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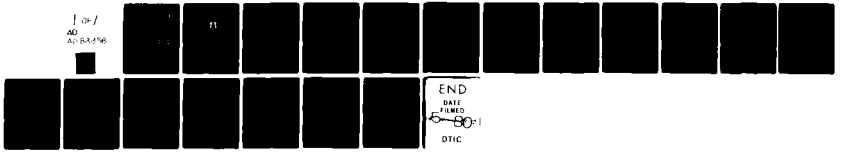

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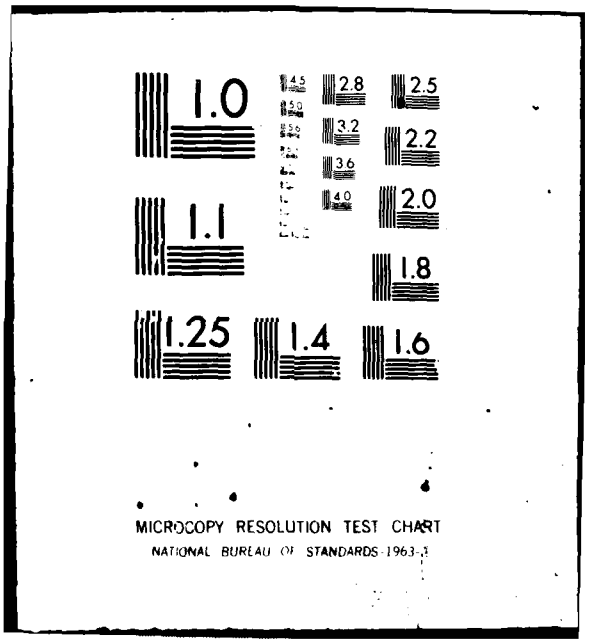
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COMPUTERS IN THE SERVICE OF SCIENCE

by

Jerzy Kolendowski, Marek Ksiezyk

EDITED TRANSLATION

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COMPUTERS IN THE SERVICE OF SCIENCE

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A considerable part of the increasing outlays of scientific institutes for mechanical equipment is earmarked for the acquisition and maintenance of computer centers. Most of these large centers for scientific and technological computations were established in the past decade. They are mainly equipped with multi-accessible computers. The network of terminals connected with these centers by means of data transmission lines is usually of regional character and many educational institutions have no linkage with the large, internationally significant computer networks.

The enormous demand for scientific calculations brought forth an ever increasing capacity of computer technology which sometimes results in an organizational detachment of the centers from their maternal institutions.

At a first glance it might appear that the initially installed capacity considerably exceeds the actual requirements of an educational or scientific institute. However, this headstart usually lasts not as long as originally planned. A characteristic case in point is that of the center of Champaign University in Illinois which has an enormous calculation capacity. With the installation of new computers during the current year it was established that the initial exploitation of the systems' available capacity reached barely 20 percent.

Some educational centers avoid the purchase of computers by using the most modern equipment owned by the state. The multi-departmental center of the Polytechnic Institute in Vienna, for instance, works on these principles.

With regard to the multi-thematical character of computations all centers are eager to acquire a maximal collection of bibliographic programs. They either maintain their own libraries or buy and subscribe to the services of others

(the most profitable method of acquiring access to programs). Among the most popular libraries are: The International Mathematical and Statistical Library (IMSL), The Nottingham Algorithms Group Library (NAG), and The Statistical Package for the Social Sciences Library (SPSS). Worth mentioning is further the specialization of some centers on certain subject matters. Thus, for instance, the computer center of the University of Oslo achieves perfect results in the field of machine languages by cooperating with a group of scientists. Another example is the development of the MINNESOTA FORTRAN (MNF) compiler by the computer center of the University of Minnesota in Minneapolis.

Multi-purpose computer centers are assisted by scientific councils which include representatives of the respective educational institutions. The tasks of these councils encompass , among other things, allocation of computer time to the respective educational institutes and determination of priorities with preference of scientific disciplines whose development is dependent on the use of computers. The dominating groups of users are usually the physicists. In one large university abroad, however, the psychologists are the most frequent users. As long as there are available reserve capacities, allocation of computer time does usually not lead to conflicting situations. If such capacities are not available (overburdening of the system) decisions are taken on the basis of some (objective) criteria.

The establishment of large mulit-purpose centers and their rapid development yielded a lot of very interesting material for the strategic and tactical planning of scientific developments on a regional or nationwide scale.(viz Table 1).

The multi-purpose center at Cracow is already two years in operation but still not sufficiently well known in our country.

In accordance with a decision of the Chairman of the Council of Ministers sufficient means for the establishment of a computer center for subscribers were allotted to the institute of ~~a~~ scientific center at Cracow in 1972. In 1975 a similar system was put into operation at the Main Computer Center CYFRONET in Cracow after an arduous period of preparations.

This center, an independent organizational unit, is directly subordinated to the minister of education, higher schools and technology.

E Q U I P M E N T

The CYFRONET Main Computer Center is equipped with a CYBER 72-16 computer made by CONTROL DATA CORPORATION. It has 1 central processor , 10 peripheral processors, an operational memory of 96,000 (60 bit) words, 3 disk memory units for 118 million signs, 8 tape memory units, 2 card readers, a reader/perforator for paper tape, 2 in-line printers , and a plotter operating in the off-line regimen.

The system also contains 6 terminals designed for operating in the input regimen (a projection monitor, card reader, and in-line printer) as well as 14 teletype terminals. The terminals are installed at 10 institutes for higher education and scientific institutions within a radius of several kilometers from the center. All terminals are linked with the center through the state telephone lines.

The configuration of the system is shown in Table 2 which includes a concise characteristic of the various equipment.

P R O G R A M M I N G

CYBER 72-16 operates under the control of a SCOPE 3.4.4 system (actual level 439).

The operation of the terminal is conducted under control of an INTERCOM s.5 system. System programming, which is shown in Table 3, includes more than 20 programming and machine languages.

The CYFRONE" Main Computer Center pays much attention to the collection of bibliothecal programs and to their popularization among subscribers. At present the center has about 2,300 programs concentrated in 7 libraries and specialized groups, such as SCEPTRE, ECAP CENPLOT, etc. All programs are recorded on tapes in the form of permanent assemblages (in complex and simplified form). This gives the subscribers the advantage of immediate access to the contents of the libraries.

This large collection of bibliothecal programs enables scientific workers to find ready and optimal solutions for many problems in a great variety of subject matters, such as:

linear algebra,

multinominal operations,

interpolation and approximation ,

special functions,

statistic analyses,

probability calculations,

numeric integration and differentiation,

differential equations,

graphic representation of results,

data transformation,

classifications and assemblage operations,

optimalization,

Table 1: Some of the Multi-Purpose Computer Centers of the World. a) Name of the Center. b) Year of Establishment. c) Equipment. d) Network. e) Character of the Center.

1. Terminal
2. Computer
3. Regional
4. Educational
5. Institutional
6. National
7. Governmental
8. Computer Center of the Joint Institute of Nuclear Research in Dubna.
9. Regional Computer Center for Lower Saxony, Hanover.
10. Computer Center of the Rhineland-Westphalia Technical College, Aachen.
11. Computer Center of the Hungarian Academy of Sciences, Budapest.
12. Interdepartmental Computer Center of the Technical College of Vienna.
13. Interdepartmental Computer Center of the University of Vienna.

a) Name	b) Year	c) Equipment	d) Network	e) Character
University of London Computer Centre	1966	CDC 6600 CDC 6400 CDC 7600 CYBER 72	a) terminalowa b) komputerowa	regionalny
Imperial College Computer Centre, London	1964	CDC 6400 CYBER 73 (KC's)	a) terminalowa b) komputerowa	regionalny
University of Manchester Regional Computer Centre	1970	CDC 7600 CYBER 72 ICL 1906A	a) terminalowa b) komputerowa	regionalny 3)
Centrum Obliczeniowe Zjednoczonego Instytutu Badań Jądrowych w Dubnej*) 8)	1958	BESM-6 CDC 6500	terminalowa	instytutowy
Regionales Rechenzentrum für Niedersachsen, Hannover 9)	1971	CYBER 76 CYBER 73 CYBER 73 (KC's)	terminalowa	regionalny 3)
Rechenzentrum der Rhein.-Westf. Technischen Hochschule, Aachen 10)	1958	CDC 6400 CYBER 175	terminalowa	uczelniany 4)
European Organisation for Nuclear Research (CERN), Genewa*)		CDC 7600 CDC 6400 CDC 6500 IBM 370/168	terminalowa	instytutowy 5)
Regnesentralen i Blindern-Kjeller, Oslo		CYBER 74	terminalowa	regionalny 3)
Centrum Obliczeniowe Węgierskiej Akademii Nauk, Budapeszt*) 11)	1971	CDC 3300	terminalowa	ogólnokrajowy 6)
CYFRONET-ŚWIERK	1973	CYBER 72	terminalowa	regionalny 3)
Interfakultäres Rechenzentrum der Technischen Hochschule Wien (12)		CYBER 74	terminalowa	uczelniany 4)
Interfakultäres Rechenzentrum der Universität Wien 13)	1974	CYBER 72	terminalowa	uczelniany 4)
University of Illinois Computer Centre		CYBER 175 IBM 360/75 IBM 360/75 IBM 370/168 B-6700	terminalowa	uczelniany 4)
Triangle Universities Computation Center, North Carolina	1965	IBM 360/75 IBM 370/135 IBM 370/135	a) terminalowa 7) b) komputerowa	stanowy

Attention: *) Included because it has the character of an educational institute.

nuclear physics and chemistry,

high energy physics,

biomedical problems,

network programming,

designe of power mains.

Table 2. Equipment Configuration of the CYPRONET Main Computer Center at Cracow.

Quantity 1	Type 2	Name 3	Parameters 4
1	7216	central unit Cyber 72	1 central processor with 98,304 word operational memory (60 bit words) memory cycle 1 μs 10 peripherial processes from a memory of 4,096 (12 bit) words 12 WE/WY channels.
3	6681	channel adapter	
1	6612	control pannel	two-screen pannel built into the digit key strip
2	405	card reader	1,200 cards/minute, linked to the type 3447 controlling device
2	512	inline printer	1,200 lines/minute, 136 signs per line, buffer memory equipment type 3555.
1	415	card perforator	250 cars/minute, control equipment type 3446.
1	3691	reader/perforator for paper tapes	reader 350 call/second perforator 120 call/second 5, 7 or 8 tracked punch tape
7	669-2	tape memory	9 track recording with a density of 800 or 1600 bit/cal, speed of 80 or 160 Kbits/second
1	667-2	tape memory	7 track recording with a density of 556 or 800 bit.cal, transmission speed 55.6 or 80 K bits/second.
1	7081-1	control device for the tape memory	can be linked with 8 tape memory units
3	844	drum memory	volumne 118 M signs, speed 6.8 M bits/second mean access time 80 M/sec.

1	3553	control device for dram memory	can be linked with 8 drum memory units
1	7077	station for long range communication	services up to 3 communication control units type 791, including a 8K buffer memory
1	791	long-range communication station	controls up to 24 communication lines
14	792-1	communication adapter	speed of information transfer 75 to 1,800 bits/second, asynchronic operation
6	731-12	LSBT plug-in terminal	line printer 300 lines/minute, 136 signs per line, card reader 300 cards/minute, monitor with screen with an area of 16 lines, 80 signs per line. 16 K memory, access time 1.1 μ s, microdrum memory with controlling program for synchronic communication with a speed of 2,000 to 4,800 bit/second.
14	390 ASR	teletype terminal TTY	transmission speed 200 billets/second
12	RACAL MILGO 2400	modem	speed 2,400 bit/second asynchronic operation.
28	RACAL MILGO 800	modem	speed 300 bit/second, asynchronic operation
1	905	magnetic tape unit for CALCOMP plotter	9 line recording equipped with: SCALE AXIS, LINE, NUMBER, SYMBOL, and PLOT programs
1	936 CALCOMP	plotter	Paper width 840 millimeters, program step length 0.05 millimeters, operating in-line. Drawing speed: lengthwise 90 millimeter/second, perpendicular 127 millimeter/ second.

Each library has alphabetic and operational catalogs of programs, which are also recorded on tapes. But so far not all those concerned have been able to make full use of the rich possibilities offered by these libraries. However, thanks to the endeavors of CYFRONET to propagate the programs of the libraries, the interest in their services is steadily raising.

Table 3. Languages and Operational Programs Available at the CYFRONET Main Computer Center in Krakow

No.	Name	Characteristics
1	ALGOL 4.1	Language for numeric computations, an implement of ALGOL 60
2	APEX III	A package of programs for solving problems of linear programming.
3	APT 2	Language for the numerical control of machine tools.
4	BASIC 2.1	Language for numerical computations of programming problems with possibilities for interaction.
5	COBOL 2.5	Language for data processing.
6	COMPASS 3	Assembler for CDC machines of the series CYBER 170 CYBER 70 type 72/73/74, CDC 6000, CDC 7600.
7	CSSL 3	Language for the simulation of continuing processes.
8	DDL 1	Language for describing data elements.
9	FORM	Language for data processing within a SCOPE 3.4.X system.
10	FTN 4.6	Language for numerical computations; a version of the FORTRAN IV language.
11	INFOL-2	A program in FORTRAN language designed for the collecting and disseminating information, with the possibility of interactive operations.
12	KWIC	Program in FORTRAN language designed for the arrangement of information according to key words in the text.

13	LISP 4.1	Language for transforming symbolic data; a version of the TEXAS LISP 4.1 language.
14	MIMIC	Language for simulating continuing processes with the possibility of cooperation with subprograms composed in FORTRAN language.
15	MNF	Language for numerical computations; a version of the FORTRAN language. With regard to the extended diagnostics it is considered a programming system in FORTRAN language.
16	PASCAL	Language for numerical computations and program writing.
17	PERT/TIME	A program for the composition of harmonograms.
18	QUERY UPDATE 2	A language for the transformation of bodies of information composed by DDL with possibilities for interactive and complementary operations.
19	REDUCE	Language for the transformation of symbolic data.
20	RUN 2.3	Language for numerical computations; a version of thr FORTRAN language.
21	SCHOONSHIP	Language for the transmutation of algebraic expressions.
22	SIMULA 67	Language for numerical computations and simulation processes.
23	SIMSCRIPT	Language for discret simulation processes.
24	SONBOL 4.3	Language for the tranformation of texts.
25	SORT MERGE	A product of the classification and linkage of data colletions in the SCOPE 3.4X system.
26	SYMPL	Language for writing compilations and system programs.

Since the establishment of the CYFRONET computer system no efforts were spared to make its services as profitable as possible. The activities of all the personnel of the Center are subordinated to this puppose. We would like to stress in particular the activities of the analysts of the system. At present they are continuously introducing new operational possibilities of the SCOPE system and working on local modifications of this system, such as:

changes in the procedures for establishing the priority of tasks according to input admittance (priority is the function of time pledged to a subscriber in

which preferenceis given to very short programs.

establishment of priorities in accordance with output, dependent on output capacity and on the results in the realization of tasks (correct - wrong.)

a permanent reserve of "input" for short programs in the line of realization.

an automatic program for modifying the contens of the operational memory in accordance with the operational regimen of the system (interactive plus complementary or only complementary).

changes in the standard programming of the punched cards center.

The introduction of bibiothecal programs and the considerable expansion of standard programs of the plotter were enormously important in raising the effectiveness of the system.

Some of the programs for improving the utilization of the system were worked out in the Department for the Coordination and Organization of Activities. CYFRONET Cracow tried to avoid the purchase of a too complex (and expensive) BAROMETER system of operational computations and elaborated its own system, consisting of several programs in COBOL language. These computations are realized on a monthly scale and encompass at present: the amount of realized tasks, system time, volume o output and input, amount of used magnetic tapes, amount of read cards, amount of printed lines, and, for interactive operations, the system time and operation time of the terminal.

Another very important factor in the utilization of the system is the modification of programs registering faults in the equipment of the system as well as the elaboration of it own program, recording the utilization of magnetic tape and faults in the operation of tape and winding frames. The printing of

permanent collections was also improved so that they became more responsive to the demands of the subscribers and offered the possibility of printing requested fragments on the printing devices of individual terminals. The program for preparing magnetic tapes for plotter recording is presently being improved and and optimal program for arranging drawings on the paper sheets of the plotter is being put into operation.

USERS OF THE SYSTEM

As planned the system includes a number of terminals. They are installed in the following educational and scientific institutes: the Jagello University, the Academy of Mining and Metallurgy, the Cracow Polytechnic, the Economic Academy, the Agricultural Academy, the Medical Academy, the Higher Pedagogical School, the Institute of Nuclear Physics, and the Geological Institute of the Polish Academy of Sciences.

Its considerable computation capacity (rapid central processor, large operational and internal memory)extensive operational system, and numerous programming languages, enable the Main Computer Center to solve a large number of the most various problems.

Today the CYFRONET system cooperates with about 800 scientists from various disciplines and with many groups of students from the educational institutes of Crcaow. Its activities include also other acedemic centers such as the University of Wroclaw, the Silesian Polytechnic the Polytechnic of Rzeszow and the Higher Pedagogical School in Czestochowa. This group of subscribers represents scientist of almost all disciplines: mathematics, physics, medicine, sociology, chemistry, engineering, astronomy, biology, linguistics, electronics, economy, information, archeology, meteorology, and geography. The produced computations deal with didactical processes as well as with scientific research. It is planned

to speed up the realization of scientific programs by introducing a large computer. It seems however certain that the complex system of mutual interaction of a large number of scientific and educational institutes and the CYFRONET system realizes and will realize computations which are very important for the national economy as well as for international cooperation. The following instances can serve as an example:

optimal production and consumption of albuminates,

treatment of cancerous diseases,

complex development of civil construction,

complex processing of coal,

development and utilization of water resources,

development of materials and semi-products for electronic equipment.

UTILIZATION

The rapid increase in the utilization of the system was very interesting. In the first half of 1977 the system solved several thousand tasks per month and used about 3 million system seconds. Drawings 1 and 2 show the exploitation of the system from September 1975 till June 1977.

This considerable utilization of the system became possible not only because of the high qualification of the personnel of CYFRONET but also because of the harmonious cooperation with scientific centers. The close cooperation with educational and scientific institutions is realized in a variety of forms. The Main Computer Center CYFRONET is supported by a Scientific Council nominated by the Minister of Higher Education and Technology, which includes independent scientists from the subscribing scientific institutes as well as experts from

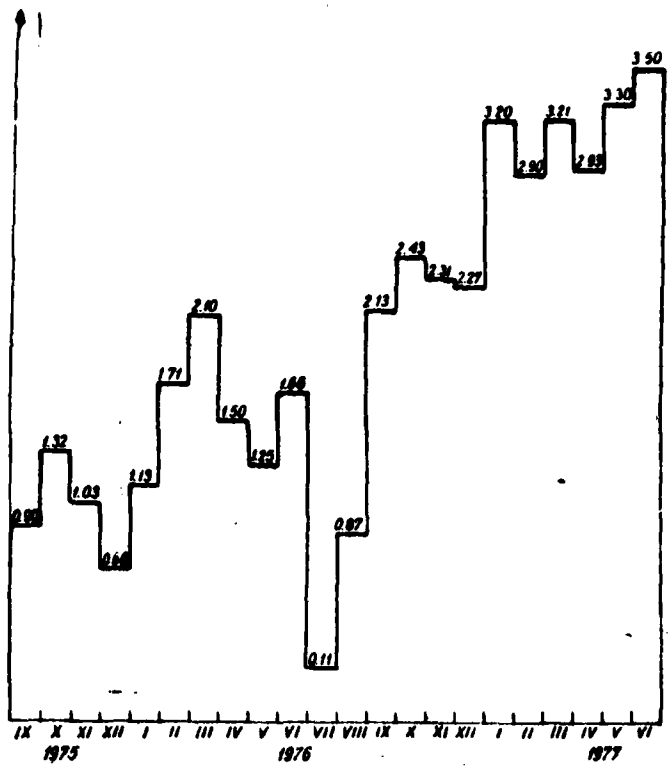

Fig. 1. The load of the CYBER 72 computer in the period 9/1/1975 till 4/30/1977 (in million system seconds)

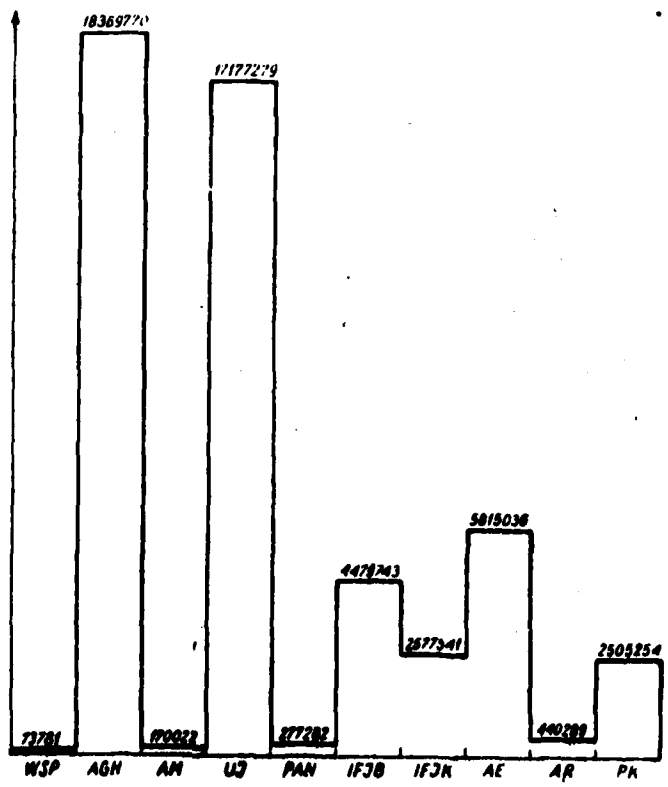

Fig. 2. Utilization of Computer Time (CYBER 72) in the Period 1/1/75 to 4/30/77 by general subscribers (in system seconds)

institutes in other cities. Recently the scientific Council was reinforced by two commissions: a statistical department and a department for experimental automation. CYFRONET also entertains direct contacts with educational institutes with the help of representatives of the presidents (or directors) of these institutes and of the managers of the terminals who cooperate with the Department of Coordination and Organization of Production and actively participate in the solution of all operational problems.

The share of the individual scientific institutes in the utilization of the system differs widely (Drawing 2) and so far cannot form a basis for the determination of priorities. The endeavors of CYFRONET and of the centers aim at transferring some computations to educational institutions and institutes, This, however, is a rather difficult and sometimes hardly effective process. Improving the equipment of the system seems the only solution capable of really extending access to the system in accordance with the actual requirements of science.

PRINCIPLES OF PROFITABILITY

In accordance with the statutes the center performs computations for higher educational institutes subordinated to the Ministry of Higher Schools and Science without charge. But because some of the subscribers initally took unfair advantage of the computers a Commission for Program Verification was established in 1976. It included experienced and reputable representatives of various educational institutes. They surveyed a large number of programs and devoted their attention not only to the planning, printing, and utilization of permanent collections but also to problems encountered in the impervement of programs and in the selection of correct numerical methods. The activities of the commission during the past 48 months brought considerable results and

fully justfied its existence.

In discussing the activities of the commission one cannot omit various operations with the purpose of raising the level of scientific information in the educational and scientific institutions of Cracow. Very important are the training courses conducted continuously by the scientific workers of CYFRONET which are very popular in the scientific and educational institutes of Cracow. Another significant factor is the individual contact of the subscribers with experienced experts of the programming department. The level of scientific information in the centers. of Cracow is further enhanced by the activities of the publishing department. CYFRONET published a script discussing basic problems in the introduction of the CYBER system and a manual of the FORTRAN language as well as a list of the CERN library. Another script dealing with the CYBER system and thematical lists of programs from various libraries (for instance programs dealing with the solution of differential equations or programs for statistical analyses) is in preparation.

The activities of the Main Computer Center CYFRONET-Cracow during the two years of its existence proved its unquestionable importance for the scientific institutions concerned. It is thus possible to say that its aims have been met in full.

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