Telecommunications Technologies

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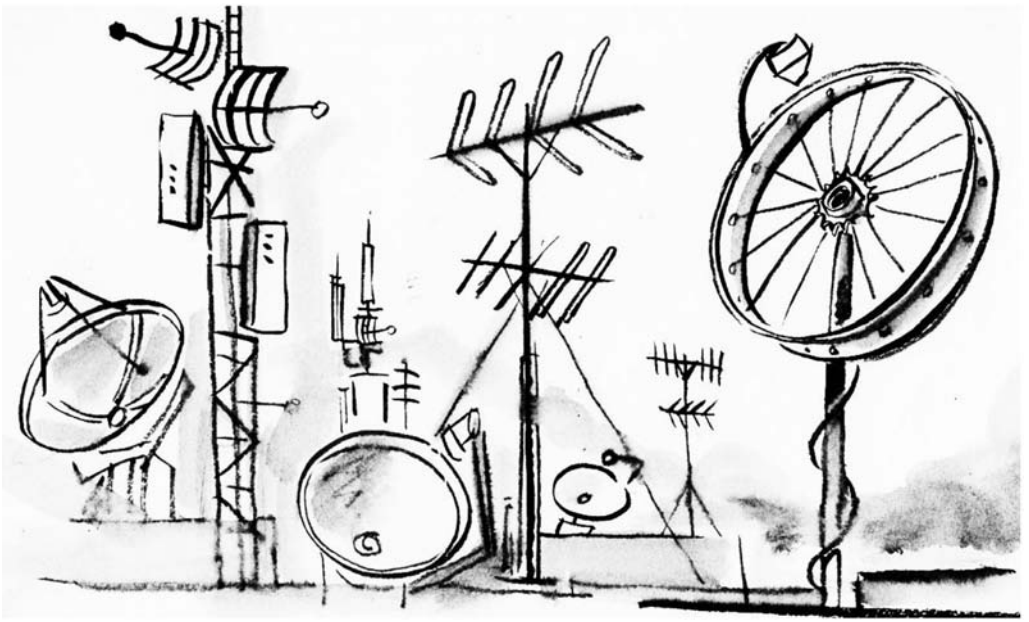

[1] The author would like to thank Lynne Orrock for her assistance in reviewing this chapter.

Introduction

The aim of this chapter is to describe many of the key technologies used in the telecommunications industry in a simple manner that will be understood by non-technical readers. This will assist anyone dealing with technical terminology to understand what they are dealing with. A glossary of technical terms has also been included at the end of this chapter. It should be noted that the glossary also contains terms not specifically mentioned in this chapter as it is intended to be a more general reference.

1. WHAT IS TELECOMMUNICATIONS?

Telecommunications[2] is a broad term for a very wide range of technologies and forms of communication. However, the primary areas are:

- radio
- telephone
- television
- data.

Prior to the era of telecommunications, communication between human beings was severely restricted by distance and speed. It required face to face contact, line of sight or written documents couriered by horse rider, messenger, ship or railway. This often took days and was limited to those who could read and write (a select few before 1900), and old news had little value. The dream for the modern age of telecommunications was simple enough: it was for one human to be able to communicate with another with sound, text (letters or numbers) or pictures in real time over any distance.

The human requirement has not changed markedly, and the many forms of telecommunications now available have come close to satisfying these needs. Why, then, is there still so much focus on telecommunications and why all this talk about convergence?

The history of telecommunications shows how rapidly things have progressed since 1835, when Samuel Morse first commercialised the telegraph; and since the radio was invented in 1896.[3]

Radio and television[4] are today huge communications industries, but they are grouped into the category of broadcasters, or deliverers of a single, common message to many. Listeners and viewers can select the channel but not the content.

The invention of the telephone[5] in 1870 made possible one to one voice communication,[6] and with the advent of the first generation cellular phone just over a century later in the 1980s, the personalisation of telecommunications moved one step closer. This, coupled with the Internet and e-mail, meant that we are closer to the ideal

[2] http://cisco.com.
[3] http://inventors.about.com/library/bl/bll_3.htm.
[4] http://www.people/emson.edu.
[5] http://inventors.about.com/library/inventors/bltelephone.htm.
[6] http://iath.virginia.edu/albell/homepage.html.

of communicating between one person and another anywhere, at any time, and through any medium. The world of converged telecommunications will deliver just this.

How has this all become possible? The next few sections will show how, by being able to express the three core elements of communication – sound, picture and text (data) in the same form, namely digital – as a series of zeros and ones, convergence has become attainable. The only remaining constraints, then, are the device and the capacity of the linking bearer type or pipe. We will see that everything is getting faster, often also smaller, and that we can get more and more down the same pipe so that the day when your mobile device will be a telephone, a television set and a computer all rolled into one is not too far off.

Technological convergence is the coming together of all the telecommunications technologies and capabilities into a single seamless form, where one system will be able to provide all your communications requirements, person to person, anywhere and at any time.

2. WHERE DID TELECOMMUNICATIONS START?

The first building block of telecommunications, besides the harnessing of electricity, was the invention of the electromagnet by William Sturgeon in 1825. This was the cornerstone of all the analogue systems to follow and its invention enabled sound to be translated into an electric signal, carried across a wire as a current and reverse engineered at the receiving end, so that the electrical current could be converted back into sound. Today the microphone and the loudspeaker still work on this same principle.[7]

Since this date, there have been many other important inventions that have driven the pace of development of telecommunications faster and faster. Some of the key inventions were the cathode ray tube (CRT) in 1897, the first transistor in 1948, the first integrated circuit in 1958, and the first memory (RAM) chip in 1970. These are the key building blocks of today's modern world of telecommunications, television, radio, satellites, computers, the Internet, telephones, CD and DVD players.

3. DIGITAL VERSUS ANALOGUE COMMUNICATIONS

The big breakthrough for telecommunications came with the advent of the computer (or integrated circuit), and when analogue[8] was replaced by digital[9] — the ability to express sound and pictures as a series of bits and bytes, or zeros and ones. This enables data to be sent between two distant devices as a string or packet of zeros and ones.

Everyday examples of this conversion from analogue to digital are vinyl records to CD, the VCR videotape to DVD, and the introduction of digital television.

One of the key benefits derived from this is that digital data can be processed, stored, compared, calculated and manipulated.

In all telecommunications, signal strength (and, in particular, the signal : noise ratio) weakens over distance due to resistance in the wire (or air), and the induction and

[7] http://inventors.about.com/library/inventors/blelectromagnet.htm.
[8] http://webopedia.com/TERM/a/analog.html.
[9] http:// webopedia.com/TERM/d/digital.htm.

generation of noise signals in the same transmission medium. As a result, the signals need to be filtered and amplified periodically to maintain an adequate signal : noise ratio. When a digital signal is amplified, the quality (or data) is retained, as a digital signal can be copied or amplified over and over without losing its content (remember, it can only be a zero or a one). So, unlike an analogue signal, which loses quality with each amplification and hence has distance limitations, digital overcomes this problem. This is because, on receipt, each packet can be verified to detect whether the data has arrived correctly. If it does not arrive correctly, in time or at all, then the packet can be sent again because it was stored at the originating device. This is unlike analogue, where the communication is always real time and cannot be stored or easily repeated.

As all analogue signals can be translated to digital (zeros and ones), once in digital form there is really no difference between data, voice or video. Thus the transmission of the data can be common and over the same link, and only when the bits and bytes reach the final destination is it necessary to know how to translate the signal back into its original analogue form. This factor lies at the heart of the convergence paradigm, and is what makes it possible to deliver all forms of communication down a single 'pipe' through a single communications technology. This removes the need for separate infrastructures or licences for voice, data, television, and radio.

4. CIRCUIT VERSUS PACKET TECHNOLOGIES

In the early days of telecommunications (in the days of Alexander Graham Bell) telephones were all analogue devices. To hold a conversation, a contiguous link (of copper wire) was required between two telephones. Each generated an analogue signal across a wire which, when received at the other end, was amplified into a (loud) speaker and heard as voice. To achieve this requirement, the first 'circuit-switching'[10] was done by people in manual telephone exchanges, who connected one line to another, initially within a town, and later to the next town, where another operator connected the caller to the local (receiver's) line. Again, a contiguous copper link had been established. As networks and volumes grew, this manual circuit switching became impracticable and new technology was introduced to replace human operators. These were electro-mechanical devices that could recognise the numbers being dialled from the analogue signal (sets of uniform pulses) generated from the dialling device – a very short set of pulses for 1, increasing to a much longer set of pulses for 9 and the longest set for 0. [11]

Although today this has almost all been replaced by digital devices, the fundamental principle of circuit switching[12] has remained. Simply put, when a call is established between two parties, a contiguous electrical circuit is established for the full duration of the call between the two devices. This is, however, inefficient for a number of reasons a simple example being that when we talk, a lot of time is spent saying nothing, and the circuit is not being used for a large percentage of the time. Also, today, technology has enabled the same piece of copper wire that comes to the home to be used for more than one conversation at a time. Since a major part of the cost of

[10] http://webopedia.com/TERM/c/circuit_switching.html.
[11] http://inventors.about.com/gi/dynamic/offsite.htm?site=http://www.ce.org/publications/books%5Freferences/digital%5Famerica/history.telecom.asp.
[12] http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci211787,00.html.

providing telecommunication services lies in the physical cables, there is a growing need to use this expensive infrastructure more efficiently.

With digital came the concept of 'packets'.[13] A packet is a piece of data (a string of zeros and ones) or a set of data broken up into a large number of discrete envelops (or packets) to form a conversation. Each packet is structured and contains a header where data about the packet is stored. Each packet is also numbered sequentially and has a send and a receive address and some information about the data in the packet. This enables the transmission to be broken up into many small pieces. Each packet travels its own route, so perhaps not all the packets go down the same route. This can result in some packets arriving early and some late (and not necessarily sequentially). Packet switching enables the content of a packet to be checked for completeness on arrival. It also enables packets to be stored for a short while at the sending end, so if a packet is not received (and acknowledged) within a set period of time, a packet can be re-sent. It even enables packets from two or more 'conversations' to be sent at the same time down the same circuit. This overcomes many of the capacity problems experienced with analogue transmissions.

But what happens if a packet is delayed or there are too many packets to fit down a circuit? There is a key difference between circuit switching and packet switching. In circuit switching the link is exclusively provided for the duration of the transmission and data is delivered sequentially and without delays. This is called deterministic communication – the time a bit of data will take to get from point A to B is known and can be relied on. Packet switching is 'non-deterministic' as neither the route it will travel, nor the order in which it will arrive, (or even that it will arrive), can be assumed or determined. Hence, when dealing with content such as voice, using a packet-based technology such as Transmission Control Protocol/Internet Protocol (TCP/IP) requires technology intervention to ensure that this problem of non-determinism is resolved, as the human ear cannot tolerate delays in excess of 180 milliseconds.

5. SPEED OF TRANSMISSION

5.1 It's all about speed!

One of the big advances in technology is that the speed of data transmission down the same bearer (copper wire, Ethernet cable[14], fibre cable, etc) has increased massively.

For example, Ethernet (over a copper twisted pair) was originally introduced in 1976 and supported speeds of 10 Mbps. This progressed to 100 Mbps in 1997, followed shortly by 1 Gbps in 1998, and already 10 Gbps is available. This is a 1000-fold increase in throughput in just a few years.

The home telephone line, originally installed to carry only analogue voice, was then used to carry data, with the first modems at 2,4 Kbps. This increased to 128 Kbps with the introduction of Integrated Services Digital Network (ISDN)[15] and now, with the appropriate equipment, the same copper wire, using Asymmetric Digital Subscriber Line (ADSL), can simultaneously support a voice call and a download of data at a combined speed of about 512 Kbps.

[13] http://searchnetworking.techtarget.com.
[14] http://webopedia.com/TERM/E/Ethernet.html.
[15] http://webopedia.com/TERM/I/ISDN.html.

5.2 How has this been possible?

The computer processor speed and rapidly reducing costs have made this possible. With digital, the computation speed of new processors has made it possible to package, reassemble, compress and check data and manage multiple protocols in very short time frames. However, to do this we need to buffer or store large volumes of data for short periods. The advent of cheap memory (RAM) has enabled this to happen.

Simply put, speed can fix most of the non-deterministic problems associated with packet-switching and speed can fix most of the problems associated with large volumes of data, such as those involved with television. When integrated with technologies such as Multiprotocol Label Switching (MPLS)[16] all of these problems are soon overcome.

6. TELECOMMUNICATIONS TECHNOLOGIES

6.1 Multiplexing Mechanisms[17]

The laying of cables in the ground or even above the ground or across oceans is an expensive business, and the productivity of such investments needs to be optimised. To achieve optimisation it is necessary to run many data transmissions or conversations over the same cable at the same time. To do this multiplexing was invented. There are four basic kinds of multiplexing, all of which help to optimise the use of large cables[18] time division multiplexing; statistical multiplexing; frequency division multiplexing, and wavelength-division multiplexing.
Each of these is described below.

6.1.1 Time division multiplexing[19]

Time-division multiplexing (TDM) is a method of putting multiple data streams in a single signal by separating the signal into many segments, each having a very short duration. Each individual data stream is reassembled at the receiving end based on timing.

The device that combines signals at the source (transmitting) end of a communications link is known as a multiplexer. It accepts the input from each individual end-user, breaks each signal into segments, and assigns the segments to the composite signal in a rotating, repeating sequence. The composite signal thus contains data from multiple senders. At the other end of the cable, the individual signals are separated out by means of a device called a demultiplexer and routed to the proper end-users. A two-way communications circuit requires a multiplexer / demultiplexer at each end of the cable or radio link.

[16] http://webopedia.com/TERM/I/label.html.
[17] http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci212614,00.html.
[18] http://searchnetworking.techtarget.com/gateway/search/1,294070,sid38,00.html?ctype=ALL&start=0&num=10&within=text&query=+multiplexing&sid=0.
[19] www.whatis.com/wsearchResults/1,290214,sid9,00.html?query=Time+Division+Multiplexing.

6.1.2 Statistical multiplexing

Statistical multiplexing[20] is a system that was developed to overcome some inefficiencies of standard TDM, where time slices are still allocated to channels even if they have no information to transmit. In such instances the cable bandwidth capacity is wasted.

Statistical Time Division Multiplexing (STDM)[21] uses a variable time-slot length and allows channels to compete for any free slot space. It employs a buffer memory, which temporarily stores the data during periods of peak traffic. This scheme allows STDM to waste no line time with inactive channels. STDM requires each transmission to carry identification information (ie a channel identifier). To reduce the cost of this overhead, a number of characters for each channel are grouped together for transmission.

STDM is the core technology used in router-based networks, and is often used for managing data being transmitted via a local area network (LAN)[22] or a wide area network (WAN). In these situations, the data is often simultaneously transmitted from any number of input devices attached to the network, including computers, printers and fax machines.

In comparison to TDM, the STDM method analyses statistics related to the typical workload of each input device (printer, fax, computer) and determines on the fly how much time each device should be allocated for data transmission on the cable. Many believe the STDM method is a more efficient use of total bandwidth available than the TDM method.

6.1.3 Frequency division multiplexing

Frequency-division multiplexing (FDM)[23] is a scheme in which numerous signals are combined for transmission on a single shared medium (such as a wire, optic fibre, or light beam) line or channel. Each signal is assigned a different frequency (sub channel) within the main channel.

Sub channels can be joined to form groups, and groups may then be joined into larger groups.

While combined in this way all the signals may be amplified, conducted and translated into frequency and then routed towards a destination as a single signal, resulting in the economies that are the motivation for multiplexing. When FDM is used in a communications network, each input signal is sent and received at maximum speed at all times.

6.1.4 Wavelength division multiplexing

Optic fibre cables today form the backbone of all global telecommunications networks. All the undersea cable and the core national trunks between the major cities

[20] www.searchtechtarget.techtarget.com/gateway/search/1,294070,sid38,00.html?ctype=ALL&start=0&num=10&within=text&query=multiplexing&sid=0.
[21] http://searchnetworking.techtarget,com/sDefinitions/0,,sid7_gci214620,00.html.
[22] http://webopedia.com/TERM/l/local_area_network_LAN.html.
[23] http://searchnetworking.techtarget.com/gateway/search/1,294070,sid38,00.html?ctype=ALL&start=0&num=10&within=text&query=Frequency-division+multiplexing+&sid=0.

are optic fibre. These have replaced old copper systems, which were bulky, inefficient, expensive and required high maintenance and frequent filtering/amplification.

Dense wavelength division multiplexing (DWDM)[24] is a technology that puts data from different sources together on an optic fibre, with each signal carried at the same time on its own separate light wavelength. Using DWDM, up to 80 (and theoretically more) separate wavelengths or channels of data can be multiplexed into a light-stream transmitted on a single optic fibre. Each channel carries a time-division multiplexed signal. In a system in which each channel carries 2,5 Gbps, up to 200 billion bits can be delivered a second by the optic fibre.

The first WDM systems combined two signals and appeared around 1985. Modern systems can handle up to 128 signals and can expand a basic 9,6 Gbps fibre system to a capacity of more than 1 000 Gbps.

DWDM promises to solve the fibre exhaust problem and is expected to be the central technology in the all-optic networks of the future. WDM systems are popular with telecommunications companies because they allow them to expand the capacity of their fibre networks without digging up the road repeatedly. All they have to do is to upgrade the demultiplexers at each end.

The South Atlantic Telecommunications Cable number two known as the SAT2 cable and the South Atlantic Telecommunications Cable number three known as the SAT3/West African submarine cable (WASC)/South Atlantic Far East Cable (SAFE) that run between South Africa and Europe are optic fibre cables running DWDM technology.

6.2 Wireless Technologies

6.2.1 GSM[25] cellular standard

The world's first digital cellular standard was developed in Europe during the 1980s to replace their ageing analogue systems, the largest of which was Nordic Mobile Telephony system (NMT) and the US-developed system, Analogue Mobile Phone System (AMPS).

The initial system was developed in the 900 MHz band, but this has subsequently been expanded to the 1800 MHz band, and others more recently to the 450 MHz band (old NMT band) and the 1900 MHz band (to fit in with the US band plans).

The technology is designed to carry voice predominantly, and multiplexes eight speech channels on a single frequency to improve spectral efficiency. The backbone structure behind the transceiver stations (BTS base transceiver stations) is a legacy telecommunications backbone utilising TDM infrastructure. Data throughput rates on such a system are understandingly low at around 9,6 Kbps. Over the years, improvements have been made to the standard, resulting in the data throughput rate being increased to 14,4 Kbps as a standard.

Newer enhancements to the GSM cellular standard are aimed at gradually migrating the network from its second generation (2G) status in the beginning (1G was the original analogue mobile phone standard developed in the 1970s and utilised

[24] www.searchnetworking.techtarget.com.
[25] http://webopedia.com/TERM/c/cellular.html.

until the end of the 1980s). The current migration objective is to move towards a 3G (third generation) mobile service which provides not only efficient voice communication but also reasonable data access speeds for use of internet access, e-mails and other data transfer as required by users. The stage currently reached in this migration is termed 2.5 G, and involves the rollout of GPRS across all GSM networks. This is an interim increase in data access rates and it relies on the introduction and use of packet switched backbones, and a packet switched air interface where earlier restrictions prevented higher data rates.

6.2.2 WiFi[26] or WLAN[27] or 802.11

These are all different names for the same basic wireless technology. This is a medium-distance wireless technology that operates in the frequency range of 2,4 GHz. It is used for connecting devices like computers to a network, and is an alternative to fixed lines. It has the advantage of mobility as it does not require a physical cable connection to a network.

This technology can generally support a speed (bandwidth) of up to 10 Mbps. This bandwidth is shared between devices within the coverage area of each receiver/transmitter, and is also limited by distance. A full 10 Mbps can be obtained within 1 km of a transmitter, but as the distance increases the bandwidth decreases as the signal gets weaker.

This is an area of very rapid development, and the term 'WiFi' has taken on a more generic meaning, now covering all forms of wireless-based data communication, not just those limited to the 2,4 GHz band.

6.2.3 Bluetooth[28]

This is a new wireless technology created for use with cellular networks. It is a short-range (10 m radius) technology also operating in the 2,4 GHz band, and is specifically for connecting headsets to cellular phones and printers or mice to PCs. This is very similar to WiFi and all the devices connected to the transmitter/receiver share the bandwidth of about 1 Mbps.[29]

6.2.4 Microwave

The term 'microwave'[30] refers to electromagnetic energy having a frequency higher than 1 GHz (billions of cycles per second), corresponding to wavelengths shorter than 30 cm.

Microwave signals propagate in straight lines and the beams do not readily diffract around hills, mountains and large human-made structures. Some attenuation (loss of signal strength) occurs when microwave energy passes through trees and softer barriers. Radio-frequency (RF) energy at longer wavelengths is affected to a lesser degree by such obstacles.

[26] http://webopedia.com/TERM/W/WiFi/html.
[27] http://webopedia.com/TERM/W/WLAN.html.
[28] http://bluetooth.com.
[29] http://searchnetworking.techtarget.com/gateway/search/1,294070,sid38,00.html?ctype=ALL&start=0&num=10&within=text&query=Microwave&sid=0.
[30] www.searchnetworking.techtarget.com.

The microwave band is well suited to wireless transmission of signals requiring large bandwidth. This portion of the RF electromagnetic radio spectrum encompasses many thousands of megahertz. In communications, a large allowable bandwidth translates into high data speed. The short wavelengths allow the use of dish antennae having manageable diameters. These antennae produce high power gain in transmitting applications, and have excellent sensitivity and directional characteristics for receiving of signals.

Microwave communication is a fixed wireless technology, the sending and receiving devices are fixed, and the antennae aligned. It is therefore very good for transmitting high-bandwidth communications across relatively long distances where there is a clear line of sight.

6.2.5 Free-space optics

Free-space optics (FSO) is another fixed wireless technology. It refers to the transmission of modulated visible or infra-red (IR) beams through the atmosphere to obtain broadband communications. Laser beams are generally used, although other sources such as light-emitting diodes or IR-emitting diodes will serve the purpose.

The theory of FSO is essentially the same as that for fibre optic transmission. The difference is that the energy beam is collimated (a parallel light stream created with laser and optic lenses) and sent through the air from the source to the destination rather than guided through an optic fibre. This obviously limits the distance over which FSO can be used. At the source, the visible or IR energy is modulated with the data to be transmitted. At the destination, the beam is intercepted by a photo-detector, the data is extracted from the visible or IR beam (demodulated), and the resulting signal is amplified and sent to the hardware.

FSO systems can function over distances of several kilometres. As long as there is a clear line of sight between the source and the destination, communication is theoretically possible. Even if there is no direct line of sight, strategically positioned mirrors can be used to reflect the energy. The beams can pass through glass windows with little or no attenuation.

Although FSO systems can be a good solution for some broadband networking needs, there are limitations, the most significant being the fact that rain, dust, snow, fog or smog can block the transmission path and shut down the network.

6.2.6 Infra-red communication

The Infra-red Data Association (IrDA) is an industry-sponsored organisation set up in 1993 to create international standards for the hardware and software used in infra-red communication links. In this special form of radio transmission, a focused ray of light in the infra-red frequency spectrum, measured in Terahertz, or trillions of hertz (cycles per second), is modulated with information and sent from a transmitter to a receiver over a relatively short distance. Infra-red radiation (IR) is the same technology as that used to control a television set with a remote control unit. The current maximum transmission rate is 4 Mbps.

Infra-red is still a developing technology and is being developed to handle a

maximum effective distance of about 1,5 km, while the maximum projected bandwidth is 16 Mbps. Since IR is line-of-sight light transmission, it is sensitive to fog and other atmospheric conditions.

6.3 Television and Satellite Technologies

6.3.1 Analogue television

Television has changed very little since it was first invented. The screen is today still made between 525 and 625 lines or 200 000 pixels (dots of colour) and the screen is 'repainted' or refreshed 25 times every second. Obviously a lot of signal is required, and that is why there are so few analogue terrestrial television stations, as each station has to use a lot of frequency band to deliver this huge amount of information. The spectrum bands are referred to as VHF (very high frequency) and UHF (ultra high frequency).

As already explained, any analogue signal can be expressed as digital, and television is also easily represented in zeros and ones. However, because the volume of data is huge it is necessary to compress the data stream in order to enable digital transmission of television.

6.3.2 Digital television compression[31]

Video on digital television is compressed using a standard called MPEG-2 (Moving Picture Experts Group). It takes advantage of how the eye perceives colour variations and motion. Inside each frame, an MPEG-2 encoder records just enough detail to make it look as if nothing is missing. The encoder also compares adjacent frames and records only the sections of the picture that have moved or changed. If only a small section of the picture changes, the MPEG-2 encoder changes only that area and leaves the rest of the picture unchanged. Using these compression schemes, MPEG-2 can reduce the number of bits by about 50 times.

To achieve this compression, digital television requires both an encoder (as the sending side) and a decoder (set top box) at the receiving side. The decoder decompresses the signal back to its full form and converts the signals back into analogue, which the television can translate into the pictures we see.

6.3.3 High-definition television (HDTV)

A new standard for high-definition television has been agreed by the US Federal Communications Commission (FCC) and the first test commercial broadcasts of HDTV have started. This standard increases the number of lines of television (or the number of pixels) to 675 X 600. This improves the picture quality substantially and allows the picture to be projected to a much greater size without losing definition (a severe limitation with current television). It is expected that over the next 10 years television will move onto a digital broadcast base and to HDTV.

[31] www.pbs.org/search_results.html?q=Digital+TV+compression&btnG.x=14&btnG.y=11&neighborhood=none.

6.3.4 C-band and KU-band satellite

Digital satellite television in Africa is transmitted over both C-band and KU-band satellite technology. The C-band covers the frequency range between 3,6 and 4,2 GHz and the KU-band runs from 10,7 to 12,75 GHz.

KU-band is popular for home reception, as it can use a much smaller television dish, but is more affected by weather conditions. C-Band requires a much larger antenna and is more reliable in poor weather.

6.3.5 Cable television

Cable television is a communications system that distributes broadcast programs by means of radio frequency (RF) in a coaxial cable. This is very similar to wireless technology, only through a cable rather than through the air. Cable is more reliable and has better quality than WiFi as interferences and weather problems are reduced. The same coaxial cable is shared by many homes in a single community. Cable television can also be used to communicate data using cable modems and deploys a form of frequency multiplexing. These devices enable you to connect your PC to a local Cable television line and receive data at 27 Mbps on the download path to the subscriber with about 2,5 Mbps of bandwidth for interactive responses in the other direction. However, this technology, which is widely deployed in countries such as the United States and which is currently not available in South Africa, is generally provided as a commercial service limited to 1,5 Mpbs.[32]

6.4 Legacy Wireline (Copper) Technologies

6.4.1 POTS[33]

As an abbreviation for 'Plain Old Telephony System', it gives an indication that POTS telecommunication network access lines are the same as they were when telephones were first installed in this country. This is basically correct, with the exception that the grade of copper and conductor insulation has been improved over time, and most of the poor grade lines have already been replaced. This is very important, as it is the newer broadband services which require higher grades of copper than those that were originally installed.

POTS lines supplied by Telkom are each an analogue twisted pair of conductors that forms by far the majority of all non-business lines in the country. In areas where runs are long, noise suppression devices are installed on poles, at intervals along the runs, to ensure that interference is kept to a minimum. For this reason, unless a user is located close to a Telkom switching centre (where there is no need for these noise suppression devices), these lines cannot be used for broadband access technologies such as ADSL.

[32] http://whatis.techtarget.com/efinition/0,,sid9_gci211727,00.html.
[33] http://webopedia.com/TERM/P/POTS.

6.4.2 ISDN

Telkom introduced Integrated Services Digital Networks (ISDN) in South Africa a little over a decade ago. The idea behind ISDN networks is to allow for the seamless integration of (digitised) voice and data over the same network. The design of the interfaces was no longer restricted by the requirements of voice traffic, but made to be more generic to facilitate data streams. In all ISDN solutions, we see that 64 Kbps channels (as required for an uncompressed and standard old technology voice CODer/DECoder (CODEC) are used throughout.

Two basic products are usually offered: a Basic Rate access ISDN (BRI) which offers two channels each at 64 Kbps plus some overhead for control; and a Primary Rate access ISDN (PRI) which offers 30 channels each at 64 Kbps plus overhead for control and framing. In South Africa, the Basic Rate ISDN products are known as ISDN2 and ISDN2a, the first giving two digital output channels and the second two analogue output channels. The South African Primary Rate access ISDN product is known as ISDN30.

Unfortunately, these products were introduced at inflated prices in this country, a problem that has restricted uptake and hindered the general economy. It is only recently that prices have been reduced to more acceptable levels, but it is too late, as users are very bandwidth hungry, and were it not for the high ADSL pricing, it is likely that ISDN would have been bypassed as a technology altogether in the country. With the introduction of some competition to Telkom, it is likely that broadband access prices will come down further, resulting in either Telkom being forced to reduce ISDN prices further or the technology failing due to too low uptakes.

7. THE INTERNET

The Internet[34] is a huge global network of networks. These networks are all joined together through the interconnection of Internet Service Providers. The Internet works because there is a standard set of networking languages (protocols) that enables the many diverse networks to 'talk' to each other. These protocols, which are generally referred to as IP (the Internet Protocol), make up a suite called TCP/IP.[35]

7.1 Internet Protocols (IP and TCP/IP)

Transmission Control Protocol/Internet Protocol (TCP/IP)[36] is the basic communication language or protocol of the Internet. It can also be used as a communications protocol in a private or any other network. When you are set up with direct access to the Internet, your computer is provided with a copy of the TCP/IP program just as every other computer that you may send messages to or get information from also has a copy.

TCP/IP is a two-layer program. The higher layer, TCP, manages the assembling of a

[34] http://webopedia.com/TERM/I/Internet.html.
[35] http://cisco.com/pcgi-bin/search/search.pl?searchPhrase=the+Internet+Protocol&x=16&y=12nv=Search+All+cisco.com%23%23cisco.com&nv=Technical+Support+%26+documentation%23%23cisco.com%23TSD&language=en+country=US&accessLevel=Guest&siteToSearch=cisco.com.
[36] www.searchnetworking.techtarget.com, http://yale.edu/pclit/COMM/CPIP.

message or file into smaller packets that are transmitted over the Internet and received by a TCP layer that reassembles the packets into the original message. The lower layer, IP, handles the address part of each packet so that it gets to the right destination. Each gateway computer (or router) on the network checks this address to see where to forward the message. Even though some packets from the same message are routed differently from others, they will all be reassembled at the destination.

TCP/IP uses the client/server model of communications in which a computer user (a client) requests and is provided a service (such as sending a Web page) by another computer (a server) in the network. TCP/IP communication is primarily point-to-point, which means that each communication is from one point (or host computer) in the network to another point or host computer.[37] TCP/IP and the higher-level applications that use it are collectively said to be 'stateless' because each client request is considered a new request unrelated to any previous one (unlike ordinary telephone conversations that require a dedicated connection for the call duration). Being stateless frees network paths so that everyone can use them continuously. Note, however, that the TCP layer itself is not stateless as far as any one message is concerned. Its connection remains in place until all packets in a message have been received.

The most widely used version of IP today is Internet Protocol Version 4 (IP v4). However, IP Version 6 (IP v6) is also beginning to be supported. IP v6 provides for much longer addresses and therefore for the possibility of many more Internet users.

On the Internet there are a number of other protocols that are in common use. These include:

HTTP	**hypertext transfer protocol**
FTP	**file transfer protocol**
Telnet	**Terminal emulation software that allows a remote user to access files and resources on a network**
SMTP	**simple mail transfer protocol**
SLIP	**serial line Internet protocol**
PPP	**point to point protocol**

There are many other important networking protocols that are not part of the TCP/IP suite, and these include:

UDP	**user datagram protocol**
SNMP	**simple network management protocol**
ICMP	**Internet control message protocol**
IGP	**interior gateway protocol**
EGP	**exterior gateway protocol**
BGP	**border gateway protocol**

7.2 IP Addressing

At the heart of TCP/IP[38] lies the key element of IP addressing.[39] This is the data equivalent of telephone numbers. Just as with a telephone number, each IP address in

[37] http://cisco.com/pcgi-bin/search/search.pl.
[38] http://webopedia.com/TERM/T/TCP/html.
[39] http://cisco.com/pcgi-bin/search/search.pl?searchPhrase=IP addressing&x=9&y=10nv=Search+All+cisco.com%23%23cisco23cisco.com&nv='Technical+Support+%26+documentation%23%23cisco.com%23TSD&language=en+country=US&accessLevel=Guest&siteToSearch=cisco.com.

the world has to be unique or else when calling we would get confused trying to find the correct phone. Telephone numbers are split into a few hierarchies:

- Country code (RSA 27 or UK 44 and so on)
- City code ([0]11 Johannesburg or [0]21 Cape Town)
- Then a three-digit exchange code and a four-digit unique code within the exchange.

IP works in a very similar way, and each IP address is made up of four number of classes (A, B, C and D). Each class is expressed as an eight-bit integer and has 256 (2^8) values. So the smallest IP address is 000.000.000.000 and the largest is 256.256.256.256. This results in there being a large but limited number of IP addresses (2^{32} = 4,295 million). This seems like a lot, but when we think about how many computers and other network devices there are, it is not enough. IP v6 will extend this and each class will be expressed as a 16-bit number, or $2^{64} = 1{,}84 \times 10^{19}$ addresses.

Obviously there is a need to manage IP addresses on a global basis with a single authority responsible for issuing blocks or ranges of IP addresses. This body is ARIN in the USA. ARIN will, on request and against an adequate justification, issue a class A, B, or C address block to an Internet or network service provider. A single Class C address block will contain 256 unique public IP addresses, a Class B address block (256 x 256) = 65,536 addresses. A Class A address block will contain 256 x 256 x 256 addresses.

7.2.1 Domain names

As human beings are not very good at remembering numbers, especially complex ones that are not well structured, domain names[40] were introduced to provide text-based names that can be used to represent an IP address. Well-known examples of these are yahoo.com and google.com.

Domain names always have two or more parts separated by dots.[41] The part on the left is the more specific, and the part on the right is the more general. A given machine (server) may have more than one domain name but a given domain name points to only one machine (or IP address).

These names, although not limited in number, need to be globally unique. This is why there has been much conflict and litigation about the registering of domain names. In order to manage all these names and to protect global brands and intellectual property rights a number of domain name authorities have been set up. In the USA this authority is The Internet Corporation for Assigned Names and Numbers (ICANN) and in South Africa it is the Uniforum Association South Africa.[42]

Domain names are used in URLs to identify particular Web pages. For example, in the URL http://www.yahoo.com/index.html, the domain name is yahoo.com. www.ananzi.co.za, the domain name for the South African search engine, Ananzi, is

[40] http://webopedia.com/TERM/d/domain.html.
[41] www.domain.com.
[42] Chapter X of the Electronic Communications and Transactions Act, 25 of 2002 establishes a '.za' Domain Name Authority to assume responsibility for the .za name space. It is envisaged that the authority will administer or license others to administer the domain names and corresponding numbers for the South African country code, .za.

actually equivalent to the IP address 196.4.90.16

7.2.2 Domain name servers (DNS)

Domain name servers[43] are translation devices on the Internet that keep tables of domain names and their equivalent IP addresses. Every time you use a domain name, a DNS service must translate the name into the corresponding IP address. For example, the domain name example.com might translate to 198.105.232.4.

How this works is that, when you enter a domain name into your browser, this request is sent to your DNS for resolution. The DNS looks up the actual IP address for this server or device on the Internet and then the actual instruction to connect your PC to the server, wherever it is in the world, is passed to your Internet access router. This device does the sending of your request to the server that you want to access.

7.2.3 E-mail

E-mail is the fastest growing form of communications and has become an important part of business and even private life. Just as we used to say 'give me a call', today we say 'send me an e-mail' instead. It has been one of the driving forces in the growth of the Internet and in data networking. E-mail applications such as Microsoft Exchange and Outlook have simplified the user interface to e-mail, and the high-speed networks that make up the Internet ensure that e-mail reaches any destination on the globe within seconds. The ability to attach files to e-mails has also made the interchange of data across continents simple and quick. E-mail is transmitted using the SMTP protocol.

Unfortunately, with this ease of use, and with a very low cost of transmission, the Internet has become flooded with spam. This is a term used to describe unwanted or unsolicited e-mails, which are usually sent to users to try to sell products or services.

E-mail is unfortunately also used by some people to spread computer viruses. The virus is usually carried in an attachment, which when opened by an unsuspecting user either attacks the user's PC or sends the same poisoned e-mail to everyone in the receiving user's e-mail address book. This quickly multiplies into millions of infected e-mails and can have devastating effects on networks.

7.3 Broadband Technologies

This is a new expression in the telecommunications world. It does not refer to any one single technology but rather to a number of different technologies. The 'Broadband' refers to the fact the technology can carry a large volume of data at high speeds, generally more than 2 Mbps.[44] Examples of these technologies are:

- **Cable (or Cable Television):** This is a co-axial-based technology that runs a

[43] http://webopedia.com/TERM/d/domain_name.html and http:www.dns.net.
[44] http://cisco.com/pcgi-bin/search/search.pl?searchPhrase=Broadband+Technologies&x=7&y=6nv=Search+All+cisco.com%23%23cisco23cisco.com&nv=Technical+Support+%26+documentation%23%23cisco.com%23TSD&language=en+country=US&accessLevel=Guest&siteToSearch=cisco.co

radio frequency (RF) in a wire rather than in the air.

- **ADSL:** This is a technology that runs over traditional copper telephone lines and which uses multiple frequencies to transmit multiple digital communications at the same time over a single line thus enabling the user to talk on the telephone and be connected to the Internet at the same time.
- **WiFi, Wireless LAN, Free Space Optics** and **Microwave** technologies, already discussed above, are broadband technologies that can transmit data at speeds greater than 2 Mbps.

CONCLUSION

When one looks at how rapidly technology has progressed, especially in the last 20 years, one can understand why legislation needs to be constantly revised and updated to keep abreast of the changes in the telecommunications environment. This makes for a very fast-moving and exciting industry but also necessitates effective regulation.

Glossary of Terms

ADSL (Asymmetrical Digital Subscriber Line)

ADSL is a broadband technology that utilises copper telephone lines, but which is much faster than a regular telephone connection, and can carry data communications and voice communications simultaneously. This is achieved by dividing the total capacity of the line into multiple, independent bandwidth channels, where each channel operates only on a specific range of frequencies. ADSL is technically capable of up to 10 or 12 Mbps, but the service South African customers actually receive has currently been restricted by Telkom to 512 kbps for downloads and 256 kbps for uploads. It is this difference in upload and download speeds that makes it asymmetrical. Unfortunately ADSL is available only to subscribers who are located close to Telkom switching centres that are ADSL enabled, and where the existing lines are of a sufficiently high enough grade of Copper. The abovementioned bandwidths are not guaranteed, but provided only if there are no bottlenecks on the local or international links required, and the Copper Quality / distance criteria allow for high speed synchronisation.

Analogue

An analogue signal is electrical and varies constantly in voltage, unlike a digital signal, which varies between two constant values, usually denoted as 0 and 1. The value of the analogue signal varies continuously during transmission, whereas a digital signal only ever changes between two set values without intermediate variations. Due to the presence of electrical noise on all links, it can be seen that a digital signal can be transmitted with significantly fewer errors or less distortion. This together with the capabilities of being able to perform functions on digital signals such as multiplexing, compressing and encryption, amongst others, results in the modern trend to move away from analogue systems towards digital ones.

Asynchronous

A way of transmitting data where each information piece is sent separately. This means that each of those information pieces has to be labelled so that the recipient machine can recognise the character. This is achieved by adding other bits to the beginning and end of each information piece, known as the start and stop bits. Asynchronous transmission is the most rudimentary type of communication, as the originating and recipient machines do not have to be in step. It is generally regarded as a cheap, reliable method of communication, commonly used by PCs and minicomputers.

ATM (Asynchronous Transfer Mode)

ATM is a high-speed switching technology that sends blocks of data (each block is called a cell) asynchronously. ATM uses 53-byte cells (5-byte heater, 48-byte payload) to transmit different types of traffic simultaneously, including voice, video and data.

Backbone

Generic term for LAN, WAN or generic telecommunications connectivity between

sub-networks. The sub-networks are connected to the backbone via bridges and/or routers, and the backbone acts as a communication highway for LAN-to-LAN traffic.

Bandwidth

Bandwidth determines the rate at which data can be sent through a line — the greater the bandwidth, the more information can be sent in a given amount of time.

BGP (Border Gateway Protocol)

BGP is an inter-autonomous system routing protocol. An autonomous system is a network or group of networks under a common administration and with common routing policies. BGP is used to exchange routing information for the Internet and is the protocol used between Internet service providers (ISPs).

Bits and bytes (per second)

A bit is the smallest binary unit of memory space, i.e. a one or a zero. Eight bits make up one byte, which is the unit length required to make one character, such as a letter of the alphabet. A computer's memory is measured in kilobytes, where 1 kbyte (kilobyte) = 1,024 bytes and where 1 Mbyte (Megabyte) = 1024 kbytes.

Bluetooth

A wireless technology enabling voice and data connections between a wide range of devices through short-range digital two-way radio. It is an open specification for short-range communications of data and voice between both mobile and stationary devices.

Broadband

A transmission medium capable of supporting a wide range of frequencies, typically from audio up to video frequencies. It can carry multiple signals by dividing the total capacity of the medium into multiple, independent bandwidth channels, where each channel operates only on a specific range of frequencies. This term has, however, become a generic term for communication technologies that can carry data at high speeds. For example ADSL, WiFi (802.11), and Ethernet, which are all Broadband technologies.

Browser

A computer program for viewing pages and navigating the World Wide Web. Examples include Netscape Navigator, Opera and Microsoft Internet Explorer.

Buffer

A buffer is a software program, a storage facility or a device that functions to compensate for differing speeds of data transmission on a network. A buffer is a temporary storage facility (working on a first in first out principle), there to make sure that data always has somewhere to go, so that if traffic is congested the data can be held up for a while in the buffer until it can be transmitted to its intended destination.

B2B (Business to Business)
B2B — an e-commerce term used to describe the online business interaction between companies.

B2C (Business to Consumer)
B2C — an e-commerce term used to describe the online business interaction between a company and a consumer.

Cache
A memory storage facility used to hold frequently used data, or current information for fast retrieval, rather than having to retrieve the same data again from a disk drive or from the Internet.

CDMA (Code Division Multiple Access)
A cellular phone technology not currently used in SA that offers improved voice quality and increased data throughput rates due to the improvement in spectrum usage (efficiency) over the older GSM standard. CDMA use is growing quickly around the world, but is unlikely to ever catch up to GSM due to the cost of replacing infrastructure and handsets.

Circuit switching
Circuit switching is only maintained while the sender and recipient are communicating, as opposed to a dedicated circuit, which is held open regardless of whether data is being sent or not. This is the main technology used for legacy voice telephony and which is now gradually being replaced by more efficient packet switched technology.

CODEC
An abbreviation for CODer/DECoder, which is usually a processor based algorithm used to pack / unpack the most information from a sometimes varying input range into the smallest sized digital message. CODECs are traditionally used to convert analogue speech into a highly compressed digital format.

Data compression
A method to reduce the amount of data to be transmitted, by applying an algorithm to the data at the source that repacks the data more efficiently. A decompression algorithm expands the data back to its original state at the other end of the link.

Deterministic
A deterministic data transmission is one where the time for the data to reach its destination is known and is repeatable.

Domain name
The unique name that identifies an Internet site. Because domain names are alphabetic they are easier to remember than a number would be. Domain names always have two or more parts, separated by dots. The part on the left is the most

specific, and the part on the right is the most general. A given machine may have more than one domain name but a given domain name points to only one machine (or IP address). Domain names are used in URLs to identify particular Web pages. For example, in the URL http://www.yahoo.com/index.html, the domain name is yahoo.com.

DNS (Domain Name Service)

An internet service that translates domain names (eg yahoo.com) into IP addresses. Every time you use a domain name, a DNS service must translate the name into the corresponding IP address. For example, the domain name example.com might translate to the IP address 198.105.232.4.

Dial-up service

The use of the legacy voice (POTS – Plain Old Telephony System) telephone system, used in conjunction with an analogue modem, to establish a communication link for network or Internet access.

DES (Data Encryption Standard)

DES is a standard where data is encrypted in fixed size blocks and a key is used of varying length, depending on the sensitivity of the data. The original DES used 56-bit key; the newer Triple DES (3DES) uses three separate keys, but has the security of a 168-bit key.

DSL (Digital Subscriber Line)

DSL is a technology used for moving data over regular copper phone lines. A DSL circuit is much faster than a regular phone connection, and can carry data communications and voice communications simultaneously. This is achieved by dividing the total capacity of the medium into multiple, independent bandwidth channels, where each channel operates only on a specific range of frequencies. There are many standard variations of DSL — ADSL, VDSL, and SDSL.

DSLAM (Digital Subscriber Line Access Multiplexer)

A DSLAM is the terminating device for multiple DSL lines, and splits the data traffic into a data communication link and the voice circuits back into the switched voice network at the telecommunications exchange.

EDGE (Enhanced Data rates for GSM Evolution)

EDGE is a radio technology for GSM networks which is packet switched, and which uses newer generation CODECs than the GSM standard, to allow more information to be sent over existing bandwidth. The name implies that EDGE is the natural migration from GPRS networks, and is the last step before a 3G (third generation) telecommunications network is rolled out.

E-mail

This is one of the most common uses of the Internet and is the sending of messages with or without attached files between users and their e-mail servers.

Encapsulation
This is a technique used to place information inside a coded packet for transmission over a medium not normally supported. An example could be the carrying of voice traffic over the Internet. The voice traffic, once digitised, is placed inside an IP packet so that it appears to forwarding equipment on the Internet to be normal data traffic.

Encryption
This is the process of converting data or plain text into a form that cannot be understood without a matching decryption process. In communications, it makes it impossible to read these messages without the required key.

Ethernet
Ethernet, one of the oldest and most successful LAN technologies. It was developed to run over co-axial cable, although it can now run over twisted pair. LAN-based Ethernet currently runs at speeds of up to 100 Mbit/sec, although other, mainly fibre-based, versions extend this to 10 Gbit/sec.

Extranet
An electronic connection using Internet technology linking business partners to facilitate greater coordination of common activities. These often come about as an extension of a company's intranet.

E1/E3
E1 – European standard for digital transmission service at 2 Mbps.
E3 – European standard for digital transmission service at 34 Mbps (or transports 16 E1 circuits).

Firewall
Firewalls are electronic barriers to protect information resources, providing secure Internet entry points by monitoring incoming traffic against attack signatures, while checking outgoing traffic for approvals. Firewalls are used to protect an enterprise network against unauthorised access and malicious attacks.

Frame Relay
Frame relay is a telecommunication service designed for cost-efficient data transmission for intermittent traffic between networks. Frame relay is based on the older X.25 packet-switching technology. Frame relay is a fast-packet technology, which means that the protocol does not attempt to correct errors. When an error is detected in a frame, it is simply 'dropped' (thrown away). The end points are responsible for detecting and re-transmitting dropped frames.

FTP (File Transfer Protocol)
FTP is a general-purpose file transfer protocol for TCP/IP systems. It is typically used for sending large files between computers across the Internet.

Full-duplex
This is the ability of a communications device to transmit and receive Information simultaneously.

Gigabits (per second) (Gbps)
One thousand Mbit of data transmitted in a second, where 1 Gbit = 1,024 Mbits, or 230 bits.

GSM (Global System for Mobile communications)
GSM is the standard and system originally developed and used for pan-European mobile digital cellular radio communication. GSM uses narrowband TDMA (in the 900 and 1800 MHz frequencies), which allows eight simultaneous calls on the same radio frequency. GSM has become the de facto standard in many countries of the world.

GPRS (General Packet Radio Service)
GPRS is a radio technology for GSM networks that supports packet-switching protocols like IP across cellular networks. It is usually charged on volumes of data rather than on connected time. It is an always-on technology, as a user can remain connected for long periods without transmitting any data. This technology is often referred to as 2.5G, as it is emulating packet based data communications over cellular links, rather than a true 3G, which is a true packet based communication means.

Hosting
The co-location of customer's computers at a commercial data centre. Can also be the storage of a number of Websites on a single computer, referred to as Web hosting or website hosting.

HTML (HyperText Markup Language)
The English-like computer programming language used to express the source statements creating pages for the World Wide Web. HTML statements are then interpreted by a browser program to provide actual on-screen formatting and images.

HTTP (HyperText Transfer Protocol)
The protocol used for requesting and supplying Web pages and other information. It precedes a standard Web address, as in 'http://', to indicate to a browser program that it should use this protocol when retrieving a Web page.

HSCSD (High Speed Circuit Switched Data)
A dedicated circuit-switched data communications technology for GSM which enables data throughput up to 14.4 Kbps in a single channel, and by aggregating channels, up to 57.6 Kbps. An asymmetrical service can be offered where, for instance, one channel is allocated for the uplink and several are aggregated for the downlink.

Internet
A communications network started by the United States Department of Defence in

1969 to enable remote computers to communicate with each other without having fixed connections. Originally known as ARPANet, it was opened up to the universities in 1970 and to the world in 1982, at which point it led the invention of TCP/IP and became known as the Internet.

Intranets
Networks that use Internet technology, but are hosted by private servers not accessible by the public over the Internet. Companies use Intranets to facilitate their internal knowledge management, communication, collaboration on projects, HR functions, etc.

IP (Internet Protocol)
A portion of the TCP/IP suite of protocols that specifies how information is addressed, sent and received between systems.

IP Address
A unique 32-bit number assigned to each host computer on an IP network, such as the Internet. The addresses are structured to specify the class of network, network address and the sub-network that specifies a particular machine or group of machines. To make it easier to understand, IP addresses are written in 'dotted decimal notation', showing four decimal numbers between 0 and 255 separated by full stops, eg 196.4.123.201.

ISP (Internet Service Provider)
Companies or organisations that specialise in linking companies or organisations and individuals to the Internet as well as providing other related services to them.

ISDN (Integrated Service Digital Network)
ISDN is an international standard of the International Telegraph and Telephone Consultative Committee (CCIT) that covers a range of voice, data and image services. It provides end-to-end, simultaneous, digitised voice and data traffic on the same links via the same exchanges. Access channels include basic rate (BRI) (2 x 64 kbps + 16 kbps) = 144 kbps) and primary rate (PRI) ([30 + 1 + 1] x 64 kbps = 2 048 kbps = 2 Mbps).

IVR (Interactive Voice Response)
IVR systems and services allow a telephone caller to 'interact' (communicate either via voice or telephone keypad) with a specialised computer system in response to pre-recorded prompts played by the system to the caller.

Java
A platform independent programming language developed by Sun Microsystems to add dynamic features to World Wide Web pages. Web pages that include Java send the browser an applet (a small computer program) which then invokes a Java interpreter on the receiving PC. This enables the applet to be operating system independent.

Kilobit (per second) (kbps)
One thousand bits of data transmitted in a second, where 1 kbps = 1 024 bits per second (210 bits).

Leased line
A fixed TDM based circuit between two locations, which in SA is sometimes called a diginet link (a Telkom product name), and is available in a range of sizes from 2 400 bps in 64 kbps increments, and thereafter as channelised E1 links (2 Mbps). Larger leased lines are also provided as ATM, E1 or E3 circuits. The line consists of a permanent dedicated circuit between two points. The cost of the line is often based on the distance between locations.

LAN (Local Area Network)
A LAN describes a high-speed data communications network (usually Ethernet based) that covers a limited area. The machines linked by a LAN may all be in the same building or a group of buildings in relatively close proximity. It is user-owned and does not run over leased lines, although it might have gateways to the public switched network or to private networks.

Latency
This is the time taken to service a request or deliver a message. Different networking technologies introduce differing amounts of latency. The more devices (number of hops) in a given communications path, the greater the latency experienced by the traffic passing over that path. The greater the physical distance the greater the latency. In packet networks where packet sizes change and paths through the network change, latency can cause serious problems with time-sensitive traffic such as voice or video.

MAN (Metropolitan area network)
A MAN describes a network spanning a geographical area greater than a LAN but less than a WAN (wide area network). These are usually fibre rings running Ethernet, currently 100 Mbit or 1 Gbit.

Megabits (per second) (Mbps)
One thousand kilobits of data transmitted in a second, where 1 Mbit = 1 024 kilobits, or 1 048 576 bits (220 bits).

Modem
An abbreviation of MODulation/DEModulation, the modem converts digital computer signals into an analogue form for transmission over analogue telephone systems. Modems work in pairs, so at the other end of the link, the signal is returned to a digital form because traditional telephone networks are designed for the human voice, which is analogue, not for digital computers.

MPLS (Multi-Protocol Label Switching)
MPLS is a fast emerging new network standard for tagging packet flows with labels, with the aim of providing better bandwidth management and quality of service on IP

networks. The switched infrastructure reacts to the information contained in the label in the event of the need to reroute, which provides higher performance and lower-latency operation than devices that have to look up the full destination address field inside the packet header. MPLS is use extensively by service providers to run virtual private networks or for the transmission of time critical packets (eg voice or video) over an IP network.

MMS (Multimedia Messaging Service)

Similar to SMS in concept, the newer MMS cellular service allows the transfer of text, audio (eg music) and graphics (digital images) to other cellular phones. The main difference from SMS is that SMS uses a signalling channel to send information, and MMS uses a data channel. This removes the restriction on the volume of data that can be sent over the medium. The only size limitations with MMS are due to handsets, the telecommunications bearer technology (such as GPRS), and any operator specific message size limits.

Multi-media

An interactive combination of text, graphics, animation, images, audio and video displayed by and under the control of a PC.

NAT (Network Address Translation)

NAT is used to convert the IP address of a device into a different address to be used on a secondary network. This is typically used to enable the use of conflicting IP addresses on internal company networks.

Name resolution

Defines the process for translating an Internet address name from the symbolic form (domain name) used by people to the numeric IP address used by the machines. It is the function of the Domain Name Server (DNS).

Out-of-band signalling

This describes a technique that uses a separate channel to the LAN to allow LAN management and control information to be sent. It allows network management devices to access LAN devices, even when the LAN itself is not functioning, thus providing an extra degree of resilience.

OC1 / OC3

A USA designation generally recognised throughout the telecommunications community worldwide and used to measure Sonet implementations. The basic unit being an OC1 and then in multiples of that, for example:
Optical Carrier 1: an optical fibre line carrying 51.84 Mbps;
Optical Carrier 3: an optical fibre line carrying 155.52 Mbps. (also termed STM1 – see definition below)

Packet switching

This is a method of switching data in a network where individual packets of a set size

and format are accepted by the network and delivered to specified network destinations. The sequence of the packets is maintained and the destination established by the exchange of control information (contained in the packet header). The packets can be sent in any order, as the control information sent at the beginning of the transmission ensures that they are interpreted in the correct order at the receiving end. Because each packet carries its own control instructions, it can use any route to reach its destination. The link only lasts as long as the transmission. This also enables many users to use the same network at one time.

PDA (Personal Digital Assistant)

PDAs are mobile devices running applications of the type a Personal Assistant would do, such as a diary, meeting organiser, directory of contact telephone numbers, etc. The latest models are able to work with email and some even double as cell phones.

PDH (Plesiochronous Digital Hierarchy)

This plesiochronous (means nearly synchronous) standard was developed to carry digitised voice over twisted pair cables more efficiently. It has evolved into some of the ANSI standards adopted by the USA, Canada and Japan, and has been used as the basis to develop the SDH standard for the rest of the world. It is founded on a basic data rate of 64 kbps per voice channel, and is combined as a multiples of 30 data channels (plus 1 framing channel and 1 control channel) to form E1 links (at data rates of 2 Mbps), and aggregated in multiples of 16 E1s plus overhead to form an E3 link (at data rates of 34 Mbps).

Peer-to-peer

Describes communications between two devices on an equal footing, as opposed to host-terminal, client-server or master–slave. In peer-to-peer communications, both machines have to use processing power.

POP (Point of presence)

POP refers to a physical location where an ISP has routing or switching equipment to which its clients can connect to gain connectivity to the Internet.

Protocol

A set of rules governing the set-up and control of information flow within a communications infrastructure. Protocols control format, timing, error correction and running order. They are essential for a device to be able to interpret incoming information. Suites of protocols are often used in networks, with each protocol responsible for one part of a communication function. eg TCP/IP is the protocol used on the Internet.

Proxy server

A server between a client application, such as a Web browser, and a real server. It intercepts all requests to the real server to see if it can fulfil the requests itself. If not, it forwards the request to the real server. Proxy servers have two main purposes: to improve performance and to filter requests.

QoS (Quality of Service)

A common way to describe the performance of systems or networks using technologies that are able to prioritise data traffic. These technologies make it possible for time dependent communications like voice and video to be transmitted ahead of non-time dependent data like e-mail. This is very important with non-deterministic data protocols like IP.

Radius Server

Remote Authentication Dial-In User Service (RADIUS) is a protocol and software that enables remote access servers to communicate with a central server to authenticate dial-in users and authorise their access to the requested system or service. It provides security, allowing a company to set up a policy that can be applied at a single administered network point.

Redundancy

In data processing and data communications, it means providing a back-up, a secondary route or spares for the major components, so that should one of them fail, the system will continue to operate without interruption. It is also described as fault tolerance.

Router

Routers are the network devices that, by analysing the packet header data, decide which route to forward an incoming packet to. Routers exchange information between them so that they know the conditions of the network, and hence learn about the route maps for the network to which they are attached.

Routing

The process of delivering a message across a network or networks using the most appropriate path. While simple in principle, routing is a specialised, complex science, influenced by a plethora of factors. The more networks that are joined together, the more complex the routing becomes.

SDH (Synchronous Digital Hierarchy)

The international standard for transmitting information over optical fibre specified by the International Telecommunications Union (ITU). SDH is built on blocks of 155.52 Mbps, while the American version called SONET is 51,84 Mbps. Both of these standards are specified for a fibre infrastructure and multiples of their basic building blocks are combined to achieve multi-gigabit speeds. SDH is designed to operate more efficiently with the PDH services (see the PDH definition above) used outside the USA, Canada and Japan. (Mapping an E3 at 34 Mbps into an OC1 channel at 51.84 Mbps can be seen to be very inefficient!)

SLA (Service Level Agreement)

An SLA is an agreement setting out the minimum network performance guarantees. It can include latency, levels of dropped packets, round trip time and other guarantees.

Simplex
A communications channel capable of transmission or reception in one direction only.

SMS (Short Message Service)
This is a simple form of cellular e-mail, whereby users can send short messages of maximum 160 characters to other cellular phones. The messages are buffered by the network operator until the recipient's phone is switched on.

SNMP (Simple Network Management Protocol)
A standard protocol used to convey management and monitoring information to and from network devices such as hubs, switches and routers. This information can consist of status, configuration details and alerts.

SMTP (Simple Mail Transfer Protocol)
A protocol used for sending e-mail messages between servers. Most e-mail systems that send mail over the Internet use SMTP to send messages from one server to another.

SNA (Systems Network Architecture)
IBM's SNA is a layered communications protocol for sending data between IBM hardware and software.

Spam
This is a word used to describe unwanted or unsolicited e-mails, which are usually sent to users to try and sell products or services.

Streaming
Media files (either voice or video clips) are sensitive to delays in transmission. Streaming is a method whereby a media clip can be delivered over the Internet as a continuous flow of data, which is achieved by buffering a portion of the data before playing out the clip, to compensate for the varied or late arrival of some data.

STM-1 /STM-4 /STM-16 (Synchronous Transport Module 1)
STM-1 is an SDH standard building block for transmission of data at 155,52 Mbps. Multiples of this basic block comprise higher bit rate streams. Thus an STM-4 has 4 times the through-put of an STM-1, or 622.08 Mbps. Similarly, STM-16 has 16 times the through-put of an STM-1, or 2.488 Gbps.

SONET (Synchronous Optical Network)
SONET is an ANSI standard (a variation of the international SDH standard) for transmitting digital information over optical interfaces. The SONET standard established a digital hierarchical network with a consistent worldwide transport scheme. SONET carries voice (or circuit switched data) data in frames at speeds in multiples of 51.84 Megabits per second (Mbps) up to 48 * 51.84 Mbps = 2.488 Gigabits per second (Gbps). SONET is the American standard accepted and adopted

by the USA, Canada and Japan, and is not used in South Africa, where PDH and SDH perform the same functions.

Synchronous Transmission
Blocks of data transmitted are synchronised in terms of order and timing.

T1 / T3
A T1 is a digital transmission service (or circuit) standard mostly employed within the USA with a basic data rate of 1 544 kbps. A T3 is equal to 28 T1 circuits with a basic data rate of 44.736 Mbps.

TCP/IP (Transmission Control Protocol/Internet Protocol)
TCP/IP is a transport and internetworking protocol that is a de facto Internet networking standard. It was originally developed by the US Department of Defence and is able to operate in most environments. TCP/IP operates at Layers 3 and 4 of the Open Systems Interconnect (OSI) model (network and transport respectively), and in 1983 became the protocol for the Internet.

TDM (Time Division Multiplexing)
TDM is a method of putting multiple data streams in a single signal by separating the signal into many segments, each having a very short duration. Each individual data stream is reassembled at the receiving end based on the timing.

Transmission media
Any means of conveying a signal, such as wires and cables. It also includes less tangible media such as microwaves or radio waves.

Twisted pair
Two insulated copper wires twisted together, with the twists varied in length to reduce potential signal interference between the pairs. Twisted pair is the most commonly used medium for connecting PCs and terminals to servers. It is the most commonly used cable system for Ethernet LANS, and was originally specified for 10 Mbit/sec (Category 3 cable specification in terms of international cabling standards). New data-grade unshielded twisted pair is specified for 100 Mbit/sec transmissions, and Category 5e cable can support Gigabit Ethernet (1 Gbit/sec).

URL (Uniform Resource Locator)
The World Wide Web address of a site on the Internet. The URL for the Sunday Times web site, for example, is http://www.sundaytimes.co.za

UMTS (Universal Mobile Telephone Service)
UMTS is a future mobile communications system that, among other features, can offer direct connection between terminals and satellites. UMTS is the accepted technology and world standard for 3rd generation (3G) mobile communications. This standard allows for the migration from GSM, CDMA and DAMPS cellular standards through its three modes of operation.

VDSL (Very high data rate Digital Subscriber Line)
VDSL is DSL technology with a modem for twisted pair access operating at data rates from 12.9 to 52.8 Mbps with corresponding maximum ranges from 4 500 feet to 1 000 feet

VPN (Virtual Private Network)
A VPN is a network that is a virtual part of a physical network, such as the Internet, but to which access is controlled by firewalls and secure tunnels to enable private and secure use by authorised users.

WAP (Wireless Application Protocol)
Wireless Application Protocol is best described as the equivalent of HTML for cellular phones, and is used for accessing the Internet from mobile phones. In effect, WAP strips out complex Internet site images to enable the display of text content on a small limited resolution mobile phone display. As can be seen, any site must be developed to be compatible with WAP, or the mobile user may not have access to the information required.

WDM (Wavelength Division Multiplexing)
This is a technique used to define technology that is capable of mixing multiple light sources at different wavelengths down a single fibre cable. There are different implementations, known as dense WDM – up to 100 optical channels supported down a single fibre – and wide WDM – four optical channels supported down a single fibre. This technique dramatically increases the bandwidth capability of the fibre. This is the basis of the metropolitan area networks built at 10 Gbps and higher.

WAN (Wide area network)
A network that covers a larger geographical area than a LAN.

WiFi (Wireless Fidelity)
WiFi is the popular term for a high-frequency wireless local area network. The WiFi technology is an alternative to a wired LAN that uses twisted pair cabling. The 802.11b (WiFi) technology operates in the 2.4 GHz range offering data speeds up to 11 Mbps per second over an Ethernet network. The term has taken on a wider generic meaning which has extended to all forms of wireless based data communication, regardless of distance, and standards (like 802.11) deployed. WiFi is considered to be a Broadband technology.

WLAN (Wireless Local Area Network)
WLAN is a LAN that communicates between computer devices with wireless signals in the air rather than with electrical signals in cables.

WWW (World Wide Web)
The World Wide Web is a subset of the Internet and consists of a huge collection of hyper-linked HTML and other documents. Much of this body has been given form and function by websites, search engines and various other applications.

XML (Extensible Markup Language)

XML is a computer language that structures and standardises data elements, allowing for the open and efficient transfer of business documents and data over the Internet. Underlying data can be interpreted more easily.

X.25

X.25 is a robust packet–based protocol designed to send packet data across old, unreliable telephony circuits. This was one of the first ITU standards for packet switched networking.

3G (Third Generation)

3G is an ITU specification for the third generation (analogue cellular was the first generation, digital PCS the second) of mobile communications technology. 3G promises increased bandwidth, up to 384 Kbps when a device is stationary or moving at pedestrian speed, 128 Kbps in a car, and 2 Mbps in fixed applications. 3G will work over wireless air interfaces such as GSM, TDMA and CDMA.