Dsl Technologies Essay, Research Paper

DSL (Digital Subscriber Line or Digital Subscriber Loop. A technology that enables high-speed transmission of digital data over regular copper telephone lines. DSL works by using more of the capacity of the phone line. Voice and traditional modems work by modulating a signal in a limited range of frequencies (thousands of cycles); broadband sends a digital signal over a wide frequency (millions of cycles). The accelerated growth of content rich applications and online gaming, which demand high bandwidth, has changed the nature of information networks. High-speed communication is now an ordinary requirement throughout business, government, academic, and home office environments. Internet access, telecommuting, and remote LAN access are three of the clearly defined services that network access providers are offering now. These rapidly growing applications are placing a new level of demand on the telephone infrastructure. In particular, the local loop portion of the network (i.e., the local connection from the subscriber to the local central office) has become a challenge for telephone companies. Historically, this local loop facility has been provisioned with copper cabling which cannot easily support high bandwidth transmission. This environment is now being stressed by the demand for increasingly higher bandwidth capacities. Although this infrastructure could be replaced by a massive rollout of fiber technologies, the cost to do so would be insupportable in today’s business models and, more importantly, the time to accomplish such a transition is unacceptable because the market demand exists today! Telephone companies are already faced with growing competition and unprecedented customer demands a new category of companies, Internet Service Providers (ISPs), has emerged in this market as providers of data services. Traditionally ISPs have used the telephone company infrastructure. However, thanks to deregulation, they now have direct access to the physical cable. xDSL has the ability to meet the customer demand for high bandwidth right now, at costs that make sense. xDSL is a group of emerging Digital Subscriber Line (DSL) modem technologies for supporting high-rate traffic transmission over POTS lines. X stands for asymmetric in ADSL, rate adaptive in RADSL, high-speed in HDSL, and very high speed in VDSL. xDSL delivers Broadband over Copper the best thing about xDSL technologies is their ability to transport large amounts of information across existing copper telephone lines. This is possible because xDSL modems leverage signal processing techniques that insert and extract more digital data onto analog lines. The key is modulation, a process in which one signal modifies the property of another. ADSL Development and Deployment Progress Of all the emerging xDSL technologies, ADSL is receiving the most attention because there is a standard (DMT) for it, and its capabilities provide NSPs with a competitive offering to cable modems. But there is increasing interest in symmetrical xDSL offerings such as HDSL and SDSL. As a local access service, ADSL’s implementation has no critical drawbacks. It can be deployed as an overlay network where there is subscriber demand, eliminating the need for NSPs to risk building out their infrastructure unnecessarily in the hope that the technology will catch on. ADSL development and deployment is focused primarily in North America, followed by northern Europe and the Pacific Rim. In North America, US West, GTE, Ameritech, SBC, BellSouth, and Edmonton Tel (Canada) are the service providers leading the current wave of ADSL/xDSL deployment. Covad, Northpoint, and a handful of other CLECs are entering high-density metropolitan areas—typically offering a portfolio of xDSL offerings at different classes of service and price points, and competing with incumbent local exchange carriers. Chicago-based InterAccess was the first ISP to offer ADSL. Telia (Sweden), Telenor (Norway), British Telecom (UK), and Telfonica (Spain) are leading xDSL proponents in Europe. In the Pacific Rim, Telstra (Australia), Hong Kong Telecom, and Singtel (Singapore) are deploying xDSL for data and video applications. ADSL modems have been tested successfully by more than 40 telephone companies, and close to 50,000 lines have been installed in various technology trials and commercial deployments. Increasingly, alternative service providers such as enterprises, multi-tenant building owners, hospitality businesses (hotels and resorts), and office park developers are offering or considering offering ADSL to their users as private network operators. Applications In early 90’s xDSL technologies were tested by some of the regional Bell operating companies in the United States, as well as several European telephone companies. At that time, the driving applications behind xDSL were video on demand (VOD) and interactive TV (ITV). Those applications were seen as potentially explosive sources of revenue growth for the residential market. In 1995, interest shifted toward the online world and more specifically the World Wide Web. The increasing demand for bandwidth with which to access the Web is one of the primary applications at which xDSL technologies are now targeted. However, xDSL technologies are also being looked at in conjunction with several other applications. These applications may produce a far greater revenue stream in near future compared to broadband Web access for residential market. Listed below are just a few examples of how xDSL technology can be utilized: Internet/Intranet Access Intranet access for organizations that are standardizing on a Web based, client server model is one of primary xDSL applications. An organization that has implemented an Intranet will require higher bandwidth afforded by xDSL in order to link their remote offices and telecommuters to the more demanding business oriented applications running on their private Web servers. LAN-to-LAN Connectivity xDSL technologies have the potential to prove far more effective in low cost, high throughput, LAN to LAN connectivity than ISDN or traditional leased lines. Frame Relay Access Since xDSL operates at the physical layer, it could emerge as the most cost effective method of carrying frame relay traffic from the service subscribers to the frame relay network. ATM Network Access As with frame relay the xDSL technologies can also be used to carry ATM cells to an ATM access device, where they are statistically multiplexed over an ATM backbone. XDSL Types Digital Subscriber Line, or DSL, is fundamentally another name for an ISDN-BRI channel operating at the Basic Rate Interface with two 64 kbps switched channels and one 16 kbps packet switching and signaling channel. This circuit can carry both voice and data in both directions at the same time. xDSL refers to those various arrangements in which advanced modulating techniques are imposed onto the local channel in order to derive higher throughput in one or both directions. The various types of xDSL are described in the following paragraphs. HDSL High-bit-rate Digital Subscriber Line (HDSL) derives its name from the high bandwidth that is transmitted in both directions over two copper loops. HDSL has proven to be a reliable and cost effective means for providing repeater-less T1 and E1 services over two twisted pair loops. This proven technology has already resulted in the deployment of over 300,000 HDSL equipped circuits throughout the local access infrastructure. HDSL transceivers can reliably transmit a 2.048 Mbps data signal over two non-loaded, 24 gauge (0.5mm), unconditioned twisted wire pair loops at a distance of up to 13 kft (4.2 km) without the need for repeaters. Eliminating the need for repeater equipment and removal of bridged taps significantly simplifies the labor and engineering effort to provision the service. This attribute eliminates the need to identify, modify, and verify a controlled environment, with power, secured access, and other factors needed to support repeater equipment. It also reduces the time, cost, and effort of isolating faults and taking corrective action when a failure does occur. Studies by some service providers have indicated that trouble shooting and replacing defective repeater equipment often costs significantly more than the cost of the equipment itself. These attributes translate into increased network up time and reduced engineering time; making possible T1 provisioning in a matter of days, as opposed to weeks. Faster service provisioning and greater up time leads to increased customer satisfaction and increased service revenues. To provision a 12 kft (3.6 km) local loop with traditional T1 transmission equipment requires two transceivers and two repeaters. To provision the same loop with HDSL, requires only two HDSL transceivers, one at each end of a line. S-HDSL/SDSL Single-pair or Symmetric High-bit-rate Digital Subscriber Line (S-HDSL/SDSL) operate on a single copper pair as opposed to the traditional two pair HDSL described above. S-HDSL/SDSL allows easy implementation of applications that require symmetric data rates on a single local loop while maintaining the existing POTS on the same loop. Because only one pair is needed in this arrangement, the capacity of the entire local loop infrastructure is greatly magnified. With this capability, local providers can extract the maximum value from their existing plant, or deploy new capacities both more quickly and at a lower capital expenditure. This allows for rapid and cost effective deployment of intermediate data rate services. Potential uses for this technology include fractional T1 with a particular advantage in 768 kbps systems, Home Office, LAN Access, Distance Learning, Internet Access, and Campus or Large Facility LAN to LAN connectivity. Since S-HDSL/SDSL can be implemented with and without POTS and at multiple data rates, it can have different capacity and reach limitations. This allows for easy, cost effective implementation of such services as remote cell site support of PCs, remote LAN access, distance education and training, digital imaging, or any other service which requires a larger amount of bandwidth. ADSL Probably the most common xDSL type is Asymmetric Digital Subscriber, which takes its name from the comparatively high bandwidth in one direction, with low bandwidth in the opposite direction. ADSL uses a single phone line for transmission. Many service providers have also come to recognize its potential to support a range of data applications. Additionally, ADSL’s ability to operate at speeds of up to 6 Mbps positions it to support real time broadcast services and pre-recorded interactive video services; and to have multiple video and data activities underway simultaneously. ADSL supports applications with asymmetric traffic demands such as: ? Web Surfing, ? File Downloads, ? Distance Learning. RADSL Rate Adaptive Digital Subscriber Line (RADSL) is a simple extension of ADSL used to encompass and support a wide variety of data rates depending on the line’s transmission characteristics. This is advantageous in situations in which there is a lower bandwidth demand and in situations in which the line quality is less than needed for full bandwidth implementations. VDSL Very High-bit-rate Digital Subscriber Line (VDSL) provides very high bandwidth asymmetrically (up to 52 Mbps in one direction and 2 Mbps in the other) to businesses and residences with broadband access requirements over a Fiber-To-The-Curb (FTTC) network. Within the FTTC architecture, VDSL will address the last section of copper cabling to the subscriber premises. Typical distance and implementation of VDSL is 1 km @ 26 Mbps. Unfortunately, this type of xDSL is not very common because of lack of FTTC networks available today. xDSL Technology (how it works) XDSL signals are designed to maximize the rate of transmission of digital signals through non loaded twisted pairs, making use of bandwidths that can be greater than 1MHz, much greater than the 3000Hz or so allocated for voice transmission. There are several types of xDSL signal in commercial use today. Each signal type is implemented in circuitry with accompanying software, called a transceiver. The transceiver design includes the encoding or modulation scheme along with decoding or demodulation applied to convert serial binary data streams into a form suitable for transmission through twisted wire pairs. The transceivers may also employ various signal processing, equalization, amplification, and shaping techniques to adapt transmission for physical attenuation and phase distortions experienced by signals transmitted through twisted wire pairs. The transceiver software and circuitry may also use coding techniques to detect and correct noise that is present on a twisted wire pair. A variety of signal processing techniques have been developed over the past10 years to increase the bit rate of digital transmission through telephone loop twisted pairs. The following sections will describe these technologies. 2B1Q The DSL acronym was first used as shorthand to refer to the line code designed to support basic rate integrated services digital network (ISDN) transmission through twisted wire pair loops. The ISDN basic rate signal is required to carry an information payload of 144kbps, consisting of two “B” channels of 64kbps each and one packet data or “D” channel of 16kbps added for framing, error detection, and other overhead functions. The ISDN line of “U” interface operates at a raw data rate of 160kbps. In the mid 1980’s the T1 committee in the United States created a standard U interface using a four-level line code referred to as 2B1Q for two binary bits per symbol carried by a quaternary symbol design. 2B1Q line code was designed to support ISDN transmission through loops of 18000ft or less, meeting voltage pulses of +/- 875V and +/- 2.625V. The symbol rate is 80000 baud and the energy spectrum used by ISDN peaks at 40000Hz. The ISDN signal is transmitted in full duplex mode, bi-directional on the same pair of wires. In order to accomplish this, transceivers must contain a hybrid function to separate the two directions of transmission. To help the receiver differentiate between far-end transmission and reflections of near-end transmission from irregularities in the twisted pair transmission line due to wire gauge changes and bridged taps, echo cancellation techniques are used. The range of operation of ISDN is dictated by both attenuation and self near-end cross talk (NEXT) from adjacent 2B1Q ISDN signals. The 2B1Q line code is sometimes referred to as a base band signal because it uses energy in frequencies down to zero, overlapping with the voice frequency band. In order to carry voice through a DSL, the voice signal is digitized using PCM techniques and carried in one of the B channels. In ISDN applications the D channel is reserved for data packets that are primarily used for call processing. In carrying simultaneous voice and data the ISDN basic rate line carries a maximum of 64kbps of data. In the absence of voice, both B channels may be bonded together to increase the data capacity to 128kbps. Both ends of an ISDN connection must use the same bonding protocol. ISDN connections are made by dialed access though a local digital switch that also terminates voice lines. QAM Quadrature Amplitude Modulation (QAM) utilizes amplitude and phase modulation to transmit multiple bits per baud. Unmodulated signal exhibits only two possible states allowing us only to transmit a zero or a one. With QAM, it is possible to transmit many more bits per state, as there are many more states. This scheme utilizes a signal that can be synthesized by summing amplitude modulated cosine and sine waves. These two components, being 90 deg out of phase, are called quadrature, hence the name Quadrature Amplitude Modulation. By combining amplitude and phase modulation of a carrier signal, we can increase the number of states and thereby transmit more bits per every state change. CAP Carrierless amplitude and phase (CAP) modulation technique is closely related to QAM in that amplitude and phase are used to represent the binary signal. The difference between CAP and QAM lies in the state representation of the constellation pattern. CAP does not use a carrier signal to represent the phase and amplitude changes. Rather, two waveforms are used to encode the bits. The encoder replaces a stream of digital data with a complex equation that symbolizes a point on the constellation diagram. Thus, for a 32-CAP, there would be 32 possible locations on the diagram, all of which can be represented as a vector consisting of real and imaginary coordinates. Consequently, 32-CAP would result in 32 distinct equations of the type, each one representing five bits of data. CAP modulation is very suitable for use with ADSL. DMT The spectrum from 0 to 4 kHz, voice band, is designated for plain old telephone services (POTS). Downstream (ATU-C to ATU-R), the spectrum from 26 kHz to 1.1 MHz is further divided into 249 discrete channels. Upstream (ATU-R to ATU-C), the spectrum above the POTS band consists of 25 channels between 26 kHz and 138 kHz. Echo canceling between the downstream and upstream signals permits reuse of these sub-channels. With the exception of carriers used for timing, each carrier is capable of carrying data. However, only those carriers with sufficient signal to noise ratio (SNR) are allocated payload for transmission. Each transmitting carrier is allotted a bit count and transmits power, based on the characteristics of the sub-channel. This results in an optimized data transfer rate for the current line conditions. DMT allocates bits and transmission power away from the induced noise. The advantages of this process are an optimized data rate and less interference with other services existing in the same sheath, due to the symmetrical nature of induced crosstalk. The DMT technique exhibits a high degree of spectral compatibility based on power spectral density, rather than absolute transmit power. DMT has a substantial advantage over single carrier modulation systems in the presence of impulse noise. DMT spreads impulses over a large number of bits, averaging peaks. Only if the average exceeds the margin does DMT produce an error — single carrier systems will error every time a peak exceeds the margin. DWMT Discrete wavelet multitone (DWMT) technology increases the usable capacity of telephone wires and coaxial cable, allowing telephone companies and cable operators to deliver two-way broadband telecommunications services over their existing networks. DWMT uses Multicarrier Modulation. A multicarrier system uses a transmission band efficiently by dividing it into hundreds of sub channels that are totally independent and spectrally isolated. In practice, implementations of multicarrier systems use orthogonal digital transformations on blocks of data, a process called subchannelization, in an attempt to achieve the frequency partitioning shown in the figure below. By keeping the signal sub channel power contained in a narrow bandwidth, each sub channel occupies only a small fraction of the total transmission band and overlaps only with immediately adjacent sub channels. When a signal is transmitted over a long copper loop (e.g. several miles), the higher frequency components of the signal attenuate significantly more (tens of dB) than the lower frequency components. Narrowband interferers from AM or amateur radio signals also affect the transmission by destroying the signal in parts of the band. Multicarrier technology, called Discrete Wavelet Multitone (DWMT), provides sub channel isolation that is superior to DMT. DWMT uses an advanced digital wavelet transform instead of the Fourier transform used in DMT. Echo Cancellation The T1.413 standard for ADSL defines two categories of modems: frequency division multiplex (FDM) modems (Category I) and echo cancellation modems (Category II). FDM systems allocate separate frequency bands for upstream and downstream transmissions. Echo canceled systems send upstream and downstream signal over the same frequencies. Since the attenuation of a signal over a copper line increases with frequency, it is desirable to transmit data using a frequency band that is as low as possible. In an ADSL system, the lowest attenuated frequencies begin right after the POTS band. In FDM system, the lower frequency band is used for upstream transmission while the downstream transmissions are allocated to the higher attenuated frequencies. Some xDSL transceivers use echo cancellation (similar to the echo cancellation utilized in the standard V.34 28.8kbps duplex modem) to exploit the lower attenuated frequencies and increase its downstream performance. By utilizing the lower frequencies for both upstream and downstream performance, the transceiver can deliver higher downstream performance, particularly on the longer loops where the higher frequencies become severely attenuated. In an effort to promote interoperability between FDM and EC systems, the echo-canceled transceivers can be configured to operate in an FDM mode in order to communicate with a category I (FDM) modem. Conclusion the twisted pair wires between the telephone central office and end users of telecommunication services has a great deal more information capacity than used for the regular voice services. Several base band and pass band transmission systems collectively referred to as xDSL, have been developed over the last ten years that enable up to several megabits per second of data to be carried over the regular telephone twisted pair line. The xDSL family of technologies provides a wide variety of line driving schemes to accomplish and satisfy different market needs over today’s infrastructure. xDSL has application in both the corporate and residential environments as well as flexibility to meet the market challenges. Since xDSL operates at the physical layer of OSI seven layers standard, it can be used in conjunction with ATM and Frame Relay technology. The most promising of the xDSL technologies for integrated Internet access, intranet access, remote LAN access, video-on-demand, and lifeline POTS applications in the near term is ADSL or R-ADSL (a rate-adaptive version of ADSL). During the past year, ADSL has concluded trials by more than 40 network service providers throughout the world, primarily in North America and northern Europe. Service introduction began in 1997, but ADSL service is still being rolled out in many areas. In the meantime, xDSL technologies and standards will continue to evolve, as will user demand for these emerging services relative to other local access service alternatives. The ability to utilize the existing telephone copper wire infrastructure as well as interoperability with ATM and Frame Relay technology, position xDSL as the most promising of the broadband access technology options for both residential and business users.

1. Marlis Humphrey and John Freeman, “How XDSL Supports Broadband Services to the Home”, IEEE Network., vol. 11, no. 1, Jan-Feb 1997, p. 14-23. 2. George T. Hawley, “Systems Considerations for the use of XDSL Technology for Data Access”, IEEE Communication, vol. 35, no. 3, Mar 1997, p. 56-60. 3. Bhumip Khasnabish, “Broadband to the Home (BTTH): Architectures, Access Methods, and the Appetite for it”, IEEE Communication, vol. 35, no. 3, Mar 1997, p. 58-69 4. ADSL Forum website , www.adsl.com 5. Analog Devices website, www.analog.com 6. Kimo website, www.kimo.com 7. Westell website, www.westell.com 8. www.encyclopediatech.com.