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FINAL REPORT

SUMMARY OF SOVIET DIGITAL SWITCHING

CONTRACT 9-L65-Z5910-1

JUNE 1986

PREPARED FOR
U.S. ARMY MISSILE AND SPACE
INTELLIGENCE CENTER
REDSTONE ARSENAL, AL 35898-5500

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ABSTRACT

This summary report on Soviet Digital Switching Technology is the second of two final reports prepared under Contract 9-L65-Z5910-1. The objective of these reports is to provide an assessment of Soviet state of the art in fiber optics and digital switching technologies along with projections of technological developments through the year 2000. These studies will provide inputs to Tasks 2 and 3 of the CASTAR project.

The information for this report was obtained from extensive Soviet literature searches as well as technical discussions with analysts at Teledyne Brown Engineering and Foreign Technology Division. It was determined that information contributed by classified sources was not significant enough to warrant classification of this report.

The Soviet state of the art in digital switching is established by examining the primary telephone exchanges and computer networks that are operational and then comparing them to their U.S. counterpart. Projections are then made by examining the literature to establish the Soviet goals for the future. The feasibility of each goal is then evaluated in light of practical and technological limitations.

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Vice President

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1. INTRODUCTION

This summary report on Soviet digital switching technology was prepared as the second of two final reports under contract 9-L65-Z5910-1. The purpose of these studies is to provide inputs to Tasks 2 and 3 of the CASTAR project. Objectives of the CASTAR project include assessment of the current Soviet state of the art (SOTA) in fiber optics and digital switching, and projection through the year 2000.

This report is based mainly on Soviet open literature, with additional technical background information provided by unclassified U.S. sources. Most of the data were provided by translations of three Soviet technical journals: 1) Telecommunications and Radio Engineering, 2) Radio Engineering and Electronic Physics, and 3) Automatic Controls and Computer Sciences. A CIRC search was also performed on Soviet communications networks, production capabilities, and individuals working in the research and development (R&D) phase of this technology. Numerous references were identified, but unfortunately many were not available as translations. For example, a reference in the JPRS's USSR Report: Cybernetics, Computers and Automation Technology (FOUO) cited a 1983 conference on packet switching. The report, which obviously contained a wealth of information, was not available as a translation.

It was determined that information contributed by classified sources was not significant enough to warrant classification of this report. Most of the material found in classified sources was found to be available in unclassified sources as well. Technical discussions with analysts at Teledyne Brown Engineering (TBE) and Foreign Technology Division (FTD) also provided significant insight and background information.

Section 2 is intended to be a brief introduction to the role digital switching plays in military communications. Two types of digital switching (circuit and packet) are emphasized along with the particular types of communication each is best suited to accommodate. Section 3 deals with digital circuit switching techniques used in the Soviet telephone network. Also included in this section are third-generation telephone exchanges which are not digital switches, but they do employ stored program control which is implemented with digital computers. Soviet progress in computer networking using packet switching is discussed in Section 4. Several networks are discussed, especially the Statewide Automated Management System (OGAS). This section also includes a review of some of the ideas of prominent Soviet academician E. A. Yakubaytis. Section 5 contains a summary of the Soviet SOTA in digital switching as well as some projections for the next 10 to 15 years.

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2. SWITCHING REQUIREMENTS OF MILITARY NETWORKS

The switching and transmission requirements of a military communications network are largely determined by the characteristics of the traffic it must handle (Reference 1). Table 2-1 shows various types of traffic along with transmission rates and call durations. The types of traffic have been divided into three general classes. Class I traffic is characterized by longer messages which require real-time delivery. Calls usually last several minutes during which time there are few pauses in the information flow. Class II traffic is composed of shorter, discrete-type messages which require near real-time delivery. During this type of traffic, there can be frequent pauses in information flow. Class III traffic is typified by long messages which may or may not be tolerant of transmission delays. The distinctions between the classes of traffic are more clearly understood by associating Class I traffic with voice communications, Class II traffic with interactive computer communications, and Class III traffic with bulk data transfers.

Class I traffic is efficiently handled by a circuit switching network. The basic ideas of a time-space circuit switch are illustrated in Figure 2-1. Each user is associated with a particular time slot and line. The figure shows a two-way or full-duplex connection between User 3, Line 1 and User 2, Line 2 where the information in Time Slot 3, Line 1 is switched to Time Slot 2, Line 2 and vice versa. The transmission resources are dedicated to this call for its duration, and are therefore inaccessible to other calls.

Class II traffic is suited to the characteristics of a packet switched network, shown in Figure 2-2. In this type of network, the message is first segmented into packets containing a fixed number of bits. Switching information is then appended to each packet in an address header. This allows each packet to be switched through the network individually. As the figure shows, individual packets of a particular message do not necessarily follow the same path. Since the packets may arrive at their destination out of order, each node must

Table 2-1. Characteristics of Military Communications Traffic

Traffic Class	Type of Traffic	Transmission Rate (kb/s)	Call Duration
I	PCM Voice	48 to 64	Several minutes
	CVSD Voice	16 to 32	
	LPC Voice	4 to 8	
	Voice Orders	2.4 to 9.6	
	APR Voice	8 to 16	
	DPCM voice	32 to 48	
	Facsimile	4.8 to 50	
	LS video	150 to 200	
II	Interactive Data	150 to 4800	Seconds to minutes
	Narrative/Record	0.075 to 9.6	
	Data Processing	75 to 100	
	Data Base Update	0.15 to 16	
	Bulk Sensor Data	9.6 to 100	
	Query/Response	0.150 to 9.6	
III	Bulk Data Transfer	4.8 to 100	Minutes to hours

SOURCE: Reference 1

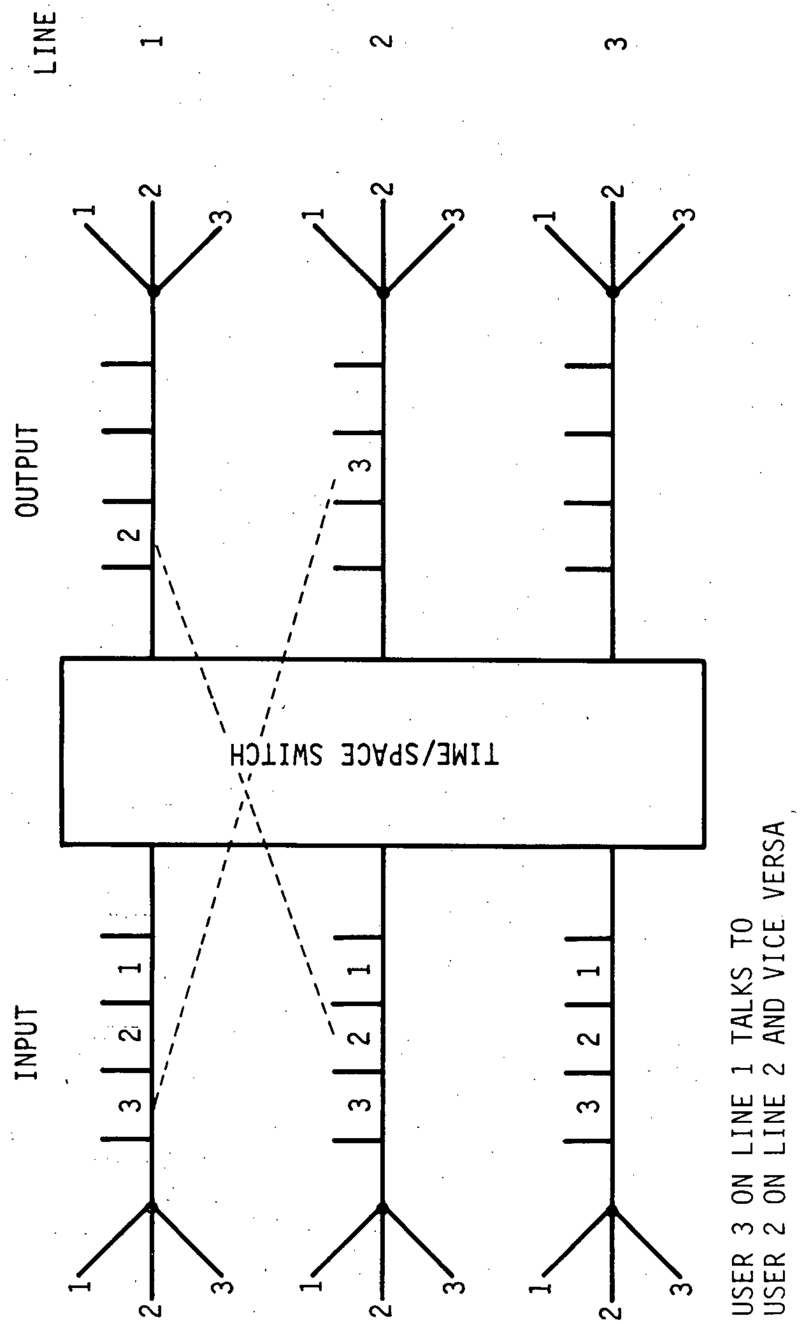
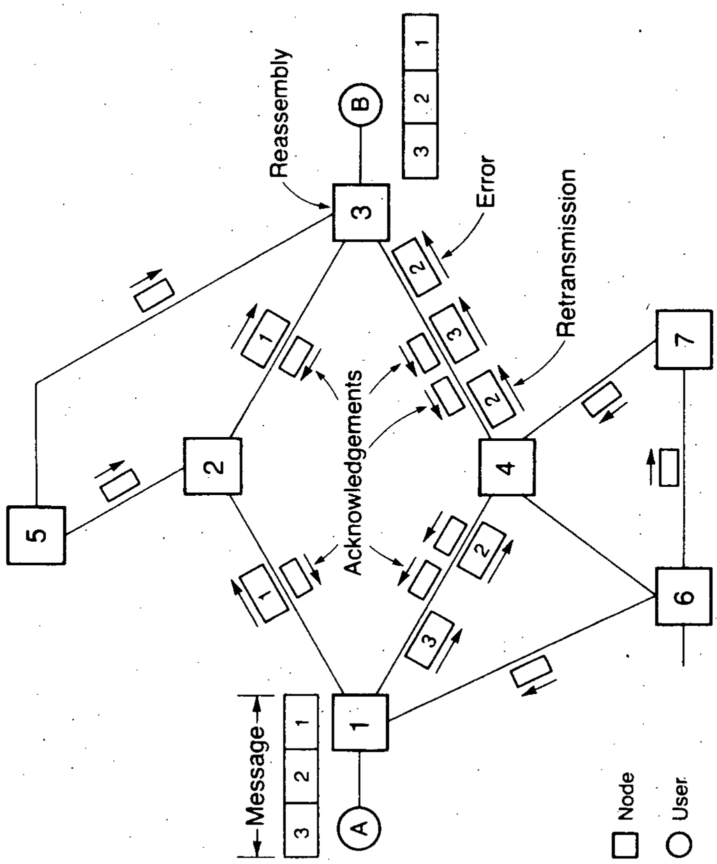


Figure 2-1. Basic Operation of a Circuit Switch



SOURCE: Reference 2

Figure 2-2. Basic Operation of a Packet Switched Network; Movement of a Three-Packet Message From User A to User B have the capability to correctly rearrange the packets. Transmission resources in this type of network are allocated on a dynamic or an as-needed basis.

Class III traffic is effectively handled by either circuit or packet switching networks. If real-time transmission is the premium, then circuit switching should be used, but transmission capacity will be inaccessible to other calls for long periods of time. If delays can be tolerated, packet switching allows other calls to send packets through the network. See References 2 and 3 for a more detailed description of circuit and packet switching networks.

A military communications network must be capable of much more than just performing switching functions. The network must operate under the extreme conditions inherent in a military confrontation. Table 2-2 shows some of the desirable characteristics and service features which will maintain reliable communications.

Table 2-2. Characteristics of a Military Network

1. Survivability and Endurability - Dynamic routing, self-diagnostic, and self-repair capabilities are necessary to maintain satisfactory operation throughout a conflict.
2. Security of Transmissions - Immunity to intercept and immunity to jamming is an obvious requirement.
3. Compatibility with Existing Networks - Where necessary or desirable.
4. Desirable Service Features
   - A. Precedence and preemption
   - B. Multiple addressing - one-to-many capability
   - C. Temporary message storage
   - D. Mode/code/speed flexibility
   - E. Message accountability
   - F. Storage of data
   - G. Low-error rates
   - H. Saturation routing - allows a subscriber to be located anywhere in the network

3. VOICE/CIRCUIT DIGITAL SWITCHING

There are basically four generations of telephone switching equipment that can be distinguished.

1. Step-by-step or 10-step exchanges are comprised entirely of bulky electromagnetic relays, many of the pulsed-rotary type from which the term "step-by-step" is derived. These use progressive control where each dialed digit successively sets up a communication path through the exchange. This is the simplest type of control to implement with electromagnetic components, but has the drawback that all equipment is tied up for the duration of the call and that even if a clear path is available it may not be properly selected because of an unfortuitous early step in the selection process. Exchanges built on this principle require a great deal of space and are very noisy in operation.

2. Crossbar exchanges are also composed of electromechanical relays but the "common control" principle permits some real improvements over step-by-step systems. All dialed digits are accumulated in a register, and then the equipment selects the optimal route. This arrangement uses less equipment to "hold" a call than to "establish" one, with a corresponding increase in operating efficiency. Crossbar equipment is considerably smaller than step-by-step, quieter in operation, easier to maintain, and uses less power.

3. The Soviet writings all refer to the third-generation equipment as "quasi-electronic" to distinguish it from the forth-generation; this nomenclature is not generally used in the United States. Quasi-electronic exchanges implement stored program control over the switching process with special-purpose digital computers, but the switching elements themselves are still basically electromechanical. Switching element contacts are usually enclosed in glass tubes, which greatly improves reliability. Because the control element is a computer, it is possible to introduce a variety of specialized services such as conference calling and call forwarding.

4. Fourth-generation exchanges are entirely digital with both the control computer and switching elements composed largely of integrated circuits. In contrast to the first three generations which were strictly space-division switches, time-division switching is often implemented in

fourth-generation equipment, which truly deserves its name "electronic switching."

The Soviet telephone network (OAKTS) still relies heavily on outdated first- and second-generation switching equipment. The Soviets will look to third- and fourth-generation equipment for near- to mid-term upgrades in the OAKTS. Figure 3-1 gives a comparison of the relative dates of introduction of telephone equipment into the telephone systems of the U.S. and Soviet Union. The MT-20, which has comparable technology to the Bell 4ESS, was introduced into the Soviet Union in 1981; nevertheless, the first Soviet-built MT-20 is not expected to be out until 1986. As a consequence of this significant lag in technology, the Soviets will rely heavily on imports as well as their domestic third-generation switches. The switching equipment expected to play a key role in the modernization of the OAKTS will be discussed in the remainder of this section. This equipment includes the MT-20, Kvarts, Istok, Metaconta 10S, and certain other equipment. See Reference 4 for a more detailed discussion of the OAKTS.

3.1 MT-20

One of the major deficiencies in the OAKTS has been automated long distance switching. In an effort to remedy this situation, the Soviets have imported the French-made MT-20, long-distance, electronic, digital exchange.

In 1979, Le Material Telephonic, a subsidiary of Thompson-CSF, entered into a contract with the Soviets to set up a turnkey operation to produce the MT-20. This agreement included direct sale of at least two MT-20s. There have been many misunderstandings which have delayed the production process. The first Soviet-built MT-20 is not due out until sometime later this year (1986). The transfer of this technology represents a major breakthrough for the Soviets in digital switching. The MT-20 will be the only all-electronic digital switch which the Soviets are capable of producing. It is expected to become their most prevalent long-distance exchange within the foreseeable future.

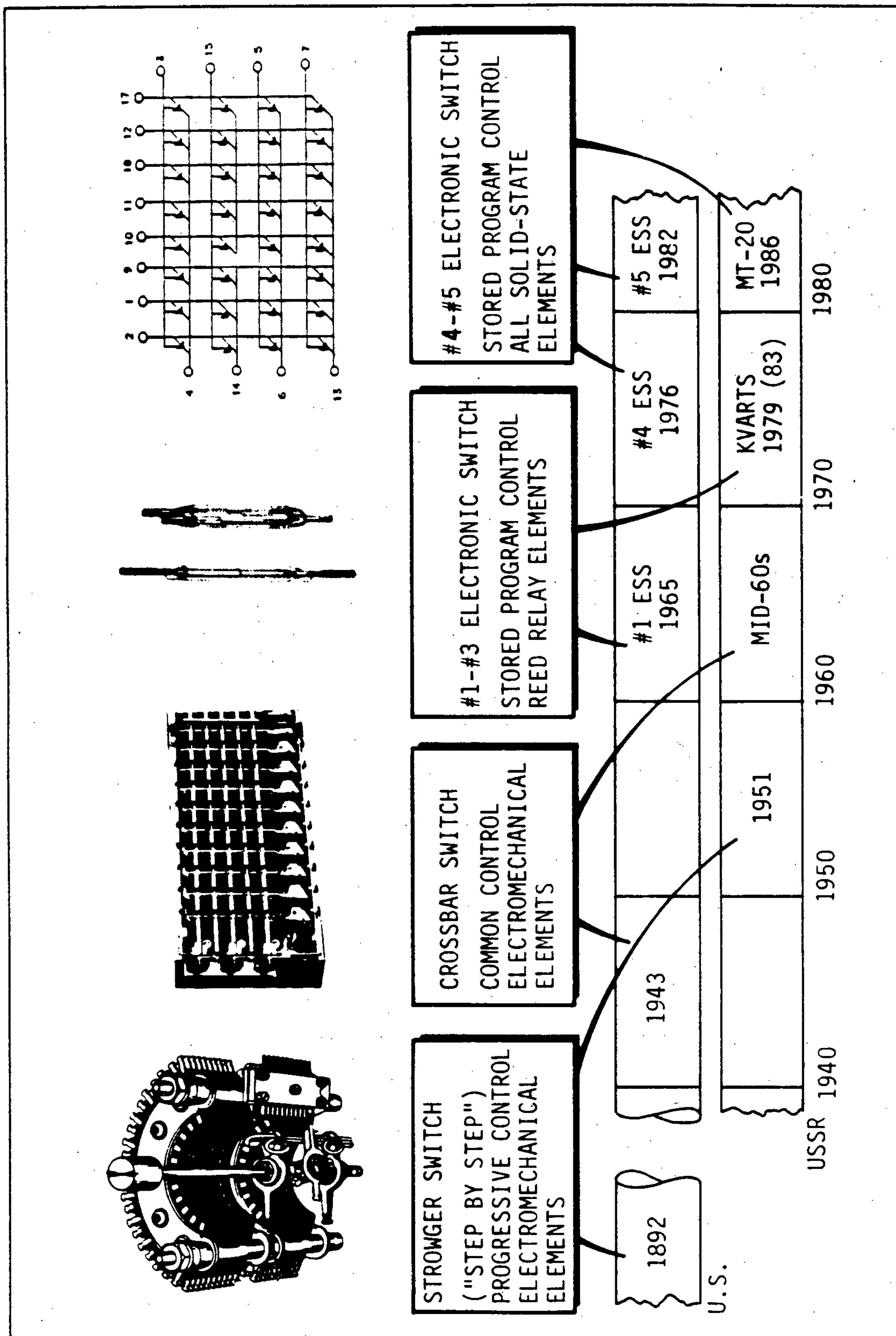


Figure 3-1. Comparative Timelines for Telephone Switching Evolution

The technology used in the MT-20 is similar to that used in the Bell 4ESS. The MT-20 is a stored, program-controlled, time-space division, digital switch. The control unit consists of two 32-bit computers operating in a load-sharing mode. The actual switching function is performed by arrays of symmetrical time division matrices (STDM). Each STDM can switch eight 2.048-mb/s PCM trunks with 32 channels each, thus forming a 256 by 256 switch. Each STDM is a single NMOS large scale integration (LSI) circuit containing approximately 22,000 transistors (Reference 5). Table 3-1 gives a comparison of the capabilities of the MT-20 and the Bell 4ESS.

Table 3-1. Comparison of MT-20 and Bell 4ESS

	Bell 4ESS	MT-20
Capacity	3360 PCM Trunks 107,520 Lines	2048 PCM Trunks 65,536 Lines
Busy Hour Call Attempts	550,000	350,000
Traffic Handling	47,450 Erlangs	20,000 Erlangs

3.2 KVARTS

The Kvarts is a long-distance, stored, program-controlled, quasi-electronic switch which was jointly developed by the Central Scientific Research Institute for Communications (TsNIIS), the Institute of Cybernetics of the Ukranian SSR Academy of Sciences, and the Robotron Association (GDR) (Reference 6). In July 1980, testing was begun on a prototype which was installed in Leningrad with its fault tolerant software incomplete. Despite this, the testing of the Kvarts was assessed positively and serial production was begun by April 1983 (Reference 7). An additional Kvarts was installed in Vil'nyus sometime before February 1982 (Reference 8). A Soviet author claims that, "During the 12th five-year plan (1986 to 1990), the Kvarts will be the basic type of long-distance exchange" (Reference 9).

The technology of the Kvarts is on about the same level as the Bell 1ESS. The switching elements are ferreeds or "gerkons" as they are referred to in the Soviet Union. Ferreeds were phased out of U.S. switches beginning in the early 1970s. It is curious that the Kvarts does not incorporate the gezakon which is the Soviet version of the remreed connector. Ferreed connectors consist of a reed contact sealed in a glass casing. Two semihard ferrite plates are required outside the glass casing to latch the connection. In the gezakon or remreed, the reed itself is made out of a semihard magnetic material called Remendur. Once the connection is made, the residual magnetism of the Remendur causes latching. The U.S. version of the remreed required four control coils, whereas Soviet efforts have reduced the number of control coils on the gezakon to two (References 10 and 11).

Stored program control is provided by a NEVA 1 control complex. Figure 3-2 shows the system layout. The NEVA 1 control complex is a special-purpose computer developed especially for new quasi-electronic switches. At present, the NEVA 1 is produced by GDR using the structual and elemental base of the Unified Computer System (RYAD). Two central processors with "parallel operation in a synchronized mode (without load sharing) ... give(s) the system its high reliability" (Reference 12). "Both control machines perform the same functions in making connections, and they compare the results of executing particular operations in servicing each call according to a definite schedule. When the results of some operations fail to match, the machine which is working properly initiates a test program to trace the fault in the malfunctioning machine, and continues to handle all calls" (Reference 6). The NEVA 2, which is basically a smaller version of the NEVA 1, is suitable for use in smaller exchanges.

The specifications of the Kvarts exchange are shown in Table 3-2.

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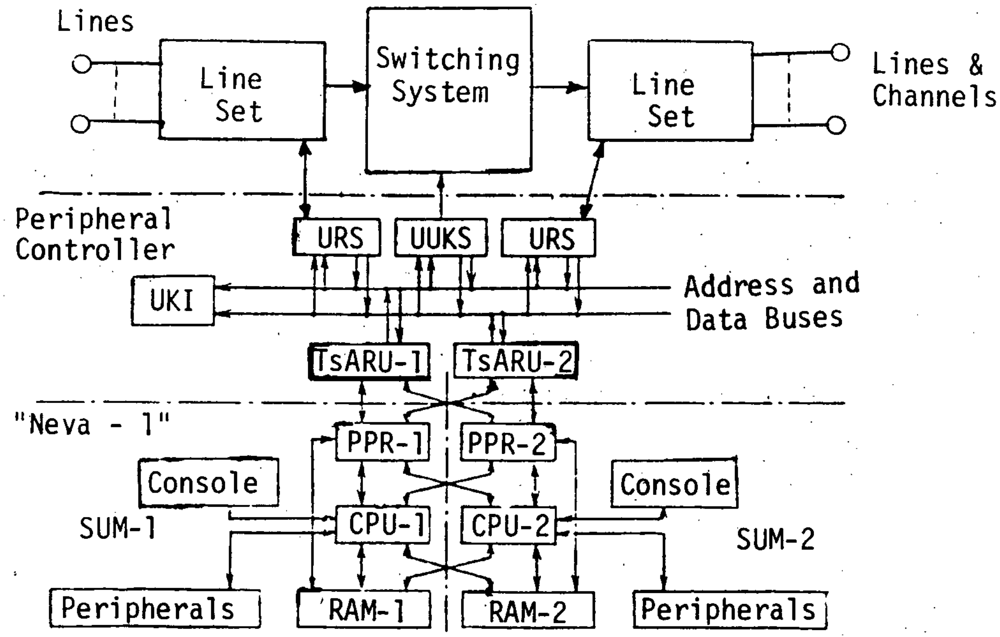


URS = Distribution & Scanning Control Device
UUKS = Switching System Control Device
UKI = Data Test Device
TsARU = Centralized Address & Distribution Device
PPR = Peripheral Processor
CPU = Central Processor
RAM = Random Access Memory
SUM = Special Purpose Machine

SOURCE: Reference 6

Figure 3-2. Block Diagram of "Kvarts" Exchange

3.3 ISTOK

The Istok is an integrated, quasi-electronic, analog-digital communications system. Istok was developed to bridge the gap between quasi-electronic and integrated digital networks. The main applications will be in the modernization of rural networks. This system is another result of collaboration between the German Democratic Republic (GDR) and the USSR. The basic switching elements, principal circuits, and software were developed by specialists in the USSR, while specialists in the GDR handled the basic construction, the production engineering, and the documentation of the mechanical design of the control equipment assembly. The concept of the Istok first appeared in the literature in the early 1970s (References 13, 14, and 15). Nevertheless, it was not until the late 1970s that tests were actually begun (Reference 16). The development of the Istok was possibly delayed until the NEVA family of stored-program control systems could be perfected. Test zones were set up in Istrinsky in Moscow and in Berlin. Tests were completed in 1980 and quantity production was started in 1981. The first production models were slated to be installed in Ogrsk RCC of the Latvian SSR (Lielvard) and in Saratov.

As previously mentioned, the main application of this system is in the modernization of rural networks. The basic idea is to tie rural automatic telephone exchanges (ATEs) together with an Istok exchange. This will allow rural telephone systems to economically realize the benefits of stored program control. These ATEs, which usually service 64 to 256 numbers, are linked to the Istok supporting exchange (SE) which can service up to 4096 lines. The SE then provides centralized stored program control for all the ATEs. Figure 3-3 illustrates this concept. Some of the services provided by Istok are abbreviated dialing, call break-in, call transfer, conference calling, time selective service limitation, waiting-call signal, and call origination.

The Istok is compatible with analog and digital signals. Figure 3-4 illustrates how this compatibility is achieved. Time

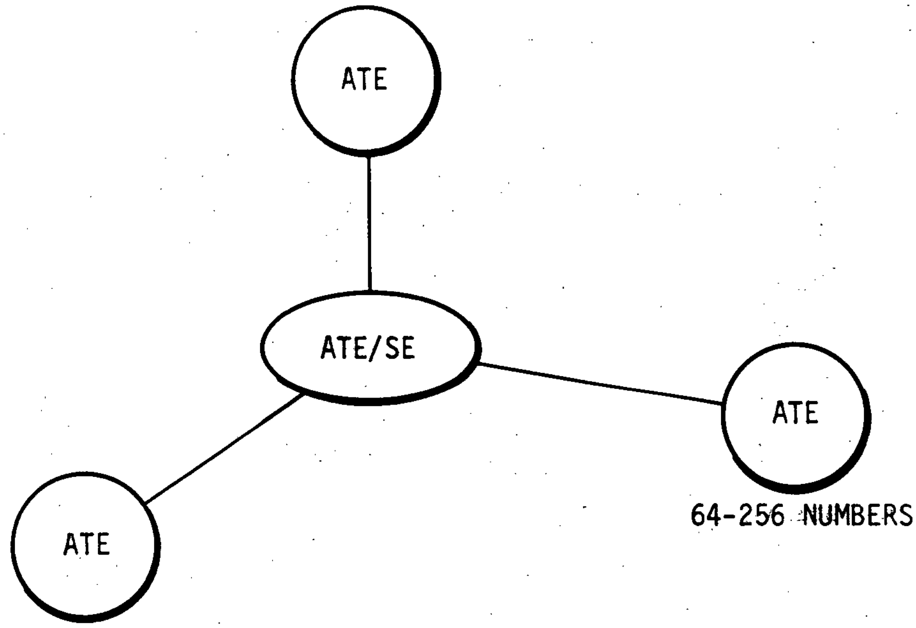


Figure 3-3. Istok Network of ATEs.

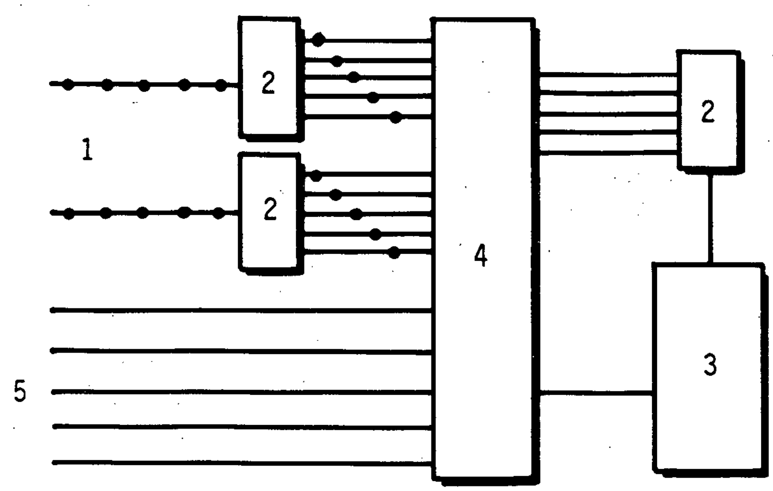


Figure 3-4. Configuration of the Istok Exchange

multiplexed digital signals (1) are separated spatially by time-space converters (2). Then both analog and digital signals are switched in a common space-division block (4). The digital signals are switched without demodulation which means that the crosspoints in block 4 must be able to handle analog and digital signals. Block 3 is a two-way, PCM converter which provides interface between analog and digital lines.

The multiple integrated connecting switch (MIS), which is the basic switching module, incorporates crosspoints known as gezakons, the Soviet counterpart of the U.S. remreed. The Soviet gezakon has provided the following advantages:

1. Manufacturing tolerances and control current tolerances were considerably widened,
2. A more planar construction which aided packaging,
3. The number of control windings was minimized to two,
4. The physical size was reduced, and
5. Suitability to multiple assembly line production improved.

The switching concept employed by the Istok is only practical if less than 50% of the lines are PCM trunks. If more lines are digital than analog, it would be more practical to use an all-electronic switch. This indicates that the Soviets expect the ratio of digital-to-analog systems in the rural networks to stay below 50% for quite some time.

3.4 OTHER MISCELLANEOUS EXCHANGES

Table 3-2 gives a summary of Soviet telephone exchanges using third- or fourth-generation technology. The Metaconta 10S is believed to be a minimally modified version of the Metaconta 10C (Reference 17). Iskra produces this exchange under license to ITT. If the Soviets are not able to acquire fourth-generation urban exchanges such as the MT-25, then the Metaconta 10S will probably continue to be procured. The Kvant is simply a large PBX that has been modified to work as a rural end exchange. The EP-128, as the table shows, is a Bulgarian PBX.

Collaboration between GDR and USSR under Unified Communication System for Analog and Digital Switching (ENSAD) has lead to the GDR-built OZ series of exchanges (Reference 18). The OZ 1000 is an autonomous, microprocessor-controlled local exchange. A K1520 microcomputer system built by Robotron serves as the controller. The concept and the design of the OZ series is probably very similar to the Istok.

Table 3-2. Soviet Third- and Fourth-Generation Exchanges

Exchange	Generation	Capacity	BHCA	Intended Use	Maker
MT-20	Fourth	65,536	350,000	Long-distance toll switch	Thompson-CSF (French)/ USSR turnkey operation
Kvarts	Third	8,000	175,000	Long-distance toll switch	USSR/GDR
Istok	Third	4,096	?	Rural nodal exchange	USSR/GDR
Metaconta 10S	Third	63,488	300,000	Pure local, local/inter-city, large transit	Iskra/ Yugoslavia
Kvant	Third	2,048	?	Rural exchange, large PBX	USSR
EP-128	Third	400	?	PBX	Bulgaria
OZ-1000	Third	256 to 1024	?	Local exchange	RFT/GDR

4. DATA/PACKET SWITCHING

A good starting point in the evaluation of the Soviet SOTA in data/packet switching is the investigation of the work produced by the Institute of Electronics and Computer Engineering of the Latvian SSR Academy of Sciences. A review of some of the numerous articles written by E. A. Yakubaytis, who is vice president of the Riga Academy, will provide some insight into Soviet philosophy on data transmission networks. Since Yakubaytis is in a position of authority at the Soviet "test-bed" for computer networking, it probably is a valid assumption that his views are representative of Soviet philosophy.

Soviet thinking seems to be directed toward building independent local-area networks and then tying these small networks together into republic or statewide networks. Figure 4-1 is a representation of what Yakubaytis calls information computer networks (Reference 19). The basic building block consists of a medium-size computer such as a SM-4 along with its 5 to 15 data terminals. Several of these subscriber systems are then interconnected via a communications subnetwork to form a local area network. Local area networks are then interfaced with the main communications system to form an information computer network. This layout allows computer resources to be distributed at various locations instead of concentrated at a single node. Also, data and limited computer power are more efficiently utilized. Both of the above factors are important considerations in a military network where survivability is a necessity.

Local area networks can be evaluated by four characteristics (Reference 20): traffic handling capability, reliability of transmission, connection time, and transmission rate. With respect to these characteristics, Yakubaytis identifies five major configurations for the communications subnet. Figure 4-2 shows that they can be classified as information routing or information selection networks. In information routing, the packets are routed through the communications subnet directly to the addressee. In information selection, the packets

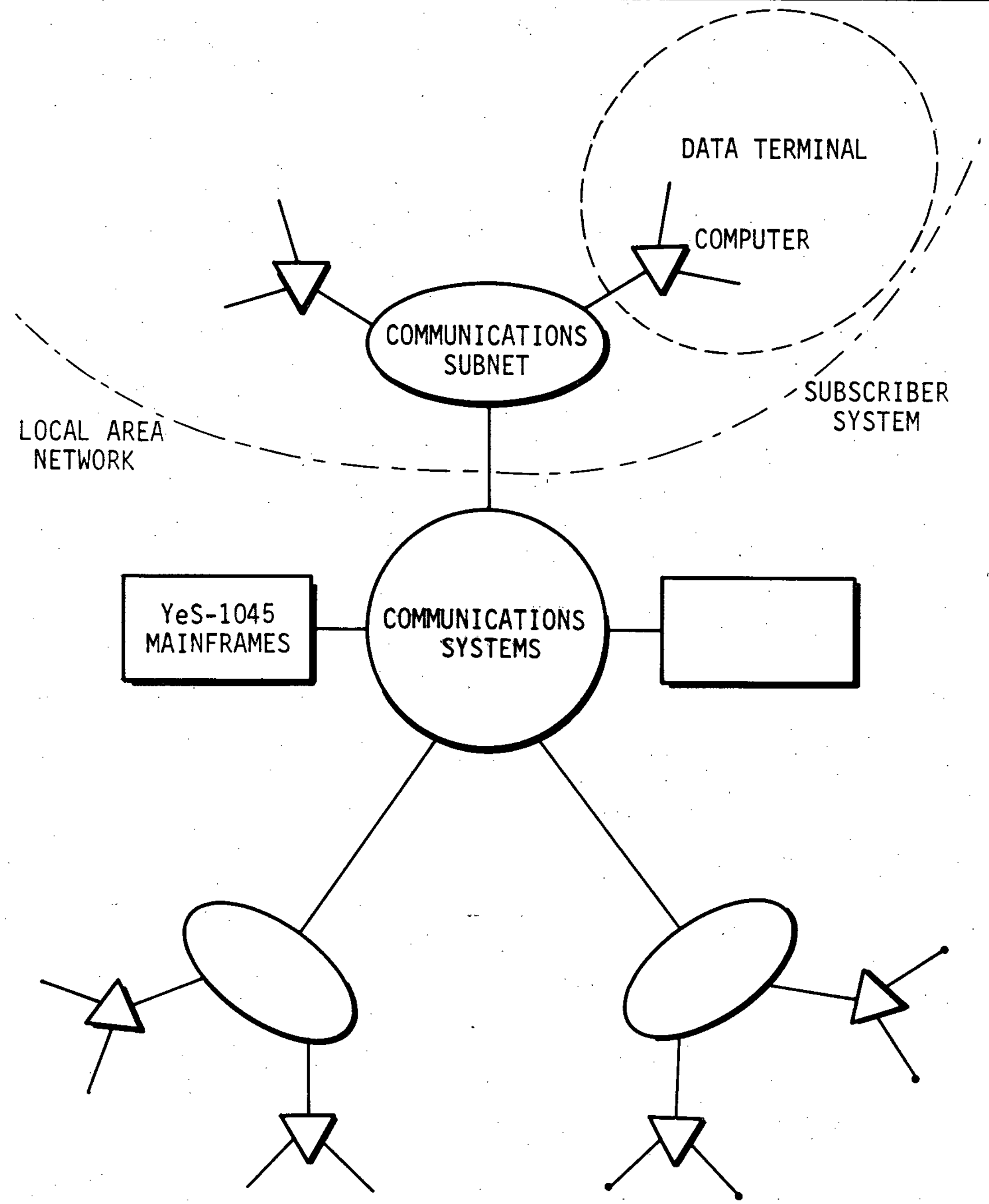


Figure 4-1. Information Computer Network

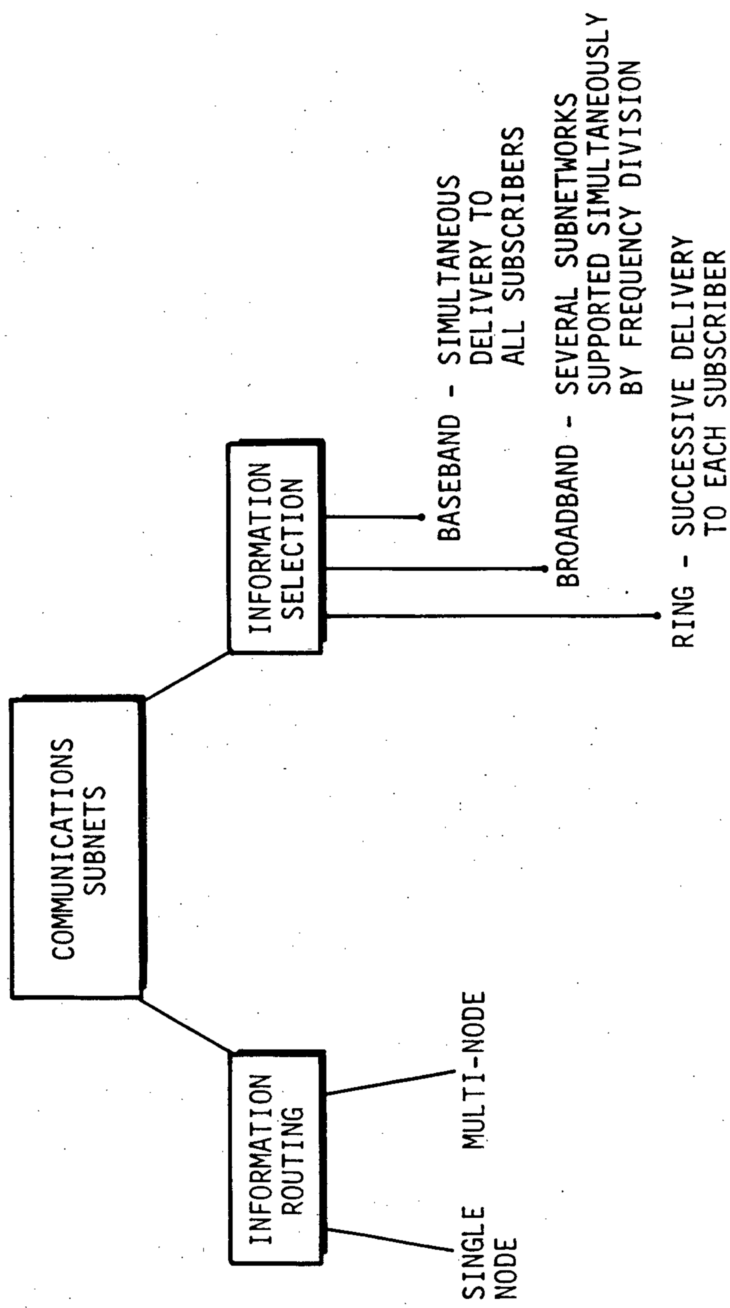


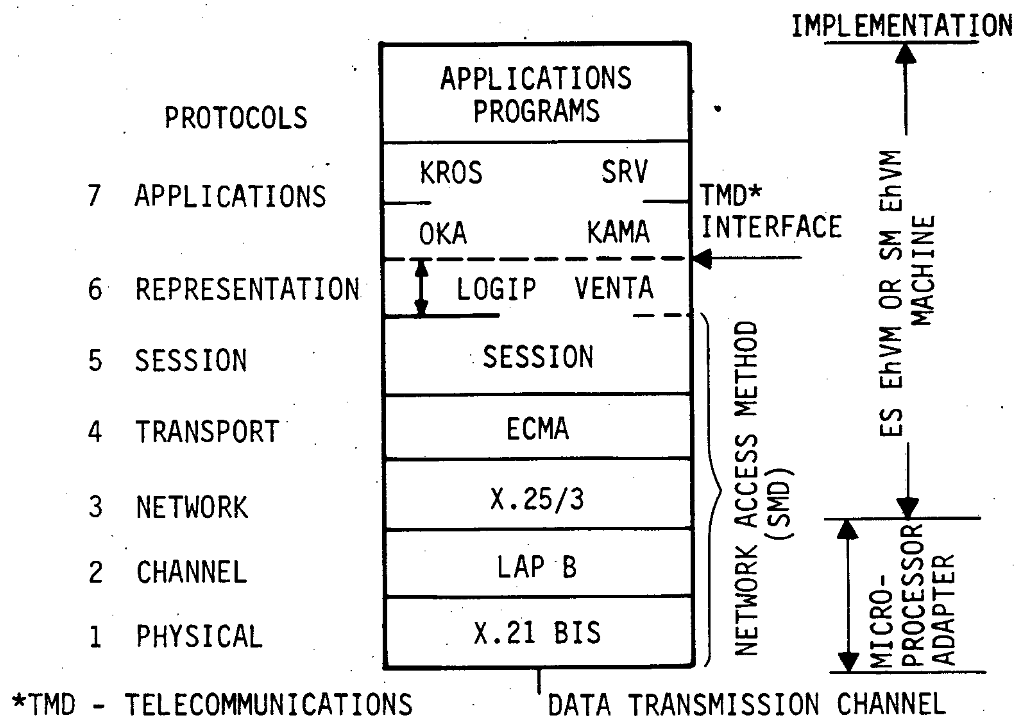
Figure 4-2. Communications Subnetworks

are delivered to a bus which is connected to all the subscribers. It is left up to the subscriber to select the packets of interest. Each of these configurations has its uses depending on the size of the network, but the most common configuration is information routing.

Another notable paper by Yakubaytis (Reference 21) presents a conceptual architecture for creating an open computer network using YeS EhVM and SM EhVM series computers. The seven-level ISO conventional architecture is employed (Figure 4-3). The bottom three levels (physical, channel, and network) facilitate implementation of the X.25 international standard. The fourth (transport) level employs a version of the protocol proposed by the European Organization of Machinery Producers (ECMA). The fifth (session) level protocol was developed by the Institute of Electronics and Computer Engineering of the Latvian SSR Academy of Sciences. The top two levels (representation and applications) employ the ES EhVM standards which define the functioning of the software complexes designated KROS, SRV, OKA and KAMA. The complex of programs that implement the five bottom levels in the ES EhVM or SM EhVM is called the network access method (SMV).

Implementation of the two bottom protocol levels shown in Figure 4-3 is provided by a microcomputer-based network microprocessor adapter (SMA). The ES EhVM or SM EhVM machine implements the protocols of levels three through seven and executes applications programs. As a result, the ES EhVM or SM EhVM machine, in conjunction with the SMA, forms the subscriber system of the computer network. Subscriber systems within a network are divided into working, terminal, administrative, and interface.

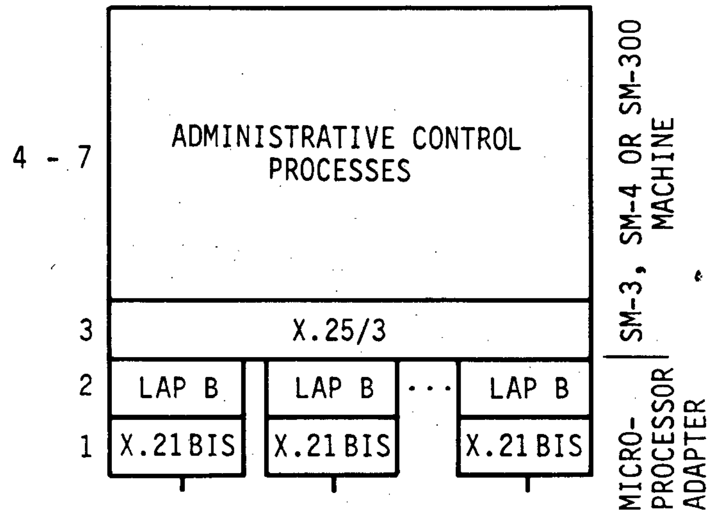
The structure of the communications system (within the open computer network architecture) is shown in Figure 4-4. The first two protocol levels, like in the subscriber system, are implemented by the SMA. The other levels are executed by SM-3, SM-4, or SM-300 minicomputers. The communications system is thus made up of an SM EhVM minicomputer and "g" adapters, where "g" is the number of data transmission channels leading to the communications systems.



*TMD - TELECOMMUNICATIONS ACCESS METHOD

SOURCE: Reference 20

Figure 4-3. Protocol Layering



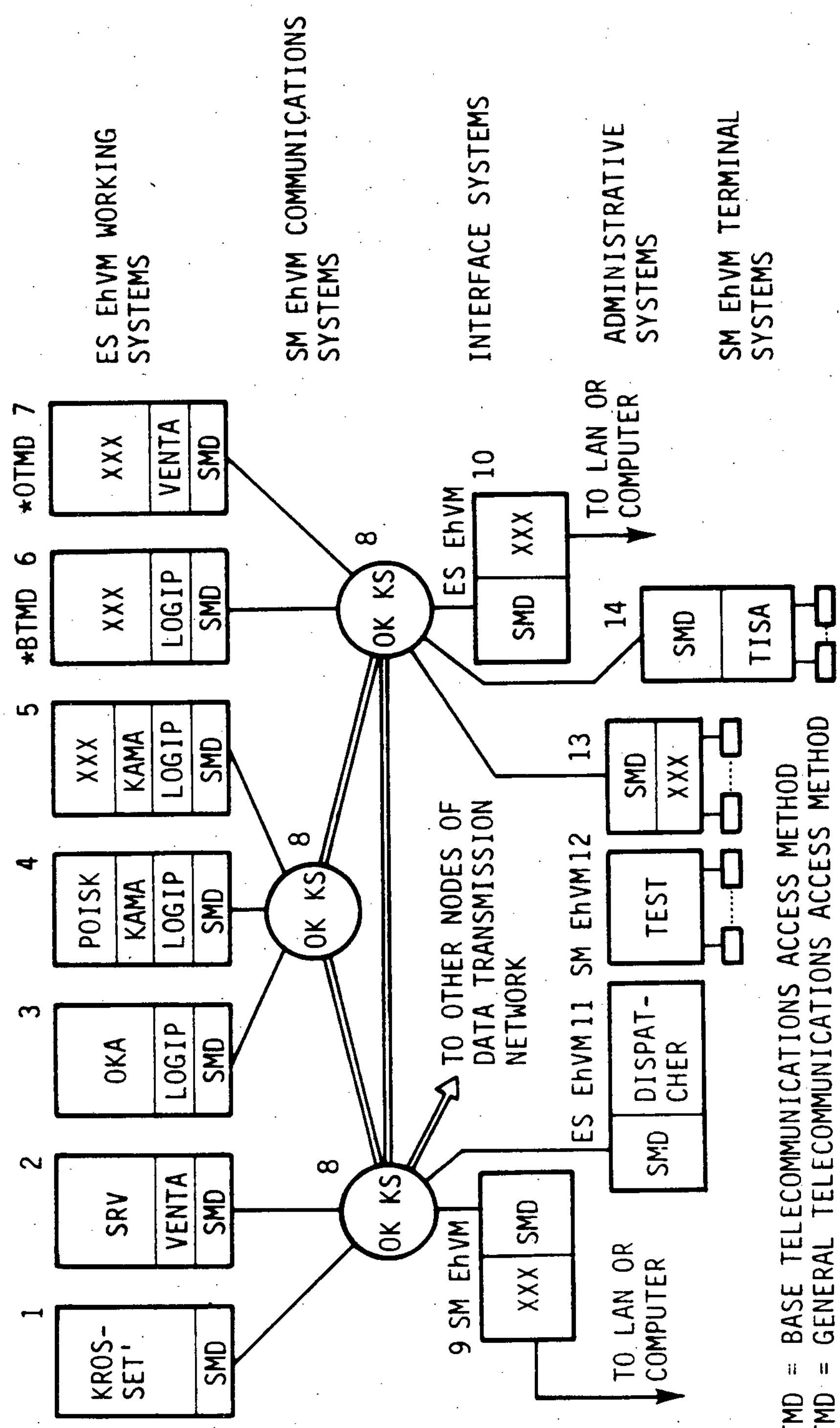
SOURCE: Reference 21

Figure 4-4. Structure of Communication System

The program complex shown in Figure 4-3 can serve as the basis for different types of computer network systems. Figure 4-5 shows 14 different types of systems that execute different tasks within the network. The notation XXX is used to designate programs written by developers or users.

Program complex eight, called OSKS, makes up the X.25 communications system. The use of one or several communications systems makes it possible to create a data transmission network. In accordance with Recommendation X.25, a computer network is formed by adding subscriber systems to this network.

Several interesting observations can be made based on the writtings of Yakubaytis. There is a distinct push to develop compatible computer hardware. Emphasis is on designing modular computer networks which are based upon domestic SM and YeS series computers. In order to



*BTMD = BASE TELECOMMUNICATIONS ACCESS METHOD
*OTMD = GENERAL TELECOMMUNICATIONS ACCESS METHOD

SOURCE: **Reference** 21

Figure 4-5. Computer Network Components

develop compatibility in a network environment, protocols must be established. Since the YeS series of computers are for the most part "reverse engineered" IBM mainframes, one might expect use of the Systems Network Architecture developed by IBM. However, Soviet literature clearly emphasizes compliance (for civil networks) with the ISOs seven-level protocol for "Open Systems Interconnection." The lower three levels of the protocol should be implemented using the CCITT recommendation X.25. Compliance with these standards would allow the Soviets to fully utilize any Western and European equipment they should happen to obtain and would also provide easier access to Western data bases. See Reference 22 for more information on the OSI model, SNA, and network protocols in general.

The Soviets do not have a nationwide data transmission network such as the U.S. Arpanet. One of the primary hindrances to their development of such networks is the inadequacy of the OAKTS for data transmission. Most examples of operational Soviet computer networks are limited to relatively small local area networks which are usually associated with one of the Science Academies. Several examples of these are described on the following pages.

4.1 LATVIAN SSR ACADEMY OF SCIENCES NETWORK

Perhaps the most extensive (and certainly the one best publicized in the United States) is the experimental computer network of the Latvian SSR Academy of Sciences (Figure 4-6). That network currently serves some dozen institutes located in Riga; its growth from 1977 to 1981, traced in Figure 4-7, is illuminating. High-level satisfaction with this effort is evidenced by the large amount of new equipment (2 to 3 systems) received each year and, even more significantly, by receipt of new computers less than two years after they entered series production. It is thus not surprising that a "computerized information network (Akademnet) developed at the Institute of Electronics and Computer Technology at Latvia Academy of Sciences" is to be used to link "all institutes of the USSR Academy of Sciences and

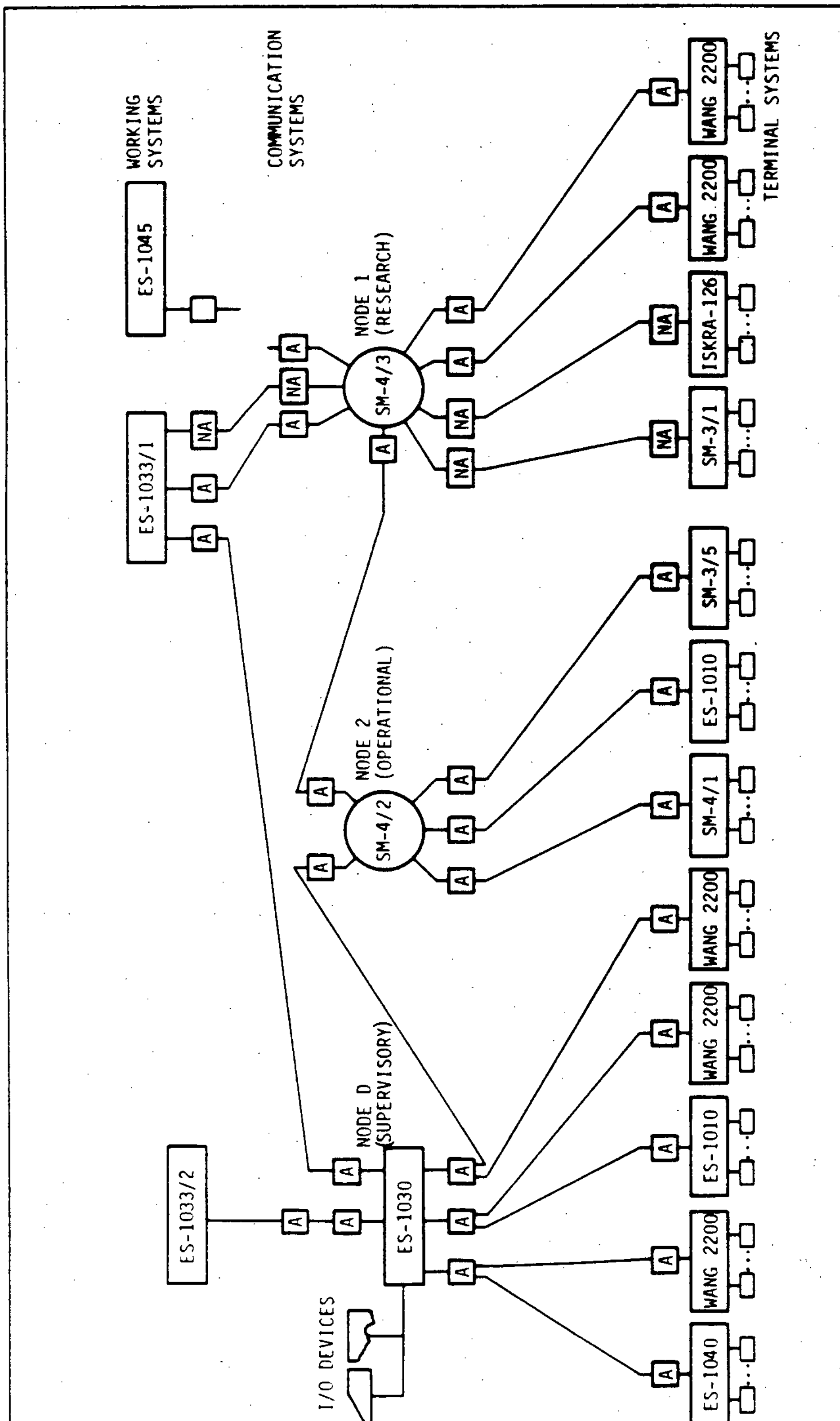


Figure 4-6. Experimental Computer Network of the Academy of Sciences of Latvian SSR (Circa 1981)

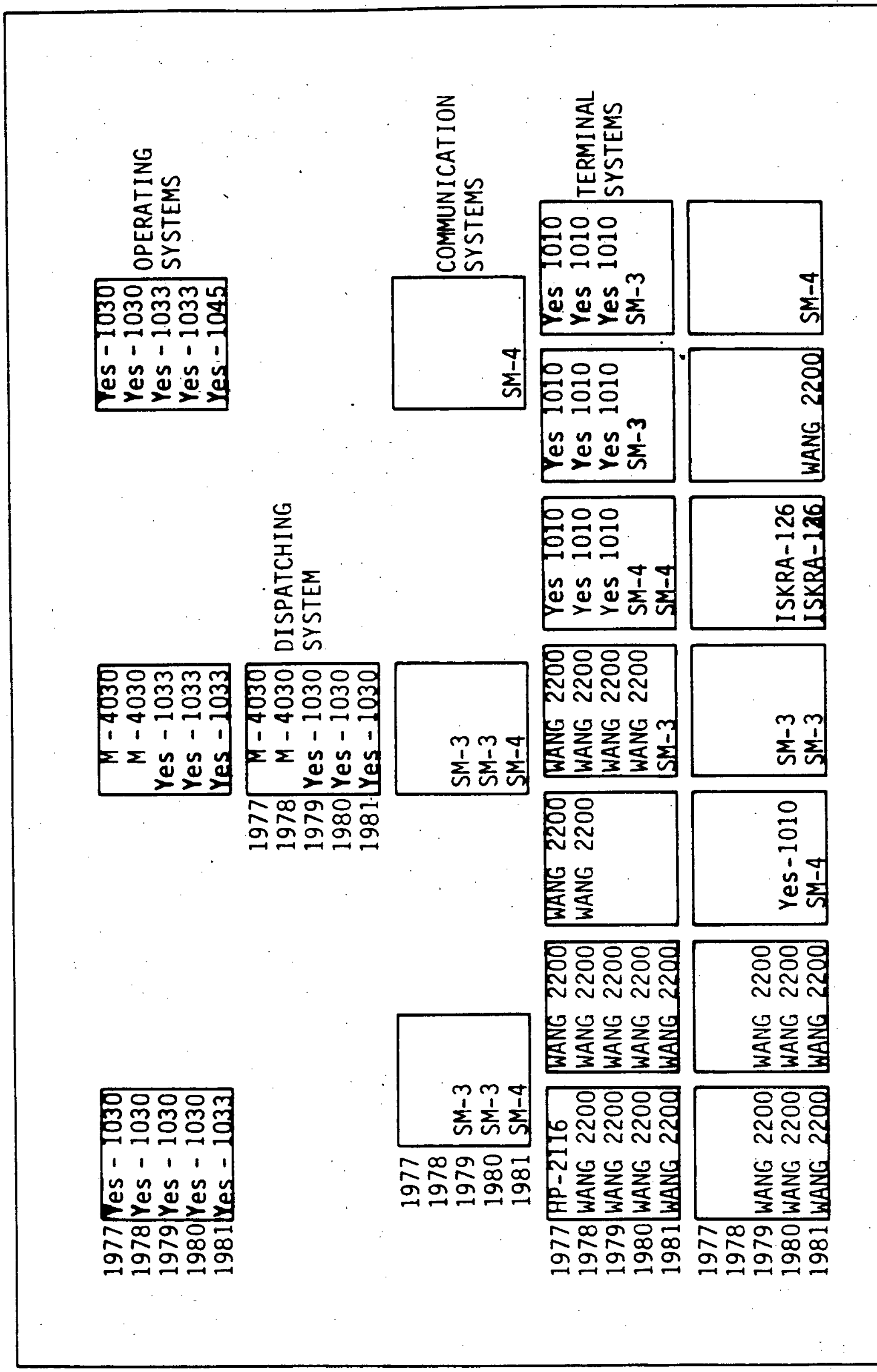


Figure 4-7. Experimental Computer Network of the Latvian SSR Academy of Sciences

Academies of the Union Republics" (Reference 23). An experimental section was already in operation in 1984 linking Riga, Leningrad, and Moscow. In 1984 the experimental intercity network would support only a 300-baud data rate, but "this will soon be increased to 1200." There are eventual plans for joint projects to develp such networks linking all CEMA members.

4.2 SEKOP NETWORK

A 1983 paper described an experimental shared-resource computer network nicknamed SEKOP (which possibly expands to "Set' Kommutatstii Paketov" or packet switching network), which had been in operation since at least 1978 (Reference 24). It consists of BEhSM-6 computers controlled by a Dispak operating system with virtual memory, termed information processors, and M-6000 ASVT-M process control computers, which function as network processors. These network processors support duplex data exchange in the packet-switching mode between any pair of information processors in the network. Each pair of network processors is connected by 10 simplex data transmission channels (5 in each direction) which are independently bidirectional. An APD-MA-TF data transmission set supports a 1200-baud keying rate. Effective data transmission rate between a pair of network processors is about 925 bps.

It is clear that the X.25 protocol is not being used in this network, probably because the high overhead of that format would slow data transfer unacceptably. Instead it apears that a simplified, four-level protocol model (Level 1 - physical control, Level 2 - data link layer, Level 3 - network control, and Level 4 - general functional protocol) has been adopted. (It should be noted in passing that U.S. DoD utlizes a somewhat similar four-layer protocol in Arpanet and other applications consisting of network access layer, internet, protocol, transmission control protocol, and several process/application layer protocols. It will be at least eight years before DoD transitions to ISO compatible protocols (Reference 25).) Developers are interested in replacing the M-6000 with an SM-2 and the 10 simplex data transmission channels with one 48-kilobaud duplex channel. This will reduce delay in delivering a single packet by about 2.4 s, and may make switchover to an X.25-based protocol feasible.

4.3 COLLECTIVE USE COMPUTER SYSTEM FOR THE ACADEMY OF SCIENCES KaSSR KAZAKH

It is planned to create a collective use computer system (VSKP) for the Academy of Sciences KaSSR (Reference 26). The intent of the VSKP is to "... increase scientific research efficiency ... through the use of modern mathematical methods and computer technology." This project will supply the computer power of YeS series mainframes by incorporating them into the network. A prototype for this network was operating as of March 1985. Five SM-3 or SM-4 computers are used as pre-or post-processors between data terminals and the central computing facility, currently equipped with YeS 1022 and 1045 mainframes. The local computer complex (SM-3 or SM-4) performs the following tasks:

1. Reception and processing (pre or post) of subscriber information and
2. Communication handler.

Later stages of development are expected to employ more advanced networking schemes using packet switching techniques. The ultimate goal is to link this network with the Akademnet. One key feature of this system is the emphasis on use of domestic equipment.

4.4 OGAS

The Soviets have undertaken a project to construct a Statewide Automated Management System (OGAS) (References 27 and 28). During the ninth and tenth five-year plans (1971 to 1980), computers were introduced into various levels of economic management. OGAS is an attempt to consolidate these automated management systems (ASU) into a centralized network for planning and management. There are approximately 600,000 organizations, enterprises, industries, associations, etc. which will ultimately be put on line. The concept of OGAS was officially announced in 1971. OGAS was originally planned to be complete in 1990, but various problems with the acquisition of needed technologies have slipped completion to at least 2000.

Figure 4-8 shows the technological requirements which are separated into two categories. The Soviets feel that concentration of computer resources into shared-resource computing centers will make the most efficient use of equipment. The State Computer Center Network (GSVTs) will be linked via the National Data Transmission System (OGASP) which is a subset of the YeASS.

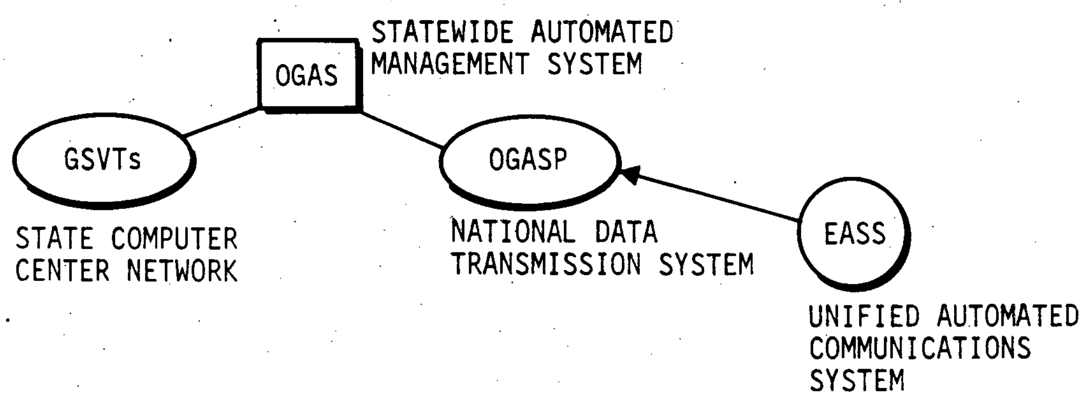


Figure 4-8. Technology Base for OGAS

OGAS will employ a four-level hierarchy shown in Figure 4-9. The bottom level will contain 90% of the information flow. According to Soviet estimates, 200 territorial computer centers, 2500 cluster computer centers, and 22,000 organizational computer centers should be able to meet the requirements of 600,000 organizations. The success of

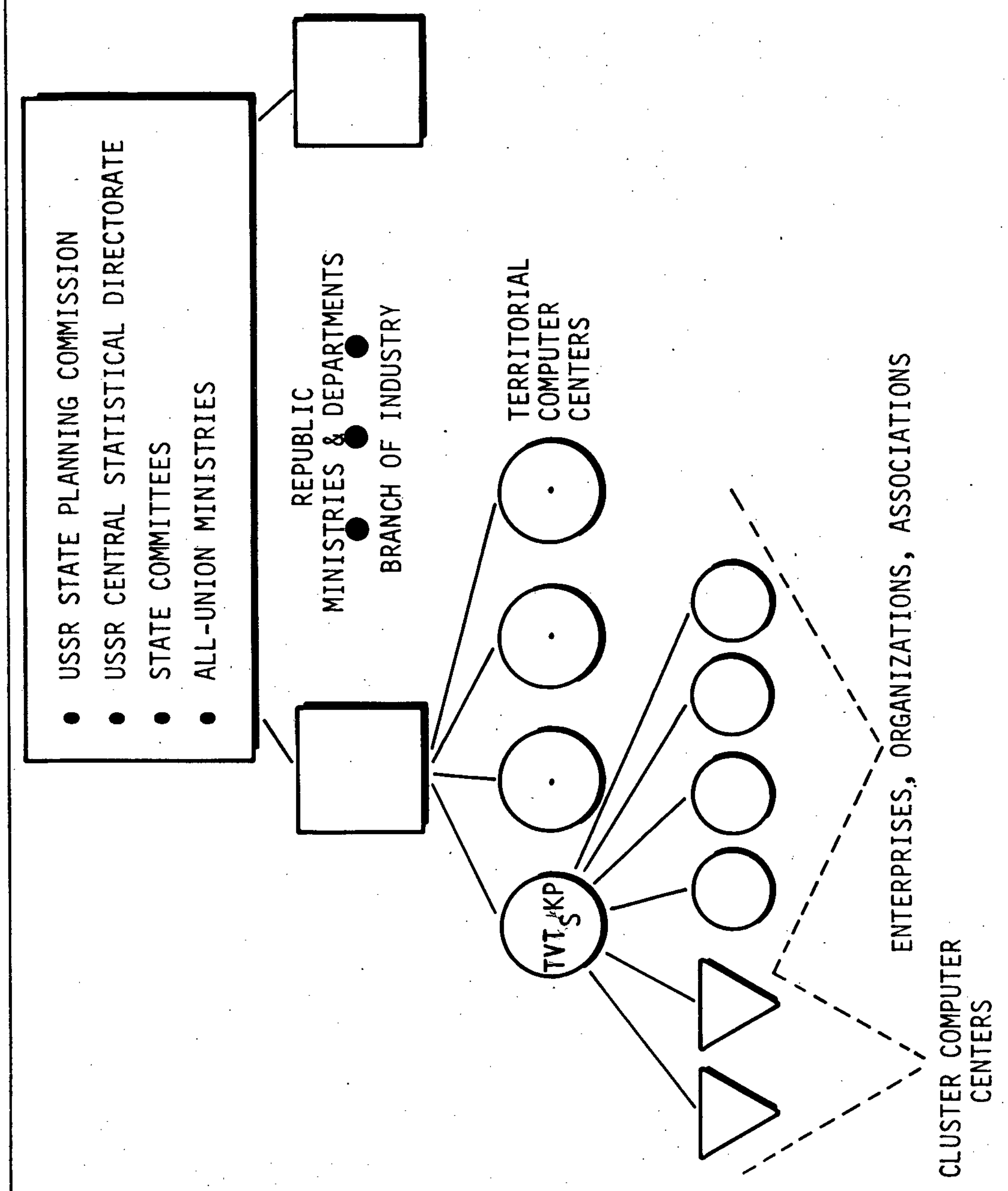


Figure 4-9. Organization of OGAS

OGAS is dependent on providing a reliable, efficient, high-speed data transmission system.

Interim transmission media will be provided by the telephone network (OAKTS) and the PD-200 network. The telephone network is less than suitable for digital transmission because of obsolescent switching exchanges. The planned upgrades in the OAKTS will begin to alleviate some of these problems. The PD-200 is a 200-pbs data transmission network, which has dedicated circuit-switching nodes (Reference 29). Initial expansion of the PD-200 was rapid. As of 5 January 1981, 129 stations were included in the network. However, major problems soon became evident. In January 1982, only 25% of the installed capacity was operational. Among the difficulties were problems with the installation and repair of the TAP-2 Hungarian-manufactured subscriber equipment and the training of subscriber personnel. In addition, there is apparently a lack of confidence in system performance. The ultimate goal for 1990 is to have a network operating at speeds up to 48 kb/s. This network is expected to employ packet switching techniques.

The computing power for OGAS will be supplied by the YeS (unified system or Ryad) series of computers and peripherals. Operation of a network this size depends heavily on standardization of components.

5. SUMMARY AND PROJECTIONS

5.1 VOICE/CIRCUIT DIGITAL SWITCHING

The SOTA in digital circuit switching in the Soviet Union is the MT-20 switch. The introduction of this technology and the ability to produce such switches falls behind comparable efforts in the U.S. by 10 years. Another indicator of the Soviet lag in circuit switching technology is their continued emphasis on quasi-electronic exchanges. Realizing that they are too far behind to catch up on their own, they have turned to imports as a near- to mid-term solution. The MT-20 and MT-20 upgrades are likely to be the cornerstone of long-distance switching into the year 2000 assuming the Soviets are unsuccessful in obtaining more modern Western technology due to export controls.

Near-term urban switching will probably rely on crossbar exchanges that are already in place. A requirement that all businesses with more than 50 phones have a PBX should relieve some of the pressure on urban exchanges. As of now, the Soviets do not have a fourth-generation urban digital exchange. They may look to third-generation exchanges such as the Metaconta 10S for near- to mid-term use while they continue efforts to import fourth-generation equipment such as the Thompson-CSF MT-25. The Istok system is obviously expected to be the major upgrade to rural service for some time, probably for 15 to 20 years.

Conversion to an all-digital telephone network will begin by introducing digital equipment into sectors where present investment in automatic analog equipment is at a minimum. An excerpt from a Soviet paper clearly indicates their plans for modernization. "According to the concept of the Electronic Automatic Telecommunications System of the USSR, the telecommunications network is divided into toll, zone, and local networks. The local networks are, to a great extent, saturated with analog equipment; and the toll network is also fairly well developed. The least covered part is the zone network and the creation of the digital network in the USSR should obviously be started in this part by using the PCM-120 digital transmission systems designed for zone networks. Through the introduction of digital toll offices at the same level, a fully digital network section can be set up, and the development can be performed in both directions of the hierarchic structure of the Electronic Automatic Telecommunications Systems, namely toward the toll and local networks." (Reference 30). Clearly a medium-sized digital exchange such as the MT-20 is ideal for this application.

5.2 DATA/PACKET SWITCHING

In direct contrast to their philosophy on voice/circuit switching, the Soviets are emphasizing the use of domestic equipment in developing data/packet switching networks. The literature allows us to make several observations about their future computer networks:

1. They will employ domestic equipment wherever possible, namely SM and YeS series computers,
2. Use of adaptive information routing algorithms, and
3. Adherence to the ISOs OSI seven-level protocol and the CCITTs X.25 interface recommendation.

If the Soviets achieve by the year 2000 the goals they have established, OGAS will be operational. It will serve some 600,000 users, and the Akademnet will link all the science academies. These goals are unrealistic for two major reasons: 1) the present transmission system is inadequate to support digital signals and 2) there is very limited experience in the actual implementation of large-scale packet switched networks.

The Soviets are also investigating the feasibility of establishing an integrated services digital network (ISDN). The concept of a unified communications network (YeASS), which is discussed in Reference 4, is directly compatible with ISDN.

In 1980, Stanislav I. Samoylenko, Deputy Chairman of the Council of Cybernetics USSR Academy of Sciences, attended the 5th International Conference on Computer Communications (Atlanta, 27 to 30 October) (Reference 31). During this conference, Mr. Samoylenko spoke of Soviet interest in an adaptive switching technique. We are uncertain about the switching format but there seemed to be quite a bit of U.S. interest. The format is possibly a hybrid switching technique such as the master frame packet switching approach (Reference 2). Another Soviet paper, Reference 32, investigates possible switching formats for an ISDN, namely fast channel-switching (ISDN-CHSW), packet-switching (ISDN-PSW), and hybrid switching (ISDN-HSW). After some detailed analysis, this author concludes that, "... in the coming years, the efforts of scientists and engineers will be concentrated on developing the ISDN-PSW as an economic telecommunications network."

REFERENCES

1. Ross, M. J., "Military/Government Digital Switching Systems," IEEE Communications Magazine, May 1983, pp. 18-15.

2. Rosner, Roy D., Packet Switching, Lifetime Learning Publications, Belmont, CA, 1982.

3. Bellamy, John, Digital Telephony, Wiley-Interscience, 1982.

4. "Modern Soviet Civil Telecommunications," Dynetics, Inc., TR-86-UCA-033, February 1986 (FOR OFFICIAL USE ONLY).

5. MT-20 Technical Brochure, Thompson-CSF, France, 1983.

6. Dedoborsch, V. G., "Construction Features of Kvarts Quasi-Electronic Automatic Long-Distance Telephone Exchange," Ehlektrosvyaz, No. 4, 1983, p. 79, W31-36-84.

7. Koblents, Ya. G., et al., "Results of Experimental Operation of Quasi-Electronic Automatic Long-Distance Telephone Exchange," Ehlektrosvyaz, No. 4, 1983, p. 65, W31-36-84.

8. Shlyapoberskij, V. I., "Microelectronics in Communications Equipment at 1983 Leipzig Spring Fair," Ehlektrosvyaz, No. 10, 1983, p. 195, W31-36-84.

9. Aleshin, A. A., "Methods of Automated Long-Distance Telecommunications," Ehlektrosvyaz, No. 4, 1983, p. 47, W31-36-84.

10. Haugk, G. and Walsh, E. G., "Remreed Switching Networks for No. 1 and No. 1A ESS," Bell System Technical Journal, Vol. 55, No. 5, May-June 1976.

11. Misulovin, L. Ya., et al., "A Multiple Remreed Connector," Ehlektrosvyaz, No. 4, 1982, pp. 12-15.

12. Beskind, A. A., et al., "Construction and Use of Computers of the 'NEVA' Family," Ehlektrosvyaz, No. 7, 1979, pp. 16-20.

13. Adzhernov, S. A., "General Principles of the Construction of IQE ADCS, Part I," Ehlektrosvyaz, No. 10, 1975, p. 2.

14. Baklanov, Yu. A., et al., "Equipment Complex of the IQE ADCS, Part II," Ehlektrosvyaz, No. 10, 1975, p. 6.

REFERENCES (Continued)

15. Groya, A. E., et al., "The Integrated, Quasi-Electronic, Analogue-Digital Communications System IQE ADCS," Ehlektrosvyaz, No. 9, 1981, p. 48.

16. Misulovin, L. Ya., "The Results of Tests of the ISTOK Integrated Analog-Digital Unified Communication System," Ehlektrosvyaz, No. 9, p. 1.

17. Metaconta 10C, Technical Brochure, Iskra, Yogoslavia, 1983.

18. Trade Technical Review, ATCH-2252086183, 1983, Volume 2, pp. 14-16.

19. Yakubaytis, E. A., "Information Networks," JPRS USSR Report: Cybernetics and Automatic Control, 7 October 1985, pp. 64-70.

20. Yakubaytis, E. A., "Communications Subnetworks of Local-Area Networks," Automatic Control and Computer Sciences, Vol. 18, No. 6, 1984, pp. 32-52.

21. Yakubaytis, E. A., "Open Computer Network Architecture," Automatic Control and Computer Sciences, Vol. 17, No. 4, 1983, pp. 307, also W31-44-84.

22. Voelcker, John, "Helping Computers Communicate," IEEE Spectrum, Vol. 23, No. 3, March 1986, p. 61.

23. "Computerized Information Network for all Soviet Institutes," TASS, 29 December 1984 (0955).

24. Boguslavskiij, L. B., et al., "Use of Modeling and Measurement to Investigate SEKOP Network," Automatic Controls and Computer Sciences, No. 2, 1983, p. 21, Translation W31-18-84.

25. Stallings, William, "The DoD Communication Protocol Standards," Signal, April 1986, pp. 26-34.

26. "Collective Use Computer System for the Academy of Sciences KaSSR," JPRS USSR Report: Cybernetics and Automatic Control, 5 September 1985, pp. 105-111.

27. Erlykin, L. A., "State Network of Computer Centers," Radioelektronica i Svyaz, No. 12, Translation W31-44-84.

28. Maksimenko, V. I., "The National Computer Network: Basic Assumptions," Radioelektronica i Svyaz, No. 12, 1982, Translation W31-44-84.

REFERENCES (Concluded)

29. Makhovic, L. P., "The PD-200 Network Needs a Lot of Attention," Vestkik Svyazi, No. 11, 1982, Translation W31-18-84.

30. Gayboronskaya, G. S., "Ways of Changing from Analog to Digital Telecommunications Networks," Ehlektrosvyaz, No. 10, 1984, p. 49.

31. Conference Record, 5th International Conference on Computer Communications, Atlanta, October 1980.

32. Zakharov, G. P., "Some Trends in the Development of Telecommunications," Ehlektrosvyaz, No. 11, 1984, p. 28.

BIBLIOGRAPHY

Silinsh, Ya. Ya., "Climatic and Mechanical Tests of the ISTOK Analog-Digital Unified Communications System," Ehlektrosvyaz, No. 9, 1981, p. 9.

Yakhnis, L. N., "Seminar on the 'ISTOK' System," Ehlektrosvyaz, No. 2, 1983, p. 64.

Yakubaytis, E. A., "Local Computer Network Architecture," Automatic Control and Computer Sciences, No. 2, 1983, Translation W31-44-84.

Yakubaytis, E. A., "Classification of Computer Networks," Automatic Control and Computer Sciences, Vol. 17, No. 1, 1983.