

STATEMENT OF [c-i-c commences] [c-i-c] [c-i-c ends]

I, [c-i-c commences] [c-i-c] [c-i-c ends], of 231 Elizabeth Street, Sydney, in the State of New South Wales, state as follows:

A. Structure of Statement

This statement is structured as set out in the following table of contents:

A. Structure of Statement.....	1
B. Confidentiality	1
C. Professional background and experience.....	1
D. PSTNs generally	2
E. Telstra's PSTN.....	7
F. Internet Protocol Communication Networks	9
G. Distinguishing between a PSTN and an IP-based network.....	10
H. IP telephony services provided by Telstra over the NBN.....	13

B. Confidentiality

- 1 Certain information in this statement is confidential to Telstra Corporation Limited ("Telstra"). I have prepared this statement on the basis that the information in this statement which is identified as confidential in it will be treated as confidential.

C. Professional background and experience

2 [c-i-c commences] [c-i-c]

3 [c-i-c]

(a) [c-i-c]

(b) [c-i-c]

(c) [c-i-c]

(d) [c-i-c]

4 [c-i-c]

5 [c-i-c]

6 [c-i-c] [c-i-c ends]

D. PSTNs generally

7 A public switched telephone network or PSTN is a telephone network based on technology that was first developed over 100 years ago.

8 The key elements of a PSTN include:

- (a) **Customer premises equipment (also known as “CPE”)** – that is, an analogue telephone or handset. The term “analogue” and the use of analogue technologies in a PSTN is explained further at paragraphs 12 to 15 below;
- (b) **The local loop (also known as the “last mile”)** – this was originally, and still typically is, a copper loop (but may now also include fibre and/or radio access media) that is connected to a local switch.
- (c) **The transport core** – this involves the carriage of voice between switches (which, in the case of Telstra’s PSTN, are typically located in Telstra’s exchanges). In a modern digital core network such as Telstra’s PSTN, the switching involves use of digital time division multiplexing (“**TDM**”) technology. Digital technology refers to mechanisms in which data is represented in the form of binary digits (zeroes and ones). TDM is a technology that enables multiple calls to be transported along the same transmission path (e.g. the optical fibres that run between Telstra’s exchange buildings), and is explained in paragraphs 23 to 29 below.
- (d) **Signalling** – which controls the call.

These key elements together form the system by which telephone calls are conveyed in a PSTN and are described in more detail below

9 Each of these elements is discussed in more detail below.

10 The central feature of a PSTN which distinguishes it from other types of networks is that it is designed to enable a **dedicated** voice connection to be established and conveyed between two end points in the network for the duration of a single call.

- 11 The point to point nature of PSTN architecture and the fact that one end user can only be connected to one other end user at a time led early engineers to place switching equipment in centralised locations (i.e. telephone exchanges). This enabled the connection of large numbers of users via switches, thereby maximizing network access. This was how the concept of **circuit switching** was born.

Analogue technology – CPE and the Local Loop

- 12 The majority of premises connected to Telstra's PSTN are connected using analogue technology supplied over the copper local loop. Analogue technology in this context refers to mechanisms by which a voice call is represented by continuously variable physical quantities in the form of an electrical signal sent over a twisted copper pair.
- 13 When a customer speaks into the microphone of an analogue handset, the electric current running between the customer's handset and the local switch has the customer's voice impressed on it. This, in effect, involves the creation of a constantly varying signal while the customer is speaking using the standard voice (3.1kHz) bandwidth over the copper loop.
- 14 Where a customer is connected to the PSTN by the copper local loop, these signals are carried on the copper network as analogue signals to the nearest local switching point.
- 15 In some cases, customer premises are connected to the PSTN using newer alternatives to copper local loops such as fibre or fixed wireless access media. These access media can also be used to connect to and carry circuit switched telephone calls across the PSTN. However, where these technologies are used, voice signals may be transmitted in digitised form between the customer's premises and the nearest local switching point, rather than as an analogue signal. However, where this occurs, the underlying digital technology used remains circuit-based in order to enable telephone calls to be carried and switched over an end to end circuit in the same way as call conveyance occurs when connected using an analogue copper based access medium. This technology, which is fundamental to the design and operation of the PSTN, is described in more detail below.

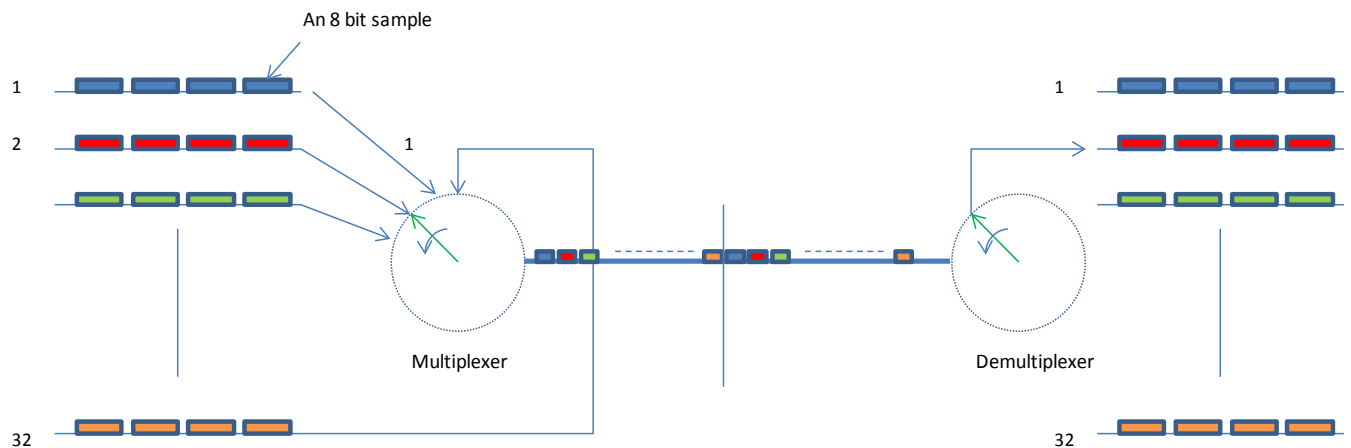
The operation and development of circuit switched technology

- 16 The PSTN uses circuit-based or “connection-oriented” systems that are principally designed for the delivery of one universal and ubiquitous service – that is, voice.
- 17 Essentially, the PSTN establishes a system between source and destination in which each call requires a “call set up” function in which a connection is made “end to end” before the call commences and for the duration of the call. That is, dedicated capacity in the network is reserved for the call.
- 18 This design allows the network operator to route and bill calls efficiently because each step of the call path is identified and managed by the network and its circuit switching systems.
- 19 By arranging telephony network switches in a hierarchical switching structure based on the function they perform (for example, the connection of local, long distance, fixed to mobile, international) and employing dedicated trunk lines between network switches, it is possible to scale the PSTN to accommodate a large number of end users across a national network.
- 20 PSTN switches operate on a link by link basis. This means that each switch within the hierarchy forwards its traffic along the link to the next PSTN switch based on the call set up process.
- 21 From the late nineteenth century up until about 1912, telephone routing was done manually by operators who made physical connections for customers. From the beginning of the twentieth century until the early 1980s, electro-mechanical switching technology was widely utilised in Australia . This means that the call routing was effected automatically through the means of telephone dials and electromagnets switching the copper connections. This technology was commonly called “step by step” switching. Using this technology, the customer’s call routing was effected stage by stage as the called number was dialled.
- 22 In both manually switched networks and electro-mechanical networks an actual **physical circuit** is established end to end as an actual electrical circuit is formed between the dialling customer connected on a copper local loop, switched in a

copper-based analogue core and delivered to the receiver on a copper local loop at the other end.

- 23 From the 1970s, Telstra began to deploy **digital switching** in its core network using processor controlled systems implemented via a technology known as time division multiplexing technology or “TDM”. This represented the final major evolution in circuit switched technology. TDM technology increases the capacity for telephone traffic between local switching exchanges and is described in more detail below.
- 24 At the local switch analogue voice signals are converted into digital signals using a process known as “quantising” also known as pulse code modulation.
- 25 In the quantising process, a customer’s analogue voice signal (at 3.1KHz bandwidth) is electronically sampled at a rate of 8,000 times per second (which is more than double the highest voice frequency). Each sample taken represents a voltage level, and each voltage level is then translated or coded as a binary coded eight bit digital string (i.e. a string of eight ones and zeros), for example {01100110}.
- 26 This results in a data bitstream of 64,000 bits (8000 samples, each sample comprising 8 bits) per second, or a 64Kbps voice channel. This is the standard digital voice channel bitstream speed and is the digitised form of the original 3.1KHz bandwidth analogue voice signal.
- 27 To enable increased capacity of transport in the core network, the digitally encoded voice signals are multiplexed (that is, combined) using TDM. Two key features of TDM are as follows:
- (a) **Reservation of bandwidth** – typically, TDM provides each voice signal with a committed 64kbit/s channel (or stream) throughout the network; and
 - (b) **Sequential interleaving of signals** – When multiplexed to a larger capacity channel, individual 64kbit/s signals are interleaved in time. For a 2.048 Mbit/s stream, thirty-two individual 64 kbit/s streams are sequentially interleaved.
- 28 These concepts are illustrated in Figure 2 and explained further at paragraph 29, below:

Figure 2: Time Division Multiplexing



29 In this diagram:

- (a) the left hand side of the diagram shows a series of 32 voice calls encoded as 64kbit/s streams, with each block representing an 8-bit call sample;
- (b) as each call reaches the multiplexing device, a highly accurate clock (synchronised to a master clock that ensures synchronous timing at all points in the network) facilitates the multiplexing (or combining) of each of the individual streams. In effect, each stream of samples enters the channel at an allocated time (hence the expression “Time Division”). This process of entering the channel in turns is referred to as interleaving;
- (c) the resulting channel has a capacity of 32 times 64kbit/s, or 2,048kbit/s (also referred to as a 2Mbit/s stream); and
- (d) the multiplexed stream traverses the transmission network (i.e. the optical fibre cables that run between exchange buildings). Upon reaching the multiplexing device closest to the receiving party (known as the “B-Party”), the stream is de-multiplexed. This means that the individual call samples are reconstituted into 64kbit/s voice channels and can then be reconverted back into an analogue voice call (3.1Khz) for carriage to the B-Party receiving the signal.

Summary of PSTN Characteristics

30 In summary, a PSTN is a telephone network that is designed to carry voice calls from the end user placing the call to an end user receiving that call via a dedicated circuit. The PSTN has a number of characteristics that are unique to that network. These include:

- (a) the network being designed to carry standard definition analogue (3.1kHz) voice communications;
- (b) a transmission medium (typically copper telecommunications wire) between the end user premises and the local telephone exchange. Each local telephone exchange is then connected to other exchanges, typically using fibre optic cable;
- (c) the voice signal being transmitted from the CPE in analogue form until it reaches the first switch or multiplexing device. At the first multiplexing device the analogue signal is converted into a 64kbit/s digital signal. From this point, the signal is conveyed throughout the network in digital form, prior to being converted back to an analogue signal at the switch or multiplexing device that is closest to the end user receiving the call;
- (d) switches, establishing a temporary but dedicated connection between the sender and receiver. The dedicated temporary link is referred to as a “circuit”, resulting in PSTN switching being referred to as “circuit switching”. Whether through manual, electro-mechanical, or digital means, the PSTN operates on the basis of having intelligent switches and dedicated transmission facilities using TDM to transport the call across the end to end circuit created via the call set up process.

31 I describe Telstra’s PSTN in more detail below.

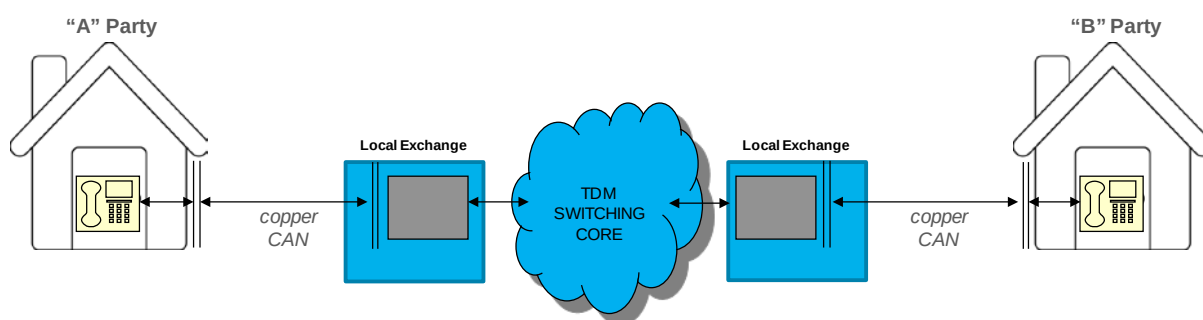
E. Telstra’s PSTN

32 Telstra’s PSTN is a fixed line telecommunications network that is used to provide voice telephony and data (for example, facsimiles and dial-up and broadband internet

access) services throughout Australia. It is connected to, though separate from, Telstra's wireless networks which provide, for example, mobile telephony.

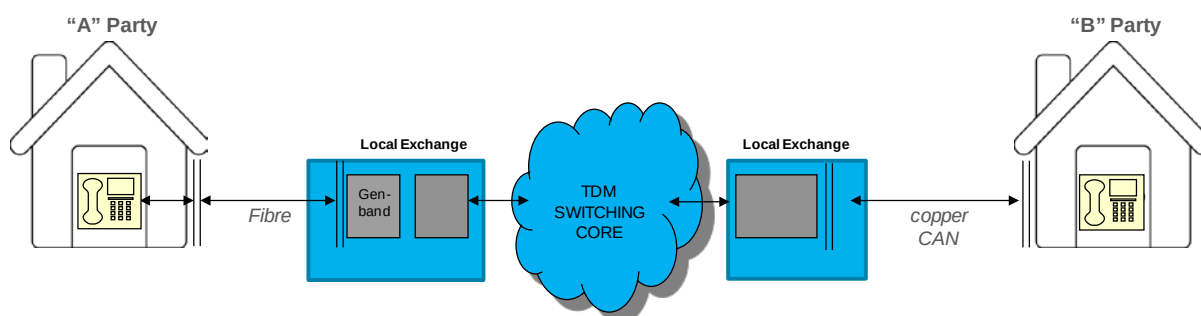
- 33 Telstra's PSTN consists of the Customer Access Network (also known as the "CAN" or "local loop") and the Inter-Exchange Network (also known as the "IEN"). The CAN is that part of the PSTN that connects a "customer" (also referred to as an "end-user") to an "exchange". The IEN is that part of the PSTN that connects Telstra's exchanges so that calls can be routed where the parties are connected to different local exchanges. Telstra currently has approximately 5,116 exchanges located throughout Australia.
- 34 The CAN typically comprises copper access lines that connect to the CPE (typically an analogue handset) to the switching and transmission equipment that comprise the IEN.
- 35 Figure 3 below shows a typical PSTN call where a person in a premises connected to the network via copper access (the "A Party") calls a second premises that is also connected to the PSTN, via a copper access line (the "B-Party").

Figure 3: Call Diagram: A-Party PSTN (copper access) to B-Party PSTN (copper access)



- 36 As set out above, although the CAN is typically comprised of copper access lines, some premises connected to Telstra's PSTN are connected via a fibre optic cable or fixed wireless connection. An example of a PSTN call in which the "A Party" (who is connected to the PSTN via fibre access, for example a Telstra Velocity customer in greenfields estate) calls a "B Party" (who is connected to the PSTN via copper access lines) is set out in Figure 4 below:

Figure 4: Call diagram: A-Party PSTN (fibre access) to B-Party PSTN (copper access)

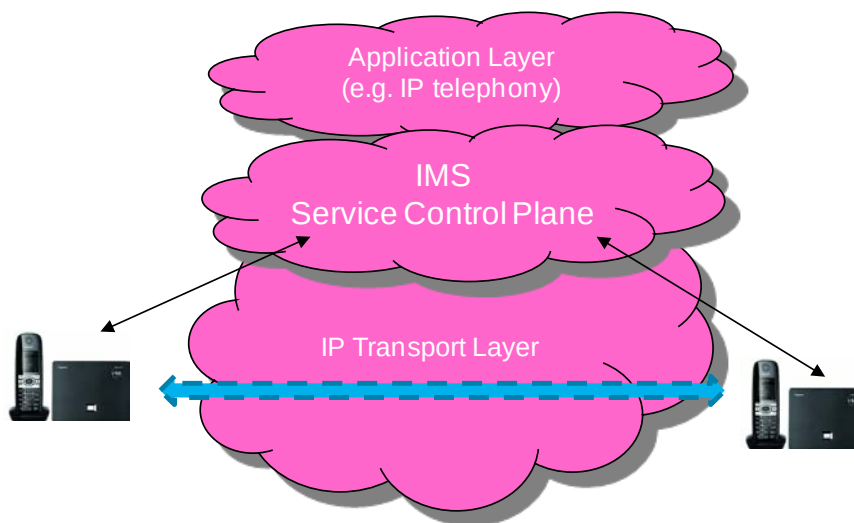


F. Internet Protocol Communication Networks

- 37 Internet Protocol (“IP”)-based telecommunication networks have evolved from computer networks rather than voice networks. They are designed to transmit large quantities of data efficiently. Transmission of voice services (or telephone calls) is a feature which has been added to IP networks over time.
- 38 Where voice services are provided over an IP-based telecommunication network this typically involves:
- (a) a transmission medium, which can vary. In the case of the NBN, this is typically fibre optic cable;
 - (b) the conversion of voice signals into digital form (data packets) outside of the network (for example within the CPE or by means of an Analogue Telephone Adaptor (ATA); and
 - (c) the transfer of individual data packets (which may be data of a particular voice call) independently throughout the network. Unlike a PSTN, the transmission of data packets over an IP network does not involve a dedicated “point to point” connection for all the data packets comprising the call. The router (which directs data packets in an IP network) is never closed, like a switch may be and, as such, paths are always open for data to follow.
- 39 As illustrated in Figure 5 below, IP-based voice services are typically connected to a computer network which utilizes IP technology in the core network. Voice is only one of many applications that sits above the IP Multi-media Core network Sub-

system (or “IMS”) control layer and the IP transport layer. The transition to an IP network involves a fundamental shift from an architecture that involves many separate and purpose built networks (such as the PSTN) to one where multiple services can be delivered over a single unified network. It involves a shift from networks where the transport of the services and the underlying services are vertically and inherently linked to a network of horizontal layers where transport of the data and applications (or services) are separated. This is illustrated in Figure 5 below:

Figure 5: Elements of an IP network



- 40 The applications layer set out in Figure 5 above is entirely separate from the IP transport layer. This contrasts with a PSTN where the voice service is not separate from the underlying infrastructure. In a PSTN the infrastructure comprising the dedicated circuit established between the A-party and the B-party *is the voice service*.
- 41 The NBN is an example of an IP network. In conjunction with service providers' compatible IP-based core networks, the NBN can be used to provide IP-based telecommunication services to end users. A description of Telstra's NBN voice services is provided at paragraphs 56 to 66 below.

G. Distinguishing between a PSTN and an IP-based network

Distinct origins of networks

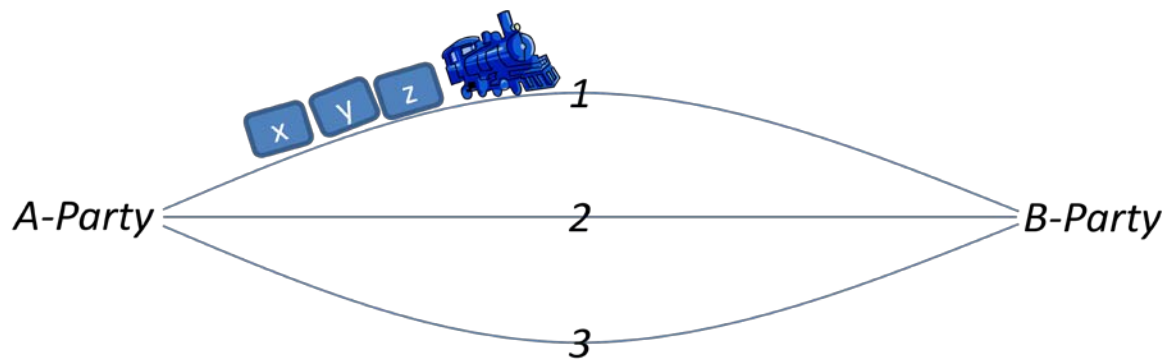
- 42 A PSTN is fundamentally a telephone network. Historically, PSTNs were, and still are, designed primarily to provide voice services using a 3.1 kHz analogue signal or a

digital signal of 64kbit/s. In contrast, an IP network is primarily designed to provide IP-based data services, of which voice is only one component. IP networks are not limited to a particular signal frequency.

Switches, in a PSTN sense, are not a feature of an IP network

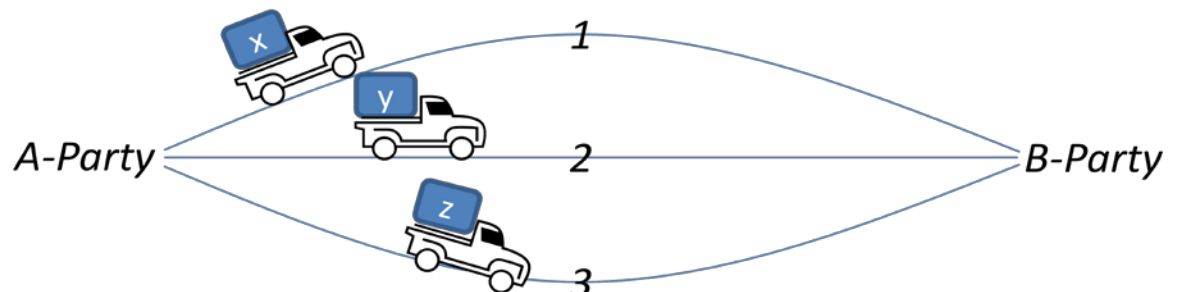
- 43 As discussed above, in a PSTN, signals are carried by means of dedicated circuits that are established by switches.
- 44 There is no equivalent to a PSTN switch in an IP network. IP networks rely on packets of data being encoded with a particular IP address to determine the path of that packet of data through the network. There is no set path for the data packet to follow. A router in an IP network directs the data packets, but is always open and does not direct the packets to any single path.
- 45 In the case of an IP network, there is no single circuit or dedicated path that the entirety of the data will take. Instead, different, single packets that make up the same overall call may take their own paths through the network guided by the particular “address” each data packet receives. In contrast, a PSTN provides a temporary, dedicated circuit – established by the switch - through which a call is transferred from the end-user’s premises to the local exchange and then through the PSTN to the receiving end-user.
- 46 The difference between a circuit switched and a packet-based network can be illustrated by the following analogy.
- 47 Consider a voice call as the equivalent to a series of transportable storage containers (in this case, containing data). The data may be transported from the A-Party to the B-Party using either a train or a number of trucks. In either case, there a number of possible routes (in this example, three routes) that the information could traverse between the A-Party and B-Party.
- 48 If the information is sent via the train, each of the containers will take the same path from A-Party to the B-Party. At each intersection the rails must be linked (i.e. “switched”). This is represented in Figure 6 below:

Figure 6: Transport of data packets over a PSTN



- 49 In subsequent journeys (or voice calls) the train may take an alternative path. However, all containers (voice information) in a given journey (call) will always travel on the same path. In this way a train with coupled container cars provides a reasonable analogy of a circuit switched voice call on a PSTN, in which each call between two parties traverses a dedicated path (circuit) which is established for the duration of the call and managed by the switching devices.
- 50 Any given train track in this analogy has a limited throughput capacity, equating in the PSTN to 64 kbit/s.
- 51 In contrast, if the series of containers were transported on a set of trucks, then each truck may travel on a different route from the A-Party to the B-Party. The network is always “on” and, therefore, each route is always open to use. This contrasts to a switch which can be closed. The truck analogy is represented in Figure 7 below:

Figure 7: Transport of data packets over an IP network

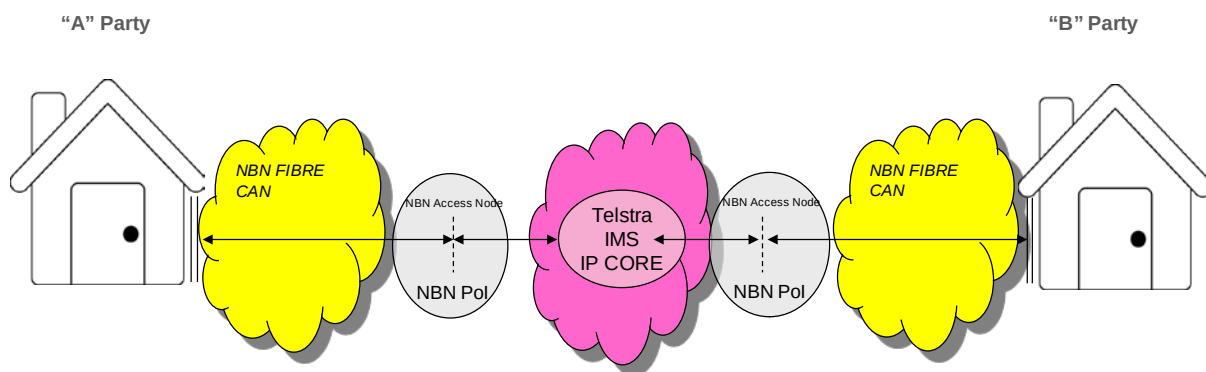


- 52 In the truck analogy, each container comprising a given set of information may travel diverse paths between the two calling parties. This is consistent with what occurs with packets of data (including voice data) in an IP network.
- 53 In this analogy, the road capacity is also variable and can accommodate different traffic levels (up to a maximum). It is not limited to 64 kbit/s.
- 54 Where the PSTN relies on a physical point to point connection and a switching hierarchy, IP networks do not prescribe a particular type of network topology (i.e. a dedicated, end to end circuit for the duration of the connection) but rather deliver data using a highly distributed communication system where the packet transport and routing mechanisms are neutral with regard to the type of traffic carried by the packet.
- 55 This creates the potential for more diverse innovation and choice for end users because in an IP network innovation is at the edge of the network and is not necessarily dependent on network providers for anything other than transporting packets across the network. Unlike an IP network, the PSTN is entirely network centric. Any new service (such as call waiting, call forwarding or three way calling when first introduced a number of years ago) requires complex network re-engineering. This architectural limitation is one reason for the relatively low level of innovation in basic telephony in the past century. An IP network, by contrast, is application based or “user centric”. New applications and services are implemented through software, predominantly on the user side and network re-engineering becomes the exception rather than the rule.

H. IP telephony services provided by Telstra over the NBN

- 56 Telstra has developed IP voice services that will be provided over the NBN, in conjunction with Telstra’s core IP network.
- 57 Figure 8, below provides a simplified representation of the NBN and how it connects to Telstra’s IP network:

Figure 8: NBN Network Infrastructure



58 The NBN comprises a fibre wireless or satellite-based access network which connects the end user premises to a NBN Co Point of Interconnect (NBN PoI). In Figure 8 above this is the “NBN Fibre CAN”. At the NBN PoI, service providers (including Telstra) establish a connection to their own core network infrastructure enabling them to provide services to end users connected to the NBN served from that PoI.

59 At the end users’ premises, the NBN terminates at Network Termination Device (NTD), typically installed on an internal wall of the premises. The NTD contains a number of ports, to which can be connected compatible CPE to enable the provision of a voice, broadband or some other service over the NBN.

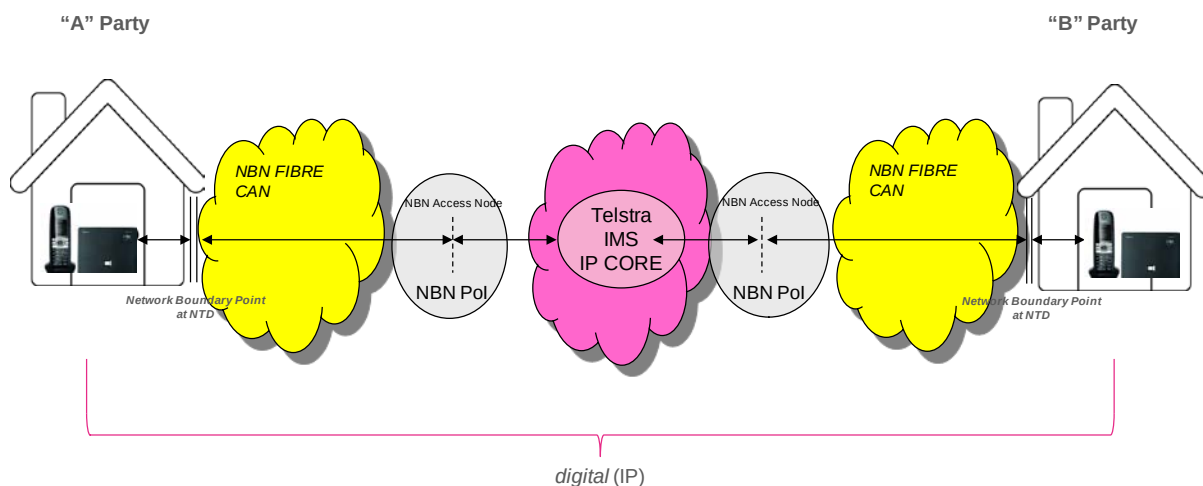
60 The typical NBN Co NTD contains two types of ports, a UNI-D port over which broadband, voice and other services (such as video) can be provided and a UNI-V port that is a port designed for the provision of standard definition voice services by means of traditional telephone CPE.

61 Telstra currently offers two voice services to end users connected to the NBN, supplied either through the NBN Co UNI-D port or through the NBN Co UNI-V Port.

62 The UNI-D port enables all types of IP data (e.g. video, television, high quality audio) to be transmitted via Telstra’s service. Standard definition voice services are one service that is able to be provided through Telstra’s UNI-D service.

63 A simplified representation of the network infrastructure involved in the supply of Telstra’s UNI-D voice service is illustrated in Figure 9, below:

Figure 9: Call diagram: Telstra’s UNI-D service



64 As illustrated in Figure 9, above, the UNI-D service operates as follows:

- (a) Telstra provides the end user with a Home Network Gateway (“**HNG**”) that is connected to the UNI-D port on the NBN Co NTD. The HNG provides end users with the ability to use either a traditional telephone handset or a VoIP handset to make and receive calls:
 - (i) If the end user opts to use a traditional handset, then when the customer speaks into the microphone of the handset, the (analogue) voice signal is sent to a Analogue Telephone Adaptor built into the HNG, where it is then converted using the G711 PCM encoding standard into data (IP packets). In this case the ring current and dial tone for the end users’ handset is supplied from the HNG.
 - (ii) If the end user opts to use a VoIP handset, the conversion from analogue voice to IP packet data is carried out by an ATA within the VoIP handset itself. The use of a specialised VoIP handset can enable higher definition (that is, better quality) voice services to be provided, as well as services of broadly equivalent quality to traditional PSTN voice services. In addition, services such as video-calling will be able to be offered to end users with suitable (video capable) CPE.
- (b) From the HNG, the voice data (stored as IP packets) is carried through the NTD and across the NBN access network to a NBN PoI. Here the data is handed over to Telstra’s IP core network.

- (c) In the example shown in Figure 9, where the B Party is also connected to a Telstra (UNI-D) voice service supplied over the NBN, the voice data will be routed through Telstra's IP core network to the NBN Co PoI that serves the B-Party's premises, where it is then carried over to the NBN access network to the B-Party.
- (d) Where the B-Party is not-connected to Telstra's NBN-based voice service (e.g. the B Party is connected to a voice service supplied over the PSTN, an alternative fixed line network, or a mobile network), then the call data will be routed through Telstra's IP core network to the PSTN (via a media gateway device that converts the IP packet data to TDM format data). Once the call is connected to the PSTN it will be switched to the B-Party (either connected directly to the PSTN or through interconnection to a third-party network).
- (e) The UNI-D service requires a powered HNG in order to operate. If power is cut to the end user's premises (e.g. due to a blackout) the service will cease to function unless an alternative power supply is provided.

65 Telstra's UNI-V voice service operates in a similar manner to the UNI-D voice service described above, although there are some differences between the two services, as described below:

- (a) Unlike the UNI-D service, the UNI-V voice service is only able to provide standard definition voice service to end users. In comparison the UNI-D service can provide higher definition voice services (as well as broadband services and potentially other services such as video and IP-TV services).
- (b) The UNI-V voice service does not require a HNG or a VoIP handset in order to convert speech from the end user to IP data. Rather, the end user is able to connect a traditional PSTN handset directly into the UNI-V port on the NBN Co NTD. An ATA within the NBN Co NTD converts the analogue signal to IP packet data. The electrical current and dial tone for the end user's handset is supplied from the NTD.
- (f) The UNI-V service can operate if power is temporarily cut to the end user's premises provided the NTD is fitted with an optional battery backup device.

The backup battery is able to power the functionality of the UNI-V port and provide ring current and dial tone to the end user's handset.

- (c) From the NTD, the UNI-V voice service data is routed in a similar manner as UNI-D data (as described in paragraphs 65(b) to 65(d) above.

66 A simplified representation of the network infrastructure involved in the supply of Telstra's UNI-V voice service is illustrated in Figure 10 below:

Figure 10 call diagram: Telstra's UNI-V service

