



Throwing Copper: An Insight to DSL in Australia

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Introduction

This paper is not designed to give you every answer about broadband in Australia or to help you get connected to your DSL provider.

It is designed to give you some idea of how all the mechanisms behind the Telstra DSL service works, how your ISP works and some of the new and future trends.

Who am I and why do I know this stuff ? I have worked in the carrier and vendor space for the last ten years, since DSL was just a twinkle in an engineers' eye. I have worked for the major Telecommunications companies in both Australia and New Zealand and have seen DSL introduced from it's infancy to the dominant broadband technology it is today.

During this time it is amazing what has changed and it makes my head spin, let alone people who are not in the industry and are trying to come to grips with what is going on.

I have primarily written this paper to help the reader understand how their DSL connection gets for the jack in the wall to the Internet and what happens to it in between.

There are 1000s of web pages about the ins and outs of how DSL works – that is not the idea for this paper – rather what happens after the connection is made.

I will also provide some commentary about the rapidly escalating Voice over IP market and how things really work.

Thanks for taking the time to read this and I hope you find it informative.

How DSL Works

DSL is quite simple in its execution but still mystifies many people. Think of it like this analogy:

Into your house you have a pipe that is say 20 cms wide – we'll call this your copper cable from your Telephone Company (Telco).

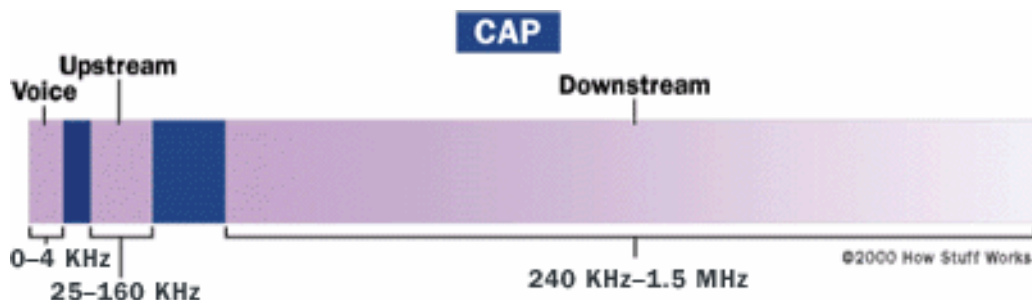
Now that 20 cm wide pipe has a lot of capacity but until recently we have only had the technology to use about 1cm of its capacity – so the rest of the pipe has not been utilized.

Now we have found a way to use the rest of the pipe using a technology called DSL (Digital Subscriber Line). It was actually invented by a scientist in Bell Labs USA back in 1988.

Essentially the scientist had found the capability to send a whole lot more data down to pipe that what was though possible a mere 20 years ago.

Of course going back to tech speak the pipe is the phone line and the width of the pipe is the frequency. So DSL makes use of the unused frequency of your copper line to transmit more data – without affecting the traditional voice traffic.

This is shown in the diagram below:



Because DSL works on specific frequencies, it is a distance dependent technology – the theoretical range is around 5.5 kms from the local phone exchange.

Before you pull out the map however, phone lines are not laid in straight lines, so there is not real way to tell the distance unless you have cable maps or know your local Telco technician.

So the closer you are to your exchange the better signal and speed you get. Also note that the upstream or send frequency is less than the receive or downstream frequency – so you send data slower than you receive data.

In Australia, the main carrier (Telstra) has packaged DSL into 4 speed groups for residential use:

- 256 kbps Downstream and 64 kbps Upstream
- 512 kbps Downstream and 64 kbps Upstream
- 512 kbps Downstream and 512 kbps Upstream
- 1536 kbps Downstream and 256 kbps Upstream

Bear in mind than DSL is actually designed for speed up to 8 Mbps Downstream and 1 Mbps Upstream – this however is under perfect conditions close to the exchange.

Why can't I get DSL ?

You've got all excited and applied for DSL – and now you have been knocked back. This is not a great feeling and you wonder what you have done wrong.

The answer is you have done nothing wrong – you just have poor communications infrastructure around your house.

There are four main reasons that will not allow you to get DSL:

1. **No Exchange Infrastructure** – DSL Equipment is installed at the telephone exchange – if your exchange does not have it or has run out of equipment then you cannot get DSL. This situation has improved dramatically over the last few years and continues to improve with many more companies starting to install DSL equipment.
2. **Too far from the Exchange** – Simply put if you are more than say 5 kms away from you exchange then your chances of getting DSL are pretty slim. Telstra has typically based its distance on a conservative 3.5 kms from the exchange but this has increased recently to around 4 kms. DSL equipment of a smaller scale based away from the exchange is also coming online to extend the distance as well.
3. **Out on a RIM**: A RIM is a “Remote Integrated Multiplexer” and is basically a chunk of the main Telephone exchange broken off and moved closer to an area. These are linked back to the main exchange with optic fibre via a switching mechanism which, you guessed it, is digital and won't work with DSL because the DSL equipment needs to be connected to copper lines (not fibre), and the cost and space limitations of providing these inside RIMs has been prohibitive.

More compact DSL equipment is being rolled out to RIMs making it possible to get DSL further away from the exchange.

4. **Heavy Metal** – If you have poor quality copper between you and the exchange, this will impact your ability to get DSL. Many older areas fall into this category. It is not common that poor quality lines also have what are known as loading coils – small amplifiers that increase the voice volume of the line but are no good to DSL.

So what do you do if you get caught up in this quandary?

Try, try and try again.

RIMs and bad copper can be overcome if there are spare lines available or DSL equipment is being installed.

Being too far way from the exchange or attached to an exchange that has not got DSL can be harder to solve but Telstra has a demand register that essentially gauges interest in an area which can dictate when an exchange is upgraded to DSL.

There is also an increasing range of new broadband technologies also coming on line. Check online to see what is available. [Whirlpool](#) is a great place to start your search.

How you get your Net

So you have downloaded this document you are now reading – but how did it get to your PC from the Internet?

In this section we will have a look at how your ISP connects to the Internet – and the steps in between. The examples I will give are based around a typical ISP that uses Telstra as its wholesaler supplier for DSL connections.

I will go through this process from the house to the ISP, discussing each aspect as we go. This will hopefully give you a good insight into how your data gets to and from the Internet.

Getting service to your house

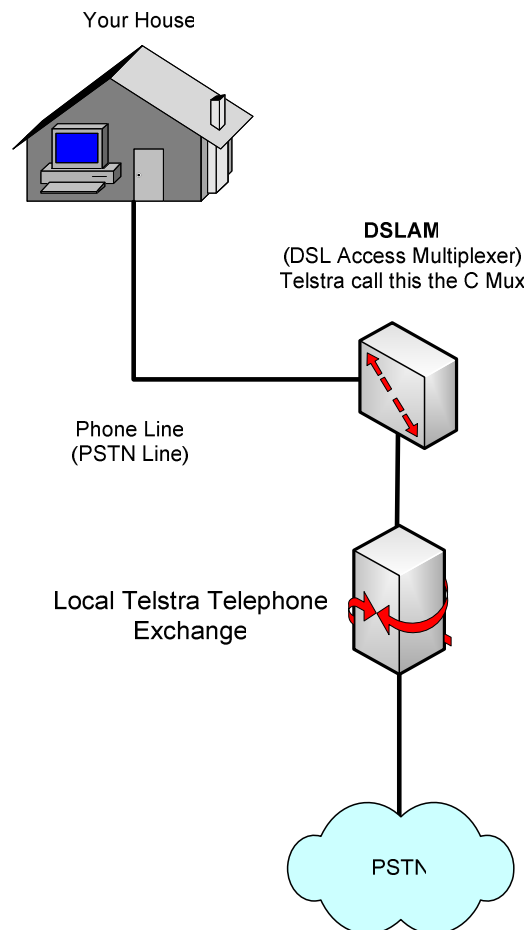
We have talked briefly about how DSL works, but now let's look at it in practical terms.

Key to getting service to your house is a piece of equipment called the DSLAM – Digital Subscriber Line Access Controller – also known by Telstra as the C Mux or Customer Mux.

The DSLAM is typically located in your local telephone exchange and is positioned between your phone line and the telephone switching equipment. The DSLAM will split out the DSL signals, convert them to Data and pass them onto the data network. Voice signals are sent to the telephone switching equipment.

Simply put, a DSLAM concentrates and transports data from multiple DSL users back to the provider networks and then onto the Internet.

Telstra have deployed and own the vast majority of these DSLAMs with over 1000 exchanges equipped throughout Australia. Other carriers such as Optus are now planning widespread deployment of their own DSLAMs in competition to Telstra.



Most DSLAMs deployed by Telstra have enough capacity for over 200 connections, and multiple DSLAMS are capable of be deployed in an exchange.

As already discussed, mini DSLAMS are now in existence that can be deployed locally in RIMs or small exchanges. These mini DSLAMS typically service between 8 and 100 users. An example is shown below:

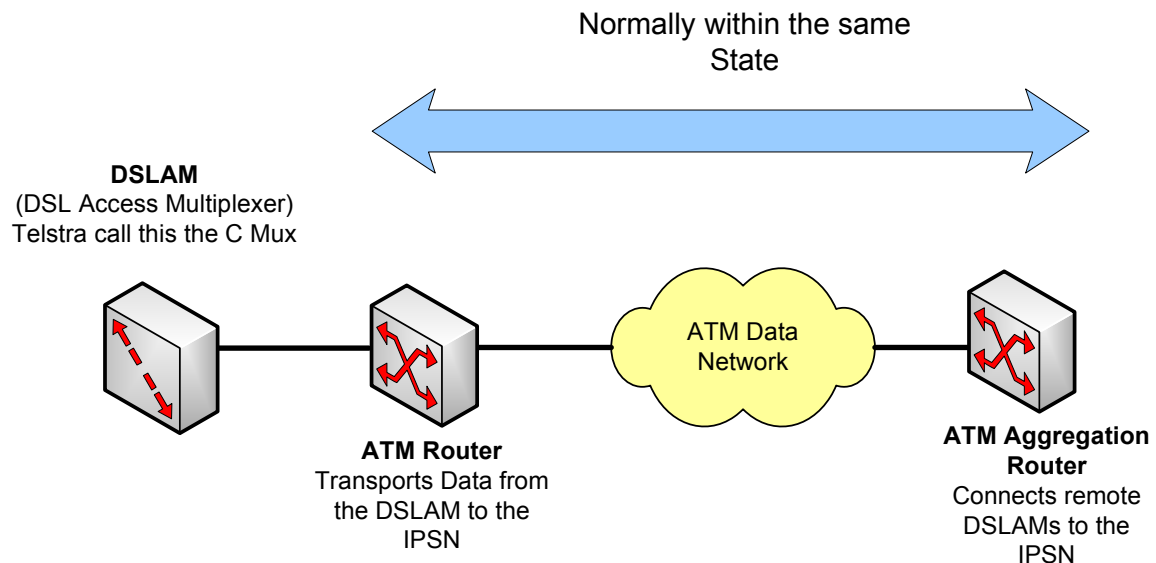


Across the State

Once you DSL signal enters the DSLAM, it is decoded and concentrated with traffic from all other users on the same DSLAM.

From this point, traffic is transported across a typically state based network to the IPSN hub for that state. For example, in Victoria most customer traffic is backhauled to the Exhibition Street Exchange in the Melbourne CBD before being sent on to their ISP.

This portion of the network is shown below:



Typically DSLAMs in Metro areas will have a high speed backhaul to the IPSN using a high speed data transmission method known as ATM (Asynchronous Transport Mode).

Don't worry about this part too much – just think that ATM can transport data up to 622 Mbps per second – or over 1000 times faster than a 512 kbps DSL connection.

However, in many areas, this is expensive both in terms of carriage and equipment and quite resource heavy in terms of data carriage. So typically Telstra will work on what is known as a contention ratio; typically of about 30:1.

What this means in the 'worst case' is that you could be sharing a 1024 Kbit/s (1 Mbits/s) connection with up to 29 other users. So if they were all using it at the same time 'theoretically' you would only get 32 Kbit/s (not very fast at all - in fact a bit slower than a normal modem).

Remember though that this means that everyone out of the 30 is using their DSL connection at full speed at the same time – an unlikely scenario in many cases.

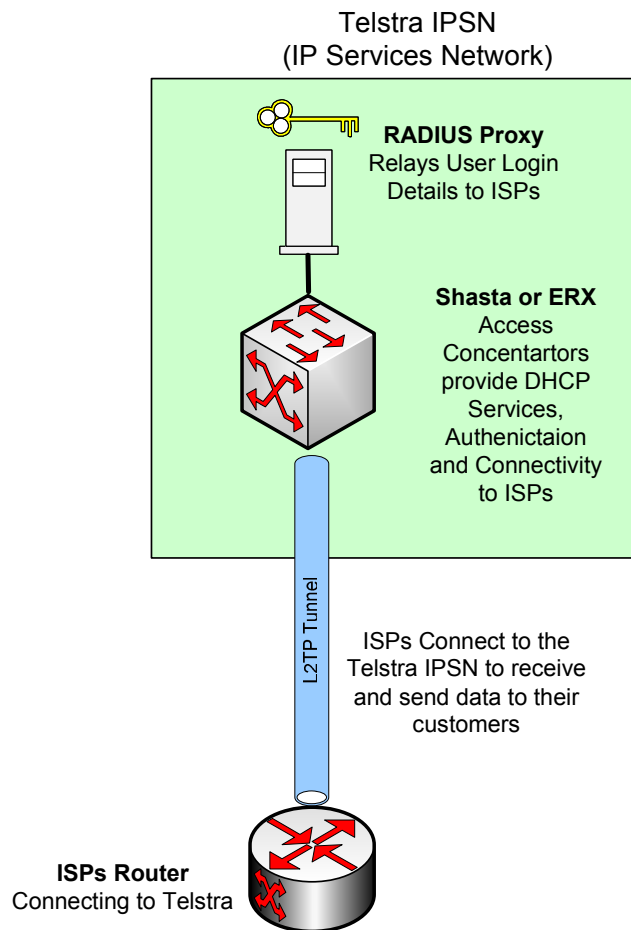
THE IPSN – IP Services Network

The IPSN is Telstra's way of getting Data from the customer and sending it to the ISP. There are however a few additional tasks that takes place within the IPSN that you should be aware of.

The IPSN also features a RADIUS proxy that takes authentication requests from users and relays these to the ISP's RADIUS servers. Of course if the RADIUS proxies are not working, then users cannot be authenticated, so there is not connection available.

Another feature is the ability to Relay DHCP addresses to customers of multiple ISPs. When you need to connect to the Internet, you authenticate and get issued an IP address that will allow you to connect to the Internet and send data.

These addresses are held by servers within the ISP and need to get addresses to it's customers – this is where the IPSN comes into play by ensuring addresses are relayed correctly.



There are two types of access concentrators used – the Shasta from Nortel and the ERX from Juniper. Telstra refers to these as a Broadband Rate Access Switch (BRAS). There are hundreds of these throughout the Telstra network for a number of purposes, most are concentrated in central exchanges in capital cities.

The Shasta BRAs were the source of much frustration in Telstra due to a number of hardware and software problems and have since been supplemented (some would say superseded) by the ERX switches. Anyone who has had DSL over the past two years or so will remember with a grimace the frequent outages that used to occur. Luckily most of these type of outages are things of the past.

Now to your ISP

We have now traveled through the Telstra Wholesale network and have arrived at the point where we jump off to the ISP.

Notice the term Telstra Wholesale Network – up to this point every aspect of the network has been fully owned by Telstra and controlled by Telstra. It is only at this last stage that the transfer of data from Telstra to the ISP takes place.

Now this is not true for all ISPs. It is becoming increasingly common for ISPs or other carriers to co-locate equipment such as DSLAMs in Telstra's exchanges, thus providing an entirely different backbone to connect to the Internet. This is true of Optus running their XYZ service and a number of other national ISPs.

So back to your ISP. They need to get a connection into the Telstra IPSN to give their customers access to their ISP services such as email, ftp and the wider Internet. They also need to pass information to and from the Telstra IPSN such as authentication and DHCP IP address information.

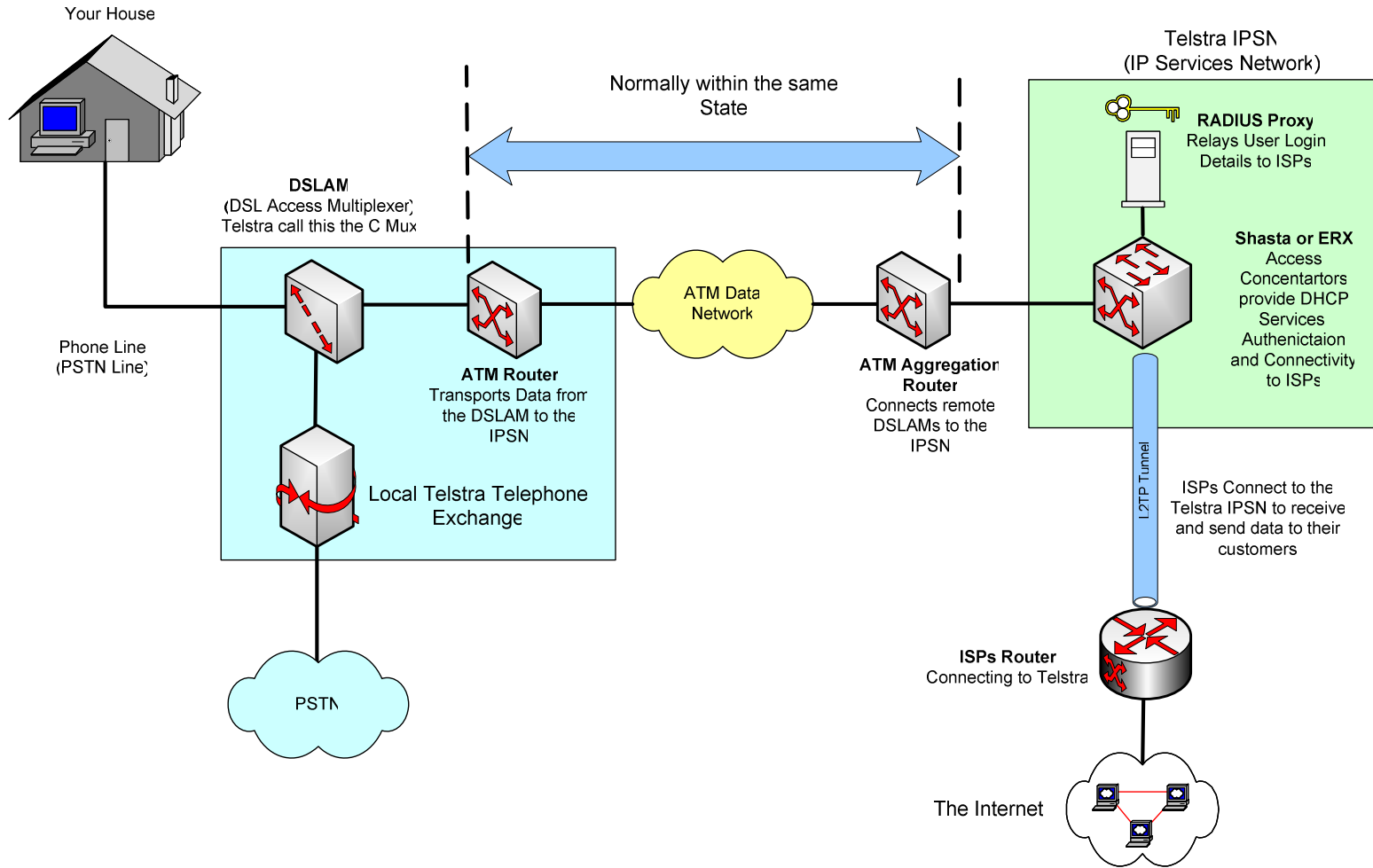
Obviously these are pretty crucial links to have and need to be both redundant and of sufficient speed to ensure good service for the customers.

Unfortunately, our friend Mr Contention Ratio is raising its ugly head again. Now an ISP cannot really match the network muscle of Telstra so most ISPs utilize contention ratios between 50:1 and 100:1 to push customer data through.

This type of ratio is improving but can be seen as an area where traffic can be held up on its journey to and from the Internet.

The following diagram now puts all this together:

How your ADSL Service gets to your ISP



Your ISP – Under the Hood

There are over 200 ISPs offering DSL services throughout Australia.

So how do you choose the right one ?

Whilst many ISP may seem the same, their back end systems, connectivity, redundancy and customer service may be vastly different.

This is usually quite difficult, if not impossible to gauge but having a understanding of how a typical ISP operates will give you an idea of what areas you need to look at and what questions you need to ask.

Remember many ISPs expect you to stay with them for a while (by virtue of the 12 month contract they make you sign) so it is worth your while to ask a few questions to ensure you are getting value for money.

Your ISP is in business to make money, so they will use every method available to get the biggest bang for their buck. Practically this means:

- Higher contention ratios
- Waiting longer to upgrade bandwidth to allow for increased users
- A solid network design but probably not the most redundant and high specification design.

While these seem like bad news for the user, it is that not different to the rules that large providers and many Telecommunications providers use.

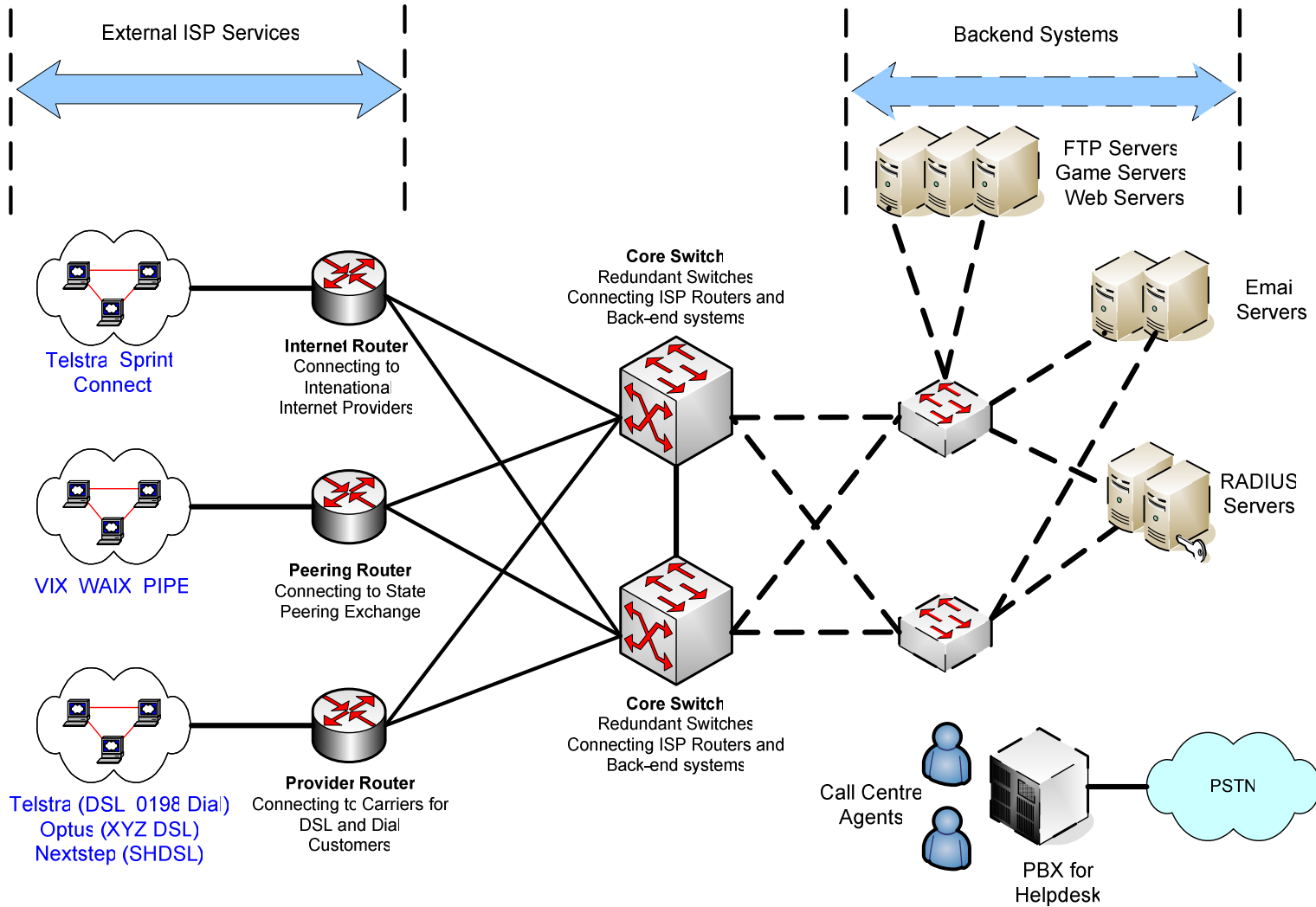
It is the ISPs who do not provide by even this level of service that are the ones to watch out for.

Providing good service is all about service availability both of the network and of the systems that support it. Hand in hand with this are aspects such as network monitoring (to fix things in a timely manner when they break) and capacity planning – to know when to order more bandwidth etc when demand increases.

Customer service is also a very important aspect of choosing an ISP; having someone competent to talk to over a connection issue or a billing query is just as important as a well designed and put together network.

Time for another diagram. The diagram below shows a near ideal configuration for an ISP. The pages following this diagram will explain just how all this fits together and what are the good points if what we see in the diagram:

Your Typical ISP



Our ISP is there to provide you with a range of services but externally and internally – so this is the way we will look at the services that are offered.

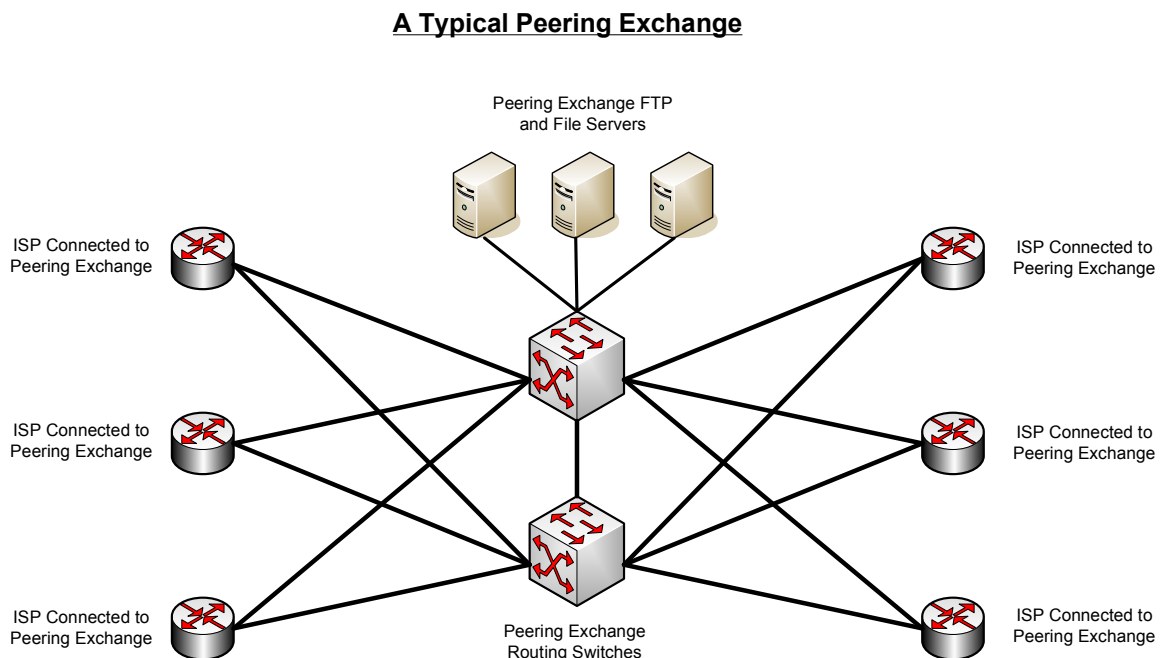
External ISP Services

There are two but usually three (or more) external connections that most ISPs will have – typically these are and external access to Internet and a feed from Telstra or other wholesale providers for customers to access the services offered by the ISP.

Points to look out for are:

- The ISP has more than a single link to the wider Internet with redundant suppliers and/or links. A good ISP will have links to the wider Internet through a number of providers such as Connect, Telstra or Sprint. And of course these links will have plenty of capacity – not full to capacity.
- That the ISP should have redundant links to their Wholesalers. These usually have to be quite large links but again these should not be full to capacity.
- Many of the larger ISPs also have connections to a state wide peering exchange. A peering exchange allows client of ISPs to talk to each other locally instead of having to go all the way out to the Internet or their Internet wholesaler and back again. A number of ISPs treat traffic that transits the peering exchange as free traffic - great if you have friend to transfer information to who is with a peering ISP.

The diagram below shows a peering exchange arrangement:



Other external links may include connection to access servers for dial up customers and connections to other data or wireless networks for high speed customers.

The important thing to remember is that your ISP should have fully redundant links to its external services and enough bandwidth to satisfy the demands of all its clients through peak times.

Many ISPs also use proxies to help reduce traffic and improve service. There are two types of proxies: Proxy Cache and Transparent Cache;

What is a proxy?

Proxies cache, or store, frequently accessed content, then locally fulfill successive requests for the same content, eliminating repetitive transmission of identical content over network links. Transparent proxies on the network cache all requests sent on port 80(http). Thus, the complete caching solution comprises a networking component and a cache component.

To localise traffic patterns, the two components work together in the following way:

A user requests a Web page from a browser. The network analyses the request and, based on certain parameters, transparently redirects it to a local network cache. If the cache does not have the Web page, it will make its own Web request to the original Web server. The original Web server delivers the content to the cache, which delivers the content to the client while saving the content in its local storage.

That content is now cached. Later, when another user requests the same Web page, the network analyses this request and, based on certain parameters, transparently redirects it to the local network cache. Instead of sending the request over the internet or intranet, the network cache locally fulfills the request. This process reduces download time for the client.

What is the difference between a 'proxy' and a 'transparent proxy'?

There is no difference in the role or the functioning of these proxies. In fact they are in many cases the same machine. The only difference is that you do not have to enter specific network settings or any configuration for your HTTP traffic to be captured by a transparent proxy. Because they are built as part of the network architecture, all port 80 traffic must flow through them.

ISP Core Network

The core network of your ISP has to do a heck of a lot of work. It takes data in, analyses where it needs to go, and either retrieves or send data as is required.

This means that nearly every packet of information, from an Email to a ping needs to pass through the core network – that is a massive amount of information.

So what are the characteristics of a good core network?

- High capacity routers and switches with redundant controllers and power supplies
- Redundant power devices and uninterruptible power supplies
- “Carrier” grade devices that are capable of moving the information around the network in a timely and error free manner

Though this seems like a high demand, it simply needs to be. This is the core of your ISP's network and is key to ensuring good service for it's customers.

There are a number of other important services that an ISP provides – this is covered in the next section.

Backend Systems

Each ISP offers a range of basic services to its customers usually concentrated in their main data centers. The most common of these is email – the new way to keep in touch.

Email is really, really important to a lot of people and needs to be reliable and timely. Most ISPs will receive more complaints about email outages than access outages and go to great lengths to ensure that the email service they provide is top notch.

Some things to watch out for or ask your ISP are:

- Capacity of their servers and their upgrade policy
- How often they back up their email servers and their restore policy
- Redundancy of their servers – do they have dual links, dual power supplies and dual CPUs etc

Again these may seem like over the top questions but this is the standard that ISPs should work to – or try to work to.

Just as important as the Email servers would be the RADIUS and billing servers.

Remote Authentication Dial-In User Service (RADIUS) was originally designed as a way to authenticate external users who were dialing in to a company (hence the name).

Over the years enhancements have been made to include different types of authentication inside the LAN (firewalls, VPNs, authentication, etc.) RADIUS is designed to carry authentication, authorization, and configuration information between a network device that requires authentication and an authentication server.

These are possibly the most important servers in the ISP network as they do all the billing and authentication – without these you cannot connect to your ISP.

There are a wide range of other servers that an ISP may house. Typically there will be an number of Web servers to allow users to host there own web pages, FTP and file servers to allow users to get software from a local source and gaming servers for network gaming (duh !!)

Again it is important to find out from your ISP things like their backup policy – it was not that long ago that the largest ISP in the country deleted a number of it's customer's web sites in an unfortunate series of events – not the best customer service.

The MOST important thing you need from your ISP however is customer service. The 200 or so companies that provide Internet feeds throughout Australia can be roughly divided into to types – Internet Access Providers and Internet Service Providers.

The difference – An access provider concentrates mainly on providing an Internet feed and is usually geared to the more tech savvy user whilst the service provider caters for both the more savvy user and those who may be newer to the net.

The choice is up to you – only you can decide which ISP is best for your requirements.

Hopefully I have provided you with some food for thought and some questions to ask.

Next let's look at Voice over IP....

Voice over IP (VoIP)

In a short time Voice over IP has become the buzzword associated with the Internet. Just look for all the Engin ads on the TV!

So what is it all about, how does it work, and what do you need to run it ?

Simply put, VoIP is a way of taking your voice and converting it from an analogue to digital format. Once voice is in digital format then it can be transmitted over an IP network the same as any other IP packet.

But this is just the start of it. There are many companies doing clever things with a packet of voice once they can get it into their network.

VoIP companies use new IP PBX technology to bring together the Internet and the PSTN into a seamless package that they can then on sell to you in the form of extra low NDD and IDD toll rates.

So how does this happen.....

Say for example you are in Melbourne and you want to call Brisbane. Your phone is attached to an ATA (Analogue Terminal Adapter) which converts voice signals into data packets.

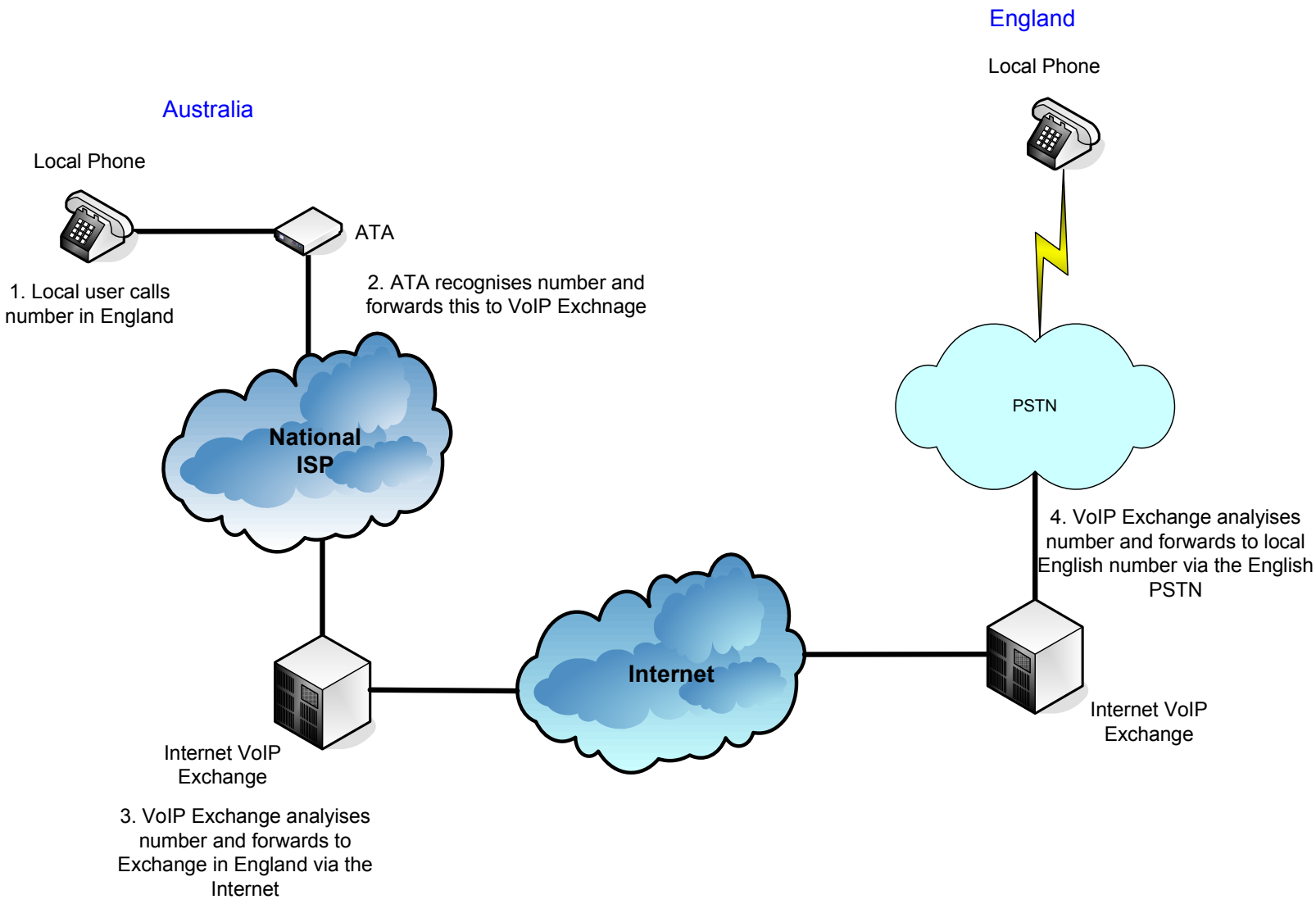
Your ATA is registered to a VoIP provider and recognises the number you have called and forwards this onto the VoIP exchange in Melbourne.

Once it arrives at the VoIP exchange in Melbourne, the number is analysed and then forwarded to the appropriate remote exchange – as an example 07 (QLD) calls will be forwarded to the VoIP exchange located in Brisbane with the IP address that matches 07 numbers.

Once it arrives here, the Brisbane VoIP exchange looks at the number and then dials that number via the PSTN – this is now at the cost of a local call as it is from the VoIP exchange in Brisbane to the local Brisbane number.

Now take this onto a global scale – the same thing can happen. So this is why VoIP allows you to call England for 5 cents per minute – the VoIP Company is only paying for a local England call cost and some Internet bandwidth,

Here's another diagram that helps explain this:



The Enemies of VoIP

To ensure VoIP works properly it has to fall within a strict set of parameters – if not the voice quality will be poor sounding like a very bad mobile call.

Let's have a look at these parameters and what they mean in practical terms. The first one is:

Latency – (AKA Delay)

This can be a real killer for VoIP – it comes from many sources and probably has the most detrimental affect on voice quality.

VoIP works best when the **END TO END** latency (the delay between each end of the conversation) is below 200 ms – a fifth of a second, Any more than this and the human ear can start to pick up the degraded quality of the voice.

There are several types of latency to be aware of:

- **Serialisation Delay** – It takes time for a packet to get through the Internet interface – for example a 1500 byte packet (the largest size Internet packet) can take up over 200 ms to transit the uplink fo a 256/64 kbps connection – completely blowing the delay budget of any voice packet that is following this big data packet. More bandwidth is definitely of use here.
- **Encoding Delay** – As we convert analogue speech to digital voice we introduce delay through the sampling and encoding process. The more we compress voice, the more we introduce delay. As an example coding to G.711 (or 64 kbps speech which really has no compression, just encoding) has not delay where as G.729 which has 8:1 compression has an encoding delay of 10 ms – so we need to add this to our delay budget at both ends (encode/decode).
- **Transition Delay** – We are at the mercy of the tyranny of distance here. For example in an ideal world it would take around 90 ms for a packet of information to travel between Australia and the UK – if it was a direct route and there were no switches etc in the way. However in real terms this delay can take between 120ms on private data lines to over 400 ms via the Internet – ping bbc.co.uk and see what you get.

When we calculate latency for VoIP we use a delay budget. This budget is typically the sum of all the delay types above added together, as well as our jitter buffer which we will talk about later on. The total of this is our total delay budget.

Above 200 ms and voice quality will suffer, though with things like voice buffering, the voice will not sound as bad, but you will feel like you are talking on a CB radio.

Packet Loss

When we convert analogue speech to digital speech we chop the voice up into samples. These samples can vary from between 10 ms ($1/100^{\text{th}}$ of a second) to 50 Or 60 ms.

There is a delicate trade off here – the shorter the sample the more overhead, the longer the sample the less overhead.

Now if you have a long sample size – say 50 ms and you lose a packet then you lose $1/20^{\text{th}}$ of your voice samples. The affect – bad sounding speech. This is the affect of packet loss.

Luckily unless something is really, really wrong packet loss is quite a rare event these days so it is not that often a problem.

Codecs used for VoIP such as G.729 and ILBC (Internet Low Bandwidth Codec) have specific characteristics that allow them to do what is known as Speech Path Replacement – this is a way of making the speech sound OK even if packet loss is experienced (up to a certain level).

Jitter – Packet Delay Variance

Jitter is an insidious character that comes about when there are gaps of various sizes between packets arriving at a destination.

This is usually caused when large packets get in the way of small packets going through a smaller size Interface. As has been mentioned before, if a 1500 byte packet tries to squeeze out a 64 kbps interface it is going to call Serialisation delay.

Now if there are voice packets either side of this big data packet then this is going to cause more delay than if a stream of voice packets follow each other out of that interface – this is what is Jitter is.

To overcome Jitter we use jitter buffers. Those of you with VoIP accounts with the various providers will use these alot – not that you will know.

A Jitter Buffer is designed to smooth out the flow of packets fromo the WAN to the LAN. The Jitter buffer is a leaky bucket – it gets filled from the top (WAN) at various intervals and drips out the bottom (LAN) at a controlled and equal rate.

Jitter buffer however add to latency as they must hold and queue packets to ensure they are released in a timely and orderly manner.

The Recipe for Good VoIP

The enemies are now known – so how do we ensure our VoIP experience is a good one.

First Point to remember - **ANY QUALITY OF SERVICE STOPS AT THE INTERNET INTERFACE OF YOUR MODEM OR ROUTER**

I emphasise this point because if you are on Telstra DSL you have no QoS and high contention to contend with.- end of story. Go back over the subjects we have covered and you will see what I mean about contention.

So if you can't get quality of service the how can we get good VoIP ? Well it is really down to keeping things in the parameters:

- Latency Budget (End to End) 200 ms
- Low Packet Loss under 1 %
- Low Jitter

So to do this you need to ensure:

- **Your link is big enough** to ensure there is little serialisation delay. If you are using a 256/64 kbps DSL connection then you have little margin when it comes to serialisation delay. Check out the following charts and consider upgrading your bandwidth.
- **You are not using applications that use excessive bandwidth** while you are trying to use VoIP. Downloading an large file or having Bit Torrent running will introduce delay and jitter, thus reducing your VoIP Quality.
- **You have a good quality connection** – this can mean anything from ensuring that the wiring and splitter for your DSL are in good order to ensuring your LAN is running well. This will include things like making sure you are running at 100 Mbps and full duplex for instance.
- **Use QoS if you have it** – many of the newer routers have the capability to provide Quality of Service. Use this if possible but ensure you understand what it will do for you. Ideally this should prioritise the voice traffic and throttle the data traffic. Remember though that this QoS is only good as far as the Internet interface of your router.

These basic principles should provide you with some benefits when it comes to VoIP. Quality will never be as good as an equivalent PSTN connection – packetisation is sure to reduce this when using compression or not.

This is not something to get greatly concerned about – most VoIP calls will have the same quality as a good mobile call (or maybe a little better).

Real World Codecs and Bandwidth

You will hear a lot of people (sales people usually) talk about how much bandwidth is saved by compressing voice and what a difference it makes etc....

Partly Right and Partly Wrong

Compression will save bandwidth however it will only save so much. Have a look at the first chart below. This shows what happens when you compress voice and then wrap it inside an IP packet.

The IP packet adds a lot of overhead to the compressed voice – as an example a voice packet compressed with G.729 has a bandwidth rate of 24 kbps. This is made up of 8 kbps of voice payload and 16 kbps of IP overhead (see notes below).

IP Bitrate

Codec Type	G.711	G.726	G.729	iLBC	Units
Encoding Rate	64000	32000	8000	4000	bits/sec
Packetisation	20	20	20	20	ms
Packet Rate	50	50	50	50	pkts/sec
Payload Size	1280	640	160	80	bits
IP Overhead	320	320	320	320	bits
IP Packet Size	1600	960	480	400	bits
IP Stream Rate	80000	48000	24000	20000	bits sec

Packetisation Seconds of speech in each packet.
Used default is 20 msec.

Packet Rate 1/packetization

Payload Size Encoding rate * Packetisation / 8 bits/byte

IP Overhead RTP(12) + UDP(8) + IP(20)

IP Packet Size Payload Size + IP Overhead

IP Stream Rate IP Packet Size * 8 * Packet Rate

Next step is to take our IP packet and send it out on the LAN – here again we add more overhead in the form of an Ethernet Packet - our 8 kbps voice sample is now up to 37.2 kbps

Ethernet Bitrate

Codec Type	G.711	G.726	G.729	iLBC	Units
Ethernet O/head	144	144	144	144	bits
Ethernet Packet Size	1744	1104	624	544	bits
Ethernet Stream Rate	87200	55200	31200	27200	bits/sec

Ethernet Overhead $\text{Src Addr}(6) + \text{Dest Addr}(6) + \text{Length}(2) + \text{FCS}(4)$
 Technically overhead should also include the
 12 byte gap and the 8 byte preamble.

Ethernet Packet Size $\text{IP Packet Size} + \text{Ethernet Overhead}$

Ethernet Stream Rate $\text{Ethernet Packet Size} * 8 * \text{Packet}$

After getting to the LAN, the IP Voice packet now goes onto the Internet. Now using DSL we add some more overhead. This DSL overhead consists of the PPPoE or PPPoA header etc. This takes our original 8 kbps Voice Stream to 42.4 kbps – nearly double the IP packet bandwidth.

This is why user using a 256/64 kbps connection may start to have problems with voice over IP.

DSL Bitrate

Codec Type	G.711	G.726	G.729	iLBC	Units
DSL O/head	376	592	224	178	bits
DSL Packet Size	2120	1696	848	722	bits
DSL Stream Rate	106000	84800	42400	36100	bits/sec

DSL Overhead $\text{RFC1483B}(6) + \text{AAL5}(8) + \text{PAD}(n) + (\text{ATM Cells} * 8)$
 This example is for RFC1483 Bridged.

DSL Overhead is highly variable due to padding and various encapsulations. i.e. PPPoA, PPPoE, etc.

DSL Packet Size $\text{Ethernet Packet Size} + \text{DSL Overhead}$

DSL Stream Rate $\text{DSL Packet Size} * 8 * \text{Packet Rate}$

Voice Codec Summary

Algorithm	Bandwidth required	Quality score	Look-ahead time
G.711a	64 Kbps	4.4 MOS	0.75 ms
<p>Actually nothing more than pulse code modulation (PCM) without compression, this bandwidth intensive algorithm introduces less than a millisecond of delay and offers highest speech quality.</p>			
G.726	32 Kbps	4.1 MOS	5 ms
<p>This type of compression, adaptive differential pulse code modulation (ADPCM), requires less than 10 ms for "look-ahead" sampling. It can double the call capacity of a circuit.</p>			
G.729A	8 Kbps	4.0 MOS	10 ms
<p>Algebraic code-excited linear prediction (ACELP) is the most popular compression algorithm found in Voice over DSL integrated access devices (IAD) and frame relay or LAN gateways because it provides high quality over modest bandwidth. To minimize encoding delay, a digital signal processor (DSP) usually is employed in the IAD.</p>			
iLBC	6.4 Kbps	3.4 MOS	30 ms
<p>New Freeware codec that has been designed especially for carrying voice over the Internet. iLBC has better tolerance to packet loss and delay than G.729 and lower bandwidth consumption. iLBC is royalty free so it is not subject to any licensing fees making it a popular codec in the Internet community.</p> <p>iLBC is the codec used by Skype – a popular VoIP program on the Internet</p>			

Conclusion

Hopefully I have given you some insight into the Australian way of DSL broadband and Voice over IP – and not confused you too much.

This is an ever changing landscape and as we see more players come into the market and more deregulation the landscape will continue to change. Wireless is becoming an increasingly viable option for broadband Internet and has quite a large appeal – the biggest being it is Telstra free.

Anyway, this is the first of many papers I will be doing so if you enjoyed this stay tuned for the next installment. I do have a full time job so I write these in my spare time so don't expect one a week, but I will try to keep these frequent.

Enjoy the Internet and may all your downloads be good ones.

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Useful Links

Whirlpool

<http://www.whirlpool.net.au>

DSL Overview

http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci213915,00.html

IT Jargon Buster

http://youth.itskillshub.com.au/starting_out/definitions/?id=21

G Service voice protocols

<http://www.javvin.com/protocolG7xx.html>

Voice Compression

http://library.telecommagazine.com/data/rlist?t=1008618652_13763217

The ILBC Codec

<http://www.ilbcfreeware.org/>