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Power Industry Computer Control System Design and Implementation Problems: A Case Study of Poland

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Abstract: The design and implementation team of computer automation systems for the Polish power industry faced many difficult problems connected with the lack of experience in this domain in the country. Another kind of problems was implied by different levels of information and communication technology in that country and in well developed ones. The differences were generated by both internal (importation limitations) and external (various embargos) reasons. But perhaps the most severe problems were the political ones, implied by the omnipotent communist system, that could spoil and often spoiled even many-year work of design and implementation teams. The paper tries to answer how, in such adverse conditions, it was possible to design and develop very successful power industry computer automation systems.

1. INTRODUCTION

The listing of one line of IT (Information Technology) and ICT (Information and Communication Technology) applications in the power industry of the case study country (Poland) is rather impressive (ref. Stapleton, 2008), especially for the IT and ICT pioneering period in that country. But, on the other side, some information is available that the design and implementation teams had to face much more severe problems than their counter-partners, in the technology, economy and politics domains (ref. Lewoc, 1991, 2005, 2006, 2007a). So it is reasonable to ask how it has been possible to gain such successes in so adverse conditions.

To give some answer to such question, the present series of papers has been written, including this paper and Dimirovski, 2008; Stapleton, 2008.

2. ORGANISATIONAL PROBLEMS

2.1 Project Leadership

The scope of the first task entrusted to the Team, i.e. the design and implementation of SAPI ODM (ref. Stapleton 2008), in addition to the primary programming job, included various important pioneering hardware tasks: design and development of special-purpose keyboards for power network control engineers, specialised power industry visual displays, computer dummy scheme controllers, single-bit tele-signalling inputs, analogue telemetry inputs, power system control outputs, digital telemechanique interfaces, and so on. It was of the utmost importance that all the tasks were controlled and monitored technically by a single person, the leading designer of the project.

Obviously, the leading designer should be a professional designer of hardware as well as a proficient programmer. At those times and, even more, at present, individuals possessing both skills were very rare and were used often by their employers as some kinds of generalists to troubleshoot problems at the interface of hardware and software.

Fortunately enough for the SAPI ODM project, a person of earlier experience I hardware and software design and development was available for the leading designer of the Team. In addition, the leading designer possessed some earlier experience in design, development and commissioning of the first Polish computer control system (ref. Wojsznis, 1971). This added to his professional abilities and enable to lead, formally or not, the project in an efficient and low cost way.

The first major action of the leading designer was to work out the preliminary engineering design of SAPI ODM and the general concept of the system (ref. Lewoc, 1972; Sawicki, 1974). The studies constituted the technical basis for many-year development work for SAPI ODM and derivative systems (Lewoc, 1975, 1977, 1978, 1980, 1983, 1984, 1992) and helped a lot in design and co-ordination of detailed hardware and software work. The significance of the hardware and software skills and experience of the leading designer for the overall SAPI ODM project is shown hereinafter, when discussing individual technical problems that have had to be solved by the Team.

It may be argued that, at present, the situation is quite different. Computer hardware and software are much more advanced and it is not realistic that a single person may cope with the two domains with the needed detailed competence.

However, the Team heard the same words thirty years ago already. And both then and now, it is quite easy for any competent hardware designer to learn professional programming, especially in low level languages, and such is the case in the systems like SAPI ODM.

2.2 Flow diagrams

For SAPI ODM and the derivative systems, software tasks were much more complex than the hardware ones. The basic hardware components (CPU, basic peripherals, basic industrial interfaces SMA, etc. – ref. Elwro, 1976; IKSAiP, 1976) were to be delivered by external manufacturers and only the power industry specific hardware units (ref. 2.1) were to be designed and developed by the Team. On the other side, a quite complex set of programs, including the specialised power-industry oriented operating system SOSAPI (ref. Lewoc, 1978) and a set of applications. For the job, the leading designer ordered that complete detailed flow diagrams were a prerequisite for that final programs are accepted.

The leading designer heard sometimes that he was obsolete requiring that detailed flow diagrams are prepared. Programmers claimed sometimes that it was a loss of time, that they could write and debug programs efficiently without flow diagrams. That did not help them: preparation of detailed flow diagrams was a *condition sine qua non* for them to be members of the Team.

Such approach paid back in a major degree in implementation of SAPI ODM and derivative systems. Indeed, preparation of flow diagrams is a rather labour consuming task when thinking about individual programmers writing and debugging their programs at once, when they remember quite well their programming problems and solutions. But, in a complex software system like SOSAPI, it is often required that individual programs are analysed, debugged or modified quite a long time after they are commissioned individually. At that time, the programmers can not, usually, remember their solutions and the flow diagrams are invaluable support in program debugging or modifying.

In addition, especially for operating systems, like SOSAPI, wherein the program control issues are more complex than the data processing ones, in other words: the percentage of branch and jump instruction is high in comparison with that of arithmetic instructions, it is very important to understand easily

the logic of the system operation. For this, flow diagrams are inappreciable while plain code is almost useless. The approach to programming with use of detailed flow diagrams proved to be very successful when developing and debugging software for SAPI ODM and derivative systems.

Another consideration here is the possible liquidity of the Team. No one could assume that the initial programmer of any program would be available for the Team after a year or two, when the final software structure would be finally commissioned. This is true for any large-scale software system but it was even much more true under the communist system, because of political reasons discussed hereinafter. In many cases, software documentation in the form of source programs only would need complete re-writing of the relevant programs. For the power industry computer automation system line under discussion, such case never happened; if it was necessary, software development tasks were taken over from the unavailable author to other programmers. Such switches were always fast and successful.

In addition, flow diagrams were a very useful tool enabling fast and easy continuation of experience. Stapletons, 2008, describes examples of SAPI ODM derivative systems, like the electric power network training simulator or the microprocessor-based version KWP or the power plant and power generating unit monitors (POWESTER) which are the derivatives of the power generating unit monitor, KSWDB, developed on quite other computer hardware. For such continuation of experience, source code alone (even in the C-language) would be rather useless while the flow diagrams made the transformation process rather straightforward and fast.

The pros and contras the flow diagrams presented hereinbefore are valid even now. It is true that some, most often lazy programmers, who are apt to treat their work as their castle so that nobody can control what they are doing, fight against flow diagrams. However, when their programs are to constitute a part of a bigger operating unit, such approach is simply unacceptable.

3. TECHNICAL PROBLEMS

3.1 Power industry data visualisation

7080 Series Alphanumerical Visual Display Units. When designing SAPI ODM, the problem of power industry data visualisation seemed to be a very serious one. For control engineers, the best and the only acceptable main form of presentation of data describing the condition of the power network under their control was that of power network schemes. Without such presentation form, SAPI ODM would be simply rejected.

However, in the early seventies, the only visual display system available for the target home made computer Odra 1325 (ref. Elwro, 1976) was the ICL’s 7080 series composed of the Cluster Control Unit (CCU) and Alphanumeric Visual Display Units (AVDUs) (ICL, 1973). The system was a very good one in comparison with other visual display systems available at those times: fast (transmission rate between CCU and AVDU's: 1 Mb/s), reliable, of large scalability (up to 240 AVDU in a single cluster). However, it was intended for displaying plain texts only and the AVDU character area was such shown schematically in Fig. 1.

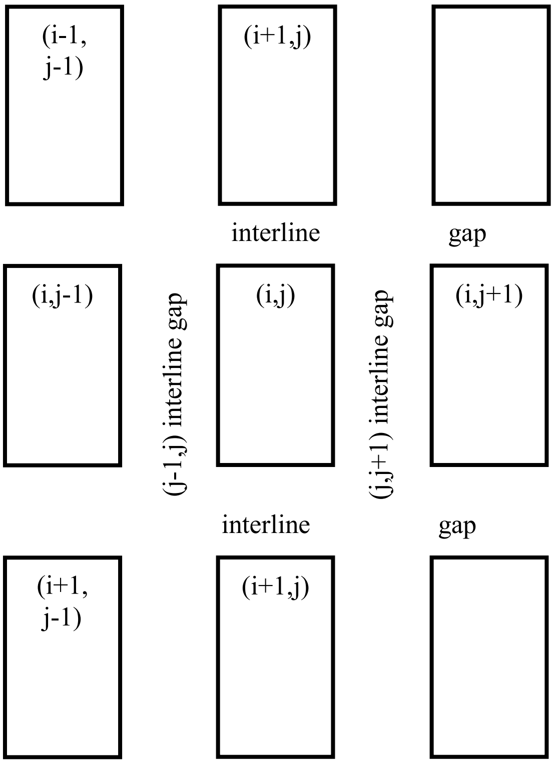

Fig. 1. Standard AVDU character area

The full $\{i, j\}_{i=1, j=1}^{40,80}$ character area consisted of the (i,j) character area proper, wherein each dot was under control of the PROM-controlled character generator, of the (*i-1,i*) interline gap and the (j-1,j) inter-character gap. Both gaps had to remain empty what excluded the necessary possibility of displaying continuous lines in the schemes. The enquired ICL Company excluded any possibility of modifications of AVDUs so that they could display electric power schemes. Considering that, the leading designer learned the detailed logic structure of AVDUs, visited the ICL Design Centre in Kidsgrove and proposed a single wiring modification enabling character generator control display of a horizontal line section within the inter-character gap. The ICL AVDU designer propose simple increasing of the vertical gain potentiometer setting to eliminate the interline gaps. Due to the minor modifications, the Semi-graphical Visual Display Unit (SVDU) character area looked like that shown in Fig. 2. The modifications plus, of course, a repertoire of the semi-graphical characters designed by the Team and entered by ICL into the character generator PROM memory enabled to display very high quality power industry circuit schemes. The SVDUs were used successfully for nearly twenty years in several regional power dispatching centres and they were assessed very positively by the control engineers.

Thus, due to combined software and hardware knowledge and experience of the leading designer, the theoretically unsolvable problem of the decisive importance for the overall SAPI ODM project could be solved in a shorter than hourly discussion with a technical expert. And during designing and implementing SAPI ODM, many such events happened, though perhaps of not so big impacts.

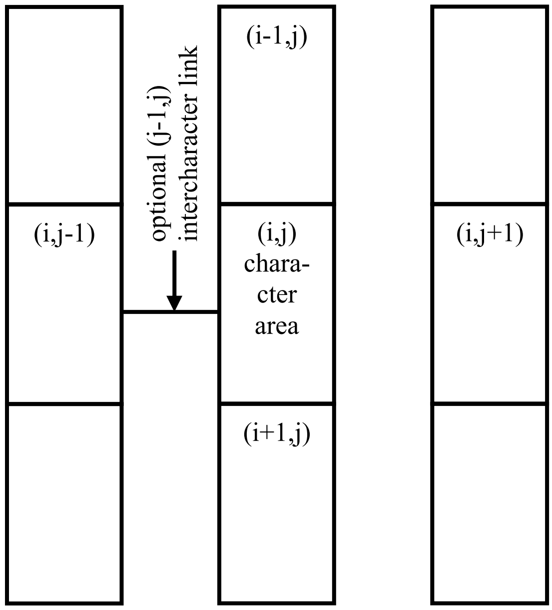

Fig. 2. SVDU character area

Intelligent Cluster Control Unit. The solution of SVDUs mentioned hereinabove did not solve the problem of data visualisation in SAPI ODM and its derivatives in full. Especially for low-budget projects, such as the training power system simulators (ref. Lewoc, 1980, 1992) or the experimental power generating unit monitor (Stapleton, 2008), where the limits for importation of hardware were very severe, the power industry Customers could not afford for importing the SVDU systems. In these cases, though of major importance for the overall power industry in the case study country, a home-made (import free) solution was a *condition sine qua non* for successful implementation of IT and ICT.

To solve the problem, the leading designer appointed and led a sub-Team that designed and implemented the first Polish application of intelligent peripherals (ref. Lewoc, 1977; Stapleton, 2008). The project covered the design and development of the inter-processor buffer between the Odra 1300 family computers and the home made minicomputer Momik plus complete 8080 Cluster Control Unit emulator for home made alphanumerical and semi-graphical visual displays. Though the operating characteristics of the CCU 8080 emulator were very much lower than those of the original CCU (for instance, non synchronous transmission only was possible between visual displays and the central processor Momik, what meant then the transmission rate of three ranks of order lower than in the original system, and the scalability range was from one to 16 comparing with 1 to 240), the CCU emulator proved to be very useful, especially in the training and experimental applications of SAPI ODE derivatives.

3.3 CUP Trips

The central processor unit Odra 1325 (ref. Elwro, 1976), intended for process control applications in the case study country was provided initially (for several years) with internal core memory. Unfortunately, the memory control circuitry were poorly designed and the memory drivers were over-controlled what resulted even in several CPU trips per day. This was the basic reason for several computer automation system failures in other industries in the case study country. However, because of the political reasons (the biggest Polish manufacturer of computers does not do such mistakes), the fault was never recognised and eliminated by the manufacturer, till the semiconductor memory was applied in the processor.

To save SAPI ODM, the Team decided to adopt the idea of automatic restart of the processor in a case of a system failure, devised by their Gdansk colleagues. This, plus a simple restart PC board meeting the Odra 1300 family standards enabled a useful restarting solution that made it possible for SAPI ODM to be applied in the power dispatching regions or areas, and that the measured long-term availability factor of the system amounted to more than 92% (note that the normal technical maintenance periods were counted as inoperability ones) (ref. Dimirovski, 2008).

3.3 Performance issues

During nearly all history of this line of computer applications in the power industry automation in the case study country, the Team had at their disposal the computer hardware that was of roughly 5-10 years obsolete with regard to that available for designers in the well developed countries. This followed, in a part, from importation restrictions in the country (and in other Comecon countries): in practice, one dollar was considered to be equivalent to an infinity of zlotys. This means that any solution realised with use of home-made hardware was considered cheaper than any other solution basing on imported equipment.

Another serious reason for the obsolete only hardware being available for the Team were various embargos. For the team, the embargo issues were simply ridiculous: everybody knew that the Soviet Army had no problems with deliveries of the most advanced electronics for their MIG fighters or rockets, while people working for peaceful purposes had, even if they managed to get some foreign currency subsidies.

On one hand, such conditions supported development of local technology. However, on the other hand, it resulted in, sometimes, severe losses due to the lack of High-Tech necessary for solving actual problems of a considerable significance for the overall economy of the country.

Due to that, the performance specifications of the computers available for the team to develop the systems from SAPI ODM to Badel, inclusively, in particular, the computing power, were significantly lower than those available in the well developed countries. Due to that, even if the Team had at their disposal some data on actual execution of similar tasks in the West, the question if similar tasks were feasible in the case study country was still open. In other words, the problems of performance evaluation were much more important for the Team than for the Western designers and programmers and could not be solved by try-and-guess method popular in the West.

Since the queuing theory formulated many questions similar to those interesting in actual design of computer systems and networks, the development of that scientific domain was tracked rather intensively. However, the actual results of the domain (ref. Kleinrock, 1976; Robertazzi, 2000) could not be used easily in investigation of actual ICT systems, application-oriented solutions were developed (ref. Dimirovski, 2008).

A definite evidence for that the performance issues were solved in an appropriate way by the Team may be that, in the actual experience, no performance induced problems were found for the implemented systems, though the computing power of the available hardware was significantly worse than that of computers available in the West while the system functionalities were comparable.

4. POLITICAL PROBLEMS

4.1 General

It should be noted that all pioneering implementations of IT and ICT in power industry automation, described by Stapleton, 2008, were developed in condition of a very severe struggle of most people of the case study country with the communist system. For the purposes of this paper, it may be assumed that the struggle was between the two systems, the system of the power, i.e. WPR (Who has got Power is Right) and the opposite system of the people, WRP (Who is Right has got Power).

In general, it may be stated that the WPR system has prevailed the managerial spheres while the technical circles preferred the WRP one. The struggle between the systems was of major influence upon the project execution conditions in the case study country, including the projects mentioned in this series of papers.

4.2 Experience continuation

The WPR system, forced in the case study country after the World War II, governed the country totally. However, it was smart enough not to make use its power all the time; this would lead to a total collapse of the country and the WRP system would loose also. It was so, in particular, in modern industries such as IT and ICT, for which earlier experience scope was very limited or none. In all, in practice, successful enterprises executing pioneering projects, the tasks of leading designers were entrusted to good, competent engineers who were allowed to run the project on the WRP rules. However, when the project was just to be completed successfully, the managerial circles started the WPR system and forced the successful leading designer out of the project, and never entrusted any important task to it.

For instance, in Wroclaw that used to be the Polish capital city of computers and automation and where most of the actual Polish pioneers in the industries worked, any leading designer except one could lead at most one successful large scale system. Considering that it is assumed that some ten years of experience are needed to educate and upgrade a good leading

designer of large scale ICT or automation projects, the losses of such approach were very serious in the scale of the whole case study country.
The only one exception of this rule was that of the leading designer of the power industry automation projects described in this series of papers. The most important thing for him to remain in the business was that, just before commissioning the system he led, he looked for another employer and arranged for being transferred for leading another important project. In total, he had a dozen or so employers in his design and research carrier.
It was not an easy decision for a young, ambitious man like him. He had to resign the fame of the system creator, possible promotion and quite considerable bonus money for implementation of a successful system. But it more than paid back: after some two or three years, the employers operating under the WPR system issued references describing his actual role in development of the system and, in two cases, he was assigned for large scale system leading designer even by his earlier employers. And, of course, he could cumulate his experience and become more and more useful for the case study country.

4.3 Divide et impera

The WPR system was very clever to locate and use the weak points of the WRP system represented by the technical circles. One of the most important ones was always the interface between hardware and software people. Usually, anyway not only in the case study country, any problem in the no man's land between hardware and software is solved by a person of no actual knowledge nor experience neither in the hardware nor software domain, who can then easily enforce the divide and rule principle.
The leading designer of most projects described in the series of papers had similar knowledge and experience in both domain (it was possible then and it is quite possible now) and, in addition to significant simplification of solving technical problems, it helped a lot in the struggle with the WPR system.

4.4 Upgrading of future leading designers

Considering the fact the leading designer will not be able to lead the first implementation of the system till the very end, to say nothing of the next implementations (due to the action of the WPR system or his own decision), it was necessary to upgrade new prospective leading designers when designing the first implementation of the system.
A common mistake made by other leading designer of pioneering ICH and automation systems (as well as other systems and in other countries) was that they usually believed that nobody except them can duly run the project involved. Various leading designers even try to lead to such conditions by keeping the most significant technical solutions in secrecy, to be indispensable for the project execution.
For the power industry projects under discussion, the situation was quite different: the leading designer treated all his younger and less experiences colleagues as prospective leading designers and did a lot to give them fair chances to become leading designers and to substitute him when necessary.
The upgrading of the design staff was carried out from the very beginning of the design process: development of the flow diagrams. The usual way was that the leading designer, who has significantly bigger design experience that the other designers of the team, drew draft schemes in presence of the design and implementation team. Only after the general solutions were designed, individual designers were allocated to solving detailed tasks. The major benefits achieved due to such approach were that the younger designers learned the design "generals", what was necessary to lead the overall project effectively and could learn some of the experience of their colleague of a bigger experience, the leading designer.
All design and implementation team members could and had to be active in the design and implementation process. The leading designer never tried to be the indispensable worker of the team. On the contrary, if some of the younger designers devised a solution other than that devised by the leading designer but such that it could be applied successfully in the overall design, the solution of the younger designer was implemented. This helped for the younger designers to develop courage necessary to cope effectively with the project problems.
An additional activity of the leading designer were the basic functions of a project manager. It was almost a must that the leading designer controls the money distribution in the design and implementation team; if not, the WPR system would, for sure, fulfil the functions in a standard way and the people of the team would not be interested in really intensive work. In the team, the managerial functions of the leading designer were fulfilled by all team members, on the round-robin fashion in order that all of them could learn all duties of the leading designer.

4.5 Backup profession

In the state of continuous struggle between the WPR and WRP systems, the leading designer had always to remember the WPR system may make a mistake and, punish him by dismissing even before the project was completed or nearly completed. In such a case, he would be entered onto a black list and could not find any work in his basic profession. The leading designer for the power system automation projects discussed was, therefore, a professional translator during his complete engineering carrier.

5. FINAL REMARKS

The technology development degree and the political consideration in the Comecon countries generated much more difficult conditions of work for the design and implementation teams in those countries compared to the well developed Western countries. In particular, this refers to the work condition of the leading designers who, in addition to coping with the technology difference impacts, have simply to establish their own just political subsystems (WRP) in order that design and development of successful pioneering systems was possible.

Nevertheless, in spite of the work conditions that were much more severe than those of the designers in well developed Western countries, development of Polish novel ICT and automation systems proved to be feasible and the systems were very precious for the overall economy of the case study country.

The experience gained when developing the pioneering systems is used till now (the Powerster system, ref. Stapleton, 2008) and even is being designed and investigated for the future (the Computer Integrated Manufacturing and Management systems (CIMMs), ref. Franasik, 2001; Izworski, 2003, 2006; Lewoc, 2006a). It is only a big pity that, after the most desirable political changes in the case study country, the large scale technology transfer that has become possible, results rather in losses than in technological development (Izworski, 2001; Lewoc 2005,2006b, 2007a).

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