Digital Subscriber Line

NIKHILESH SHARMA
Dept. of Electronics & Communication Engineering, Poornima College of Engineering, Jaipur

Abstract -- Asymmetric flow of information is the key feature of the ADSL (Asymmetric Digital Subscriber Loop) technology, i.e. higher data transmission rate towards the user than from the user towards the network. Characteristic is the short message sending by the user with a certain request to the sever. The sever responds to the request by a significantly longer message of various electronic forms (data, digitized speech, pictures or video). Therefore, this technology is most often used by small and medium users. ADSL is currently the only commercially available DSL technology which is still experiencing the break- through on the services market. It enables faster access to the Internet, LAN (Local Area Network), videoconferencing, VoD (Video on Demand) and interactive multimedia. In order to standardize such se/Vices, the! TU (International Telecommunications Union) G. 992.1 (standardized DMT- discrete multi-tone line coding technology) and ANSJ (American National Standards Institution) Tl.413-95! 98 are used for ADSL. DMT (Discrete Multi-Tone), as the more popular one, uses the line coding technique, which splits a certain frequency range into several sub-channels. Most of these sub-channels are used for upstream and downstream transmission of speech and data, whereas some are used as pilot signals or kept in rese/Ve. Such modulation technique expands the frequency spectrum, allow-ing the usage of broadband se/Vices per one pair of wires. In this way the sharing of speech and data se/Vice transmission is real-ized.

Indexed Terms -- asymmetric transmission, distance of the user, broadband access network, standardization, modulation techniques, voice and data se/Vices

I. INTRODUCTION

Today's signals that travel via common copper (Cu) wires are no longer of the elementary form. They range in the initial frequency range from 300 Hz to 3400 Hz, for speech transmission, to significantly higher marginal modulation frequencies. The men-tioned narrowband frequencies of speech may be transmitted by modulation as well. In the modulation procedure the input signal acts as the modulation sig-nal, which uses some of the properties of the signal carrier (amplitude, frequency or phase) and thus cre-ates the modulated signal. Modulation is thus used for the translation of the signal from its basic band into higher frequency area, with the important fact that frequency bands of the modulated signals should not overlap. Various modulation procedures, which take into consideration various techniques of expanding the frequency range, allow multiple usage of a single connection path, i. e. higher and faster throughput of information, either in the form of speech or data, thus contributing to the quantity of the performed traffic. Today's transmission solution of signal multiplexing shows huge advancement compared to the earlier process of the very speech transmission. Regarding the in-creasing importance of data transmission in the world of telecommunications, all the services have been adjusted to the applications that require much higher rates of accessing the data on the network, compared to the rate of sending data towards the network. Due to this, the ADSL technology is being implemented for the transmission of data, video, voice, etc. via cop-per pairs, and at the locating. For these systems to function, the directions and data transmission methods need to be harmonized, as well as the priorities of sending. There are various standards and protocols for that purpose.

As an «expanded» approach to data network, ADSL technology does not represent an alternative to the copper cable network, but rather its qualitative up-grade. Basically, the copper pair is used, thus influencing the exploitation characteristics of the cable net-work.

II. ADSL TRANSMISSION TECHNOLOGY CONCEPT AND EQUIPMENT

The switching system has to have the capacity to receive and route high-intensity traffic. This means that it may switch the entire traffic flow which occurs at the time of peak load on the network, with allowed losses. Such maximal utilization level is stipulated by the methods of gradual introduction of new

technologies. Traffic flows are measured and analyzed in order to study the increase or the decline in telecommunication traffic in certain environments and to propose the introduction of new solutions with the aim of developing the telecommunication service functions through the existing infrastructure, in order to reduce the capital investments of the operators to a mini-mum. The characteristics of the new level between the network operator and the user.

The information technology and the basic functioning of the system for the "phone" users, justifies the usage of infrastructure, which allows the implementation of broadband services (via pairs), using the existing support. The technology of expanding the frequency range allows the usage of several dissimilar services realized on the same phone connection, not affecting the telephone technology hard-ware are determined by the elements of combining the broadband and the narrowband transmission into a joint structure. The implementation of such multi-functional systems into the access node is facilitated by hardware at the level of line cards of telephone ex-changes. The communication within the system functions in two available interfaces, the basic and the re-quested interface. The basic interface solves the applications such as: PSTN (Public Switched Telephone Network-analogue connection through an existing Cu cable), ISDN BRA (Basic Rate Access) and ISDN PRA (Primary Rate Access), ADSL full access, G. lite and El (Primary Digital Group) digital link. Re-quested interface is applied in software elements: STMl (Synchronous Transport Module), El, open interface V5.2i ATMF standards. ADSL subscription line has its own line connection towards the telephone exchange. The user connection to the network is facilitated by DSLAM (Digital Subscriber Line Access Multiplexer) device - multiplexer which is fitted with line connections on the exchange side, and these are modems ATU-C (ADSL Transmission Unit Central Office), separately for the connection via ISDN, (Integrated Services Digital Network), and separately for POTS (Plain Old Telephone System) line. On the subscriber's side it is necessary to connect the modem ATU-R (ADSL Transmission Remote Unit) for the simultaneous flow of telephone and data services, with splitting in the frequency spectrum. The technical functioning refers to line connection subscriber - exchange downstream and exchange - DSLAM (ATU-C) upstream towards the access net-work. Figure 1 shows the procedure of connecting POTS and ISDN subscriber via the splitter in the telephone exchange (DSLAM cabinet).

User equipment (CPE-Customer Prenisec Equipment) represents the termination of a segment of the access network and "gate" to the subscriber. De-pending on the status of the subscriber line, the user equipment has two installation options which depend on the category of connections, namely, the connection to POTS or ISDN interface (Figure 2).

When introducing new services it is necessary to replace or expand at the telephone exchange only the CPE (Central Processor Equipment), and to convert the new services into an acceptable ATM (Asynchronous Transfer Mode) network format. The modem access is basically the connection of the modem and the splitter to the Cu network, and if ISDN service al-ready exists it can be upgraded by ADSL. This means, additional access to the Internet using the same connection. Such connection does not influence the previously available services. The connection of such a modem with the computer can be realized by Ether-net (network) or USB (Universal Serial Bus) inter-face. In the former case the configuration requires NIC (Network Interface Card), and the computer has to be adjusted to TCP/IP (Transmission Control Protocol/Internet Protocol) protocol. When this option is used, the data between the modem and the computer are transmitted by the standard network cable. In combination with HUB (distribution) the configuration allows connecting of several computers to a single modem. The latter case includes the standard USB cable for connecting the model and the computer. Unlike the previous method, this one does not allow the connection of several computers via a single modem.

III. INFLUENCES ON THE TRANSMISSION PATH

The quality of ADSL connection is affected by physical and electrical parameters of the pair.

a) Physical element is caused by mixing the wire diameter on the route, cable squeezing, and other

mechanical impacts, which usually results in the reflection at higher frequencies. The possible quality deterioration may be caused also by the connection of wires in the cable resulting in incorrectly connected pairs interfering with ADSL transmission (Figure 3).

Due to such emissions, today, we are introducing "pair" cables, in which wires are twisted in pairs (500x2x0.6- cable code), rather than four-wire cables (500x4x0.6- cable code), thus limiting the inductivity in a single pair. Other influencing factors, such as water breakthrough and cable aging cause deterioration of the insulation resistance to a mar-ginal10 Kohm for high-quality ADSL connection.

b) Electrical element on the pair is determined by cross talking (nearer and further end), signal attenuation, radio interference and occurrence of im-pulse noise. Cross talking (NEXT - Near End Crosstalk and FEXT- Far End Crosstalk) is caused by ADSL device signals, whereas the remaining interference is caused by the influence of TV and radio transmitters as strong sources of electromagnetic radiation in the cable environment.

Such assumed conditions cannot be measured and are mainly simulated by the so-called injectors (noise generators), which are used to test the pairs within cables. Injectors are devices that work in pairs (receiving and transmitting sides) and they simulate the conditions on the line. Certain attenuations which affect data transfer, and increase over distance and frequency determine the maximal throughput of such a route, especially for the installed ADSL via POTS and ISDN lines. For such cases, of copper access lines (pairs) which can let through frequencies in the MHz range, the impulse noise (Noise A) and radio interference influence (Noise B) are measured (Figures 4 and 5).

The quality of ADSL connection depends on the length of the subscriber pair in the access network segment. Therefore, the access nodes (DSLAMs) are in-stalled even outside the access exchanges, as close to the subscribers as possible, in order to reduce the length of subscriber lines. The ideal positions for locating DSLAMs are the locations of RSS (Remote Sub-scriber Systems), to which the subscribers are connected. In this way the scope of the ADSL technology to the subscriber is optimized. By using the ADSL technology the rate towards the user ranges from 128 Kbit/s to 8 Mbit/s in the frequency band of over 240 KHz, whereas the transmission rate from the user to-wards the network is between 16 Kbit/s and 1.5 Mbit/s in the frequency band between 25 and 200 KHz (Fig-ure 6).

Maximum resistance of the loop which is used by ADSL can be up to 1500 ohm. With higher loop resistance, one of the transmission solutions of other DSL technologies (HDSL, SDSL, VDSL, etc.) can be used, in which line parameters are assigned dynamic properties of other transmission forms.

For this purpose, there are computation methods which are used to calculate maximal subscriber distances regarding the network characteristics and so as to keep the transmission quality and parameters above the minimum.

IV. ADSL STANDARDS IN TELECOMMUNICATION NETWORK

Telecommunication network connects various devices in the telephone exchanges with the user terminal equipment, which means that several factors affect the ADSL port functioning:

- Quality of the installed telecommunication equipment;
- technical support at the telephone exchange;
- quality of service, i. e. speed of connecting to the Internet at rates from 64Kbit/s to 6.144 Mbit/s
- Functionality of access telecommunication equipment in using open interfaces V~.1 and V5.2 i. e. ETSI (European Telecom. Standards Institute) recommendations;
- ADSL standards, ANSI Tl.413, ITU-T G. 992.1 I2;
- DMT line signalization.

The standards determine the modulation tech- niques planned for normal functioning of ADSL mo-dems and terminal devices at the exchange and access

network. The network conditions in fixed telecommunication network are essential elements for the functioning of the modem Internet telephony, i.e. adoption of software ADSL support-standards for data transmission. Protocol standardization generates high-quality exchange of data traffic in connect-ing the operators in the network. Similarly, the standardization processes - ETSI (European Telecommunications Standards Institute) recommendations have a set goal of increasing the quality of transmission by using new technologies. The principle of this process is to test equipment models at special laboratories, which function according to the new recommended standards. ADSL, standard ANSI T1.413 Is-sue 2, allows software cooperation with POTS tel-phone line and require installation of ADSL terminal equipment and POTS splitter at the user connection line. This refers to telephone line connection in the office premises. For the standard, !TU- T) G992.1, it should be noted that it has been deter-mined for the transmission system and media by Annexes-Annex A - for technical parameters in the guide-lines for the functioning of ADSL via POTS.

- Annex B- defined for the control of ADSL cooperation of iSDN telephone line and ISDN splitter, at the user's side. speech occupies a range from the 1st to the 6th sub--channel. By measuring the performances of each sub-channel (256), 1-15 "description" bits are as-signed to each, depending on the signal/noise (SIN) ratio, which are registered and compared on the re-ceiving and transmitting end.

DMT (Discrete Multi-Tone) standard:

DMT (Discrete Multi-Tone) standard allows control of the transmission quality level over the installed copper pairs, as an assumed precondition for the nor-mal operation of ADSL communication. By frequency multiplexing of the channel upstream and down-stream in the band from 32 Khz to 1.104Mhz it connects the user equipment (ATU -R) to DSLAMs (ATU -C). The mentioned frequency range is split into 256 transmission channels (Figure 7), each of which occupies 4.312 Khz of bandwidth. Every sub--channel uses 64QAM modulation (Quadratur Ampli-tude Modulation).

DMT modulation can transfer information both upstream and downstream, either with frequency separated or overlapping. One of the aspects of sav-ing the frequency band up-and downstream is the usage of a segment of downstream band for output. This makes the streams overlap, and the possible occurrence of echo is eliminated by a special tech-nique (Echo cancelling technique). It is also neces-sary to insure additional hardware which distin-guishes between the sent data and the received data. In case of frequency separation of transmission streams, a maximum of 33 sub-channels can be used upstream, and 217 downstream. The remaining 6 sub-channels are not used, but kept as a reserve. The pilot frequency uses the 64th sub- channel, and.

V. CONCLUSION

Digitization of transmission via copper pairs, parallel to the development of new strategies in applying the information and communication technologies is becoming a development trend. In the business world, the trends show that the information technology is developing with the challenges of providing always new solutions as various services in telecommunication and entering new fields of technology and realizing the plans. Regarding development of copper pair transmission technology, it is simpler and more profit-able to use the existing well-developed network for the level of new services and, of course, to keep introducing at the same time new technologies of transmission media (DSL). The installed copper pairs in the access network and their usage for the broadband transmission by various technologies, depending on the sub- scriber's distance, present a wide transmission range for data services. The insight into the changes occur-ring every day in telecommunications is necessary in order to achieve the understanding of the ADSL technology and to monitor its influence on other techno-logical branches regarding the improvement of the al-ready existing, very high level. Such application of the broadband ADSL technology realizes a number of ad-vantages such as:

1. Usage of the existing network infrastructure (cop-per pairs)
- low installation costs;

- fast connection of new subscribers;

2. Facilitating higher data transfer rates
- bandwidth greater than in case of POTS/ISDN; transmission rates variable from 100 kbit/s to 8 Mbit/s;

3. Co-existence with POTS/ISDN equipment on the same pair
- telephone calls and the Internet at the same time (second virtual line);

4. Always On Connection
- access to LAN;
- Network resources used only when actually needed.

The development trends contribute significantly to the upgrading of the existing systems by new systems of integrated services. Facilitating "expanded horizons" through new services without additional investments into the fixed networks (only into the peripheral units), opens up new knowledge and substantially raises the threshold of technological progress.

Faculty of Transport and Traffic Engineering Vukeliceva 4, 10000 Zagreb, Republic of Croatia ERVIN GREINER, B. Eng. E-mail: ervin.greiner@t.ht.hr Croatian Telecom Inc. Folnegoviceva 5, 10000 Zagreb, Republic of Croatia

REFERENCES

[1] S. Ivezic, D. Celj, V. Mandaric, Z. UnkoviC, InfOJmation Technology, Strategy Planning for Telecommunication Company- an Experience>>, ConTel, 1997, Zagreb

[2] M. Kos, V. Brlic, Sirokopojasne mreie i usluge, MIPRO 98, 1998, Opatija

[3] Z. Popovic, M. Baric, Ericssonov pristup sirokopojasnim komunikacijskim mreiama, MIPRO 98,1998, Opatija

[4] C. G. Larson, «Software Systems for a Telecommunica-tion Operaton>, ETSI - Atalink Ltd, State of the Art 1995, London

[5] R. Gewirtz, DSL providers look for value - added ser-vice, Reality Bites, Teledotcom Review No. 20, 2000, New York

[6] T. Hills, Analysis reportADSL- Megabit Internet Access Arrives, Communication - Application, Review July 1998,London

[7] Siemens AG, XpressLink V 1.3- Broadband Subscriber Access withADSL, 2000, Germany

[8] Siemens AG, Broaden Your Horizons, 2000, Germany

[9] Figures 1,2,6,7- Prezentativni materijal, Hrvatske Te-lekomunikacije, 2002, Zagreb

[10] Figures 4,5 - Rezultati mjerenja, Hrvatske Telekomu-nikacije, 2003, Zagreb

[11] Figure 3- Internet (www.dslprime.com)