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Process Computer System Development at Bougainville Copper Limited

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Bougainville Copper Limited (BCL) operates a 50 Mtpy copper/gold/silver mine and concentrator on Bougainville Island, Papua New Guinea. BCL has installed an in-house developed data logging and supervisory process control system using a DEC PDP 11/73 mini-computer in the mill and has recently installed a similar system in the crushing plant. Together with the central DEC VAX 11/780 computer, they form part of a high speed, fibre optic, local area network in the concentrator.

The in-house developed software, known as BIAS (Bougainville Copper Information and Automation System), was developed as a low cost option to interface to a number of different existing plant input/output systems while providing the capability to make maximum use of computer networking facilities. The package includes the more usual control system colour displays and data logging features, but also makes provision for two novel features:

(a) Any user connected to the computer network can access the system displays. This allows metallurgists and management to monitor (but not control) plant operation from their offices.

(b) Specialized application programs for performing advisory and supervisory control, dynamic simulation, and data analysis are easily incorporated into the system.

The mill process system currently runs rougher/scavenger flotation stabilizing control and general data logging. The crushing plant system currently performs data logging only; however it will soon be augmented with the facility to run dynamic crushing plant simulations.

Future developments will concentrate on making greater use of the detailed information available from the mine's fully automatic truck dispatch system which runs on a VAX 11/780 computer. Milling process control will be expanded to examine possible economic control of the operation of regrind and cleaner flotation circuits. An advisory water management system to optimize water supply within powerhouse generating capacity constraint will also be investigated.

Introduction

The Bougainville Copper Limited (BCL) Panguna Mine is situated 670 m above sea level in the Crown Prince Range on Bougainville Island, Papua New Guinea. Annual concentrator throughput is 50 Mtpy (135 000 tpd) of ore grading 0,42% Cu, 0,48 g/t Au, and 1,2 g/t Ag to produce 582 000 tpy of concentrate containing 175 000 t Cu, 14,3 t Au, and 46,1 t Ag. Concentrate is piped 30 km to the coastal port of Loloho where it is shipped to smelters in Europe and Asia.

Mining is by open cut methods with an ore to waste ratio of about 1:1. Figure 1 gives an overview of the BCL concentrator flowsheet. Run of mine ore is reduced to – 150 mm in two primary gyratory crushers before conveying and stockpiling ahead of the main crushing plant. A preconcentration screening plant (commissioned in early 1987) is used to upgrade certain ore types by scalping off coarse, low grade rock from higher grade fines. The product from this plant (– 32 mm) is sent directly to the coarse ore stockpile ahead of the crushing plant.

Conventional two stage crushing using 8 secondary screens and crushers, 16 tertiary crushers, and 30 tertiary screens is used to produce a mill feed which is 80% pass-

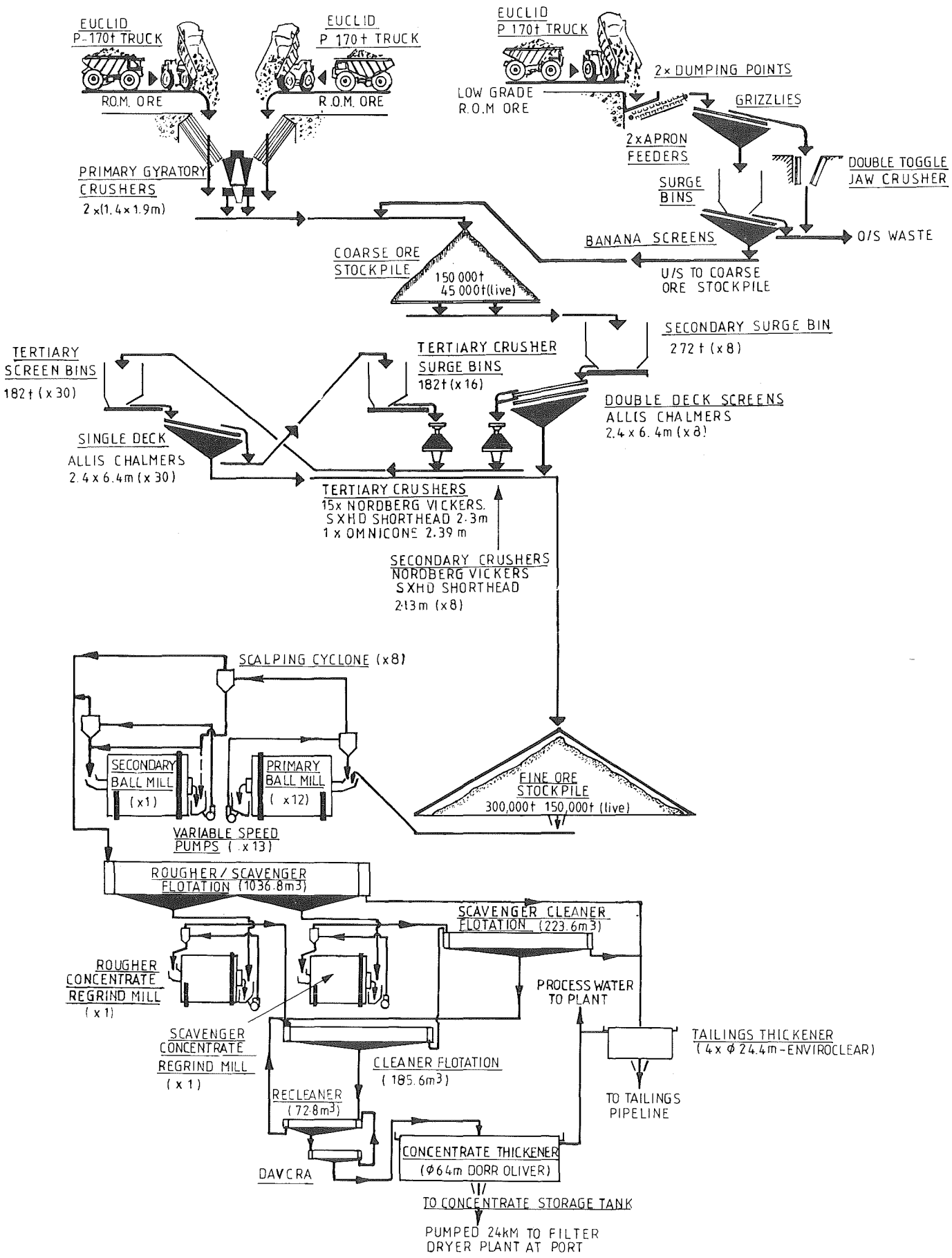

FIGURE 1. B.C.L. concentrator flowsheet

ing about 6,5 mm. Large diameter mills (5,5 m × 6,3 m and 5,5 m × 7,3 m) are used to produce a flotation feed which is 80% passing 250 μm. Currently the milling circuit consists of 12 primary mills and one secondary mill. The flotation circuit consists of initial roughing and scavenging stages whose concentrate is reground separately before passing to a conventional cleaning circuit.

BCL has sought to embrace new technologies wherever possible in an effort to remain an efficient, low cost producer. Some process examples of this approach include the use of large diameter ball mills, high capacity tailings water recovery thickeners, large capacity 38 m^3 flotation cells, and co-development of 750 kW Omnicone crusher. In parallel with the installation of new process technology in the concentrator, BCL has also upgraded plant instrumentation and introduced computerized systems for process control and data logging. It is the present status of the development and application of process computer systems at BCL which forms the subject of this paper.

History of concentrator systems

BCL commenced operations in 1972 with a plant throughput of 29 Mtpy. Since then ore grades have dropped by over 60% but copper production has been maintained approximately constant by investment in more crushing and milling capacity, increasing the availability of equipment, and improving metallurgical performance. Recent productivity efforts have been directed towards improving BCL's competitive position in a climate of sustained, depressed metal prices. An important contribution to improved metallurgical performance has been the effort devoted to improving plant instrumentation and the effective use of integrated process computer systems.

Crushing plant

The crushing control room consists of a large plant mimic panel with single station controllers, dials, strip chart recorders, alarm anunciation, and equipment start/stop buttons. It has remained essentially unchanged in format since start-up in 1972.

The crushing plant originally used Ramsey PEIC single station controllers for crusher power draw control and relay logic for equipment interlocking and sequencing. By 1979 Foxboro SPEC 200 equipment was installed for bin level control.

In 1981 Square D 8881 PLCs were installed on the secondary crushing circuit to perform limited data logging, equipment interlocking and sequencing, some calculations (e.g. crusher power efficiency), and hardcopy reporting. The Ramsey controllers on the secondary crushers were also replaced with YEW controllers which were interfaced to the new PLCs. Newer SY/MAX series Square D PLCs have been introduced in other locations as required (e.g. primary crusher, ROM conveyor drive house, and preconcentration screening plant).

Instrumentation upgrades have proceeded in parallel with the movement towards greater data logging and control, culminating with the present use of Milltronics' air ranger III sonic level sensors and Ramsey microtech weightometers.

Crushing plant process control has always remained relatively simple with operator manual setpoint control. Some data logging was introduced with the installation of the 8881 PLCs but this is still very rudimentary, being confined predominantly to monitoring crusher power draw efficiency.

Mill

At start-up the mill used YEW single station controllers for mill circuit control on the eight original mills. Relay logic was used for equipment interlocking and sequencing. Three subsequent mills were installed using essentially the same philosophy. Foxboro SPEC 200 equipment was used initially for mill 10 control but this was later replaced with YEW. The SPEC 200 is currently used for water flow, reagent addition, and weightometer integration and display.

In 1980 a TDC 2000 system with one operator station was installed to perform mill lift-up monitoring. This system was subsequently expanded with the installation of the twelfth ball mill to perform all control, interlocking and sequencing associated with mill 12. A second operator station was also added at this stage. The system was steadily expanded in subsequent years to perform reagent addition control, mill 13 control and monitoring, tailings water recovery control and monitoring, and sundry other smaller functions.

Between 1980 and 1984 the mill underwent a sustained upgrade of most instrumentation, particularly primary element sensors. Mill density gauges, magnetic flow meters, and weightometers were upgraded to improve accuracy and reliability. A Courier 300 on-stream-analyser (OSA) was installed in 1980 to provide on-line flotation assay information.

Milling process control development was undertaken from 1975 to 1980 using a DEC Universal Digital Controller which was capable of digital and analog input/output. The compter was programmed in Assembler and Focal. The system was used primarily for mill circuit control trials. Unfortunately, it suffered from a nubmer of hardware and software problems and was eventully abandoned. The upgrading of the TDC 2000 system to a supervisory control system was later investigated but the cost could not be justified.

A flotation control project in co-operation with the Julius Kruttschnitt Mineral Research Centre was undertaken from 1983 to 1984 using a FOX 300 control system. Stabilizing control trials were conducted on one third of the plant's rougher/scavenger capacity (three well instrumented, parallel banks of nine OK38 cells). The encouraging results which emerged from this project laid the foundation for the subsequent development of an in-house developed supervisory process control and data logging system.

Concentrator offices and laboratories

Technical and scientific computing within the concentrator began with a DEC PDP 8 mini-computer. This single user machine was replaced successively by a series of DEC mini-computers, namely, a PDP 11/10, PDP

11/04 and PDP 11/34. With the purchase of the multi-user PDP 11/34, a simple concentrator database program was developed in Fortran which stored several hundred concentrator operating and production statistics on a daily basis. Because of the nature of the program, database enquiries required a computer programmer to write specific programs for each type of enquiry.

In 1984 a DEC VAX 11/780 computer was installed to handle the steadily expanding demands of an increasing number of users. The concentrator database was expanded and completely rewritten using the Adabas database management system and the associated 4th-generation Natural database enquiry language. This has greatly simplified data storage and subsequent retrieval for analysis. Because of continued growth in applications the VAX 11/780 computer will be expanded in late 1987 to a VAX-cluster with the addition of a VAX 8530 computer.

Development of the present networked systems

System alternatives

Following on from the successful rougher/scavenger flotation control trial, a decision was made to proceed with a production control system on all rougher/scavenger banks. Given the lack of data logging and related facilities in the crushing plant, it was decided to install a data logging system there also. To facilitate system maintenance and support, it was decided to install identical systems in both the mill and the crushing plant.

There were three basic options available for installing a process control and data logging system:

(a) purchase a proprietary control system consisting of computer and plant interface hardware and software;
(b) install a mini-computer system and purchase proprietary control system and plant interface software; and
(c) install a mini-computer system and develop the control system and plant interface software in-house.

After approaching a number of control system manufacturers with requirements it was soon realized that there would be insufficient justification to proceed, given the costs involved. Each manufacturer had a computer system (sometimes made by another company) with integral plant interface hardware. The system software was understandably designed to operate with only the manufacturer's particular interface hardware. Because of the separate instrumentation development paths followed in the crushing plant and the mill, this meant a massive write-off of existing plant interface hardware in either or both the plants for each system evaluated, or the costly exercise of interfacing one manufacturer's system with another.

While with the benefit of hindsight it is possible to fault the separate development approach, the equipment chosen at the time was the most appropriate for the particular applications involved. The requirements for the crushing plant were (and still are) mainly logic based, and hence the selection of PLCS, while those in the mill were more process control orientated, hence the Honeywell TDC 2000 system. Also, when these decisions were undertaken, the dramatic expansion in computing potential and capabilities for the price was not foreseen.

Option 2 involved the purchase of a DEC mini-computer system (because DEC equipment was already well known and supported on-site) as well as the separate purchase of proprietary software for performing supervisory process control and data logging with our existing range of plant interface hardware. This option was rejected because of the desire to implement supervisory and advisory control algorithms, undertake on-line dynamic simulations, and communicate information with the central Concentration VAX computer, all on the same system. It was determined that there would be significant difficulties in incorporating our specialized applications into the proprietary control system software framework.

The third option, entailing complete in-house software development, was therefore examined after the cost effectiveness and functionality of the first two options were deemed unsatisfactory. Before dismissing, or alternatively, rushing into the development of an in-house control and data logging software package, a detailed review of the features required of such a system was undertaken. Consideration was also given to additional benefits which might be derived from the inclusion of other facilities not normally found on conventional control systems. On the basis of this review it was determined that there was sufficient justification to proceed.

The broad scope for the project called for the development of a software package which would provide:

(a) communication interfaces to all existing and future (unknown) plant interface hardware in the crushing plant and the mill;
(b) comprehensive data logging (with alarm checking) and storage of all necessary plant and calculated data;
(c) easy configuration of new plant points and displays;
(d) a colour terminal interface to all system users;
(e) a full range of point, group, trend and mimic process displays for presentation of current and historical data;
(f) facilities for regular and demand report generation of stored data;
(g) communication with other computers including other control system computers;
(h) remote computer user access (read only) to all system displays;
(i) supervisory and advisory control capabilities (but no direct loop control);
(j) facilities to run on-line or parallel dynamic simulations of processes and off-line simulations for possible evaluation of operating strategies; and
(k) facilities to perform on-line data analysis using stored data.

The novel features of the software package are its network-wide access capabilities to enable wider dissemination of the data collected, and facilities for incorporating specialized application programs (e.g. supervisory and advisory control algorithms, dynamic simulation, on-line data analysis, etc.). The system was not designed to perform direct plant regulatory control since it was felt that this is best performed by the existing controller instrumentation.

The vehicle chosen to support these goals was a DEC PDP 11/73 mini-computer running the microRSX operating system. The PDP 11/73 was chosen because it offered excellent price/performance. A DEC RC25 dual 26 MB fixed/removable Winchester Disk system was chosen for disk data storage. The operating system, control and data logging system software, and logged data reside on the fixed disk. The entire system can therefore be backed up in one operation to the removable disk pack. Almost all software was written in Fortran 77 with the remainder in Macro 11 assembler. The complete software package is known as BIAS (Bougainville Copper Information and Automation System), a name which emphasizes the integrated and automated approach to information collection and dissemination.

Inter-computer communication alternatives

It was realized early that certain information logged by the process computers would also be needed by the central VAX 11/780 computer for the concentrator database. Several alternatives were investigated, namely:

(a) serial terminal link running at 9,6 kbps on an existing telephone line;
(b) serial terminal link running at 9,6 kbps on a dedicated shielded line;
(c) Ethernet network link running at 10 Mbps on coaxial cable; and
(d) Ethernet network link running at 10 Mbps on fibre optic cable.

While option 1 was by far the cheapest it was however unacceptable because of the frequent problems encountered with noise on the telephone lines (particularly during heavy storms which can occur several times a week). This option also required significant programming effort in order to have both computers communicate with each other.

A specially laid, shielded cable was considerably more expensive to install than option 1 while retaining the overhead of software development. While options 3 and 4 also required dedicated cables, in addition to network interface hardware and software, the added expense was considered to be justified, given the reduced programming effort required and the enormous increase in functionality offered.

The coaxial cable network option was cheaper than fibre optics but it had three major drawbacks, namely:

(a) the cable path between computers passes high voltage transformers and very near to high voltage cable trays, making an electrically noisy environment for 10 Mbps transmission rates;
(b) there were possible earth potential differences between locations; and
(c) there is a significant risk of susceptibility to power line and lightning induced transients in the cable.

The extra marginal cost for the networked option, compared with the serial terminal link was very easily justified. The mill and the crushing plant (and later the primary crusher) had a number of central VAX 11/780 computer users who were connected by telephone lines using modems and statistical multiplexors. These suffered from lack of speed, noisy connections and intermittent failure during the frequent heavy storms. The network option using terminal servers which connect directly onto the network (not via a computer) were therefore ideal for these remote terminal users since it provided reliable, high speed access to all computer systems.

Networked computer system overview

Figure 2 schematically illustrates the DECnet network of computer systems within the mine and the concentrator. Basically, the network consists of two high speed Ethernet local area networks (LANs) connected by LAN bridges to give what is known as an extended local area network. In order to achieve 10 Mbps transmission speeds, the maximum end to end distance in an Ethernet LAN is limited to 2,8 km.

Each device connected directly to the network is known as a node. Examples of nodes include computers and terminal servers. Each node requires a network communications controller in order to send and receive message packets over the network. No tokens or master/slave device designations are used to regulate access to the Ethernet communications channel. Instead, a technique known as Carrier Sense Multiple Access with Collision Detection (CSMA/CD) is used. Nodes are attached to the network by means of a four-twisted-pair wire transceiver cable which is non-destructively clamped onto a length of Ethernet coaxial cable using a transceiver. In the BCL environment the Ethernet coaxial cable is connected over large distances by fibre optic cable with fibre optic repeaters at either end.

The LAN bridges are used to connect LANs and thereby extend the distance over which high speed network communications can take place. LAN bridges buffer message packets destined for nodes not within the LAN of the transmitting node. Also, through their intelligence, they do not transmit messages across the bridge if the sender and receiver nodes are within the same LAN. The LAN bridge also functions as a fibre optic repeater.

Terminal servers provide an efficient means for connecting up to eight (remote) terminals directly to the network. The remote user issues a connect or set host command at the start of each terminal session in order to connect to any computer on the network. Once connected, the user then logs onto the computer and conducts an interactive terminal session in the normal manner. Terminal server connection in a networked environment is particularly efficient because a user only uses the resources of the computer to which he is connected (cf. a terminal connected directly to a computer communicating with a remote computer over the network uses resources on each computer).

There are five different geographical locations within the mine and concentrator in which lengths of Ethernet coaxial cable have been installed for the connection of nodes. Both the mine and concentrator possess large multiuser VAX computers to satisfy general purposes, technical and application computing needs. The crushing plant and the mill have smaller mini-computers that run the in-house developed BIAS supervisory process control and data logging system. These process computer systems

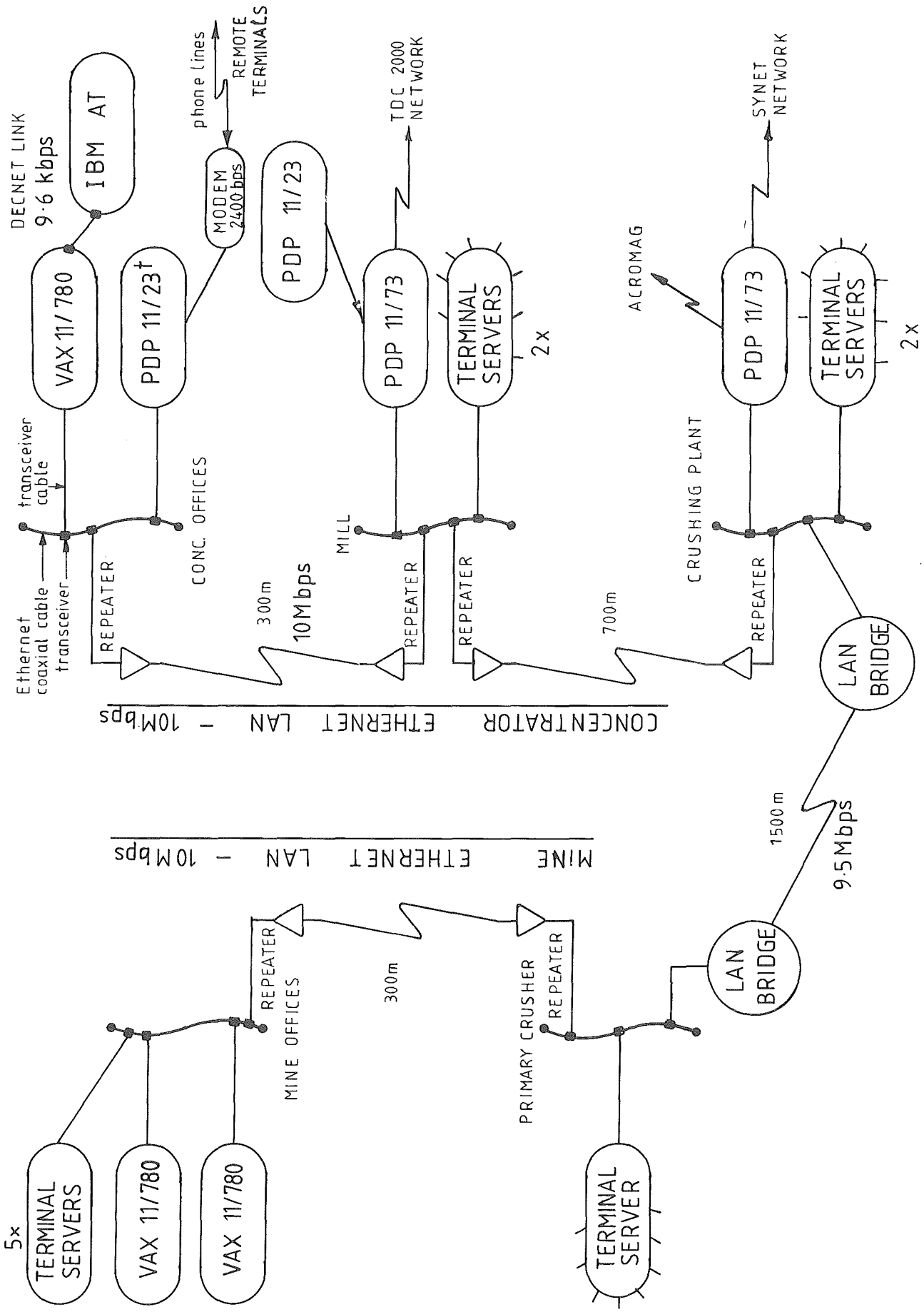

FIGURE 2. B.C.L. DECnet crushing plant network

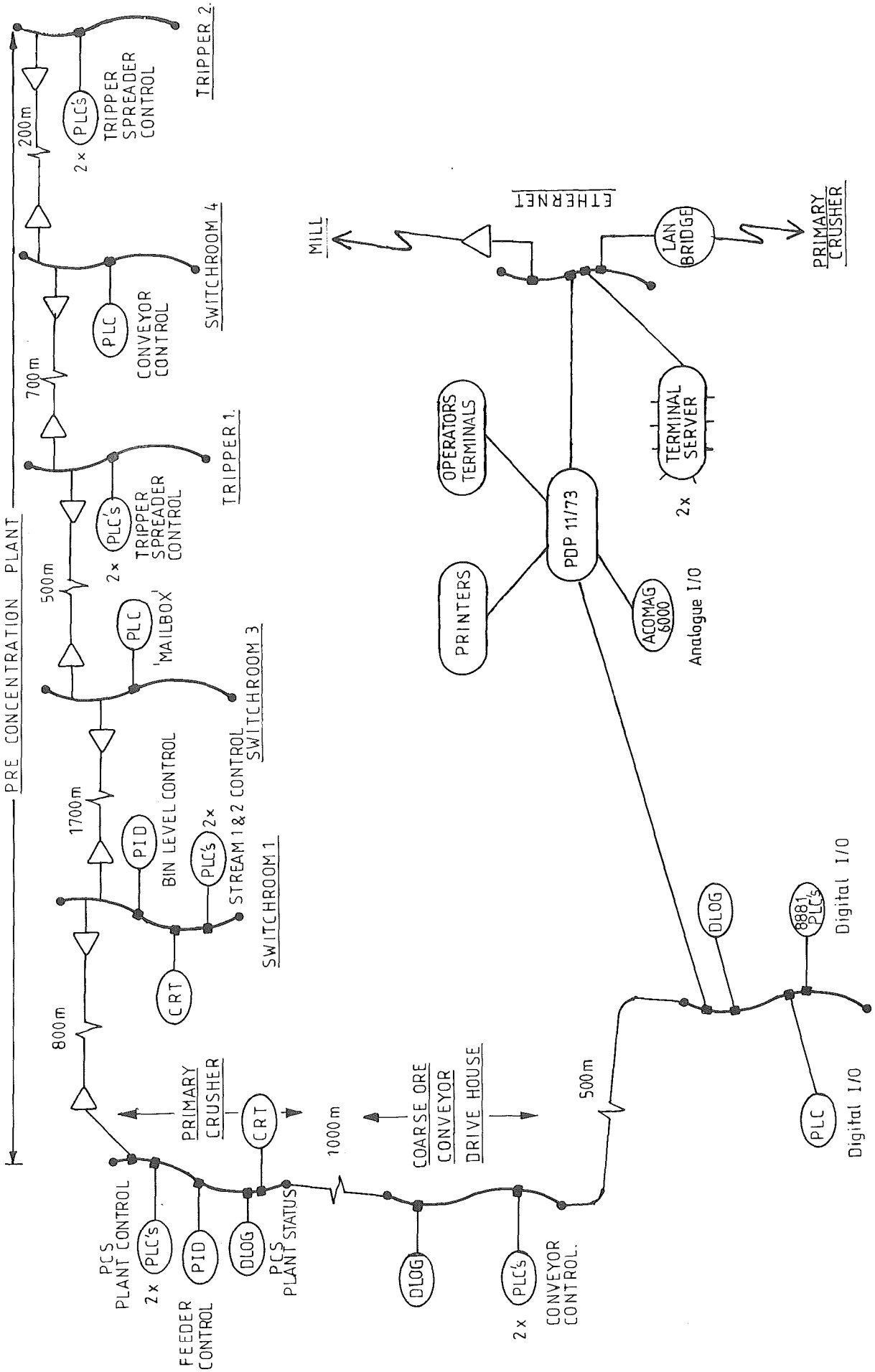

FIGURE 3. Crushing plant network

also communicate with local instrument data networks (Square D SY/NET network in the crushing plant and the TDC 2000 data hiway in the mill) in order to integrate almost all information transfer within the mine and concentrator sites.

Crushing plant system

The crushing plant process system, illustrated schematically in Figure 3, is used primarily for data logging purposes. The PDP 11/73 computer is connected directly into the Square D instrument communications network known as SY/NET. The SY/NET instrument network runs at 0,5 Mbps and has similar functionality to that of the Ethernet computer network. RS422 serial lines connect devices to SY/NET network interface modules which function as network communication controllers.

Devices connected to the BCL SY/NET include:

(a) Square D 8881 PLCs (two in the crushing plant);
(b) Square D SYMAX 300 and 500 PLCs (all locations);
(c) Square D process control modules (PCM) which drive up to four four-loop single station controllers (all locations);
(d) Square D-log modules which are 29 kB microcomputers programmable in Basic (primary crusher and crushing plant); and
(e) DEC PDP 11/73 computer (crushing plant).

The newer SYMAX series 300 and 500 PLCs perform interlocking and sequencing control in all locations. In the primary crusher and preconcentration screening plant they also provide the analog and digital i/o interface to the plant. Because of the large number of analog signals in the crushing plant, an Acromag 6000 i/o device was more cost effective to install for all analog i/o. The 8881 and SYMAX PLCs are therefore used almost exclusively for digital i/o. The d-log modules are used primarily for moving data stored in the memory of one device to another. The crushing plant computer inputs and outputs data sequentially with each i/o device on the SY/NET.

Mill system

Figure 4 schematically illustrates the mill process system where three separate systems are used to perform i/o with the plant, namely:

1. Honeywell TDC 2000 system,
2. Courier OSA and computer,
3. Analogue Devices' Micromac 5000 i/o device.

The TDC 2000 system consists of a 0,25 Mbps coaxial cable data network (known as a hiway) connecting multiple eight loop analog controllers, analog and digital process interface units, and colour operator stations. This system is used primarily for regulatory control of flotation reagent addition, tailings, water recovery, and mills 12 and 13; interlocking and sequencing control of mills 12 and 13; and limited data logging. This system is connected to the mill computer via a parallel interface to a Honeywell General Purpose Computer Interface (GPCI).

The Courier 300 OSA provides copper, iron and percent solids assays for 14 flotation streams on a 7 minute cycle. The OSA computer is connected to the mill computer serially over a terminal line. Every two minutes the OSA computer prints a special assay report which is decoded by the mill computer.

The Micromac 5000 is a 48 kB microcomputer (programmable in a powerful i/o orientated Basic) with the ability to perform extensive analog and digital i/o. The Micromac 5000 is used as an intelligent front end for preprocessing certain signals. It is connected to the mill computer via a serial terminal line.

Process control and data logging

Crushing plant

The crushing plant BIAS system was commissioned in June 1987. The system is functionally equivalent to that in the mill except that the plant i/o interface software is different. Data logging in the crushing plant involves monitoring crusher power draw, feeder speeds, bin and stockpile levels, tripper and shuttle positions, tertiary screen direction, and weightometers.

Using models already developed to describe unit performance of secondary and tertiary screens and crushers, a dynamic simulation procedure for the entire crushing plant is being constructed. Data collected in real time will be input into the simulation in order to determine unknown operating variables, in particular the final product size for the plant.

The crushing plant operates, for the most part, on a fixed throughput strategy in order to maintain sufficient live capacity (plus a safety margin) in the fine ore stockpile to allow uninterrupted operation of the 12 primary ball mills. The primary objective of the plant is to ensure that the ball mills never run out of ore. The secondary objective of the plant is to produce the finest possible product size since ball mill product size (and hence flotation recovery) is directly proportional to ball mill feed size. Final product size is manipulated on a short- to medium-term basis primarily by changing the number and direction of tertiary screens operating and by changing tertiary screen cloths (different apertures).

With the on-line calculation of final product size, operators will be better placed to appreciate product sizing effects induced by changes in plant operating variables, such as secondary or tertiary crusher closed side set and tertiary screen direction. This means that the objective of reducing the crushing plant product size can be pursued more actively in the short-term by the operator.

The dynamic simulation will also be used to examine in advance the effect of various operating strategies. For example, after a prolonged line shutdown (eight hours) the level in the fine ore stockpile drops significantly. In order to ensure that further unscheduled shutdowns do not result in the ball mills running out of feed, the stockpile level is often increased rapidly by increasing plant throughput. Typically, this is achieved by installing coarse cloths on the tertiary screens with a consequent increase in final product size. The number and duration of coarse cloths used is determined by the operation superintendent's experienced assessment of the situation. This experience will be augmented with quantitative data on the throughput/product size/economic trade-offs of various strategies by using dynamic simulation to predict

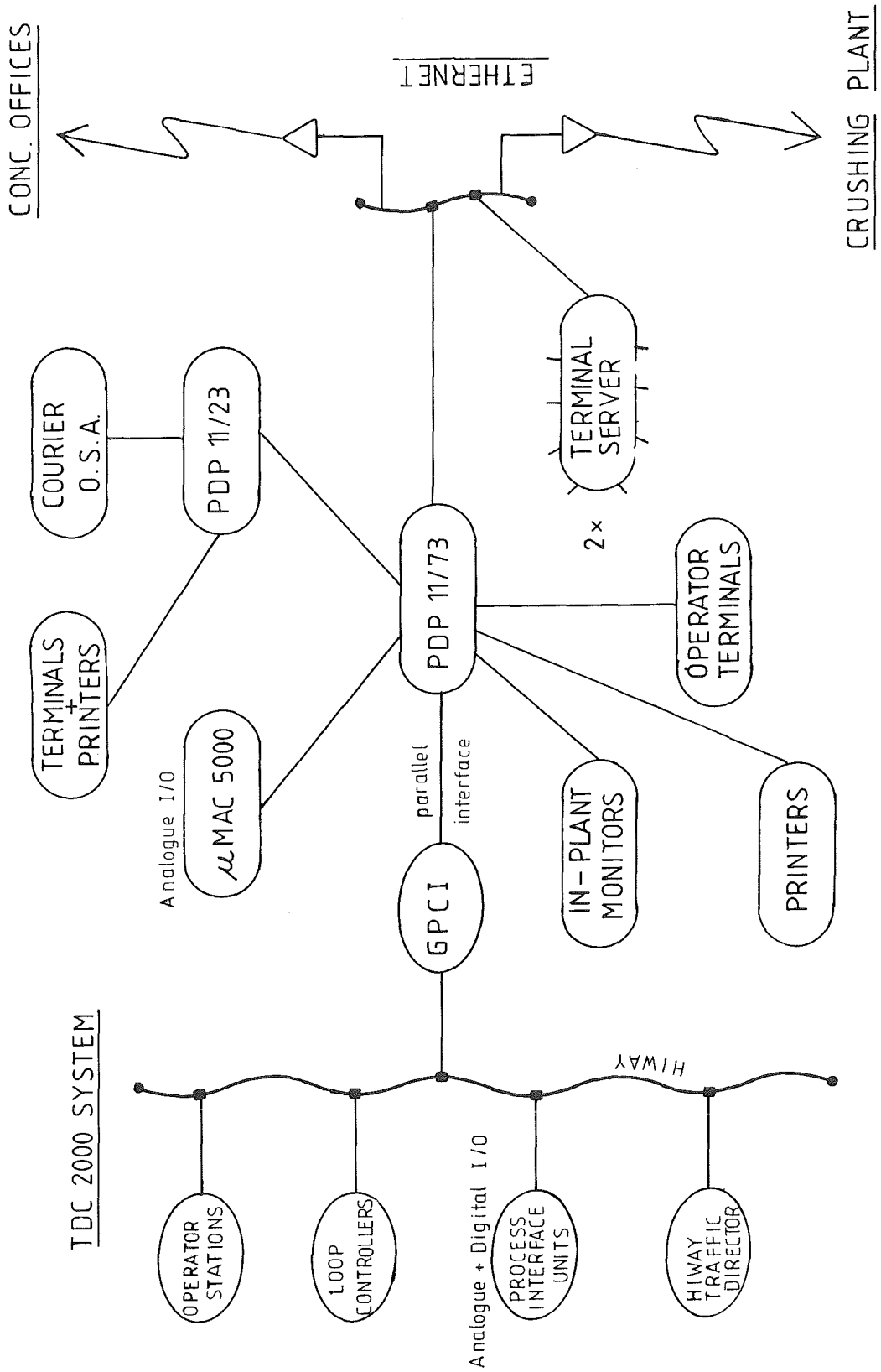

FIGURE 4. Mill network

results. Furthermore, these predictions can be refined and re-evaluated as conditions change with time.

A simple procedure for optimizing the movement of trippers and shuttles above bins and the stockpile has been developed. The trippers and shuttles move back and forth between operator selectable endpoints. The endpoints are chosen to ensure that bins are kept within an operating range of levels. An objective function which penalizes empty and full bins is used to select the optimum endpoints automatically. It is expected that this procedure will allow floor operators who continually monitor bin levels to perform other duties.

Mill

With the exception of mills 1 to 11, the TDC 2000 system performs all direct regulatory control functions within the mill. The BIAS system performs supervisory control of rougher/scavenger flotation. Rougher and scavenger concentrate grade are controlled by manipulating bank pulp levels. Concentrate grade setpoints are determined by feedforward and feedback terms including head grade and recovery. Collector and frother addition rates are also controlled. The objective is to stabilize rougher/scavenger flotation in order to minimize disturbances in the subsequent concentrate regrind and cleaner flotation circuits.

Rougher/scavenger flotation consists of three sides (modules) of three parallel banks (nine banks in total). Sides 1 and 2 are Denver 600 cells (18 cells per bank) while side 3 (the newest) consists of Outokumpu OK38 cells (9 cells per bank). Each side is controlled as though it were a single bank, since concentrates from each of the three parallel banks gravitate to a common sump from which OSA sample streams are diverted. This approach is reasonable provided that the parallel banks are properly balanced prior to the commencement of control. Bank balancing involves bringing all banks to the sample pulp level and then adjusting air flow rate to each cell in order to maintain nearly equal pulling rates across corresponding cells.

Rougher/scavenger flotation control has operated as a production tool since September 1986. Analysis of its performance indicates that it is certainly meeting its objective of stabilizing circuit operation. While before/after comparisons are difficult to evaluate because of ore type variations, flotation recoveries have increased by a statistically significant amount.

In part, this can be attributed to the closer scrutiny of circuit operations undertaken during the control trials. Also, operators were given more precise guidelines for circuit operation as well as undergoing comprehensive education in circuit performance analysis and control. This, in conjunction with the availability of improved data logging and analysis tools, has resulted in the operators becoming more sensitive and responsive to circuit operation.

Data collected in the TDC 2000 system and Courier 300 OSA which are required for storage in the concentrator database running on the VAX 11/780 computer are now automatically downline loaded from the mill process computer. Previously, these data were manually recorded by operators in the mill and then entered into the VAX computer by clerks the next day. This procedure was a wasteful double handling of data which was subject to errors in transcription.

General

With the advent of the networked BIAS process computer systems, the mill and crusher operations foremen, metallurgists and managers have access to most aspects of plant operation by personal terminals. In addition, remote users in the concentrator offices can monitor plant operation from terminals on their desks. This is particularly useful for the chemists to monitor OSA performance and project metallurgists to monitor on-going plant trials and testwork. In general, it is felt that the readily available facilities of the crushing plant and mill BIAS systems (and concentrator database) are helping to promote a greater sense of information awareness amongst personnel. The overriding emphasis of this approach has been to promote more effective use of the significant quantities of information available in order to help improve plant operation.

A 2,4 kbps acoustic modem allows dial-up access to the concentrator VAX 11/780 computer by remote users over a telephone. This facility is available to metallurgical and other staff on call-out duty for convenient around-the-clock access to plant operating data via the BIAS process computers.

Future developments

The BIAS process computer systems will be used in the future to implement several process control and data logging functions, including further flotation and grinding circuit control and advisory water management control. Perhaps the most interesting use however will be the on-line logging of mining data to assist in improving concentrator performance.

One of the mine VAX 11/780 computers runs a fully automatic truck dispatch system which optimizes truck movements. In addition, this system collects certain information which has potential for use by the concentrator. Data of interest to the concentrator include:

(a) the shovel origin for each truck load of ore dumped at the primary crusher or preconcentration screening plant;
(b) the ore blend currently entering the coarse ore stockpile;
(c) shovel digging rates for each truck load of ore dumped; and
(d) primary crusher digestion times for each truck load of ore.

ROM ore can typically be mined at up to six different shovels locations within the Panguna ore body. There are several major ore types present, each of which can exhibit significant variability in ore properties (e.g. copper and gold grade, pyrite content, acid copper solubility, ore hardness, size distribution, clay content, etc.). Hence, concentrator performance can (and does) vary appreciably with ore type (shovel location) and with ore blend (mix of shovels operating). Shovel digging rates and subsequent primary crusher digestion times will be used to infer ROM

feed size distribution and ore hardness.

These truck dispatch data have potential to assist in the operation of the crushing plant by providing feed-forward information for determining future short-term operating strategies. In the mill (provided an adequate model of mixing in the fine ore stockpile can be developed) the data would be of enormous value in flotation circuit optimization. Ore type fluctuations, which could possibly influence recovery would be known in advance, thereby allowing an orderly changeover of reagent conditions and operating strategy to be implemented.

Conclusions

A high speed network for computer-computer and user-computer communications (Ethernet) was installed to provide a flexible backbone for present and future information processing needs at multiple geographic locations. Process computers running an in-house developed supervisory process control and data logging package (BIAS) connect plant instrument data networks to the computer network. All network users have access to the process displays generated by the process systems. The emphasis on the development of these networked systems is improved data accessibility in order to promote greater information utilization.

In addition to concentrating plant information, the process computer systems are capable of running supervisory and advisory process control schemes. In the mill stabilizing control of rougher/scavenger flotation is currently in operation. This is soon to be followed by advisory water supply management. The crushing plant system has recently been commissioned. Eventually it will run a dynamic simulation of the plant to predict product size. Information collected by the mine's automatic truck dispatch system will also be used to assist in plant operation.