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Data Communication in the USSR - The Telecommunication Infrastructure and Relevant Administrative Procedures

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DATA COMMUNICATION IN THE USSR - THE TELECOMMUNICATION INFRASTRUCTURE AND RELEVANT ADMINISTRATIVE PROCEDURES

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PREFACE

This working paper is part of the IIASA study "Telecommunication Equipment and Administraive Procedures relevant to Experimental and Operational East-West Computer Connections". This work is supported both by the Control Data Corporation in Minneapolis and the Austrian Ministry for Science and Research in Vienna.

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DATA COMMUNICATION IN THE USSR - THE TELECOMMUNICATION INFRASTRUCTURE AND RELEVANT ADMINISTRATIVE PROCEDURES

A. Butrimenko and I. Sebestyen

0. INTRODUCTION

Data communication in a large country such as the USSR is a very complex subject, which has to be approached from many different sides. Therefore in what follows we try to elaborate this topic first from the general status quo and of the telecommunication network of the USSR. The present status of the telephone network, which still represents the backbone of data communication, is a very important factor in determining what actually can be done in data transmission. We devote a separate chapter to the description of communication satellite systems, which already play an important part in telecommunication and data transmission in the USSR, and which are even more promising for future data transmission applications; their potential is truly tremendous.

In a subsequent chapter we describe the present PTT telecommunication services, its present administrative procedures, and some tariff questions. This chapter aims to provide a general overview of what is available for data communication users, special emphasis being paid to the international aspects of these services.

Finally, we describe briefly the state of computer networking in the USSR, showing present practices, applications and some future trends. In particular we point to some of the existing international computer communication systems already in use.

1. STATE OF THE TELECOMMUNICATION NETWORK

1.1. The Telephone

Data communication possibilities over leased lines or public switched telephone networks has been largely determined by the state of development of the national telephone network, which is influenced by many factors only referred to briefly in this study.

The first well known factor is that the development level-- measured, for example, as numbers of telephone stations per 100 population--is generally dependent on the economic capacity of a given country, often expressed as Gross National Product per capita. As shown in Ref. 1 and in a number of other publications, there is generally a linear correlation between GNP/capita and the number of telephone stations/population (Figure 1). There are obviously other factors that impact on this development level, such as the geographical characteristics of a given country, the usage pattern and social role of the telephone, and historical development trends.

Figure 1 shows also that countries with extremely large scarcely populated territories operate telephone network services that are actually less developed than one might expect according to their GNP/capita figures. This is obvious, since the difficulty of extending the telephone network infrastructure to remote parts of countries--often with climatic extremes, such as in Siberia--cannot be compared with the network expansion in densely populated and highly industrialized areas, such as the Netherlands.

Much has been said about the social role of the telephone, e.g., in Ref. 2. There are regions in the world, e.g., the USA, where the social role and impact of the telephone, both on the private and business life, is more determinant than for example in Europe. This obviously influences differently the needs of telephone users in various countries.

Another important factor is the development history of a given national network. Using the traditional wired technology, the development process of a national network is both extremely slow and resource consuming. Figure 1 shows that even in the United States, which had one of the most favorable conditions for building up a telephone network, this was a long and time consuming process. In [1] we showed that the full penetration (80%) of the telephone in US households took about 72 years, a progress that was about four times slower than for the radio or the television service. For other countries this relation is far worse. The trend might be changed to some degree with the introduction of new technologies, such as fiber optics, integrated high speed telephone networks, and satellite communication, but for the moment it remains slow.

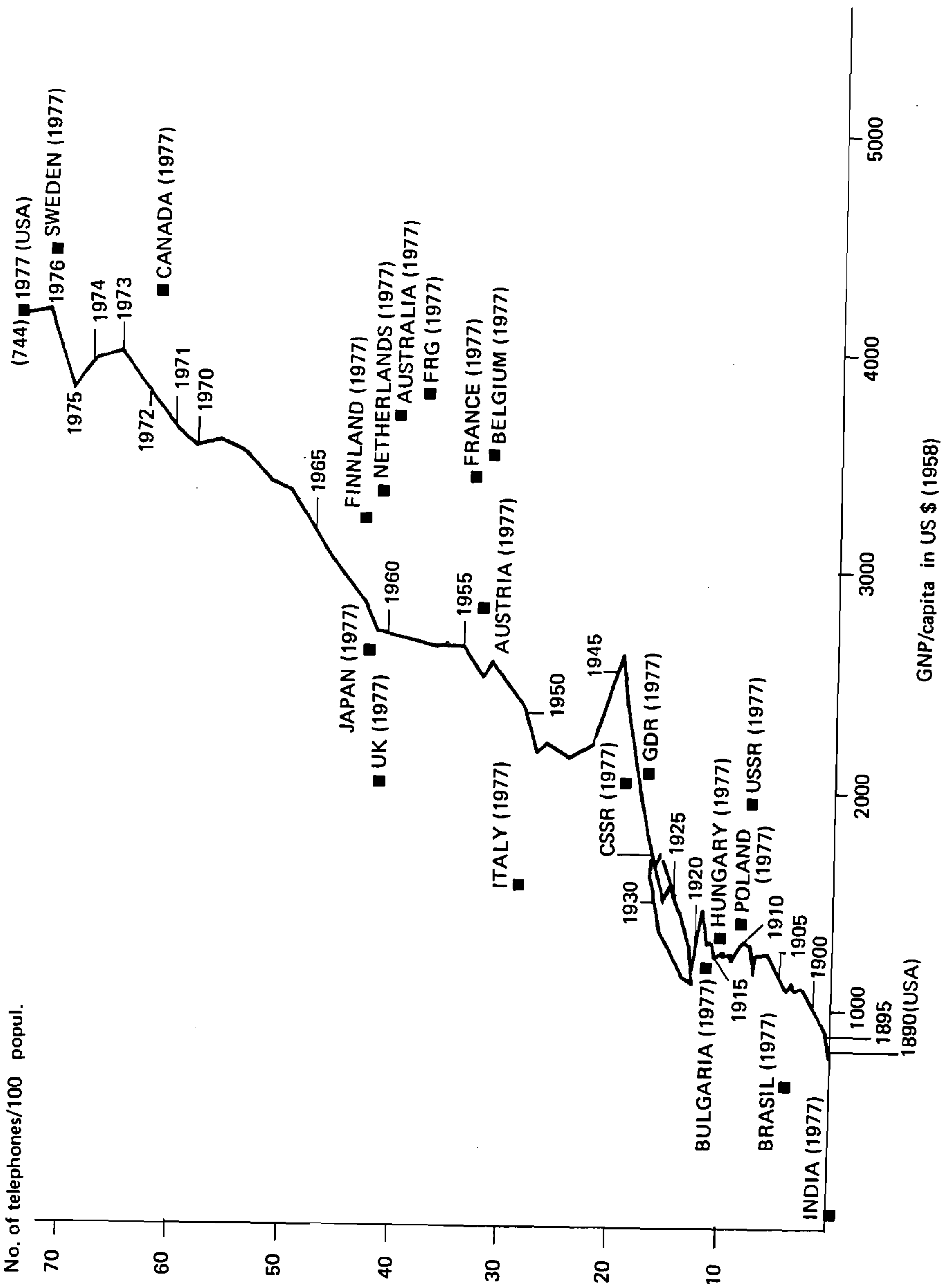


Figure 1. The linear elation between the number of telephones and GNP/capita in a given country. USA figures suggest that the historical development followed the same rule.

The present state of development of the USSR telephone network can be fully derived and understood from the above considerations.

Geographically the country, with its territory of 22.5 million km^2 occupying about 20% (!) of the whole earth, has a scarce population especially in remote rural areas. From this point of view the characteristics of the USSR are somewhat similar to those of Canada and Australia, although the population distribution pattern differs in some ways: in Canada the majority of the population lives in a 100-150 km wide "belt" along the US-Canadian border; a similar concentration can be observed in Australia, especially around Sidney and Melbourne. The population pattern of the USSR is, however, distributed.

Some comparative data are given in Table 1 for selected national PTT telephone networks. In 1980 the USSR had about 20.5 million telephones in service. However, the ratio of telephones per head of population is relatively low for a country that belongs to the industrialized world. There are many factors contributing to this low ratio: the GNP/capita figure, the unfavorable geographical and climatical conditions for building up the network, and the social role of the telephone in the USSR. The historical development of the network is also important. For a long period of time the industrialization policy of the country gave higher priorities to industries--such as the steel industry--that contributed directly to the production capacity of the country. Thus the general state of the telephone network is somewhat less developed. According to Table 1 the situation is improving, the growth rate figures are promising; the 7.3% increase between 1979-1980 in the number of telephones in service implies that the country is expanding its telephone network as fast as is

Table 1. Countries that have reported 500,000 or more telephone. Comparative data for the years 1980, 1979, and 1970. (Reported data are as of January 1, 1980. Source: AT&T Long Lines, 1981, The World's Telephone's - a Statistical Compilation as of Janurary, 1980, AT&T Long Lines Overseas Administration, Morris Plains, USA).

	Total telephones in service					Ratio of telephones per 100 population		
Name	1980	1979	Percent increase 1979-1980	1970	Percent increase 1970-1980	1980	1979	1970
Argentina	2,759,736	2,659,949	3.8	1,668,426	65.4	10.3*	10.0*	6.9
Australia	7,396,212[558]	6,266,290	18.0	3,598,692[580]	105.5	52.0[406]	43.7	29.3
Austria	2,812,676	2,617,634	7.5	1,334,339	110.8	36.6	34.0	181.1
Belgium	3,447,697	3,270,882	5.4	1,936,814	78.0	35.0	33.2	20.1
Brazil	6,494,000	5,522,445	17.6	1,787,000	263.4	5.1	4.5	1.9
Canada	15,560,264[581]	15,059,428[578]	3.3	9,302,828	67.3	65.6[443]	63.5*	43.8
Chile	553,856	531,143	4.3	348,258	59.0	4.9	4.8	3.6
China-Taiwan	2,566,078	2,099,310	22.2	338,803	657.4	14.7	12.3	2.4
Colombia	1,524,000	1,444,972	5.5	545,851[573]	179.2	5.8	5.7	2.6
Czechoslovakia	3,072,829	2,981,197	3.1	1,895,229	69.5	20.1	19.7	13.1
Denmark	3,144,558[581]	2,935,124[582]	7.1	1,599,952	96.5	61.4[597]	56.5[597]	32.5
Finland	2,244,365	2,127,392	5.5	1,089,700	106.0	47.1	44.7	23.1
France	22,211,952	19,870,006	11.8	8,114,041	173.7	41.4*	37.3	16.1
German Dem.Rep.	3,071,515	2,956,390	3.9	1,986,190	54.6	18.3	17.7	11.6
Germany, Fed.Rep.of	26,632,302	24,743,467	7.6	12,456,268	113.8	43.4[58]	40.3	20.4
Greece	2,664,050	2,487,495	7.1	861,003	202.4	28.2*	26.5*	10.0
Hong Kong	1,517,294	1,382,214	9.8	502,374	202.0	30.2*	29.2	12.5
Hungary	1,186,526	1,142,597	3.8	777,739	52.6	11.1	10.7	7.5
India	2,615,075[559]	2,423,762	7.9	1,159,519	227.9	0.4[423]	0.4[578]	0.2
Iran	730,000	n.r.	-	286,220	155.0	2.2	-	1.0
Ireland	586,000	554,000	5.8	287,108	104.1	17.3[325]	16.8*	9.8
Israel	1,081,480	1,028,087	5.2	457,721	136.3	28.2	27.5	16.0
Italy	18,084,996	17,080,870	5.9	8,528,354	112.1	31.8	30.1	16.0
Japan	55,421,515[490,564]	52,937,304[579]	4.7	23.131,688[581]	139.6	47.6[490]	45.8[579]	22.4
Korea, Rep.of	2,898,687	2,387,336	21.4	562,111	415.7	7.8	6.6	1.8
Mexico	4,532,557	4,140,271	9.5	1,327,702	241.6	6.4*	6.0*	2.7
Netherlands	6,852,776	4,140,271	8.1	3,120,766	119.6	48.6	45.4	24.1
New Zealand	1,729,916	1,762,130	-1.8	1,202,590[581]	43.8	55.0	56.1	42.6
Norway	1,725,678	1,636,491	5.4	1,090,662	58.2	42.3	40.2	28.2
Philippines	519,642	593,127	-12.4	293,543	77.0	1.2	1.2	0.8
Poland	3,243,693	3,095,303	4.8	1,756,248	84.7	9.1	8.9	5.4
Portugal	1,305,580	1,253,530	4.2	698,075	87.0	13.1	12.7*	7.3
Puerto Rico	651,388	604,271	7.8	302,214	115.5	18.5	19.3	10.9
Singapore	625,130	540,209	15.7	136,267	358.8	26.5	22.9	6.7
South Africa	2,662,399[551]	2,456,329[574]	8.4	1,482,299[581]	79.6	10.8*	10.0*	7.3
Soviet Union	22,464,000	20,943,000	7.3	n.a.	-	8.4	7.9	-
Spain	11,107,624	10,311,423	7.7	4,126,363	169.2	29.4	28.0	12.5
Sweden	6,407,031	6,160,359	4.0	4,306,905	46.8	77.1	74.4	53.7
Switzerland	4,446,005	4,292,205	3.6	2,846,535	56.2	70.4	59.8	45.4
Turkey	1,747,854	1,578,586	10.7	513,569	240.3	3.9	3.7*	1.5
United Kingdom	26,651,384[585]	24,934,670[577]	6.9	13,947,000[581]	91.1	47.7	44.6	25.0
United States	175,505,000[587]	168,994,000[575]	3.9	115,222,000	52.3	79.1	77.0	56.4
Venezuela	1,165,016	920,252	26.6	377,862	208.5	8.5	6.2	3.7
Yugoslavia	1,912,833	1,732,558	10.4	622,939	207.1	8.5	7.6	3.1

reasonably possible. The growth rate for the USSR compares favorably with the growth rates for other developed countries that are in a similar phase of development (e.g., Austria) and is obviously higher than for those countries that are about to get close to their saturation level, such as Sweden, Switzerland, or the USA.

1.2. Space Technology in Telecommunication

In the development of the PTT networks, recent technological advances such as satellite communication--in which the USSR is one of the leading countries--are of major importance. According to [11], for such purposes the USSR at present operates the MOLNIYA type of satellites in highly elliptical orbits that are quite suitable for high latitude service areas, together with a number of geostationary satellites (STATSIONAR, STATSIONAR-T) using the 4/6 GHz spectrum. Satellites of this type are used not only for the national needs of the USSR in telephony, TV, and radio broadcasting but also for the requirements of the INTERSPUTNIK International System and Organization of Space Communications.

Typically, the bandwidth of a satellite space channel is measured in tens or hundreds of Mbit/s. Typical inputs into this space channel are voice (tens of Kbit/s), data (from a few Kbit/s to Mbit/s), and image (up to several Mbit/s). It is therefore necessary to multiplex these inputs into and demultiplex them out of the space channel.

In the national satellite communication system of the USSR two types of multiple access (multiplexing techniques) are used: FDMA (frequency division multiplexing) and TDMA (time division multiplexing).

a) FDMA

The FDMA technique is used in the majority of telecommunication satellites, also in the USSR. It is used in links with low traffic such as the analog transmission of voice. In this case a certain part of the frequency spectrum within the transponder passband is assigned to each transmitting and receiving station in the network separately all the time and all the stations can operate simultaneously emitting carriers modulated by telephone messages or TV-radio broadcasts in the allocated frequency bands (Figure 2).

The advantage of FDMA is its simplicity and its adequacy for telephone transmission. Its disadvantage, however, is that it uses bandwidth in a somewhat inexpensive way and it lacks the flexibility required by data transmission, which can vary between low data rates of a few hundred to a few million bit/s.

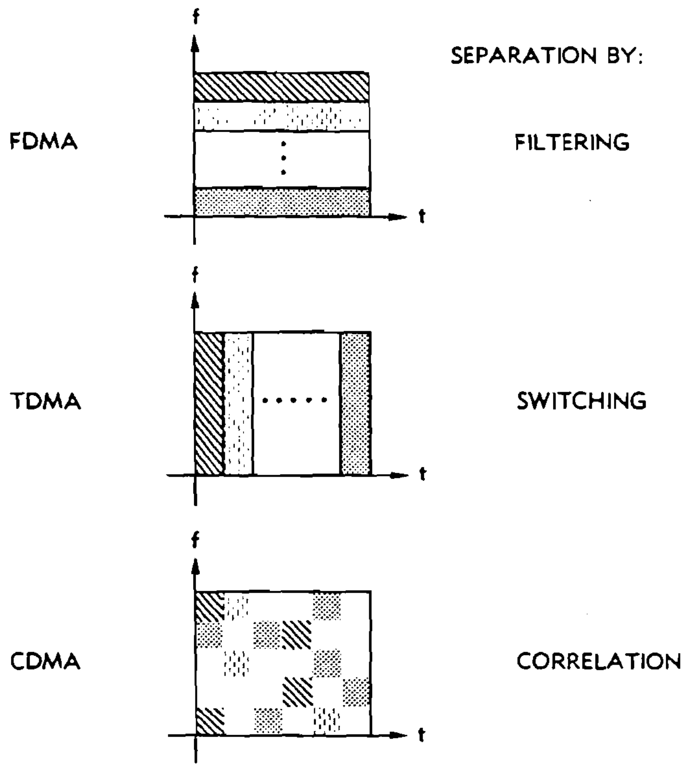
In the transmission of discrete analog data, the transponder capacity may be as high as in the transmission of digital data. Discrete data transmission offers certain advantages. First of all, discrete data available from a computer, control systems, etc., may be transmitted most efficiently. If for transmissions over the voice frequency channel, the rate of 9.6 kbit/s may be achieved, then by using the primary standard discrete channel, the binary data stream may be transmitted at 32-64 kbit/s. Apart from this, discrete data transmission allows forward error correction, new modulation techniques (e.g., a hybrid amplitude-phase modulation), and the use of source redundancy, which in the near future will make possible a several fold increase in the communication system capacity.

A number of links provided with digital data transmission equipment using FDMA have been operating in the USSR domestic satellite network for several years.

As a rule, in these communication links, a data signal from the trunk exchange goes via the connecting line to the earth station at the terminal ADC/DAC input for conversion of analogue data in digital form. The terminal equipment uses adaptive PCM (pulse code modulation) techniques and performs analysis of the signal block containing a fixed number of samples of the input signal function. If the values of all samples in a given block do not exceed specific threshold quantities, values of all samples increase 2,4 or 8 times. An output terminal signal, which is a binary data stream at 512 kbit/s, then goes to the FDMA equipment, where the assigned carrier frequency is phase modulated. With reliability at the receive side of the order of 10^{-6} per bit, simultaneous transmission of 12-14 carriers is possible in the transponder. This corresponds to a transponder capacity of 6-7 Mbit/s.

b) TDMA

According to the TDMA (Time Division Multiplexing) principle each user is allocated all of the space channel for some of the time. Thus each user gets allocated a certain time slot. User time slots are allocated in such a way that time slots for users transmitting from a given earth station are continuous. For a fixed duration of so-called TDMA frames, bursts and time slots are allocated for different earth stations (Figure 3).



TRADEOFFS IN SELECTION:

- COMMUNICATION CAPACITY
- NUMBER AND VARIETY OF ACCESSES
- POWER/BANDWIDTH
- SIGNAL QUALITY
- INTERCONNECTIVITY (PRESENT & FUTURE)
- PRIVACY
- TERRESTRIAL INTERFACES
- COST

Figure 2. Modes of multiple access [14].

The synchronization of a burst is a key problem for a TDMA communication satellite because it must ensure that bursts, sent by two different stations, never overlap when they reach the satellite. Synchronization can be assured by a master station, the so-called slave stations constantly monitoring the frame reference burst from the master station to extract their own bursts timing information. A major advantage of TDMA over FDMA is to be able to operate with dynamic allocation, i.e., to be able to allocate bursts and slots within a frame according to the instantaneous transmission need of the users. The capability is more often referred to as Demand Assignment (DA).

The communication links with TDMA are used to establish communication between large administrative-economic centers. The first link of this type for 120 duplex channels was put into operation in 1977. At each earth station of the link, signals for two 60-channel groups coming from the trunk exchange via the radio relay or cable link are converted to digital signals and form two streams of about 6 Mbit/s each. After time compression, 62.5 microsecond synchronous bursts are formed with a period of repetition of 125 microseconds. The bursts comprise specific code words for mutual synchronization of stations and a preamble necessary for synchronization of the coherent demodulator at the receiving side. The time required for initial acquisition of synchronization of the slave station does not exceed 125 microseconds.

As the satellite communication systems may be most efficiently used for one-way multidestination transmission, such systems are widely used in the USSR for TV and sound broadcasting, transmission of photoelectric signals of newspaper pages, etc.

Experiments on newspaper page transmission via communication satellites were first carried out in the USSR in 1968, and in the course of time the first satellite newspaper transmission system Moscow-Khabarovsk was put into operation.

The latest development along this line is a special ORBITA-RB satellite system developed for digital transmission of sound broadcasting and newspapers. Newspaper transmission in this system is provided via a 2.048 Mbit/s dedicated digital channel capable of high capacity (the time required to transmit one printed page is less than 1 minute) and high quality operation (the scanning is up to 26 lines per millimeter). For sound broadcasting this system provides about 30 high quality sound programs to ORBITA earth stations using approximately half of the standard

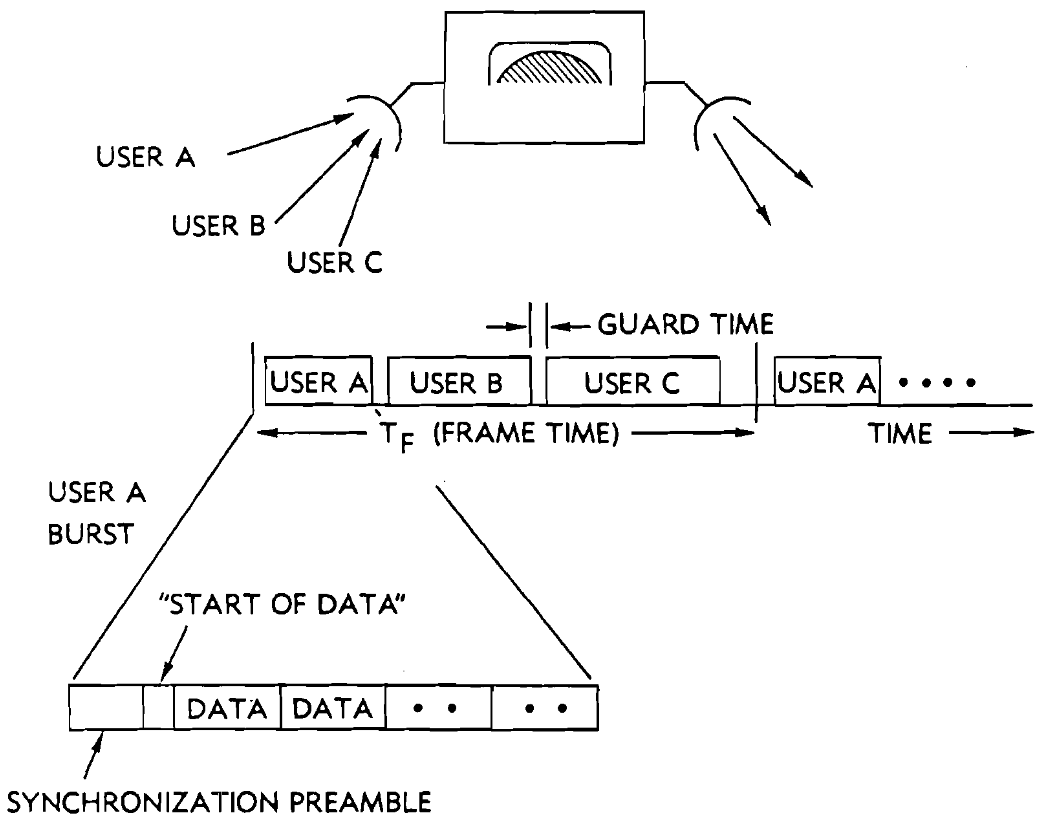


Figure 3. TDMA philosophy.

satellite transponder capacity. It also provides stereo program transmission. An important advantage of broadcasting satellite systems is that the channel cost and transmission quality of such systems do not depend on the distance to receiving stations.

It can be expected that satellite systems will be used increasingly for high speed data transmission in the future.

It is interesting to note that according to [13] the general trend worldwide is that satellite channels, originally viewed as a transmission path for wideband information such as TDMA and FM network quality television, are increasingly used for 56 kbit/s digital transmission. This can be appreciated by recognizing that the newer generation of computers, have protocols that allow direct computer interfacing with the satellite system, that accommodates the time delay. This makes possible more widespread interconnections by satellite of computer and data systems operating at the data rates of 2400, 4800, 9600, 56000 bits and up to so-called carrier rates (1.544 Mbit/s). For this type of application earth stations designed especially for this purpose have to be introduced with modems that can multiplex the traffic of the individual data circuits, which can be up to 56 kbit/s.

The advantages of digital communications by satellite at the 56 kbit/s rate can be listed as follows:

- Up to this time, practically all data communications have taken place over telephone networks that are designed for voice, not data.
- The telephone network generally restricts data transmission to 9600 bit/s and below.
- The telephone network generally serves a computer data system at a 10^{-5} bit error rate and lower; a satellite link can be served with a 10^{-7} bit error rate and a 0.9995 availability.
- Satellite transmission of digital data over medium to long distance and to multipoint locations is less costly than the use of terrestrial microwave.
- Satellite transmission of digital data can handle higher data rates than can be provided by wire lines.
- Higher speed satellite data systems to handle rapidly increasing volumes of data demanded by business involves less capital expenditure than the expansion of terrestrial microwave systems.
- Emerging low cost terminals make satellite distributed digital data links highly cost effective--even for short distances.

Thus, considering the present status of the terrestrial data communication infrastructure of the country, its geographical characteristics, and its technological advances in space technologies, it can be expected that the above outlined digital communication by satellite will attain much importance. According to [12] the role of satellite communication in international telephony of CMEA countries is also increasing. For the socialist countries this activity is based on the INTERCOSMOS program. INTERCOSMOS is a program of comprehensive cooperation among the socialist countries in the peaceful exploration and use of outer space--embracing also space communications activities--in which 10 countries take part: Bulgaria, Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Mongolia, Poland, Rumania, the USSR and Viet Nam.

Work in the field of space communications has led to the creation of the INTERSPUTNIK international space communications system and organization, which broadcasts television programs, telephone messages, and other types of information.

Current members are Afghanistan, Bulgaria, Cuba, Czechoslovakia, Democratic Yemen, the German Democratic Republic, Hungary, Mongolia, Poland, Rumania, the USSR, and Viet Nam.

The INTERSPUTNIK communications system comprises a space segment and earth stations. The space segment, which includes communications satellites and control systems, is the property of the organization or is leased by it from its members. The earth stations are the property of the countries that build them or the organizations that operate them. INTERSPUTNIK currently operates using Soviet satellites on the basis of lease. The system employs two STATSIONAR satellites in geostationary orbit at longitudes of 14^0 west (Atlantic region) and 53^0 east (Indian region). Two relay units on board each satellite are used for telephone/telegraph links and for the exchange of radio and television programs.

Thirteen ground stations operate the INTERSPUTNIK system: seven in Europe (Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, and two in the USSR), four in Asia (Afghanistan, Laos, Mongolia and Viet Nam) and one each in Central America (Cuba) and North Africa (Algeria). There are plans to build earth stations in Syria, Democratic Yemen, Guinea, and a number of other countries. In addition to the members of the organization, other countries (France, Italy, Spain, Yugoslavia, etc.) also use the channels of the INTERSPUTNIK system.

The INTERSPUTNIK communications system is used mainly for exchanges of television programs with broadcasts lasting 4 to 8 hours daily, with more than 20 countries participating in the system. About the same number use its channels for international telephone and telegraph links. Plans for the development of the system in the next few years include bringing additional channels into use on board the STATSIONAR satellites and introducing new equipment in the earth stations, so as to increase the amount of information transmitted and improve the quality and reliability of the communication channels.

INTERSPUTNIK coordinates its activities with the International Telecommunication Union (ITU) and other international organizations in connection with the use of the frequency spectrum and the application of standards for communications channels, and in other areas as well. Relations between INTERSPUTNIK and the Pan-African Telecommunication

Network (PANAFTEL) are being expanded and consolidated.

It can be expected that in the long run INTERSPUTNIK capabilities will also be more and more utilized for high speed data transmission purposes, since the concept of the digital data earth terminal can also be extended to international systems.

In a similar way, in the USA [13] COMSAT now offers a new international digital service, DIGISAT, which uses INTELSAT satellites for communication between earth terminals. DIGISAT employs digital Time Division Multiplexers (TDMs) at earth stations, which accept multiple channels at the lower data transmission rates on the input side and combine them into a single 50 and 56 kbit/s SCPC (single channel per carrier) channel for transmission through a satellite. On a single 50 kbit/s channel, a multiplexer using input signal rates of 2.4, 4.8 and 9.6 kbit/s can handle the transmission and reception of up to twenty 2.4 kbit/s channels, ten 4.8 kbit/s channels, five 9.6 kbit/s channels, or combinations not exceeding a total of 48 kbit/s. Earth stations are equipped with individual multiplexers assigned to each international destination. The TDMs used in this service can also provide clocking and regeneration of digital signals.

In a similar way INMARSAT, the International Maritime Satellite Organization also offers through its satellites high speed data services up to 56 kbit/s.

2. PTT TELECOMMUNICATION SERVICES, PROCEDURES, TARIFFS

2.1. Line Ordering

Communication lines in the USSR for data transmission are leased from the PTT in accordance with the requirements of the customers.

International leased lines are provided by the PTT under the condition that two corresponding customers, who are to be connected by the line, supply separately their requests to their national telecommunication administrations. In the Soviet Union such requests should be addressed to the Department of Foreign Relations of the Ministry for Telecommunication in Moscow (MINSVJAS, 7 Gorky Street, Moscow, K375, Telegram address: MINSVJAS MOSKVA, Telex: 961).

The Ministry for Telecommunications is responsible for handling all technical matters with the corresponding PTT administrations of the "destination" countries as well as with the telecommunication administrations of the "transit" countries that are between the USSR and the "destination" country. The request to MINSVJAS for a leased line should include:

a) the exact address of the customer organizations to be connected and addresses of premises where the line should be terminated

b) specification of the required line quality in accordance with the recommendations of CCITT

c) a clear statement of who is responsible for payment, i.e., is the whole line to be paid by one customer organization, or is every organization paying the line on the territory of its own country, or are there any other arrangements?

d) in case the domestic customer organization is paying for the line (or part of the line) the order should be signed by both the director (or his deputy) and the person responsible for budget (accountant). Account number and the bank should be specified in the order.

In case the organization is only confirming the acceptance of the line ordered by the other party abroad the "order" need only be signed by the director (or his deputy).

In practice, the preferred situation is that the two organizations cover costs incurred in their own countries (on the territory of the country where the organization is located). As a rule this procedure saves time when establishing the line.

Leased lines can also be ordered for domestic (or intercity) communication within the USSR. The above mentioned guidelines are also applied in this case, except that the line has always to be paid by only one of the organizations.

As to the duration of line lease, normally leased lines (or permanent connections) are ordered for not less than one month. This applies to all types of lines (i.e., international or domestic); however, it does not exclude the possibility of establishing the line for shorter periods in the case of special events (e.g., exhibition, experiment). It is advisable in these cases to lay out the background of the request for the PTT, e.g., an international agreement, governmental decision to fulfill a particular project, so that the request can be implemented in a timely manner. Usually the time scale for establishing a leased line is on the order of two months, which is about average for European standards.

2.2. Communication and Terminal Equipment to be Connected to Leased Lines

As a general rule all communication devices (modems, multiplexers) should be provided by the customer. The Telecommunication Administration of the USSR normally does not follow the policy of providing or renting any communication equipment and thus no tariffs for these exist.

The usual practice is that telecommunication equipment (such as modems, and multiplexers,) to be connected to the line should be agreed upon between communicating organizations and full technical documentation be submitted for approval by the Telecommunication Administration (MINSVJAS). For the equipment to gain acceptance by MINSVJAS it must correspond with the recommendations of the CCITT, which is practically always the case, since the majority of telecommunication equipment--such as the ones of the Ryad series-- used in the USSR follows the CCITT recommendations anyway. After the technical documentation is supplied together with the application to MINSVJAS, the Telecommunication Administration checks the documentation provided before granting approval. Usually no special physical checking of the equipment is needed. The time scale of the licensing procedure to allow the attachment of additional or new equipment for an operational leased line is about ten days.

2.3. Line Quality

Leased lines provided by the Telecommunication Administration are guaranteed to correspond to the recommendations of the CCITT, M. 1040 up to 4800 bit/sec speed. In practice experience has shown that lines can be used on 9600 bit/sec speed, but this is not guaranteed by the PTT because intercity lines in the USSR do not have so-called frequency phase correction.

Testing of the line quality is usually carried out by the Telecommunication Administration, although the Administration allows testing of the line by a customer if he wishes to do so. Their only requirement is that the testing equipment and procedure should correspond to the usual CCITT recommendations. However, no testing equipment is provided for customers by the Telecommunication Administration on a lease basis.

2.4. Costs and Tariffs

In contrast to the PTT policies of many countries, no separate charges are usually required by MINSVJAS for installing lines and services. The usage tariffs, however, are the following:

a) Leased Lines

Cost calculations for national (or intercity) lines both (two and four wires) are based on the following principles:

a) Independent of the speed or multiplexing mode used the basic price is just for telephone channels ("wires"), because this is the actual resource that is used.

b) Costs are calculated on the basis of the standard tariffs for long distance calls on the assumption that the line is used continuously for 24 hours per day, i.e., (cost per day) = (price for one minute) X 1440 min.

c) Tariffs for standard telephone calls depend on distance zones. There are 10 zones starting from less than 100 km with a cost of 0.05 ruble/min and finishing with more than 8000 km with a cost of 0.6 ruble/min.

   In addition, the cost for dedicated lines can also include expenses for the part of the line between the premises of the organization and the nearest central exchange station.

   In the case of international leased lines the costs consist basically of two parts. The first part is the cost of the line on the territory of the USSR, namely, between two geographical points: the place where the ordering organization is located, and the imaginary crossing point of the country boundary with the direct line between the two destinations to be connected. The costs for this part of the line are calculated as they are for national lines. The second part, generally the cost of the line on the territory of the other country (or countries in case of transit through the territory of third countries), is basically negotiated and handled by the PTT in that country and is defined on a case by case basis.

b) Public Switched Telephone Network

Public switched telephone lines can also be used for data transmission, and their tariffs are based on the same scheme as for ordinary telephone calls.

According to the present practice, it is, however, not advisable to use speeds higher than 1200 bit/sec. "Urgent" telephone calls for the case of ordering the switched line from the operator is a possible option . In this case the costs for normal telephone calls are multiplied by two. These "urgent" calls can be served only by operators and are established as so-called higher priority calls.

According to practice, normal switched telephone channels can also be used for international data transmissions, but similarly with a speed not higher than 1200 bit/sec. Tariffs applied in this case are the same as those for normal telephone calls. Costs for one minute are between 1 and 7 rubles. Calls to European countries cost between 1.0 and 1.5 rubles per minute, to Asia 3 rubles, to the Middle East and North Africa 4 rubles, to America 4 rubles, and finally to Australia and some remote areas up to 7 rubles.

With some countries, reduced tariffs (60 percent of the normal tariff) are agreed on for communication from 7 p.m. till 6 a.m. local time.

2.5. Telegraph and Telex Lines

Telegraph and telex lines can also be used for data transmission. In this case the Telecommunication Administration can provide teletype and equipment for facsimile transmission.

Installation of the telex in the USSR costs 60 rubles with 33 rubles per month maintenance. Rental of the telex connection costs 65 rubles per month.

Costs for telegraph communication varies from 0.3 ruble/word up to 0.9 ruble/word under normal tariff and are doubled for urgent placing of messages.

3. COMPUTER NETWORKING IN THE USSR

In this expansive phase of development in the telecommunication infrastructure of the USSR, efforts have been concentrated on the expansion of the telephone and other telecommunication networks and lower priority has been given to provide "value added PTT services", such as the introduction of special public packet switched data network services. However, The PTT provides the basic infrastructure to various organized communication users for building up their own "interorganizational" communication systems and networks, which are, according to the networking terminology, "private networks". In this case the PTT provides for its customers sufficient physical lines with parameters fulfilling the appropriate recommendations of CCITT. The Administration in return expects that the customers building up their own networks use telecommunication equipment that fulfills the above CCITT recommendations in order that the basic physical service by the PTT can be secured. In this respect all the "value added", higher level services are usually built up and provided by the "private" network operators themselves.

A few private computer networks have already been implemented or are under development. A particular group of these private networks is the of the scientific institutions belonging to the Academy of Sciences in the USSR. There is a strong driving force among these institutions to build up and operate a set of high level data networks. According to Eduard Yakubaitis [3, 4], in the USSR, distributed systems are in operation in Moscow [5], Novosibirsk [6], and Riga [7], but also in several scientific centers of the country. According to [4], the Institute for Electronics and Computer Techniques for the Latvian Academy of Sciences is building up a dedicated computer network for the Academy. Up to the summer of 1981 all the major computers from Academic institutions dealing with energy, physics, forestry, chemistry, and computer technology were integrated into the network, and the final goal is to hook up all the computers of the Latvian Academy of Sciences into the network. The main purpose of this type of networking is joint research and better cooperation between the academic institutions. As mentioned above similar regional networking projects are being implemented in several parts of the USSR. The computer networking teams in Riga , Moscow, Kiev, Novosibirsk, and some other places are already at the stage of interlinking the regional academical networks, which would actually form the integrated computer network of the USSR Academy of Sciences.

Trends and plans to interlink the USSR Academic network to similar networks abroad are already on the horizon. For example, the leased line connections between the computer network of the Hungarian Academy of Sciences and in particular the Institute for Automation and Computerization should be mentioned. According to [8], on December 3, 1981 a leased computer line was put into operation between Budapest and Leningrad where large main frames such as a Soviet BESM 6 system can be accessed in an interactive regime. The use of this line enables among other things the joint writing and editing of papers in the jointly published journal of the USSR and Hungarian Academy of Sciences. In addition, access to databases and graphical software systems are typical uses of this link. Since the Computer Network of the Hungarian Academy of Sciences is also interlinked with the TPA 70 node computer of IIASA, on an experimental basis connections between the Leningrad data center and IIASA were made early in 1982. But this is not the only computer link between Academic Institutions in the USSR and Hungary. In [9] Geza Huba from the Central Physical Institute of the Hungarian Academy of Sciences (KFKI) reports about a 4 wire leased computer link between KFKI in Budapest and the Space Research Institute of the USSR Academy of Sciences. This permanent computer-computer connection was put into operation on January 26, 1981 and is mainly for high speed exchange of computerized data.

Dedicated lines are established between the Institutes for System Studies in Moscow and the Center for Scientific and Technical Information (Sofia), as well as between the Institute for System Studies and the

Central Technical Base in Prague and through it to the International Institute for Applied Systems Analysis (IIASA) in Laxenburg (Austria).

According to [8], these computer links will eventually lead to the establishment of an interlinked computer network of the Academy of Sciences of the Socialist countries. This international "private network" in the field of science and research will be a unique one in a sense that in Western Europe and North America similar types of organizations often use the national PTT data networks for their interconnections. For this reason, in order to facilitate cooperation between academic institutions of socialist and western countries, connection at some point between the PTT networks and this international "private" network is a logical consequence. IIASA might play an important role in achieving this level of cooperation.

Another typical example of an operational "private" network in the USSR is reported in [10], in which multilevel information processing networks built on the ES (Ryad) and MES basis are described. For example, the hierarchical network system GTSK-Moscow of the Moscow Savings Bank is given. This special network, tailored for the special needs of a large savings bank, serves more than 3000 terminals in an online regime distributed in branch offices of the bank. The number of personal saving accounts handled by the system exceeds 8 million. According to the special "savings bank" oriented tasks both online and batch type of services are basically supported by the network. On the highest level of the hierarchy an ES-1055 large mainframe performs the function of a central data processing center, which collects all data and reports coming from the next lower level, the so-called regional centers based on doubled SM4 machines. In the central system those data processing functions are performed that concern the banking system as a whole. Also, an archival database of the system is installed there. The regional centers, 32 in all, store local databases in a decentralized and distributed way; in addition they serve all local terminals belonging to the branch office. The basically SM4 based and supported telecommunication network supports online work and work with distributed databases in an efficient way. The regional centers are connected with the central office over leased lines rented from the PTTs, which operate with high speeds, the lowest speed applied in the system being 1200 baud.

It is clear that the networking requirements of the savings bank system and of the USSR Academy of Sciences networks are completely different. The savings bank network is a specialized, purpose-oriented system, which is best achieved if all the special requirements--such as transaction security, time availability, privacy, etc.,-- are taken into consideration as a whole. The academic network on the other hand has to be an open system in order to incorporate as many different types of computer system as possible. Here emphasis had to be given both to batch exchange of data and online access from terminal to computer. Also the security requirements of this network differ considerably from those of the savings bank system. For this and similar reasons it is not advisable to combine these two systems.

On the basis of examples such as those above, it can be said that the development of computer networks in the USSR follows a "sectoral" pattern. Instead of common services, "private" computer networks such as the savings bank network or the academic network have been built and more are being established in the near future.

However, this does not mean that at some point the PTT will not introduce its own data service. It will when it is recognized that such needs have also to be satisfied by centralized efforts, since there are also a number of applications in which PTT networks are more beneficial, e.g., access to public bibliographical databases.

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