these pairs is a major downside, so crosstalk and noise interference was particularly common problem.

Because the wire diameter was relatively large in comparison to the now standard 0.40 mm as used in urban pair cable technology, the series resistance component was rather low, so the characteristic impedance usually settled on near to 600 ohms. This should explain why so much early telecomms equipment and virtually all audio / studio equipment were based on “600 ohms” as the “standard impedance”.

By the 1920’s the amount of telephone wires on telephone poles was immense and it took up a huge amount of geographic space. Each cross-arm on the above picture was capable of carrying only four circuits, so it was extremely common to have “phantom” circuits sitting as pairs over quads of wires.

The Vertical Terminating blocks shown on the right are an early version (circa 1940) where the cable is solder terminated on the left-hand side of the block (obscured) and physically linked to a through terminal seen on the right hand side of these blocks.

From here, “Jumper Wires” usually unshielded twisted pair (0.5 mm) connects to other vertical blocks on the MDF that in turn connect to specific equipment.

Note a much earlier version of Vertical Block on the extreme left with provision for Fuses and Lightning Arrestors.

These MDF Terminating blocks would have been used for terminating open / aerial wires (like seen in some country areas and sometimes still remaining beside some rail lines. Underground cable is far less prone to damage by induced lightning but in country areas, lightning protection is absolutely essential to minimise equipment damage, particularly in lightning prone areas.

### *Urban Buried Cable CAN*

The technology of pair cable was well established by 1920 but was very expensive, so this is why open wire was very common. From about 1920 through to about 1935 much of the open wire CAN in city areas was converted to underground cable.

The first cables were silk or cotton covered as the insulation over the copper twisted pairs, but after about 1930 paper insulation became the standard insulation medium and the cables were typically lead sheathed to keep the water out.

Cables were previously used extensively in the Inter-Exchange Network so this technology flowed from there to the CAN, where generally the copper diameters were somewhat thinner because generally the distances for the CAN were considerably shorter than for the (mainly metropolitan) Inter-Exchange Network.

This technology remained dormant for several decades and it was not until the late 1950s that polyethylene insulated copper pair cables started to be used in conjunction and sometimes replacing the older paper insulated cables.

With paper insulated cables used in the Inter-Exchange Network it was standard practice to pump in dry air to dry out the paper insulation – to minimise the leakage resistance that naturally increased as the cable got wet.

The problem is that with lightning the earth currents are so great that the produce pin-holes in the lead sheathing and then water leaks in. By having a slightly positive air pressure the water was pressurised out of the Inter-Exchange cables.

With lead-sheathed paper insulated cables used in the CAN, there was no real consideration given to pin-hole water leakage for a number of reasons. In the first case these cables were relatively short, (compared to IEN cables) so the probability of these cables getting waterlogged was “low”. Further, the IEN traffic was typically 100% so the priority was there, as the typical usage on a busy CAN line in those days barely reached 13%.

The management hierarchy was based around the size of the switches, typically in “thousand” groups, so the focus was there and not on connecting the switches; so that what these switches connected would be useful! But that is totally another story!

So, the paper insulated CAN cables were never really protected against water seepage, and only in the most isolated and desperate cases some CAN cables were pressurised for a while to dry out the insulation. In any case most of the line work was with the CAN, and many of the joints had their sheathing opened, so that pairs could be swapped over to tails to connect premises.

Because Australia is a large continent with a small and distant population the then Post Master General’s Department worked largely autonomously with State Management running what were essentially separate empires but most of the switching equipment was Headquarters purchased.

Cable technology was evolving but because of the Depression and World War 2 shortly after, materials were a crippling shortage and very expensive. State bodies purchased what cables they could and consequently there was a range of similar but different copper thicknesses based on State purchases and the companies providing the cables.

To complicate matters the wire extrusion die used for drawing copper into wire was expensive and it wore with use, so there was a considerable variation in production.

This infrastructure is by far the most common form of fixed CAN, and has been since about 1940; consisting of pairs of 0.40 mm insulated twisted copper wires that are bundled together like rope into what is called a cable. In almost all metropolitan situations these cables are buried and because they are out of sight - they are out of mind!

In the late 1950's polyethylene insulated cables came out for the first time. This was a major forward step as these were considerably easier / faster to manufacture, and by then the process variations in pair wire diameter had been largely minimised.

The big advantage of these cables was that the insulation was colour coded for easy numbering. The earlier paper insulated cables were also numbered by printed stripes on the paper insulating strips wound about the bare copper wires.

One of the recognised advantages of having colour coded insulation was that the identification was much faster and far less prone to identification error, the unrecognised advantage was that the colour worked out to be a plastic stabiliser, and unfortunately the white "mate" is without colour so it deteriorates much faster than the other pair's insulations, crippling the life of these cables.

This is rough cross section of 800 pair Poly Ethylene Insulated Unit Twin (Pair) (PEIUT) cable that would feed out from a suburban exchange MDF towards a Pillar or Sputnik (or large footpath manhole), where the cable would then be terminated and fed further out on many smaller cables, feeding out towards the residences.

From about the early 1980's most cable supplied is polyethylene insulated included a petroleum Gel to keep the water away from where air would be between insulated pairs.

The problem with water is that it has a permittivity of about 80 when compared to air. This high permittivity causes the capacitive component of the cable to be about 80 times greater with paper insulated cables totally ruining their transmission properties.

The water-induced localised capacitive component in plastic insulated cables greatly upsets the transmission, impedance and crosstalk values in particular for ADSL applications, which uses frequencies well above the Voiceband frequency range (up to 3.4 kHz or 0.0034 MHz) that these cables were originally engineered for.

Apart from that, the Gel was later found to slightly react (erode) the copper wire near and at the joints causing maintenance issues.

### *The Main Distribution Frame*

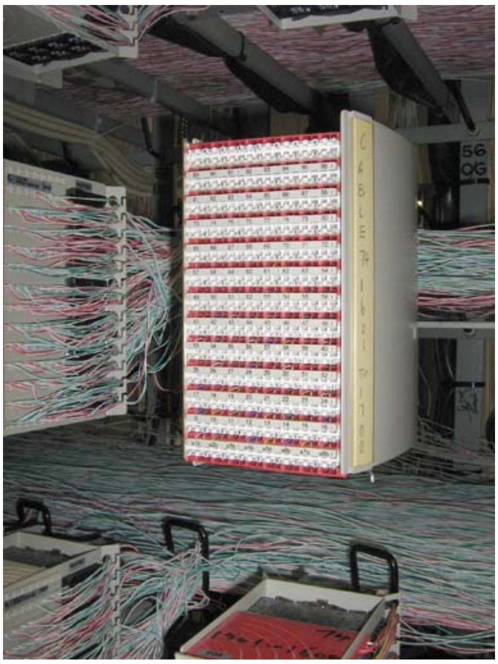
This MDF is showing the Equipment side:

This is a typical metropolitan Main Distribution Frame (MDF) and these are usually about 3 m high, 1.2 m wide and about 20 m long to accommodate the various cables that are terminated on it.

The cables are terminated in "Verticals" and these vertical bars have Mounting Blocks on then to terminate the pair cables. The Equipment side terminates cables from the equipment, and the Line (or Drop) side terminates cables that go to the street.

In most cases where there is Pair Gain equipment including Digital Services Line Access Multiplexer (DSLAM) equipment for asymmetrical (data transfer speed) Digital Services Line (ADSL). It is common to terminate one side of this equipment as though it was main cable (on the Drop side of the MDF).

(The “Drop side” refers back in time to when all connections were with Aerial wire on poles, where the Line side of the MDF referred to the side that connected to the Aerial line, and the Drop side referred to the Equipment connecting side of the MDF, where the Aerial line had “dropped to connect through the MDF to the equipment”.



The Vertical termination block shown here is a more recent structure that can terminate cables to jumper wires.

In this case the wires are terminated into Insulation Displacement Connectors (IDC’s) that the through the tight fork cuts through the insulation and makes a “cold weld” as a low resistance joint.

## The Physical CAN Structure

Fundamentally the Customer Access Network is essentially a Tiered "Star"[4] network where the centre of the network is located at a Node (usually a Local exchange), and the network extends out to the premises (and to non-premises), where phones, modems, PABXs, Web Hosts, Data storage / Cloud Computing and equipment such as road and rail signals and metrological equipment is directly terminated.

The structure of this network is that there is no switching or direct connection between customers' lines, as all these lines connect back to the local exchange site. A Local Exchange is usually located in or very near what is called the "Copper Centre" of the "Exchange Switching Area" (ESA).

In Australia, there are more than 5000 ESA's that boundary to each other, (like a single layer of bubbles on water). Each ESA is entirely separate and are only connected via the Inter-Exchange (Backhaul) Network.

To visualise a Star network - position your right hand in front of you, palm down, and now extend your fingers as far apart from each other as you can - you have a Star formation from the centre of your hand to your fingertips.

To visualise a Tiered Star network, position the base of your left hand on the finger tip of one of your extended (spread-out) right hand fingertips. You now have a simple tiered star - where one thicker structure (in this case the right hand) feeds off to another thinner star.

Depending on the switching size of the Local Exchange; from the site's MDF, the large/main cables are typically 200 pair, 400 pair, 800 pair, 1200 pair and/or 2400 pair, feeding out to large footpath-located pits usually about 500 m or more away where the cable is physically jointed and extended out to a "Distribution Area" (DA) within the "Exchange Switching Area" (ESA).

It is quite common to have more than 10 DA's within the one ESA. This Tiered-Star is the typical structure of most CAN's with the tails from the much thicker main pair cables (from the Local Exchange sites) joining into several smaller cables in large footpath located pits or in "Sputniks" as shown below.

These much greater number and much thinner cables in turn join to smaller cables that join into (non-) premises lead-ins. The demarcation point between the CAN and the Customer Premises Network (CPN) is at the first terminal joint from the CAN.

## Pillars/Sputniks and Pits

Underground main cables feeding a DA are usually jointed in a large Pit about and connect premises for the next 500 m to 1000 m outwards from here. To make work practices considerably easier, the cross terminating to smaller cables is often done in 450 pin or 900 pin "Sputniks". The Sputnik technology came about in the very late 1950's, about the same time that plastic insulated cables started to appear.

Before then there were risers in the streets like these "Sputniks" but the earlier designs were hexagonal asbestos structures with a padlock on them, and they specifically terminated paper-insulated cables. Paper insulated cables would also be able to be terminated in these "new" post 1959 "Sputniks".

[4] http://www.moore.org.au/comms/06/20070820%20The%20Six%20Network%20Structural%20Levels.pdf

The big advantage of these Sputnik / risers were that the (inside) terminations for the cables were solidly mounted so the cable-side wires were not able to be moved unless if the riser supports were deliberately removed – most likely for including or removing a cable from the Sputnik.

Depending on the terrain, the cable will usually continue underground from a Sputnik or Pit to a Pillar or much smaller Pit where there will be a joint to split off several Customer Premises drop lines.


The picture above right shows a pillar in the foreground, used to join a main cable from the local exchange to several minor cables.

On the left hand side this is a picture of an opened pillar, showing the main cable terminated in the vertical white bars, and the jumpering (red and white pair wires) feeding to the minor cables (tails) towards many Customer Premises.

Note the thick rubber ring near the base of the Pillar to seal out the moisture when the pillar cover is installed.

In the background of the right-hand picture there is a dual pit in the footpath that would probably have a 200 pair split from a (2400 pair?) main cable feeding to the adjacent Sputnik. The Sputnik would also have several thinner (less pair) cables connected to it, for distribution into this part of the DA through the pit. The pit would also have a jointing box to connect six or more nearby household lead-in / drop lines.

Other pits along the footpath would similarly join household lines and connect though similar pits to the pillar. With smaller cables it is common to have sealed joints in the pits with no external pillar. As most of this is out of sight, few people know that this vital infrastructure exists and most people are at a loss to know how and where the pairs connect under their front gardens to their premises!

There are probably more than about 9,000,000 services connected with of this type of CAN infrastructure in Australia. Typically this is a metropolitan CAN infrastructure having a maximum length of about 4100 metres. A typical average length of about 2900 to 3000 metres for residences and about 300 to 700 metres for commercial businesses - because most telephone exchanges are usually relatively close to the centres of Commercial Business Districts (CBD’s).

## *Quality Improvement in Cable Standards*

Cable purchasing was originally done on a State basis and there was considerable variation in the copper diameters as required for various State-based Telecom Australia administrations. Consequently wire diameters ranging from 0.32 mm, 0.40 mm, 0.51 mm, 0.64 mm, 0.81 mm were reasonably common, and this gave rise to a very wide variation in transmission Quality over same / similar distances.

In an effort to drive down overhead costs some administrations experimented with aluminium cable with disastrous results. The aluminium cable joints shrunk under contact pressure, creating high resistance (noisy) joints over some few years, as the exposed aluminium wire surface gradually corroded forming a high resistance oxide layer that also contributed to noisy joints.

From about 1983-1984 Telecom Australia HQ narrowed the purchasing range of copper pair cable back to 0.40 mm for metropolitan use and 0.64 for rural (non-urban) use, and by the early-1990's the wide variations in CAN transmission Quality considerably narrowed (Quality improved).

The remaining problem was that each Telecom Australia State Administration had developed its own CAN transmission standard since about 1920. The variation in range was very substantial and it was not until about 1992-3 that a common transmission standard for the CAN was agreed on through Telecom Australia Headquarters.

Before 1975 after which moves to privatise the then Post Master General's Telecommunications area, virtually all joints in the pair copper CAN including joints on the MDF were soldered. As the push for privatisation became greater, so was the executive management push to make the workforce more "efficient"; that is do more work with less people.

The oxymoronic problem was that at that time the executive management were brought up through the Depression and World War 1 and 2; and following that, it was a "duty" to find work for people no matter how incapacitated they were. Consequently there were a large number of people doing rather meagre work, but this virtually solved a massive social problem where otherwise these people would be without a useful purpose in life – carrying massive mental and physical injuries.

A large majority of these people were craftsmen who did repetitive work to a very high Quality standard. As these people were retired or paid out to leave, the Quality of the workmanship fell away, but the fault rate stayed low for many years after because the large majority of the cable joints were very good.

One of the "efficiency" techniques brought in was to not solder cable joints but to simply wind these together (and paper sleeve these joints). Similarly with the MDF's to not solder here but simply wind the wire over the terminal. In most cases this efficiency drive worked well, but in isolated cases some sealed cable joints had noisy pairs in them and finding / fixing these was a nightmare because as the cable joints were moved other pairs became noisy because of loose non-soldered joints.

A new jointing technology was introduced by the 3M Company in the early 1980's where a small outside insulated dual ring/clip would "cold solder" two crossed over wires in the jaws of this clip. Now pair copper cable joints cold be effected in a fraction of the time using a pliers-crimp, and this worked very well – most of the time.

The problem was one of incorrect pair wire diameters and/or incorrect clip sizes where wires that were too thick for particular clips resulted in the clips not fully closing. Over some years these clips would then spring open, or gradually become loose (eg with aluminium wire), seriously degrading the CAN operational Quality. These cable joints needed to be opened and totally re-jointed with the correct clips then fully re-sealed again.

As if incorrect clip sizes for a widely ranging number of wire diameters was not bad enough, another of the "business efficiencies" introduced was the multiple connecting of pairs so that customers could be quickly connected to a spare pair that was available at multiple pillar / or pit locations.

Not only did the "triple joints" introduce extra cable to the existing cable, the chance of extra noise aggravated the situation, and the clips more than often popped open after some years. The extra un-terminated cable pairs made the connection have a worse than expected attenuation and frequency response.

Further, if triple-jointed pairs were used with ADSL these unconnected lengths of pair cable acts as reflective stubs (just as in waveguide and stripline filters), critically damaging the smooth frequency response well above the voice frequency range that is used by ADSL technologies.

Another classic failed "business efficiency" was the introduction of "Random Wire Jointing", where instead of literally connecting pair for pair when joining end-to end cables (as was the standard for all Inter-Exchange Network cables and most CAN cables previously), pairs from one cable could be randomly jointed to pairs in the next cable and not in numerical sequence.

This "business efficiency" massively improved the speed at which cables could be jointed, and combined with the rather portable "F Set" (wire "Finding" equipment using high levels of signal injected at the distant ends and a very sensitive electromagnetic field probe), cable jointing became rather quick!

While the strategy of "Random Pair Jointing" was sound, particularly for CAN cables that were typically about 2900 to 3000 m long on average, the education of the physics of wire transmission was not carried through to those that did the field work.

Consequently, the term "Random **Pair** Jointing" was inadvertently changed to "Random **Wire** Jointing", and considering that in some cases the wires were broken in the cable or near the cable joint, instead of pairs being jointed, individual wires (from other pairs, broken or not) were often randomly connected to effect a direct current (DC) loop to "fix" the cable.

This random wire (not pair) connection situation caused massive crosstalk and noise between pairs, such that complete cables had to be either abandoned – or sections of the cable totally replaced – once it was realised that the Quality of the workmanship was so poor.

In hindsight it is obvious that the Directors / Executives had focussed on a maximised return on investment (ROI) instead of a maximised Quality of workmanship. If they had focussed on a maximised Quality of workmanship then the maximised ROI would have taken care of itself.

## *Urban Aerial Cable*

To minimise construction costs, nominally 50 pair cable is often strung on poles, in a somewhat similar fashion to power lines, but these cables have a (steel) support wire to hold the cable between the poles. Aerial Cable technology is quite common in older housing estates and for temporary arrangements, or where the ground is solid rock - making trenching rather difficult.

This is a fairly large Aerial Cable coming across a major road (from the left hand side of the picture), where it is anchored with a wire rope. The Cable then loops down then up into a black canister where it is jointed into another cable and strung under the power lines alongside the major road.

Note the other Arial Cable for Pay TV / Internet below it (left hand side of the picture.)

## *Sub Terrain Lead-In*

Almost all customer / business premises have their telecommunications cable provided in a sub-terrain conduit, about 600 mm under the ground surface. This nominal 20 mm diameter plastic conduit usually feeds from a pit and runs under the lawn / garden and usually comes up in residences through the floor very near to where the phone is situated.

The first termination point is the end of the CAN and the start of the Customer Premises Network. This is the CAN / CPN demarcation point.

In businesses the lead in usually goes to a communications cupboard, or communications room, where there is a distribution frame, and this is where the CAN finishes, and the Business Customer Premises Network begins.

In practice, most premises have a single lead-in quad cable about 6 mm in outside diameter, so there is usually plenty of room to feed a parallel cable through the same duct / conduit.

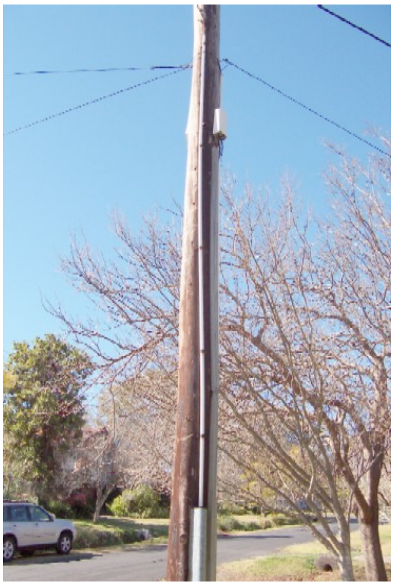
Unfortunately a high percentage of these conduits are either poorly installed because they were rushed in on a time schedule not a Quality process and consequently a relatively high percentage of conduits have kinks in the ducting, and/or are not jointed properly (if at all) making retrofitting (eg with Fibre to the Premises) both slow and expensive.

### *Aerial Lead-In*

In most non-metropolitan situations where there was Open Wire (pre-1940) CAN, the lead-ins were fed directly from a telephone pole.

With the change from Open Wire to Urban Aerial Cable and Buried Urban Cable, a cost-effective solution is to leave the pole and lead-in and run the cable to the lead-in.

This solution is very common in most country towns and many older suburbs.



This is a typical arrangement with an aerial lead-in from a telephone pole. Note that there is a single cable that runs up the pole on the right hand side (on the shady side) inside a wooden protective cover.

The cable extends into a white “Jointing Box" where the three customer drops are connected out the bottom of the box and then go up above this box where two eyebolts screwed into the pole.

The drop leads are then slung aerial fashion to the Customer Premises. These drop lines have a much stronger third (iron) wire that is the support for the copper pair, and this is tied to the eye bolt.

The CAN finishes and the Customer Premises Network begins where the lead-in terminates in the Hoarding Board at the roof.

Near a customer premises, an Urban Aerial Cable is strung from power pole to Power Pole. The cable runs down the front of this pole and is jointed in a black box where several customer drops feed out up into a white conduit.

The customer drops then are strung from an eye bolt in the post by their support iron wire to the customer premises hoarding board on the roof, where the lead-in terminates; and this is where the CAN finishes and the Customer Premises Network begins.

### *Rural Buried Cable*

For distances greater than 4100 metres, a thicker diameter copper wire (0.64 mm) is used in the cables and this works up to about 10,500 metres where the Voice Frequency Specification and line current specification limits are really being pushed.

There are probably about 500,000 premises connected with type of CAN infrastructure, but usually a mixture of 0.40 mm and 0.64 mm insulated twin copper cables connects these premises. The thicker cable is selectively engineered (towards the premises end) to economically keep within the maximum signalling and transmission specifications.

In practice CAN Engineering is done to minimise the infrastructure cost wherever possible. For premises further than 4.1 km away from the Local Exchange site, the distance is worked out. The cable structure is then engineered such that the resistance is just within limits with the least amount of 0.64 mm cable as possible.

Again in practice, this is usually worked out with a group of homesteads and the furthest homestead is the marker for the design and every other homestead is then within specification.

### *Unconditioned Local Loop*

*"**Conditioning**," means to add some form of amplification or other device to improve the transmission and/or signalling specification of that line pair. The term "unconditioned" therefore means that a pair of insulated wires (in a cable or series of joined cables) extends directly from the local exchange to the premises.*

Part of the analogue line signalling specification is determined by the total resistance of the pair of wires extending from the local telephone exchange to the premises. The loop resistance is measured by shorting the wire pair at the customer premises and then measuring the resistance at the local telephone exchange.

The name for line signalling when calling from the CPE to the IEN is through the CAN with an analogue telephone is called "Loop Disconnect Signalling".

*So "Unconditioned Local Loop" (ULL) really means a physical pair of wires extending from the local exchange Main Distribution Frame (MDF) to the customer premises (connection point), used for analogue telephony that has no additional equipment or devices included to alter the transmission and/or signalling specification.*

### *Conditioning the Line and Broadband*

It should now start to become obvious that there are several technologies that can constitute a Customer Access Network (CAN) the basics of these need to be identified - along with some pseudo-engineering legal jargon.

With an Analogue CAN (which is currently the vast majority and consists of twisted pair / copper cable); this analogue access network technology provides for landline Voiceband Phones, Dial-up Internet, Fax and Security services etc.

If there is a direct connection between the IEN to a particular customer premises network (CPN) is a physical pair (without any amplification, encoding or other pair gain system included), then this type of Customer Access Network (CAN) is - in legal jargon, termed an Unconditioned Local Loop, while Technicians and Engineers call it a "Physical". With a Digital CAN (which includes Dial-Up Internet, ADSL, Mobile Phones, ISDN, MegaLinks, Frame Relay, SHDSL, and Cable Internet). The lead up to these transmission systems will be briefly covered in an associated document[5].

Most Pair Gain Systems are a combination of an extended Digital transmission system with physical pairs after then towards the customer equipment - but the whole system acts like an analogue transmission system - so they are considered “Analogue CAN”.

One of the big problems for rolling out ADSL is that it is severely line length limited for a number of reasons. The associated document[6] covers some of thee problems.

Similarly with Hybrid Fibre Coax (HFC)[7] as used in Cable TV and Broadband internet in metropolitan areas

In metropolitan areas the radial length from a local telephone exchange is about 3.8 km for urban cable, and with metropolitan Mobile customer access (Mobile Base Station Towers)[8] it is about 4 km, but to minimise on 'black spots' there are now also a large number of remote mini-towers with tiny footprints up to about 500 m.

In rural and remote areas, (read "non-urban") cable pairs are thicker so the radial distance can be up to about 7 km from local exchanges before amplification and/or Pair Gain systems are employed to reach customers, and Mobile phone reach is up to 30 km from base stations. In very rare instances, radio systems in the CAN may hop to reach more than 100 km to the customers.

Another form of Broadband CAN connectivity id Fibre to the Premises (FTTP) and this technology comes in several forms, but the basics are described in the associated document[9].

Broadband connectivity is a problem and can be inexpensively resolved by a cooperative arrangement of ADSL for premises less than 2.2 km from the metropolitan Local Exchanges and with HFC beyond there. This document[10] shows how this can be rolled out before FTTP finally replaces both these aged technologies that have a rather short time until they both are seriously obsolete!

I believe that almost all Australia could be inexpensively connected to Fast Secure Stable, low latency Broadband using non-urban FTTP! This document[11] shows how the use of standardised (economy of scale) thick SMOF cables for all inland Backhaul cables can easily be double-used for non-urban CAN connectivity at a very small fraction of the Trenching costs, radically reducing the CAN build costs in non-urban areas to provide very inexpensive FTTP infrastructure almost everywhere.

[5] http://www.moore.org.au/comms/04/20030323%20CAN%20Line%20Conditioning.pdf
[6] http://www.moore.org.au/comms/04/20030323%20Digital%20CAN.pdf
[7] http://www.moore.org.au/comms/04/20030223%20Cable%20Television%20and%20Internet.pdf
[8] http://www.moore.org.au/comms/04/20030323%20Personal%20Radio%20Device%20Connectivity.pdf
[9] http://www.moore.org.au/comms/04/20030323%20Optical%20Fibre%20in%20the%20CAN.pdf
[10] http://www.moore.org.au/comms/20130509%20Inexpensive%20Metropolitan%20Broadband%20Infrastructure.pdf
[11] http://www.moore.org.au/comms/20130412%20Inexpensive%20Non-Urban%20FTTP.pdf

## *Foreign Terms: Central Office and Chief Office*

The term "Office" comes from the "Post Office", because that is where the much-earlier switchboards were originally located that connected to the physical CAN to the "Transit Network". Everybody had "Maggie phones", where they used magneto signalling to drop-indicator cord-plug connected switchboards that were located in the back of the Post Offices.

At and before this time, and because most lines were Open Wire, the maintenance was virtually continuous and the then most important person in the Post Office's telegraphs and telephones area (in the USA) was the "Wire Chief". This was the person that sat on the Test Desk and measured / tested the customer lines for faults, then directed the line staff as to where to go to find and fix line faults.

In Australia the Technician behind the Test Desk was affectionately known as the "Test Deck Jockey"!

So, as the telephone exchanges became predominant in the back of the USA Post Offices, the merging of the phrases "Wire Chief" and "Post Office" became the "Chief Office"! Again this term is particularly a USA term, not Australian.

When the first automatic step by step switching (Strowger Switches) were used, the phones were powered from a nominal -52 V DC centralised battery located in the Local Telephone exchange near the back of the Post Office.

This exchange-based battery was also called a "Central Battery" as it powered line current to all the phones that were being used. This small current was / is used for line signalling, loop-disconnect signalling, and also for the speech path in the customer premises phones.

Particular to the USA; the merging of the term "Post Office and "Central Battery" became "Central Office".

These terms have been included in many USA publications that have been fostered by a procession of rather expensive North American backgrounded Telecomms CEO's into Australia.

The equivalent Australian terminology is either the Local Exchange site, the Telecommunications Building or the Communications Site. Colloquially, the Small Country Automatic Exchange is acronymed as a SCAX (hut) or a CAX if it is not that tiny; and the building terminology for a Telephone Exchange is acronymed as TE.

It is the Local Exchange site where the CAN connects through the Main Distribution Frame (MDF) as discussed above, and is cross-jumpered there to cables that connect to the Local Switches – where the circuit passes through a "speech circuit" and this is the "Demarcation Point"[12] for Voice Frequency telecomms.



**Comments and Corrections are welcome**

[12] http://www.moore.org.au/comms/01/20051102%20The%20IEN%20Connectivity%20Model.pdf