Series in
Mathematical Biology
and Medicine
Vol. 5

Building a Man in the Machine

COMPUTATIONAL MEDICINE, PUBLIC HEALTH, AND BIOTECHNOLOGY

Part III

Austin, Texas, U.S.A. 24 – 28 April 1994

editor

Matthew Witten
University of Michigan
Ann Arbor, U.S.A.

World Scientific
Singapore • New Jersey • London • Hong Kong

35. P.J. Fisher, W.C. Stratmann, H.P. Lundsgaard and D.J. Steele, *User reaction to PROMIS: Issues related to acceptability of medical innovations* (in) **Use and Impact of Computers in Clinical Medicine**, eds. J.G. Anderson and S.J. Jay (Springer-Verlag, 1987) pp. 284-301.
36. S.B. Bacharach and E.J. Lawler, **Power and Politics in Organizations** (Jossey-Bass, 1980).
37. A. Strauss, L. Schatzman, D. Ehrlich, R. Bucher and M. Sabshin, *The hospital and its negotiated order* (in) **The Hospital in Modern Society**, ed. E. Freidson (Free Press, New York, 1963), pp. 147-169.
38. C.E. Aydin, *Occupational adaptation to computerized medical information systems*, Journal of Health and Social Behavior 30 (1989)163-179.
39. C.E. Aydin, *Professional agendas and computer-based patient records: Negotiating for control*, Topics in Health Information Management 15 (1994) 41-51.
40. C.E. Aydin, *Computerized order entry in a large medical center* (in) **Evaluating Health Care Information Systems; Methods and Applications**, eds. J.G. Anderson, C.E. Aydin and S.J. Jay (Sage, Thousand Oaks, CA, 1994), pp. 260-275.
41. T.A. Massaro, *Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior*, Academic Medicine 68 (1993) 20-24.
42. T.A. Massaro, *Introducing physician order entry at a major academic medical center: II. Impact on medical education*, Academic Medicine 68 (1993) 25-30.
43. D.A.B. Lindberg, *The development and diffusion of a medical technology: Medical information systems* (in) **Committee on Technology and Health Care. Medical Technology and the Health Care System: A Study of the Diffusion of Equipment-Embodied Technology**. (National academy of Sciences, Washington, DC, 1979), pp 201-239.
44. J. Singer, H.S. Sacks, F. Lucente, and T.C. Chalmers, *Physician attitudes toward applications of computer database systems*, Journal of the American Medical Association, 249 (1983) 1610-1614.
45. A. Mowshowitz, **The Conquest of Will: Information Processing in Human Affairs**. (Addison-Wesley, Reading, MA, 1976).
46. G. Zaltman, R. Duncan, and J. Holbek, **Innovations and Organization**. (John Wiley, New York, 1973).
47. J.G. Anderson, *Computer-based patient records and changing physicians' practice patterns*, Topics in Health Information Management 15 (1994) 10-23.

Developments of computational methods and networking in medical institutions in Hungary

ISTVÁN GYŐRI
Department of Mathematics and Computing,
University of Veszprém,
8201 Veszprém, P.O.Box 158, Hungary

JÁNOS KARSAI
Department of Medical Informatics,
A. Szent-Györgyi Medical University,
Korányi fasor 9, Szeged 6720, Hungary

ATTILA PETHŐ
Laboratory of Informatics
University Medical School, Debrecen,
4028 Debrecen, Nagyerdei krt. 98., Hungary

ATTILA SALI
Department of Medical Informatics,
I. Semmelweis University of Medicine ,
1085, Budapest, Üllői u. 26., Hungary

January 2, 1995

Abstract

In the paper we are dealing with the applications of computers in the Hungarian medical education, research, and medical informatics. We give a review of the educational programs, of the main areas of applications, emphasizing the problems, milestones and the remakable development of medical informatics in Hungary during the last years.

Keywords: computer based education, health care systems, networking, medical informatics, integrated information systems.

1. Introduction

Medicine and medical education are very important in computing applications all over the world. This is also the case in Hungary. Especially, the whole spectre of applications, from health care systems to scientific modelling, can be followed at the medical universities.

The interactions and variations of technical possibilities, user's expectations, the tasks and their solutions, and the huge work of dedicated experts led to the present state, where the informatics is an organic part of the everyday life of the Hungarian medical universities. There are introduced new information systems based on top-level hardware-software devices. This concerns the research, education and clinical work, too. In the paper we present the progress and the results of developments.

Above we suggested, that all the areas of medical computer applications can be found at the Hungarian medical universities. The reason is the special structure, that is not usual in some countries.

In addition to the theoretical departments, the clinical departments also belong to the universities, mainly doing the practical education. The tipical

structure is shown on Figure 1.

It's consequence is that the computer services must support not only the education, research, but also the routine health care and the financial management. These areas are unseparable, they only mark the main directions. See Figure 2.

We note, that the presence of clinical and diagnostic departments has a key role in improvements, because of the demands of everyday work and of the business relations to the Health Insurance Company, which are the main motivators of the developments and immediately improves even the educational program of theoretical subjects.

Next, after some words about the history, we discuss the cases of applications in health care, economic work, graduate and postgraduate education, research and the information infrastructure.

2. The history

The history of medical informatics in Hungary is longer than 20 years, when the Computing Centers at SOTE in Budapest and at SZOTE in Szeged were founded. The other universities recognized the importance of informatics some years leter. The Laboratory of Informatics at DOTE in Debrecen was established for example in 1992.

The organizational structure of medical universities

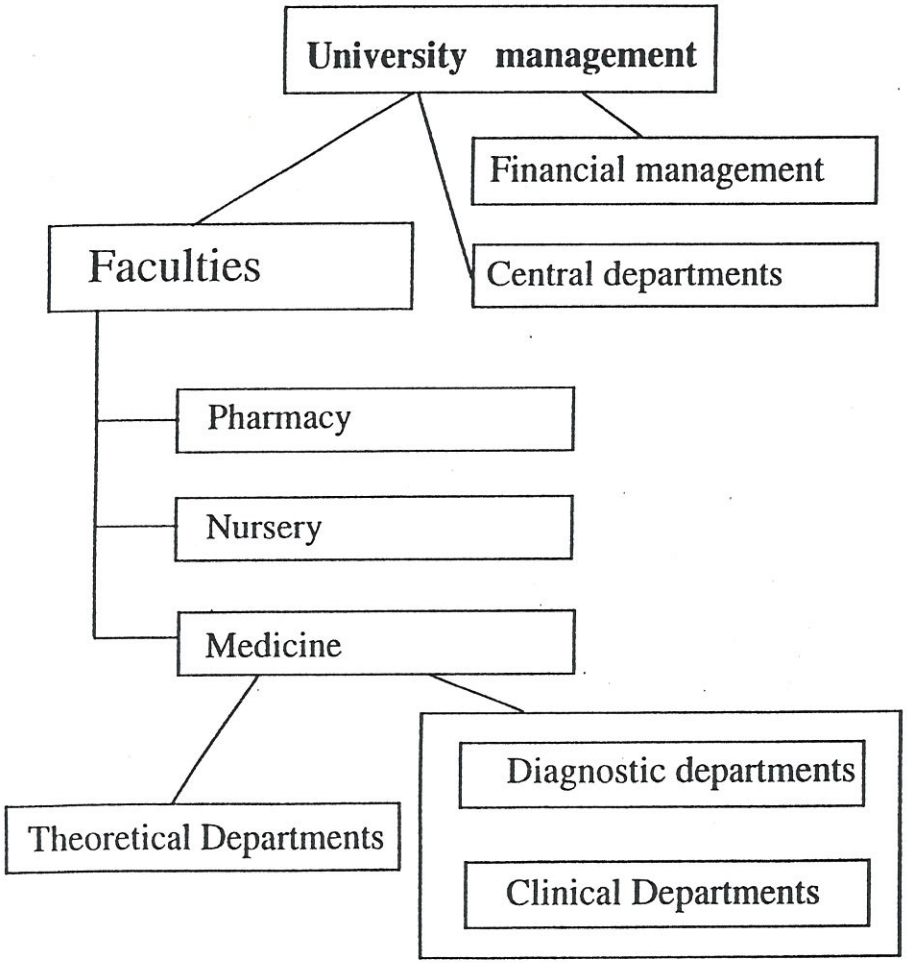

Figure 1

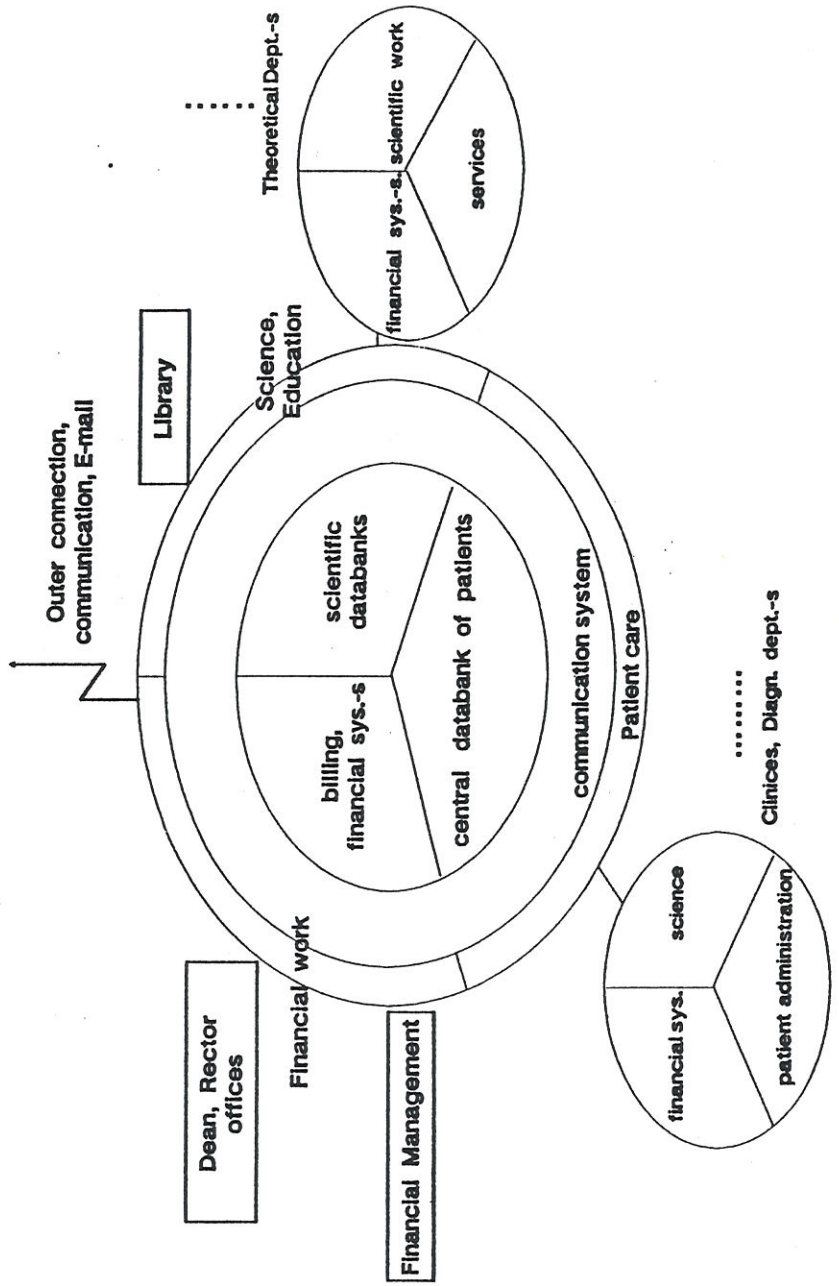

Figure 2

At the beginning, the restricted capabilities of the hardware the main applications were the evaluation of handly-collected data. There were also experiments to develope clinical administration systems, but their success was restricted.

The main reasons are the following:

- the potential users were not prepared for the new technic.
- the hardware could not satisfy the functional and speed expectations
- the lack of experience of the developers in developing complex systems

About ten years later the ideas were realized with success.

With the apparance of desktop computing devices and local area networks a new age started. They meant an explosion in applications. The PC-s were at once introduced in all areas. The interest of the doctors and requirements of the management increased. In consequence, the education of computer technics was started in the middle of 80-s. In-and outpatient systems, laboratory systems etc. were developed for the clinical departments. E-mail functions helped the local communications. The researchers could start to use scientific packages.

These applications were very successful. The most important success factors are:

-good medical modelling
- close cooperations with the users,
- restructuring the working enviroment to the new possibilities,
- structural problem-solving, step-by-step introduction,
- responsible help of the university leaderships,
- central coordination and management,

- decreasing the prices, weakening of COCOM,
- good examples,
- Hungary-wide coordination of medical informatics,
- the introduction of cost-sensible insurance system,
- central support of the development of the infrastructure of the universities.

The success of developments generated new demands, requirements. The most important of them are the necessity of

- international network connection,
- central databank services,
- integrated clinical information system,
- use of the "live" systems in education,
- central high powered processor capacity for scientific calculations,
- central resource management.

To realize these requirements comprehensive informatical investments started at every university in Hungary. In the following sections we summerize the present state of results and applications.

3. The infrastructure

In the 90-s complete university-wide networks were developed. All the departments are networked. The university networks are parts of the world-wide Internet. The networks have optical backbone and mostly coaxial wings (Ethernet, Token-Ring). The following parameters illustrate the

sizes: of ~ 20 bridges, ~ 40 multiport repeaters, 1-2 routers, length of cableing approx. 50 km, 25 subnetworks (example of SZOTE-SZEGED).

The used network softwares are Novell-Netware, TCP/IP, DECNET. The departmental servers are mostly Novell PC-servers, serving the ~ 500–1000 PC-s in the departments (10-50 in each). For some services (Email, Internet connection, CD, etc.) central servers are installed and managed by the computing centers. The mailers are VAX-VMS or UNIX machines. There are "Charon" mail- gateways to Novell mailing (Pegasus mail). CD servers with Novell or IP are used for scientific databank services (PC service!)

While the most application are PC-based, in some areas there are necessary high powered RISC servers and workstations as comput-servers. To reach them X-terminals and X-windows emulator softwares are installed. What concerns the education, there are networked cabinets (for example, 2-4 PC cabinets and 1-2 X-terminal cabinets) for education. In addition to the special servers for education, the students, who want to do research, can reach other resources. The students can work over Internet (mail, transfer, etc.). We note that the resources work continously 24 hours a day.

Figure 3-4 show the logical structure of SZOTENET and SOTNET, respectively. In details see ([1]).

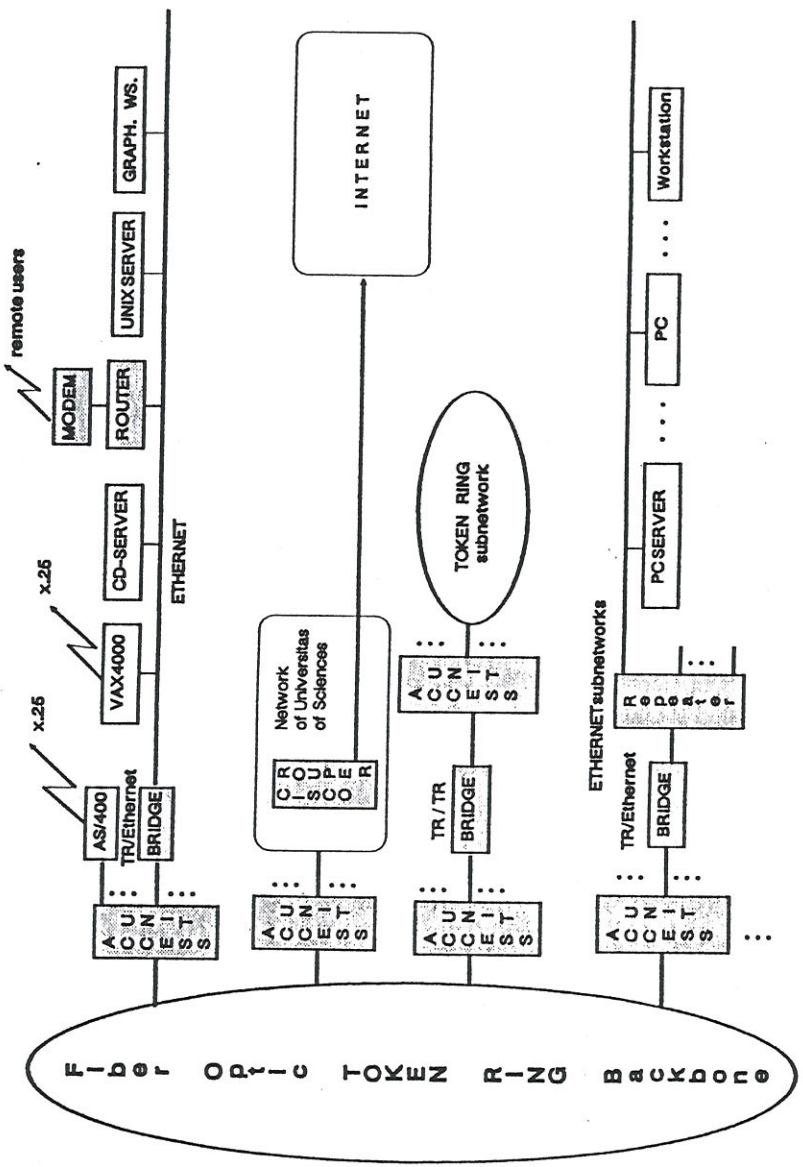

Figure 3 The logical scheme of SZOTENET

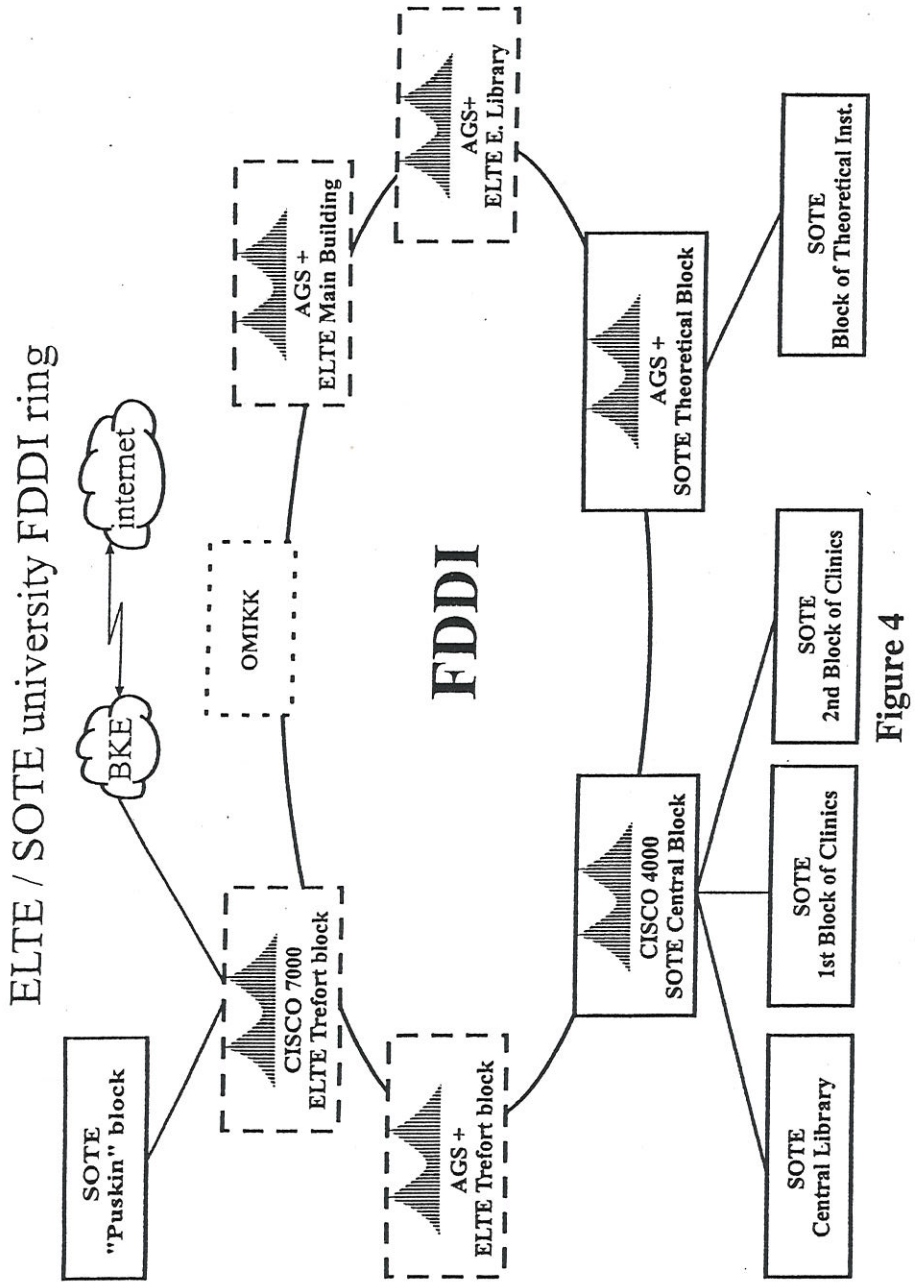

Figure 4

4. Education of Informatics and Mathematics

As we have seen above, the technical conditions (resources, cabinets) make possible to realize the most modern educational programs in the frame of both the graduate and postgraduate courses and of courses for the teaching and research staff.

We summerize the main course programs. As example, Figure 5 shows the schedule.

Mathematics for pharmacy students.

The course is computer illustrated from 1994 at SZOTE. The Mathematica package is used for this purpose. ([2]). The main topics are: biomedical processes and functions, exponential, logaritmic functions, differential and integral calculus, differential equations, functions of several variables, applications in pharmacy.

Biostatistics for pharmacy and for Ph.D students

The practicals are computer-based. Packages SAS, SPSS and Statgraphics are used. The main topics are: elements of probility, distritutions, normal distribution, data analysis, tests, regression analysis, variance analysis ([3]).

In the informatical courses the students use the "sharp" resources, programs, that they can meet in their clinical work or research.

The courses

Course	since	term	hours
Albert Szent-Györgyi Medical University			
Graduate courses			
Faculty of Medicine			
Basics of informatics	1984	1/1	1+1/week
Faculty of Pharmacy			
Mathematics	1981	1/1	2+2/week
Biostatistics	1992	1/2	1+2/week
Informatics	1992	3/1	1+2/week
Pharmacy adm. systems	1992	4/1	0+2/week
Postgraduate courses			
Computers in Research	1993	1/1	0+2/week
Biostatistics	1993	1/2	2+2/week
Mathematics for Biomed. Research	1993		2+2/week
Fundamentals of med. informatics	1993		2+2/week
University Medical School Debrecen			
Graduate Courses			
Basic informatics	1994	1/1 or 1/2	2+0/week
Postgraduate courses			
Biomedical Research	1994		2+2/week
Statistics in the biomedical research	1993		2+2/week
Computers in Research	1994		0+2/week
Semmelweis University of Medicine			
Faculties of Medicine, Dentristry			
Informatics	1985	1/1	1/week
Medical Informatics	1994	5/1	3/week
Faculty of Pharmacy			
Mathematics	1981	1/1,2	2+2/week
Informatics	1985	1/1	2/week
Pharmaceutical informatics	1992	5/1	2/week
Postgraduate courses			
Informatics	1994		3/week
Computer Networks	1993		2+2/week

Figure 5

Basics of Informatics for all graduate and Ph.D. students

The topics are: basics of personal computing (DOS, utilities, etc.), Windows, documents-editing, spread-sheet programs; Email, network services scientific databanks. Since the preliminary knowledge level of the students can be very different, there are basic and advanced groups organized ([8]).

Fundamentals of Medical Informatics

This course is not technical, the applications illustrate the learned ideas. The main topics: the main areas of medical informatics; informatics of research; information structures, information flow; clinical information systems; informatics of social health care; special areas ([4]).

In addition to the above considered ones, there are organized special courses, like

- advanced applications,
- network in medicine,
- signal processing,
- courses on program packages,
- multimedia,
- graphic workstation applications, etc.,

Moreover, the are subjects, which are also based on computers, like

- biopharmacy,
- pharmacy information systems,
- chemical modelling,
-integrated medical information systems.

We note that the interest from the students is huge. The PC cabinets are full between the lessons.

5. General services, Applications for research

Nowadays, some computer services are so organic in the scientific work that they can be considered as parts of the informatical infrastructure.

Networking. For local connection for PC-s, mainly Novell Netware is used, since the main services are file and print services and mailing. Decnet and Internet are for international connection and for connection to the processing servers (VMS, UNIX servers, station). International electronic mail through Internet and EARN is available. The international connection is quite new (3-5 years) and satisfies a very old demand from the research.

Local databanks, Information services. In addition to library informations and news, the medical CD-databanks like MedLine, Current Contents, Science Citation Index, Excerpta Medica are available from any networked stations.

Scientific Packages. For the widely used packages (SAS (PC, UNIX), SPSS, Mathematica, Word for Windows, etc.) licences are bought and installed on the central resources. The computing centers coordinate and manage their usage.

The packages of special interest are ordered and installed locally in the

departments, but some of them work on central servers of high speed (for example in chemistry, pharmacokinetics, etc.).

We have to mention here the systems, running on fast graphic workstations, which have been available for 1-2 years. Their graphic and multimedia capabilities haven't been recogenized yet fully by the users. We feel, that this is the last moment, when the users are generally satisfied with the PC-s.

6. Patient's care

As we mentioned above, this area is the one, which forced first the modernization of computing infrastructure.

As results of earlier developments, at all universities and at all clinical departments, there work unified in-and outpatient departmental information systems with common standards. Now the developments are directed to university-wide integrated clinical information systems, since the optimization of cost-income, giving management information and supplying care histories are not possible without such a complex system.

The realizations of this goal are different. At SOTE-Budapest the integration of the networked PC-based systems is developed (see Figure 6). In Szeged and Debrecen the PC-based system are going to be changed for a central information system, which works on some high-powered central servers.

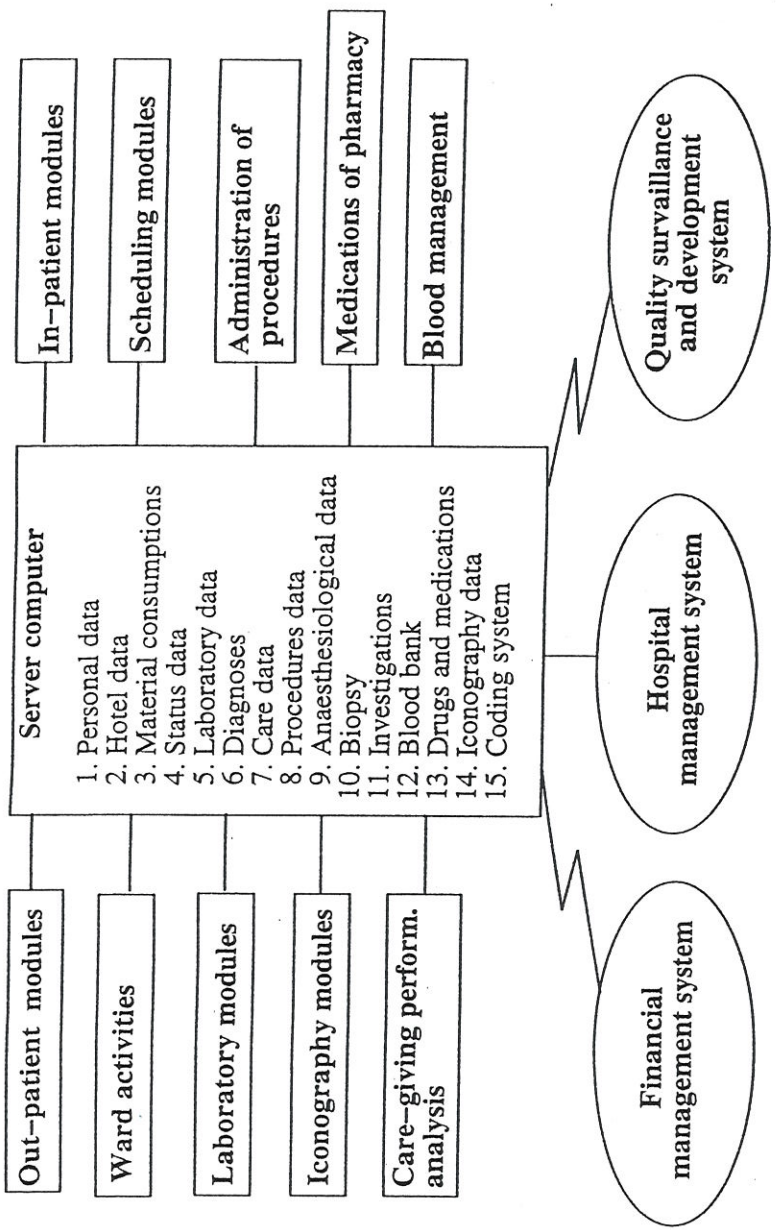

Figure 6

The module structure of the Semmelweis Integrated Hospital Information System

7. The organizational conditions

The tasks in doing medical informatics can be completed only under well-organized conditions. The computing centers, departments of medical informatics have basic role. They form the concepts, develope, adapt the systems, manage the university network and central resources. These departments deal with educational tasks too.

At almost every clinical or theoretical department there are computer experts working for the local developements and system management. The departmental informatical representative coordinates the informatical work (not technical!).

To emphasize the importance of medical informatics, the university leaderships founded the informatical committes, which "politically" help the professional work.

We believe, that these conditions, the dedicated willing and the expert are the main factors of the success of computer applications in medicine in Hungary.

References

[1] Győri I., Karsai J.,*Results and plans of a medical information system at A. Szent-Györgyi Medical University in Hungary*, in the **Proceedings of 5th International Conf. on System Sciences in Health Care**, Omnipress Publishing, Prague, 1992.

[2] Karsai J., Forczek E., *Computer visualization in the course of mathematics for pharmacy students*, in the **Proceedings of the Colloquium MEDICOMP'94**, Szeged, 1994.

[3] Boda K., *Computer assisted teaching of biostatistics at the Medical University of Szeged*, in the **Proceedings of the 4th Intern. Conf. on Teaching Statistics**, Marrakech, 1994.

[4] Sali A., *Education of informatics at tha Semmelweis University of Medicine* in the **Proceedings of 1st International Conference on Informatics in Higher Education**, Debrecen, 1992.

[5] Sali A.,*A Clinical Pharmacy System* , in the **Proceedings of the Colloquium MEDICOMP'92**, Szeged, 1992.

[6] Agócs L., Dulane S.K., *Informatics in Education at University Medical School of Debrecen*, in the **Proceedings of 1st International Conference on Informatics in Higher Education**, Debrecen, 1992.

[7] Agócs L., Dulane S.K., *A practical Introduction to Informatics*, **University Handbook, University Medical School of Debrecen**, Debrecen, 1992.

[8] Szekrényes L., Bodroghy E., *Laboratry Database for the research and routine work*, in the **Proceedings of MEDICOMP'94**, Szeged, 1994.

Simulation of Medical Laboratory Organization

Mario Veitl, Stylianos Kapiotis and Oswald Wagner
Clinical Institute for Medical and Chemical Laboratory, University Vienna, Waeringer Guertel 18-20 A-1090, Austria
mario@ai.univie.ac.at

and

Austrian Research Institute for Artificial Intelligence, Schottengasse 3, Vienna A-1010, Austria

ABSTRACT

This paper shows how discrete simulation can be used to model the working process in a medical laboratory. Such models give a deeper understanding of the system and can be used to predict changing behavior caused by disturbances like breakdowns of analyzers or organizatory changes. The models are based on data, which was collected and evaluated in the Clinical Institute for Medical and Chemical Laboratory Diagnostics of the University of Vienna. At first different models of analyzers and working processes will be shown, which are subsequently arranged to model of laboratory processes. The experiments show different scenarios of organizationary approaches and their system behaviors in the case of disturbances. Furthermore, we discuss cost savings in the decision making process due to inexpensive evaluation and possibly rejection of different decision choices based on the results of computer simulations. The models are based on a systemdynamic approach.

Keywords: simulation, laboratory organization

1. Introduction

Medical diagnosis and therapy needs a huge amount of analytical results given by clinical chemical laboratories. New medical treatments and research need more monitoring, process control and diagnostic aids. The number of parameters and samples constantly increase. The 10 year analysis Benge [1] from 1980 to 1990 show an increasing workload 12,1

This paper shows how simulation models of clinical chemical laboratory procedures could be created by using the system-dynamic approach. Examples are given to demonstrate the complexity of the behavior of such systems. The methods which we present here are not restricted to laboratories, they could also be used in other healthcare areas. We think that especially emergency planning can benefit from this approach.

2. Method