A DISTRIBUTED PROCESSING SYSTEM ARCHITECTURE IMPLEMENTATION FOR ANALOG TELEPHONIC PLANT MODERNIZATION, MONITORING AND CONTROL

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ABSTRACT

A digital technology hardware & software system implementation is presented to overcome the problem of electromechanical telephonic switching network obsolescence, without having to face the high-costs involved in its full substitution. The basic hardware architecture relies on a proprietary bus, controlled by a 386SX-based processor, with specific distributed I/O processing boards, in a expandable network schematic connection.

I. INTRODUCTION

Due to the fast advances in the communications development area today, the engineers often face the problems that arise when equipment from different technology generations have to interact. We have a good example on telephonic switching networks, where there are forty-years-old electromechanical telephonic plants interacting with modem ones, based on digital technologies. As long as the new technology brings new facilities and better quality communication lines, the old technology becomes obsolete far away from its lifetime end. If we look at telephonic market worldwide today, we observe that the companies budget limitations imposes a choice of investment: besides the plant modernization or full replacement dilemma, there is an increasing demand for new subscriber lines and services. In Brazil's case for example, a full substitution of the existing seven million electromechanical-type terminal would last seventeen years wasting US$ 200 million / year. We must also take into account that soon the today's technology will be obsolete, and more cost-attractive partial modernization now will allow a state-of-the-art substitution in twenty years after.

Following we present an electromechanical telephonic switching network modernization system, proposed to overcome this problems. The "SET-MSC" system architecture is conceived not only to fulfill the market needs for new services, but also to find out and remove specific bottlenecks, either inside the own network or in its interface with other ones. Its hardware and windows-oriented software guidelines are devoted to facilitate technician's work on its maintenance, as well as to incorporate the flexibility to adapt the system to different manufacturer's plants with few modifications. Once the system's architecture is introduced, it is used to show a case study of a Siemens ESK electromechanical telephonic plant modernization.

II. HARDWARE STRUCTURE

The hardware architecture can be divided into three main levels as shown if Fig. 1: the highest one, called UCOG - that means "Management and Operational Central Unit" - is a central supervisory system, based on a PC compatible computer running a windows-oriented software. The databanks in this unity are continually updated by the second level remote systems, that are "smaller" versions of the UCOG. These second level systems, called ULO - Local Operational Unit - have its data-banks related exclusively to the equipment to which they are connected. The ULO connection to the electromechanical equipment is made by the third level system called UCAD - Data Acquisition and Control Unit - this one being the base of the whole system. The UCAD system is a proprietary hardware architecture developed to interact with the electromechanical system and interface it with the PC computers. The first and second level systems are essentially data-storage devices with data correlation and processing, that supply the technicians with full supervisory information and control capabilities, in a user-friendly interface. The second level systems are optional, since the third level equipment can update the first level directly, in case of an unassisted central. The UCAD ULO interface is made by IEEE 802.3 ethernet interface, and the ULO-UCOG interfaces uses X25 standard communication protocol. The direct connection UCAD-UCOG can be made optionally by a modem, with board in a private line using a X25 concentrator, or in a public-switching telephonic network. In this case, the connection can be made through the MOD board, the serial SER board connected to an external modem, or even an ISA bus standard internal modem attached to a bus adapter.

The UCAD system relies on a proprietary bus with 21 slots, whose master controller, called P32, is based on the Intel's 386SX microprocessor. For greater reliability, two

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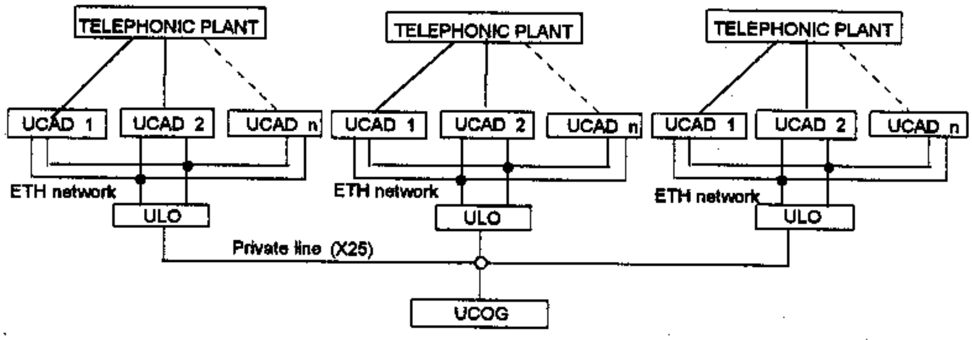

Fig. 1: SET-MSC general hardware structure.

P32 boards can operate in parallel, one of them supervising the correctness of the other one, and getting the bus control in case of error. So are the FNT power supply boards that can operate in a load-sharing configuration. The bus is conceptually an ISA bus with some changes in order to accomplish some required features as "plug-and-play" automatic board recognition, extended data and control lines and mechanical requirements. In a large system, various UCADs equipped with a AMD79C960-based ethernet board - the so called ETH board - and the ULO can be connected by 10-BASE-2 or 10-BASE-T interfaces, so they can real-time correlate data from as much individual points as needed. Again for greater reliability, both the ethernet and the modem boards previously mentioned have duplicate circuits.

The P32 bus master controls a set of different boards of various functions, that now will be briefly described: the simplest ones are the digital input board - EDI - and digital output board - SDI. A variation of these boards, capable of sensing tri-state condition is also available, and are named ED3 and SD3. They have a set of "digital" inputs/outputs in the relay standard actuation levels, appropriately protected against high-voltage surges. They use hybrid technology to reach a high integration level, and are used to monitor relay states and actuate them. These monitoring and actuation obey an intricate set of conditions that are dictated by the electromechanical equipment functioning, and by the features that are under observation/control. These conditions are translated into software procedures and plant's configuration data bases, stored in P32's 2MB EEPROM up to a limit of 80%. Then, these data are transferred to the ULO or UCOG. Optionally, the user can request an update at any moment from the ULO/UCOG "control panel". After processing, the results are shown in the form of tables, curves and bar-graph reports, useful to the analysis of plant's performance. The software also incorporates real-time alarm messages for any equipment malfunctioning. Point specific monitoring/actuation resources are also included, like traffic measurement, subscriber duties and line-blocking, etc.

The communications interface between old plants relies on a handshake-type protocol named MFC, confined to the spectrum range of standard telephonic lines. Despite the new technologies in a modern plant, its connection to the old ones is subject to this limiting factor, once the information transit time will be dictated by the old equipment. We can say that the electromechanical plant itself is a bottleneck of overall system. If we accelerate this information exchange, than that subsystems within an analog central that are under high demand will sooner be free to perform the next linkage. In this way there will be an actual increase in its capacity. In the SET-MSC system, the register and R2 sender/receiver electromechanical subsystems are monitored and can even be replaced by the REG and DSP boards, the first one being a plant-specific board, and the second one being a TMS320C25-based R2 transceiver (which performs the MFC interface) with recursive digital filtering and adaptive threshold detection capabilities.

POS	F0	S0	P1	P2	P3	P4	P5	P6	P7	P8..P10	P11	P12	P13	P14	P15	P16	P17	S1	F1
SLOT ID	30	28	1	2	3	4	5	6	7	8 .. 10	11	12	13	14	15.	16	17	29	31
NAME	FNT	P32	ETH	ETH														P32	FNT
SLOT Nb.	1	2	3	4	5	6	7	8	9	10..12	13	14	15	16	17	18	19	20	21
BASE ADDR.	7800	7000	400	800	C00	1000	1400	1800	1C00	2000 A 2800	2C00	3000	3400	3800	3C00	4000	4400	7400	7C00

Fig. 2: Basic UCAD rack configuration

Finally, a set of boards, as the ADC - analog functions, VOZ - voice processing, and JIS - supplementary services driver, can be included to implement the supplementary services available today only in digital plants, like messages, follow-me, etc., as well as new ones like automatic call-back to undesired callers, for instance, with its phone number stored in system's memory.
The UCAD standard system, laying in a 19" rack, has the configuration illustrated in Fig. 2. Each slot has a physical identification called ID, depending on its position. The FNT, ETH and P32 boards are the only ones with pre-defined positions. As mentioned previously, for lack of redundancy, there are two slots for each of these boards. The FNT and P32 slots are reserved, but the ETH slot can be used by any kind of functional board, depending on the desired configuration. The remaining functional boards, chosen among the cited options, are defined according to the type of telephonic plant and analog subsystems for which the monitoring/actuation is desired. Whenever possible, the physical connections to the existing analog system are made in parallel, to minimize the SET-MSC system influence over the basic plant operation in case of malfunction. The data base binary identifiers that map the plant's configuration into the software procedures are stored in P32's flash EEPROM. The P32 automatically identifies a hot board insertion and uses the data base to configure it, in a "plug and play" fashion way. The data base identifiers basically incorporate physical and temporal descriptors, that say where and how frequently a mapped point must be read/written. The software structure description in the next section will clarify this structure. For more complex subsystem boards as the REG and DSP, the resource mapping is not as rigidly fixed as the binary-oriented structure inherent to digital input and output boards, once the corresponding plant subsystems are naturally dynamically allocable.

III. SOFTWARE STRUCTURE

Once the hardware structure is known, we can start a brief description of SET-MSC software by the operating system it relies on. Due to inherent safety aspects of Windows NT over Windows for Workgroups operating system, the first one is preferred for management at the UCOG level, though it is possible to choose the UCOG's operating system as Windows for Workgroups. This last one is also adopted at ULO level, whose safety requirements are not so rigid. The UCAD level runs under a dedicated ROM BIOS software, originally written in C and assembly. The Windows user-friendly environment is of singular importance in this case, because the technicians that normally interact with the electromechanical equipment have few contact with computers, and are naturally against new technologies not well understood, interfering in their system. So, the benefits that come with the new equipment must be really attractive as soon as it is put to work. The SET-MSC UCOG/ULO software is programmed using C++ object-oriented language, and all characteristics inherent to Windows interface are available, like context sensitive on-line help, status and tool bars, etc.

The UCOG/ULO data base management incorporates Rushmore technology, and it can be divided in two parts: the configuration and the dynamic collected information data bases. The configuration data base, is composed of the so called system archives and the telephonic switching plant archives. The last ones describe the central configuration, being dependent on the type of central. On the other side, the system archives describe the SET-MSC system hardware installed, and are independent from the type of central. Since the installed hardware is determined by the amount of monitoring and degree of actuation intervention desired for an specific central, these data bases are intrinsically correlated, but they are separated in software for easy of maintenance. So, usual changes that occur in a central, like expansion or resources relocation, are made independent from changes in the MSC system hardware, from the viewpoint of the software. This architecture choice also creates an independence from the central manufacturer as far as possible, making the system portable to virtually any type of analog telephonic switching network. At the UCAD level, the configuration information assumes the simplified form of binary identifiers, which carries physical and temporal information, that is which points to read/write and how frequently. As a development aid tool, the software has an embedded logic analyzer, for event timing analysis.

The way the UCAD treats the dynamic data base, that one with the collected information and operators asynchronous intervention commands, is peculiar to this application: once the analog central events occur in timing scales much greater than the digital events in the microprocessor, the data banks are mounted over the device's status transitions, that is, when a bus read cycle takes place, the actual state is compared to the last one, and only the changes are updated to the flash memory. This memory optimized utilization gives to the UCAD, for instance, a week of autonomy in the case of tariff data collection without the need to transfer it to the ULO, though this transfer is programmed to take place at every five minutes. Such delicate kind of data, very well considered by the switching network owners, is duplicated in another UCADs of the system and at the ULO, and as they are in flash EEPROM memories, they are not lost in case of a power supply failure. For supervisory data, the ULO update is scheduled for every 15 minutes, but the updating can be requested asynchronously at any time by the authorized operator. The exception is the alarm data, which is automatically sent to the ULO immediately for the appropriate operator action. All alarm events and operators interventions are registered for ulterior analysis, and through a synoptic frame, the alarm priorities can be examined and reset. The alarm and electromechanical devices status buttons are always visible in operator's screen.

The operator access to SET-MSC resources is subject to security constraints, that are also peculiar to this application: once the technicians have generally the knowledge of only a specific kind of function, and this function identifies their job, the software's security system is not user-oriented, but function oriented. Once the operator's function is defined to the system, only that resources and degree of intervention intrinsic to his job are put under his control. This kind of security scheme prevents erroneous system use by unauthorized persons that try to act over the system in areas they don't understand.

A cleaning mechanism is also included. As time evolves, the collected data base increases, and some of the archives loose their degree of importance. Associate to each data archive, the system maintains an attribute of "importance", based on criterion like generation date, utilization rate, etc. The storage capacity depends only on the UCOG/ULO installed hardware, and when they are in the limit, the operator can request an automatic cleaning, that is made in many steps, for the operator to verify if the required disk space is already achieved, and to avoid unnecessary data removal.

The central mapping configuration is organized in groups of electromechanical devices, named organs. The group criterion adopted is the organ type. A group of archives exist that describe, in a modularity fashion, the group characteristics, like plant configuration, routes, line drivers, associated system boards, etc. Once that any change takes place at the installed analog plant, the new configuration is updated at the ULO level, modifying the cited archives. Automatically, the ULO updates the UCAD and the UCOG.

Though SET-MSC it is a very complex system to be well understood in a summarized paper, the application example presented in the next section will clarify a little the way all things described are placed together.

Table I: Telephonic plant to system wiring connection, distributed by electromechanical device unit.

MSC Board	Plant Device	Function	Nb. wires
EDI	TWM	Subscriber MUX	51
	RSA	Subscriber MUX	2
	REG A	Control	2
	ZREG A (2)	Control	26
	REG K	Control	2
	RWM	Route selection	52
	ZUL	Route selection	20
	GRSK, GRSG, KRSK, KRSG	Line drivers	4: 1 each
ED3	TWEG	Subscriber MUX	1
	MER	Control	1
	MEV	Control	1
	JESP	Line driver	1
SDI	TWM	Subscriber MUX	1
	GRSK, GRSG, KRSK, KRSG	Line drivers	4: 1 each
SD3	RSA	Subscriber MUX	1
REG	REG	Control	28
DSP	REG	MFC protocol	6

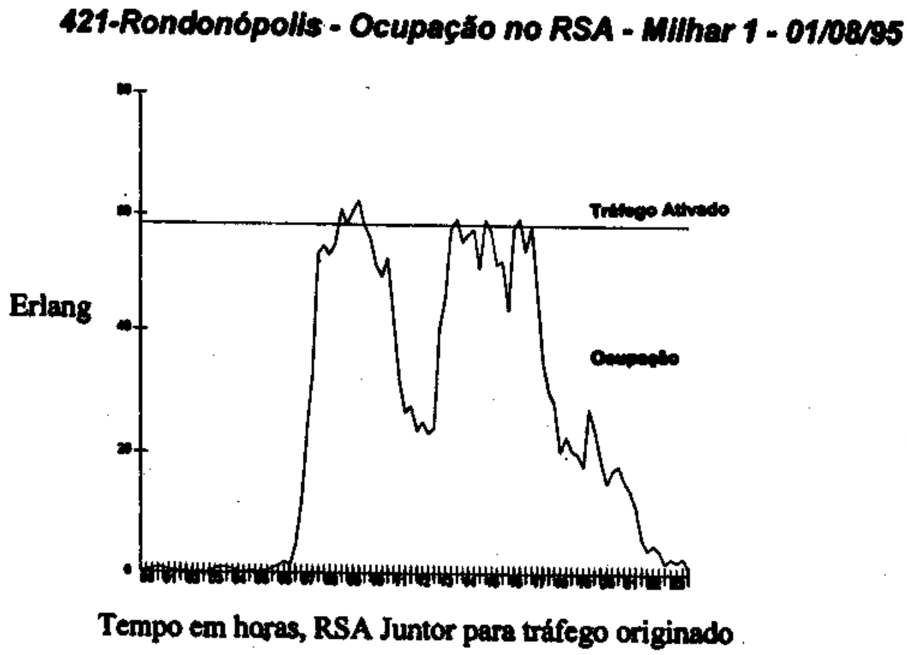

Fig. 3: SET-MSC Typical one-day period telephonic traffic measurement curve for RSA electromechanical device.

TELEMAT

Relatório de Exceções

Dias pesquisados:	Central:	Grupo:
Terça-feira 01/08/95 às 00:00 até às	421-Rondonópolis	RSA - Milhar 1

Possíveis Linhas Cruzadas

Nome do Órgão	Número de Órgão	Número de Eventos	Tempo Médio de Retenção	Tempo de Ocupação (Seg)	Tráfego Cursado (ERL)

Troncos Sempre Ocupados

Nome do Órgão	Número de Órgão	Número de Eventos	Tempo Médio de Retenção	Tempo de Ocupação (Seg)	Tráfego Cursado (ERL)

Troncos Sempre Livres

Nome do Órgão	Número de Órgão	Número de Eventos	Tempo Médio de Retenção	Tempo de Ocupação (Seg)	Tráfego Cursado (ERL)

Troncos Toma e Cai - Retenção média menor que 50% da média do grupo

Nome do Órgão	Número de Órgão	Número de Eventos	Tempo Médio de Retenção	Tempo de Ocupação (Seg)	Tráfego Cursado (ERL)

Troncos de Liberação Lenta - Retenção média maior que 100% da média do grupo

Nome do Órgão	Número de Órgão	Número de Eventos	Tempo Médio de Retenção	Tempo de Ocupação (Seg)	Tráfego Cursado (ERL)
RSA11003 Milhar 1 - RSA- 12	18	864	59,54	51440	0,60
RSA11004 Milhar 1 - RSA- 13	19	704	72,12	50775	0,59
RSA11005 Milhar 1 - RSA- 14	20	695	71,27	49530	0,57
RSA11006 Milhar 1 - RSA- 15	21	702	69,21	48585	0,56
RSA11007 Milhar 1 - RSA- 16	22	760	60,80	46210	0,53
RSA11011 Milhar 1 - RSA- 47	26	630	64,06	40355	0,47
RSA11012 Milhar 1 - RSA- 48	27	602	66,59	40090	0,46
RSA11013 Milhar 1 - RSA- 49	28	609	60,91	37095	0,43
RSA11015 Milhar 1 - RSA- 51	30	515	59,13	30450	0,35
RSA11016 Milhar 1 - RSA- 52	31	517	59,84	30935	0,36
RSA11018 Milhar 1 - RSA- 54	33	412	61,41	25300	0,29
RSA11019 Milhar 1 - RSA- 64	34	339	70,87	24025	0,28
RSA11023 Milhar 1 - RSA- 68	38	299	64,46	19275	0,22
RSA11025 Milhar 1 - RSA- 70	40	232	73,32	17010	0,20
RSA11028 Milhar 1 - RSA- 64	43	249	63,21	15740	0,18
RSA11033 Milhar 1 - RSA- 69	48	101	72,08	7280	0,08
RSA11038 Milhar 1 - RSA- 65	53	124	61,13	7580	0,09
RSA11039 Milhar 1 - RSA- 66	54	110	65,05	7155	0,08
RSA11040 Milhar 1 - RSA- 67	55	119	79,83	9500	0,11
RSA11042 Milhar 1 - RSA- 69	57	197	60,96	12010	0,14

Data e Hora de emissão: [illegible]   Página 1   Usuário/Cargo:

Fig. 4: SET MSC typical exception report.

IV. APPLICATION EXAMPLE

Following we'll present some selected results of the system operating at TELEMAT's Rondonópolis Siemens ESK Public Switching Network, situated at Mato Grosso state, Brazil. Table 1 brings an idea of amount of wire interconnection per electromechanical device unit. The electromechanical device names adopted are the standard manufacturer's names.

In normal operation, a number of different reports are accessible, like traffic measurement, electromechanical devices status, alarm history, deviation from average behavior, exceptions, etc. These reports can be visualized from macro to micro scale. For instance, the operator is able to plot a traffic measurement curve for all the plant, an specific route, a group (devices of the same type), an individual device, etc. The same is true for the UCOG level, which centralizes information from a lot of spatially distributed plants.

A typical one-day period telephonic traffic curve is shown in Fig. 3 for an specific RSA device. It shows a straight line indicating the ideal traffic (based on installed capacity), and the actual measured traffic.

A resource of special interest is the way the system can correlate data that are not expected to be correlated, aiming to find out malfunction or short-circuits between devices or even between relays. Fig. 4 shows a report in form of a Table of Exceptions, that is, undesirable events like (in order of appearance) possible cross-talk, always busy and always free subscriber lines, undesired interrupted calls (connect-and-crash calls), line trunks with high retention time rate (greater than 100% of group mean), this last one being visualized in detail. The electromechanical device is identified in the first and second columns, the number of events used to calculate the parameters is at third column. The retention and the busy times are in the fourth and fifth columns. The traffic in Erlangs is shown in the last column.

In Fig. 5 we can see a hardcopy of one of the many iterative screens available, showing the electromechanical devices status and the kind of intervention over them. At columns from left to right have: the sequential event numbering, the degree of attention required for the status condition, date, time, functional group, device within the group, physical placement in the plant, current and previous status. Three kinds of status are shown: normal, blocked by system operator (using MSC blocking capability) and manual blocking - the last one being detected when the blocking is made directly on the relays of the electromechanical device.

V. CONCLUSIONS

The presentation of SET-MSC system's design philosophy was considered by the authors to be a valuable contribution to distributed system designers, where the opportunity was created to implement and test the techniques studied in academic environments. Once the system is implemented with standard electronics hardware and software techniques, we tried to highlight its modular design orientation, leading to easy portability for virtually any kind of public analog switching network.

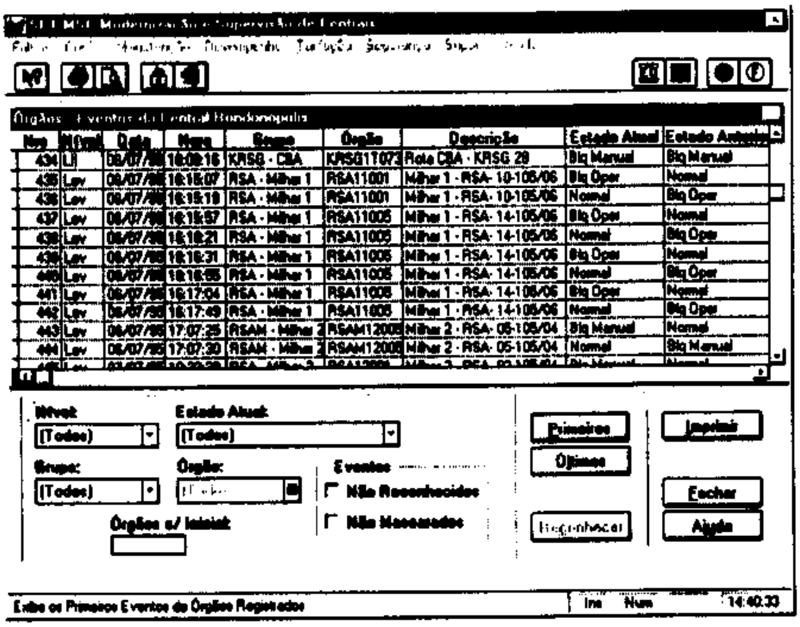

Fig 5: Typical SET-MSC screen with electromechanical devices status in chronological order.