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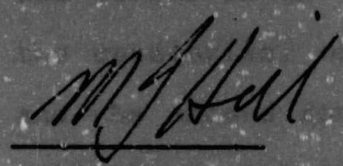
THE NETWORKING OF NC AND CNC MACHINES TO FACILITATE THE ELECTRONIC TRANSFER OF CAD/CAM DATA

MARK JEFFREY HILL

A dissertation submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for degree of Master of Science in Engineering.

Johannesburg, 1989

I declare that this dissertation is my own, unaided work. It is being submitted in partial fulfillment for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



Mark J. Hill

25TH day of January 1990

SYNOPSIS

This report describes the design and implementation of an electronic data transfer system between NC/CNC machines and an NC Programming facility. Three distinct components, the BTR Interface, BTR Database, and BTR Network are identified and discussed in detail. The BTR Interface is divided into two categories, one for NC machines (parallel interface), and the second for CNC machines (serial interface). A cost analysis is presented, as well as all the relevant program code and explanation thereof.

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1. INTRODUCTION

Since the late 1940's, manufacturing automation has been the chief aim of production engineers. First, it was implemented mechanically, then improved with primitive control devices like vacuum tubes and mechanical relays. Major steps followed, and with the arrival of modern computers and technology, automated manufacturing equipment such as CNC machines, robots and programmable logic controllers available off the shelf, it was relatively easy to automate particular, isolated manufacturing activities.

A hypothetical factory can be represented by the islands of automation shown in figure 1.1.

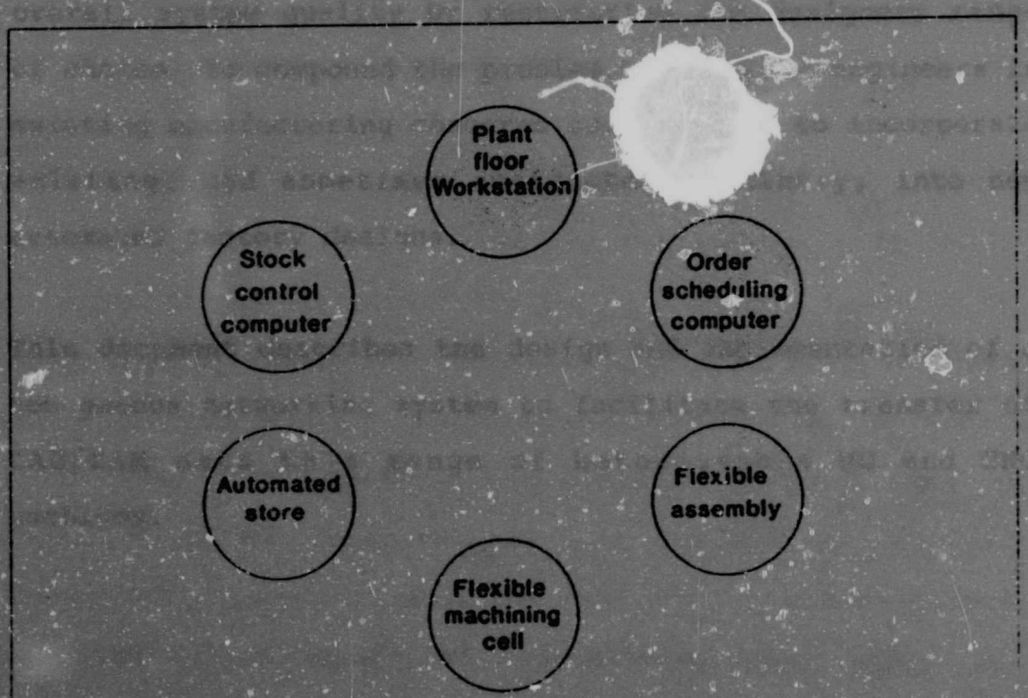


Fig 1.1 Islands of Automation

The variety of automation problems represented by these islands generally leads to an equal variety of different manufacturers' equipment as the factory designers attempt to match manufacturers' strengths to the system's requirements.

The problem arises when factory designers attempt to make these differing manufacturing devices communicate with each other. Each manufacturer of equipment has developed unique methods of information transfer and processing, without paying much attention to integrating their equipment with that of another manufacturer. It would be possible to source equipment from as few manufacturers as possible, preferably one, but this would inevitably compromise the overall system quality by restricting the designers range of choice. To compound the problem, production engineers in existing manufacturing concerns usually have to incorporate existing, and sometimes antiquated machinery, into new automated factory designs.

This document describes the design and implementation of a homogenous networking system to facilitate the transfer of CAD/CAM data to a range of heterogenous NC and CNC machines.

2. OVERVIEW : ORIGINAL CAD/CAM SYSTEM

2.1 The Site

The site under discussion is an NC machine shop consisting of approximately 22 NC and CNC machines. A further 8 NC and CNC machines are located in areas surrounding the NC machine shop. The machines cover an area of approximately 6000 square meters. These machines include the following :

- 3,4,5 axis and multi spindle machining centers
- single and twin turret lathes
- 5 axis routing machine
- 5 axis shotpeening machine

The machines vary widely with respect to the levels of technology they represent. Some of the machines were built in the 1960's, while others are the latest on the market. The newer CNC machines have modern controllers with built in input and output interfaces for information transfer to and from host computers. These machines also have on-board memory and can store a few complete NC programs in memory at the same time. However, the older NC machines have no interfaces to host computers at all, and have no on board memory. NC programs have to be read into the controllers one block (line) at a time from a paper tape reader. As each line of the NC program is executed, the following line is read into the NC machine.

Every NC and CNC machine had a paper tape reader incorporated into the machine controller. The medium of data transfer between the NC programming department and the NC machines was paper tape. An example of the type of paper tapes used appears in Appendix A.

2.2 CAD/CAM System

The site incorporates an offline NC programming department consisting of approximately 8 programmers. All NC programming is carried out by this department and no programming is carried out directly on the NC or CNC machines. The programmers use a CAD system to "draw" the part to be machined from a detailed drawing. An NC software package is then used to graphically specify the toolpaths of the NC program. The software produces a cutter location file which is postprocessed to produce an NC program. These NC programs range in size from 5kb to 250kb. The length of paper tape needed ranges from 10 meters to 600 meters. The NC programs, (standard ASCII text files), are stored on hard disc and punched out on paper tape. The tapes are stored on the shop floor in a paper tape library until needed, and are returned after use. Figure 2.1 graphically describes the above process.

The CAD system consists of a minicomputer with graphic workstations/terminals. All part drawings and NC toolpaths created over the past 5 years are stored on this system.

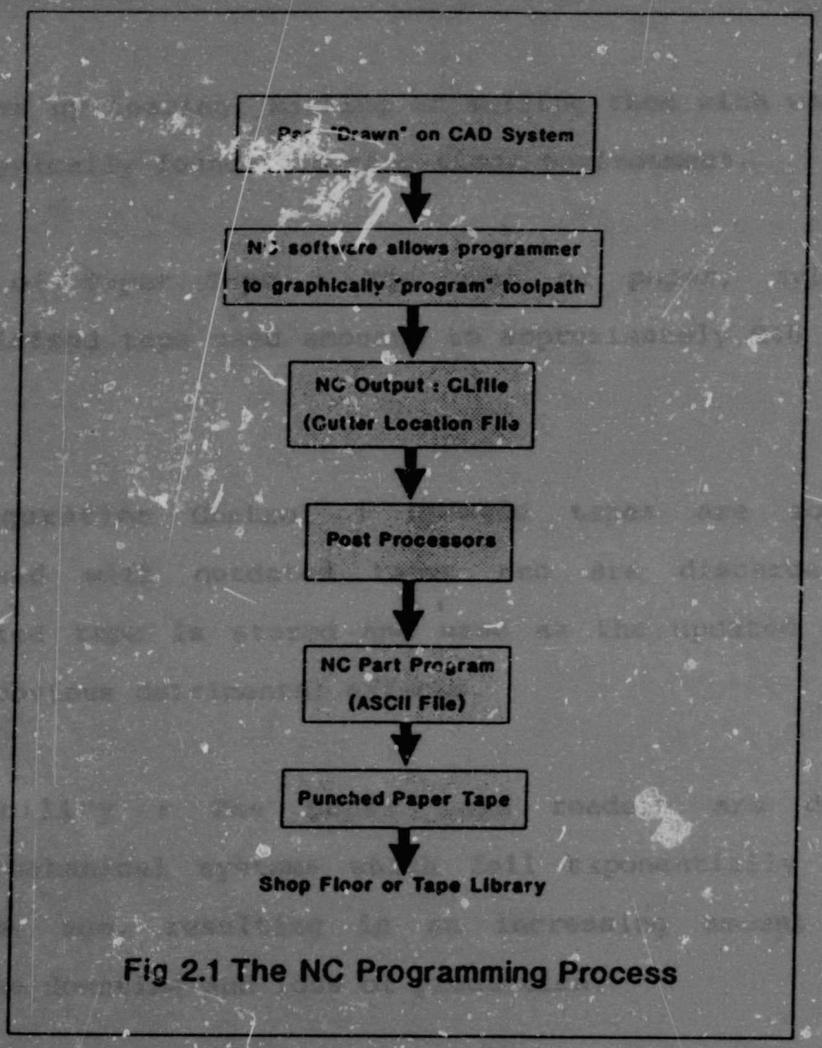


Fig 2.1 The NC Programming Process

either on hard disc or magnetic tape. All NC programs created before the 5 year period reside on a mainframe computer situated approximately 2 km from the NC programming department. Terminals to the mainframe are available, as well as an electronic link to the newer CAD/CAM system for file transfer.

2.1 Problems Associated with the Original System

Damaged Paper Tapes : Paper tapes are easily rendered

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