Paul L. Tuan
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SOME NOTES ON TERMINAL PROCESS CONTROL COMPUTERS

I INTRODUCTION

This informal note is the first of a series of preliminary material to record in capsule form the findings and observations relative to terminal computers. This material will eventually serve as input to the preparation of the yard-design handbook. This note documents some of the observations derived during recent visits to the Southern Pacific Railroad Company, CONRAIL, WABCO, etc. by Paul Tuan and Peter Wong. This write-up gives emphasis to terminal process control computers (PCC), but the PCC description is preceded by a brief introduction of yard computer systems in general.

For the purpose of developing a framework for future reports, this note is intentionally written at a general level. Each of the sections will be later expanded into greater detail. The number of sections is also likely to expand as more topics are addressed in the course of the research.

In the context of this write-up, the term "terminal" is used interchangeably with the term "yard" when referring to railroad classification yards.

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*This document does not constitute an official report; it may be revised as research proceeds.

II THE PURPOSE OF YARD COMPUTERS

A. General

The main purposes of yard computer systems are:

- To enhance operational efficiency through better and more timely information for operational and management decision. This role is commonly referred to as the management information system (MIS) function.
- To perform automatic classification and routing functions in the yard. This role is commonly referred to as the process control (PC) function.

B. MIS Function

The MIS function can be further subdivided into 2 groups: 1) those functions that primarily benefit system central data processing, and 2) those functions that primarily benefit the local yard. However, policies and procedures regarding the division of responsibility between "central" and "local" differ from one railroad to another; a clear-cut grouping scheme is therefore not possible. The most common information that is made available through a terminal MIS computer system includes the following:

- Car locations and descriptions
- Yard inventory (by track, by position, or by area)
- Train lists
- Advance consists
- Classification table
- Hump switch list
- Yard crew and engine dispatching information
- Operational planning and management decision systems (models)
- Statistical and management reports

C. PC Functions

The process control function may apply to the entire yard or only areas of the yard. The most common application of PC systems is to perform automatic control at the hump end only. The hump process control computer system usually takes the hump switch list as input (often from the MIS computer) and automatically sets switches, controls retarders, and furnishes the MIS computer with the outcome of the control process (i.e., what it did with the cars). In addition to a set of commonly practiced control functions, certain PCC's can also detect broken wheels, measure the velocity of movement, determine weight class, direct unauthorized movement, etc. The information that normally resides in a hump PCC includes train lists, switch lists, class table, hump speed control parameters, retarder control parameters, and so forth.

D. The Relationship Between MIS and PC Computers

There are various philosophies and preferences regarding the PC and MIS computer network architecture (in both hardware and software). The various approaches are listed below:

- MIS and PC functions are performed by the same computer.
- MIS computer and PCC are separate and are linked through off-line data communication only.
- MIS computer and PCC are parallel-linked with a larger central computer at system central. There is also an on-line linkage between the two at the local yard.
- PCC is subordinate to MIS computer.
- MIS computer is subordinate to PCC.
- PC function is centralized in one single computer complex.
- PC function is distributed among several data-linked but not control-linked computer systems. For example, the use of a micro-computer at the pull-out end, and a larger PCC at the hump end.

III DISTRIBUTION OF COMPUTED DATA PROCESSING FUNCTIONS

To describe the various computer network architectures among railroad yards, we first divide the locations of the system installation into three levels:

1) At the system central
2) At the yard central
3) At the user station.

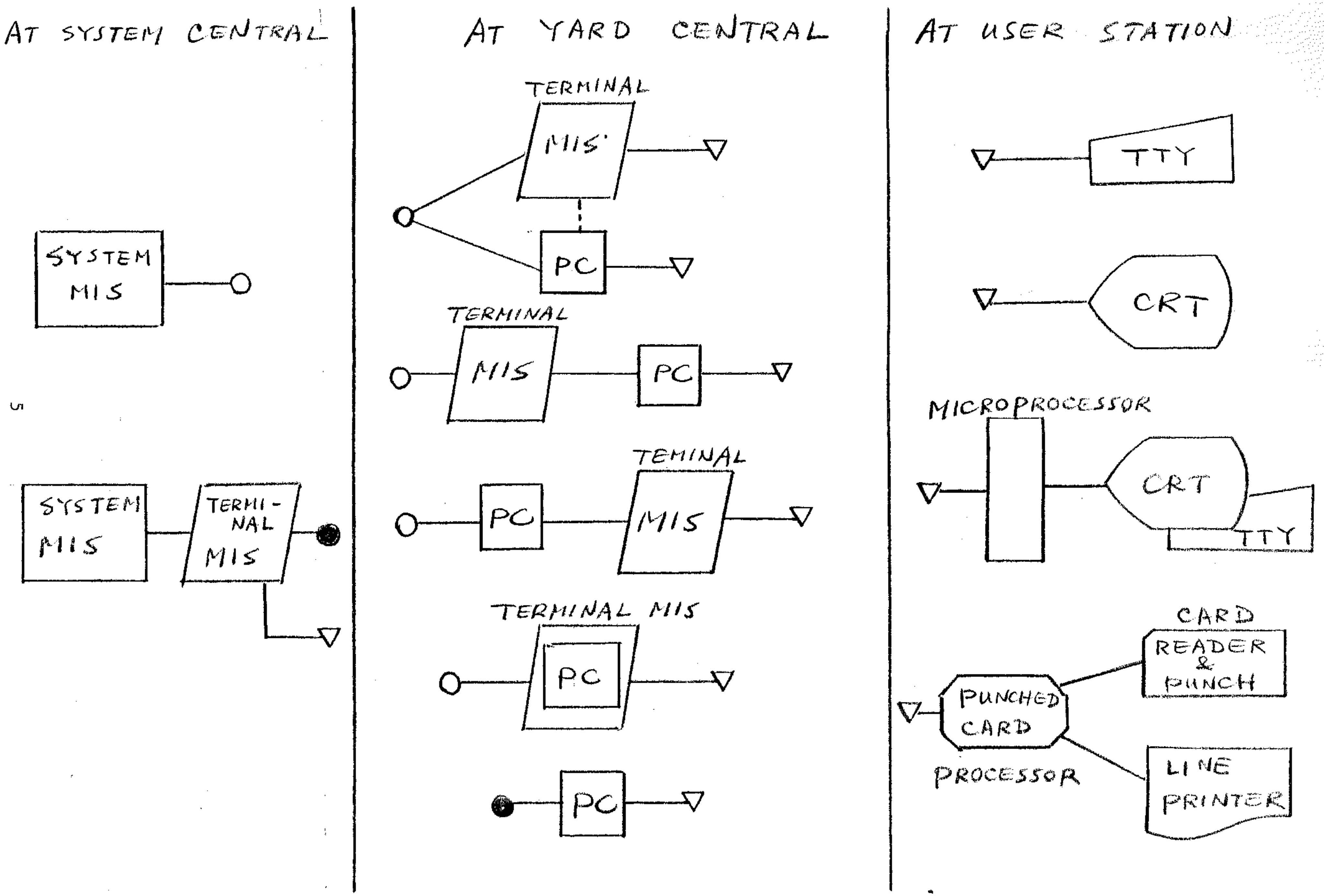
In many small yards, the computer apparatus (remote I/O terminals) at the user locations are directly linked with the main-frame processor at the system central, and the local yard does not have its own on-site computers. More railroads are now looking into the possibility of using intelligent terminals or microprocessors to enhance I/O functions at the user station in order to reduce data link costs and formatting requirements at the host computer.

Next, we divide the computer data processing functions into four levels of information utilization:

1) System MIS--This requirement is typified by S.P.'s TOPS system.
2) Terminal MIS--This requirement is typified by S.P.'s TCC system or Missouri Pacific's YATS system.
3) Process control
4) Remote I/O terminal operations--TTY's, CRT's, card processors and line printers.

Figure 1 gives the various options and combinations in computer network design.

FIGURE 1. VARIATIONS OF COMPTER NETWORK LINKAGE



IV FURTHER DISCUSSIONS ON PC COMPUTERS

In order to limit the scope of discussion to a manageable size, the following material pertains only to PC functions at the hump end.

A. Maximum and Minimum Systems

A maximum PC system has a wide range of capabilities in sampling input data from the field, for example:

Measuring Device	PC Data
• Scale	• Weight class
• Radar	• Speed
• Wheel detectors	• Rollability and velocity
• Photosensors	• Length, height, and car location
• Hump approach track circuit	• Hump signal status
• Exit retarder track circuit	• Last car pull-out information

Together with train consist data, hump switch list, and on-line instructions from yard personnel, the sampling and control software in the PCC transforms field inputs into control signals in order to perform hump engine speed control, retarder control, switch activation (for automatic routing), system monitoring (display of system status), and so forth.

In a maximum system the PCC may also conduct a limited MIS function, for example, maintaining track inventories.

In a minimum system, it is possible that most of the above listed devices (e.g., wheel detector, radar, photosensor, scale) are not used. The functions of wheel detectors are replaced by presence detectors. The car movement and location information is derived by relying on more internal computation and less field inputs.

B. PCC Software Architecture

The PCC software can be aggregated into the following four groups:

- Sampling routines
- Data reduction routines
- Control function routines
- System monitoring and MIS routines.

Depending upon the field devices under the PCC's surveillance and control, the sampling technique can either be on a fixed-time increment basis (cycling) or on an event occurence basis (interrupt). The determination of which technique to use is a matter of trade-off between data resolution and computer resource cost.

The data reduction software is essentially a continuation of the sampling routines in which raw input data is translated into useful decision information. For example, the absence or presence of a wheel detector occupancy will be translated, along with other input information (e.g., system clock time) into car speed.

The control function routines generate control signals from both input data (reduced) and prestored control parameters and decision rules.

The MIS and system monitoring routines massage and organize the existing input and output information into statistical and management reports.

C. A Typical PCC Configuration

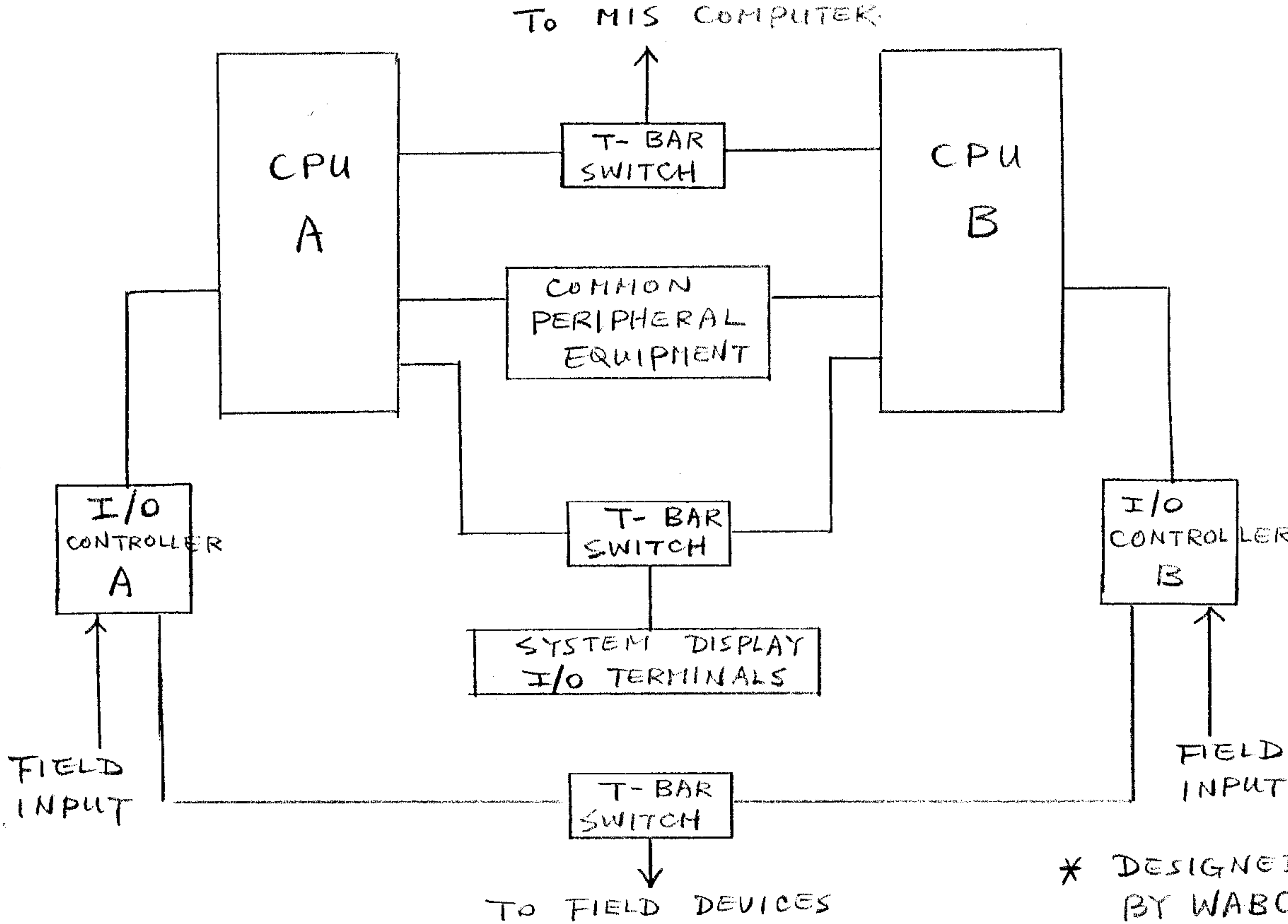
For the purpose of enhancing system reliability, two CPU's are often used in parallel in a PCC system. The failure back-up system is usually provided with one of the following two alternatives:

1) Semi-automatic Switchover (or Cold Standby)--In a semi-automatic dual-processor system, the secondary computer may be engaged in a totally different application (for example, an MIS-type job), while the primary computer is controlling the humping operation. In the event of a failure in the primary computer during a humping process, the process must stop and the control function may have to be transferred to a manual back-up. The standby computer cannot instantly take over the current humping process since it does not have the switch list or the state variables of the current control process in its working storage. It must first unload its non-PC applications and then initiate the CPU with PC software and data tables. In this manner, the second computer can only start with a new switch list.
2) Automatic Switchover (Hot Standby)--Under this architecture the dual-processor system provides an instant switchover in the event

of a failure in the primary processor. The second processor is always on "hot" standby, which implies that the occurence of a failure in the primary processor will not cause the humping process to stop. During a control process, the field inputs enter both processors simultaneously and the calculations are done in a redundant fashion. However, only the output from the primary processor is normally allowed to exit. The output from the secondary processor is compared with that of the primary processor. In the event of a difference greater than predetermined tolerance limits, a determination would be made as to which computer is at "fault". As can be surmised, a dual-processor PCC does not provide a real fail-safe or fault-tolerant system since it lacks an objective referee to select the correct answer in case of a discrepancy. A "voting system" also is not feasible since there are not sufficient numbers of parallel CPU's to form a majority. Figure 2 depicts a typical hot standby dual-processor PC system.

FIGURE 2. A DUAL-PROCESS PC SYSTEM

(A SIMPLIFIED VERSION OF THE CHESSIE SYSTEM*)



* DESIGNED BY WABCO