**Wide Area Networking (WAN)** 

The technologies studied earlier are effective for setting up networks on rather small distances. However frequently for building of a network, there is a necessity to connect among them computers removed from each other on large geographical distance. A typical example - connection of the user of Internet services with remote provider. In given case it is perfect other world - world of technologies WAN. Wide area network is data communications network that serves users across a broad geographic area and uses transmission devices provided by common carriers.

One more difference of a WAN consists that the LAN can simply be constructed by own strength. For construction of a WAN the huge material input are required, which include: cost of cable works, expense for the communication equipment and intermediate intensifying equipment, and also operational expenses for constant maintenance of services of all network. Therefore, as a rule, there is a necessity to subscribe to an outside WAN service provider, such as a regional Bell operating of company (RBOC). A choice of provider is the very important part of competent construction of a WAN, as just provider defines WAN technology for connection of the subscribers and main function a network will depend on it. Less often WAN is completely created by the company independently for own needs. As creation of WAN is a very expensive task, more often company rents the central channels of communication, based on which independently builds own territorial networks.

WANs generally carry a variety of traffic types, such as voice, data, and video as just multi-service networks is a priority direction for creation of new and development old networks, because the association of different kinds of the traffic in one channel allows reducing expenses of creation and purchasing of the equipment.

WAN technologies function at the three layers of the OSI model: the physical layer, the data link layer, and the network layer

**WAN Connections** 

The main criteria at a choice of technology are required speed and price. [Table 32](http://www.certiguide.com/apfr/cg_apfr_Rck60156.htm) shows typical areas of WAN implementation and approximate throughputs of channels required to meet the application’s need.

|  |  |
| --- | --- |
| **Table 32: WAN Applications and Typical Speeds** | |
| **Application** | **Speed** |
| Terminal mode | 300 to 9600 bps |
| E-mail transmission | 2400 to 9600 bps |
| Remote Admin | 9600 to 56,000 bps |
| Digital voice | 64,000 bps |
| Work with databases | to 2 Mbps |
| Digital video | from 1.5 to 2 Mbps |
| Compressed video mode | from 2 to 10 Mbps |
| Full-screen video mode | 1 Gbps and up |

Plenty of ways for connections exist, which are defined by WAN technology. Depending on technology, the equipment and the provider are selected.

[Table 33](http://www.certiguide.com/apfr/cg_apfr_Rck61850.htm) lists some widespread WAN technologies and their transfer speeds.

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| --- | --- |
| **Table 33: WAN Technologies and Transfer Speeds** | |
| **WAN Technology** | **Speed** |
| Dial-up (analog modem) | up to 56Kbps |
| X.25 | 9600 bps to 2 Mbps |
| ISDN | 64,128, 544, 2,048 kbps |
| Framed T1 | 64 kbps |
| Framed E1 | 64 kbps |
| T1 | 1.544 Mbps |
| E1 | 2.048 Mbps |
| E3 | 34.064 Mbps |
| T3 | 44.736 Mbps |
| Frame Relay | 56 kbps to 44.736 Mbps |
| xDSL | to 51,84 Mbps |
| ATM | 25 Mbps to 2.46 Gbps |

**WAN Technologies** 

All of the WAN technologies can be categorized in dedicated and switched variants. The preferred and optimum technology of WAN construction is the mode of switching of packets. However, frequently switching mode appears inaccessible in a specific widespread geographical region. Nevertheless, under the circumstances it is most likely then an area with widely distributed services by telephone networks or networks with dedicated phone lines that is already established and supporting the WAN structure. Therefore a combination of both technologies switch and dedicated allows to build a corporate network by combining both ways WAN is operating.

**Dedicated Lines** 

Dedicated lines, also called leased lines, provide full-time service. Dedicated lines typically are used to carry data, voice, and video. In network design, dedicated lines generally provide backbone connectivity between major sites, as well as LAN-to-LAN connectivity. When dedicated line connections are made, a router port (basic devices for dedicated and packet/cell switched technology are routers) is required for each connection, along with a CSU/DSU and the actual circuit from the service provider. The cost of dedicated-line solutions can become significant when selected to connect many sites.

**Packet/Cell Switching** 

Packet/cell switching is a WAN in which network devices share a permanent virtual circuit (PVC), which is like a point-to-point link to transport packets from a source to a destination across a providers of transport network like Sprint, MCI or other phone company.

In result, there is a connection with the high speed compared on speed to dedicated lines. The main advantage is that one WAN connection can give access to a plenty of the removed points at the expense of use of various routes through a network.

Switched networks can carry variable-size frames (packets) (Frame Relay and X.25) or fixed-size cells (ATM).

The most common packet-switched network type is Frame Relay because it provides high speeds of transfer, large than with dedicated lines flexibility and smaller price. The given technology perfectly works at creation of multi-service networks, where it is necessary to use QoS (Quality of Service) - to differentiate the traffic on the data, voice, video by certain rules. It is necessary for the consumer to stipulate with service provider CIR (Committed Information Rate) - guaranteed speed of transfer. One more advantage is that provider can dynamically give throughput as required.

**ATM** 

ATM differs by that uses cells of the certain size. The given technology provides exact measurement and simplicity of management of bandwidth. It is intended for multi-service networks and can be applied not only as WAN but as LAN technology. In the last case, speeds can go up to 25Mbps. However given technology was superseded from LAN by Fast Ethernet, which works on 100Mbps and is more clear to administrators of networks, and from WAN FR, as last is more economic and while provides necessary speeds for standard tasks.

**Circuit Switching** 

The most inexpensive way to create WAN connection is circuit switching. With the minimum of expenses on the equipment and means, the creation of a WAN is possible.

Circuit switching is a method in which a dedicated physical circuit is established, maintained, and terminated through a carrier network for each communication session. Circuit switching operates much like a normal telephone call. ISDN is an example of a circuit-switched WAN technology.

Circuit-switched connections from one site to another are brought up when needed and generally require low bandwidth. Telephone service connections are limited to 56.6 kbps, and ISDN BRI connections are limited to 128 kbps. Circuit-switched connections are used primarily to connect remote users and mobile users to corporate LANs. They are also used as backup lines for higher-speed circuits, such as Frame Relay and dedicated lines.

Two opportunities inherent with Circuit switching access:

* Dial on demand used with modem access, allows establishing a connection through regular intervals of time according to the prescribed timetable, or establish the connection when the user sends an inquiry to the remote resource, which allows to save money resources and to establish connection only as required.
* Bandwidth on demand, allows increasing bandwidth if necessary, for example for ISDN. Cheapest of a circuit switched method is dial-up, created by usual analog telephone networks through the modem.

**Modem, IDSN, DSL and More** 

Modem (modulator-demodulator) - is a device that interprets digital and analog signals by modulating and demodulating the signal, enabling data transmission over voice-grade telephone lines. At the source, digital signals are converted to a form suitable for transmission over analog communication facilities. At the destination, these analog signals return to their digital form.

The official name of such networks is PSTN (Public Switched Telephone Network); they sometimes in addition named POTS (Plain Old Telephone Service). However, these networks are rarely used for construction modern WAN because of their low speeds of access. Such kind of WAN is applied for not strict users, entering in a network from their houses or for those network accesses who are taking place on business trip.

The speed of connection is limited to 33,6kbps, if digital connection is not applied. In the latter case, speed runs up to 56Kbps. However, in USA and Canada the Federal Communications Commission (U.S. Government agency that supervises, licenses, and controls electronic and electromagnetic transmission standards) has entered restriction until 53Kbps on speed of transfer of telephone lines. The quality of communication through the analog modem depends on the involved lines and used equipment.

**ISDN** 

Integrated Services Digital Network (ISDN) and Digital Subscriber Line (DSL) are types of networks in which the currant POTS lines permitting the data transmission with much higher speeds. The connected place should not be far from the nearest point of presence (POP) of the telephone company containing the special communication equipment. For ISDN this distance should not exceed 5.5 km. Moreover, for DSL the distance depends on technology and speed of transfer (the farther the less speed). These technologies refer to as technologies of last mile, as they are developed for delivery of the data from the user up to POP.

Ideas of transition POTS for digital data processing, in which the end subscriber transfers the data only in the digital form expressed for a long time. Originally, it was planned that ISDN would completely replace existing digital POTS. But as a result of long process of creation and change of the standards, and also because of high technical complexity of the user interface ISDN stay as alternative to dial-up. The greatest distribution ISDN has received in Germany and France. In USA until recently, it was unpopular, due to the reputation as complex, difficult for installation and not reliable technology. The improvement of a situation with ISDN in USA began from 1994-1995, when ISP offered to their clients ISDN services for browsing in the Internet.

Approximately, in the same time the main manufacturers begun actively to produce network ISDN equipment and routers with ISDN support.

The constant tariff, and also installation and monthly payment are in most cases paid. As the tariff constant, then an opportunity perfectly approaches to use dial on demand for economy.

The ISDN connection approaches for those to whom connection is necessary for small intervals of time, for example for reading e-mails.

The connection is established almost instantly, as all connections are digital and there is no analog transformation.

There are two rate interfaces: BRI and PRI.

**BRI**   
  
BRI (Basic Rate Interface) represents the user with 2 channels of 64Kbps each for the data transmission (B channel) and one channel of 16 Kbps for the service information transmission (D-channel). Total speed of the interface BRI for the user is 144 Kbps. The common speed in view of the service information is 192 Kbps. However, BRI does not only support the circuit 2B + D, but also B + D or even D.

**PRI**   
  
PRI (Primary Rate Interface) consists of 23 B channels and one D channel of 64 Kbps with common throughput of equal dedicated lines throughput of a type 1 meets to 1,544 Mbps in USA. In Europe consists of 30 B channels and one D channel 64 Kbps and corresponds to the channel E1 equal to 2,048 Mbps. Is intended for business clients and represents it (?) as alternative to leased lines, as gives comparable throughput and quality of a signal, but has the greater flexibility.

The advantages of ISDN consist in: bandwidth on demand, opportunity to transfer on one channel voice traffic, and on another the data traffic, and also in view of economy, as for dedicated lines it is necessary to pay without dependence from whether that they are used or not.

As ISDN uses standard wiring to POP, the equipment is necessary only on the ends of a line. To telephone with 2wire line (refers to U) the NT1 device (network termination 1) joins, which is given in usage in Europe and Japan by provider and remains in provider’s property. In USA, the task of purchase NT1 lays on the consumer. This device transforms signals for communication on 4 wires to the interface S/T, used by the terminal equipment (equipment, which directly establishes connection)

**DSL** 

**DSL** (Digital Subscriber Line) or xDSL is a general name of the group of related technologies, which today are actively advanced and continuously developed in many countries of the world. These technologies designed for high-speed transfer on existing telephone wires allow by the cheapest way to solve a problem of last mile separating the consumer from the supplier of services.

DSL promotes distribution of high-speed Internet, and creation VPN (Virtual Private Network), that is corporate network, which basis is Internet or other public network. The data in such network pass through the special tunnel inside the usual channel and are accessible only to participants of the virtual private network.

The speeds of transfer in different technologies DSL vary and also some technologies function asymmetrical, they have different speeds for sending and receiving, but as DSL advances as service for access in Internet, asymmetric property of the traffic is not large problem, as in the basic users of Internet receive from a network much more data, than transfer.

The DSL connection is constantly active, that is similar to the dedicated line. Besides, the low prices and the high speeds of transfer have resulted that these services become more and more popular. Some technologies DSL use frequencies lying outside of a range of voice communication that enables to use the voice traffic with the data traffic through the one pair of telephone wires. For the purpose splitters are used – devices of division frequencies of a signal on a vote and data.

However and this perfect technology has lack for multi-service users - absence of an opportunity of Quality of Service, that complicates creation of voice, video and data networks on the basis of the given technology.

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| **Table 34: Common DSL Technologies and Attributes** | | | | |
| **Technology** | **Speed** | **Distance** | **Simultaneous Voice and Data** | **Where to use** |
| HDSL (High-rate DSL) | 1,544Mbps (2pairs) 2,048Mbps (3 pairs) | 100 - 3000 m | No | Instead of T1/E1 for Internet; LAN & PBX; |
| SDSL (Symmetrical DSL) | 1,544Mbps or 2,048Mbps (1pair) | 100 - 7000 m | No | Instead of T1/E1 for Internet; LAN & PBX; VoIP |
| ADSL (Asymmetrical DSL) | 1,544 – 8,448 Mbps for downstream and 640 - 1,544 Kbps for upstream | 100 - 5000 m | Yes | Internet, Intranet, VPN, video on demand, VoIP |
| VDSL (Very-high-rate DSL) | 12,96-51,84Mbps for downstream and 1,6 – 2,3 Mbps for upstream | 100 - 1500 m | No | Access to multimedia resources; HDTV |

From the equipment for creation of DSL networks, it needs a usual telephone line POTS and DSL modems on both ends of a line. Sometimes, when the point to multipoint connection is required DSLAMs are used this device combining many DSL modems in one case. Such devices usually used by Internet providers. They place them directly on PBX for communication with the clients. All DSLAMs connect among themselves with the help of backbone and routers. A network of modern DSL ISP looks thus.

**Cable Modem** 

Networks provide a high-speed access in Internet and for creation of VPNs, it commence to apply for the user's end of cable TV recently. For these purpose, there is a special kind of modems - cable modem. Cable modems use available transmission protocols in networks via the TV coaxial 75-ohm television cable. They transmit from a network to the computer with speeds up to 30Mbps and reverse from the computer to a network with speed up to 10Mbps. Thus the very high quality of transmitted signal is kept.

As against of traditional modems of switched PSTN cable modems are part of the system with a topology "point - multipoint", in which a set of cable modems of the different users are connected in hybrid optical-coaxial environment to the controller of head unit of the operator CTV. Similarly to xDSL modems, the cable modems work in a mode «always on», i.e., and is constantly connected to the head unit.

The implementation of cable modems allows rather gracefully solving problems of an analogue user's telephone line, connecting lines and resources of switching stations of a PSTN. The cable modems transfer the Internet traffic directly on the Internet router, located on head unit of the CTV system. Greatest advantage of technology of cable modems is also that it can use an existing cable infrastructure of CTV systems. Besides, the element base of cable modems is accessible and the setup is rather inexpensive, and allows joint work of cable modems of the different manufacturers. The majority of cable modems represents external devices connected to the personal computer through the standard card 10Base-T Ethernet or the port USB; there can be in variants as a card inserted into a free slot of ISA or PCI. For the installation procedure, the technology is most likely plug and play. For access to data transportation, the network of the system Cable Modem Termination System (CMTS) is used, because of the concentration of access.

CTV systems, using cable modems, share a platform of collective access. Because the users of the given systems divide the frequency accessible to all of them among themselves into time of transfer of the data, in process of increase simultaneously of active users decreases the speed of transfer of the data for each of them. As against of traditional telephone communication, at which the subscriber receives on time of a call the dedicated connection, the cable modems do not occupy the fixed frequency band during all session of transfer of the data, the band is divided between all active users, which use network resources only during real reception or transfer of the data. To increase the average speed of transfer of the data for each user is the expansion of optical fiber cables to groups of potential users. Optical fiber cables allow lowering the number of the users served by each segment of a network, which naturally results in an increase of a band of frequencies accessible to each of them.

**Wireless** 

The most precisely currently available technology can be defined as use of radio waves for granting broadband network services to the individual users. In addition, this technology is not only advantageous in those regions, where the telephone cable network is insufficient, but also where the level of telephone or cable networks is rather high. In this case, operators using technologies of broadband wireless access are already direct competitors of the local telecommunication providers.

Comparable with the organization of television translation, the wireless lines are organized by a principle of direct visibility. The signal transfers via aerial, usually located on a height or on a high building, to special reception aerials established on the user’s buildings. Reception the pure spectrum of frequencies can be a rather difficult task; other problem is the requirement of direct visibility for the majority of organized lines. As well as in a case with television broadcasting, any obstacles (for example, dense top of trees, height, high buildings and even the strong atmospheric precipitation) can in the certain measure complicate reception. It is necessary to take into account and distance, as the signals of wireless communication can be accepted only within the limits of certain distance from the transmitter. The solution of this problem can be the installation of a network relays on all zone of service (by a principle of cellular communication).

Because the radio system provides already coverage of the certain zone, it means much easier planning of a network in comparison with cable systems. The wireless systems allow much more operatively adaptation to changes of requirements and amount of the users.

The standard IEEE 802.11 was the first standard for WLAN products from independent international organization developing the majority of the standards for wire circuit networks.[202](http://www.certiguide.com/apfr/cg_apfr_Wireless.htm#ftn202)

IEEE ratified expansion of the previous standard. Named IEEE 802.11b, it defines the standard for products of wireless networks, which work on speed 11 Mbps that allows successfully applying these devices in large organizations. The compatibility of products of the various manufacturers is guaranteed by an independent organization, which refers to as Wireless Ethernet Compatibility Alliance (WECA). Now there are more than 80 companies as members of WECA, including such known manufacturers, as Cisco, Lucent, 3Com, IBM, Intel, Apple, Compaq, Dell, Fujitsu, Siemens, Sony, AMD and others. [203](http://www.certiguide.com/apfr/cg_apfr_Wireless.htm#ftn203)

802.11 defines two types of equipment - “client”, which represents the computer completed with wireless network interface card (NIC), and “Access point”, which carries out a role of the bridge between wireless and wire circuit networks. The point of access comprises the transceiver, wire interface (802.3), and software engaged in data processing. ISA, PCI or PC Card network card can act as wireless station in the standard 802.11, or built-in decisions, for example, telephone set 802.11.

The standard IEEE 802.11 determines two modes of operations of a network - mode "Ad-hoc" and client/server (or mode of an infrastructure - infrastructure mode). In a client/server mode, the wireless network consists of a minimum of one access point connected to the wire network, and some set of wireless terminal stations. Such configuration is called a Basic Service Set (BSS). Two or more of BSS, forming uniform subnet, form the Extended Service Set (ESS). As the majority of wireless stations need to receive access to file servers, printers, Internet, accessible in wire local network, they will work in a client / server mode.

The mode "Ad-hoc" (also named a point - point, or Independent Base Set of Services, IBSS) is a simple network, in which the connection between numerous stations is established directly, without the use of a special point of access. Such mode is helpful in the event that the infrastructure of a wireless network is not generated (for example, hotel, exhibition hall, airport), or for any reasons where required infrastructure cannot be generated.

802.11b provides the access control on MAC level (second level in OSI model), and mechanisms of encoding known as Wired Equivalent Privacy (WEP), which purpose is the maintenance of a wireless network security equivalent to wire networks security. When WEP is turning on, it protects only packets, but does not protect headers, so other stations in a network can look through the data necessary for network management. For the access control in each access point is placed so-called ESSID (or WLAN Service Area ID), without knowledge of which the mobile station cannot be connected to an access point. In addition, point of access can store the list of competent MAC addresses, named as the Access Control List (ACL), permitting access only to those clients, whose MAC addresses are in the list.

For enciphering the data, the standard gives opportunities of enciphering with use of RC4 algorithm with a 40-bit shared key. After the station connects to an access point, all transmitted data is ciphered with use of this key. When the enciphering is used, the access point will send the ciphered packets to any station trying to be connected to it. The client should use his key for enciphering the correct answer for authenticate itself and to receive access in a network. Above the second level of a network 802.11b supports the same standards for the access control and enciphering (for example, IPSec), as other networks like 802.

At present, development of the standard of the following generation - standard IEEE 802.11a, using a strip of frequencies in area 5 GHz takes place. The speed of transfer in the given networks runs up to 54 Mbps.

Speaking about wireless technology it is impossible not to tell about hot spots. This is probably the most “hot” topic in the world of telecommunications. The reason is the increase of interest to mobile data transfer, when there is depression in cellular 3G businesses. Hot spot is a small zone outside of the office or home, where mobile users could have access to the Internet or to their corporate network. A typical example of mobile user is corporate executive been on official business trip or even vacation, she/he needs to access to emails and attachments, web-servers and other corporate network resources. Hot spots are in places, where mobile users stay: in airport lounges and railway stations, in hotels and business centers, exhibitions, Internet-cafes and even parks. Another common areas of hot spots installations can be within corporate networks (for high-speed Internet access for clients, customers and visitors to increasing of business quality and service) and at universities, schools, libraries.