THE VIRTUAL MANUFACTURING CELL

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Abstract. A virtual manufacturing cell is being developed at the National Bureau of Standards as part of the control software for the Automated Manufacturing Research Facility (AMRF) project. The traditional group technology (GT) cell has evolved from the need to maintain the flexibility to manufacture a family of parts while gaining some of the efficiency associated with a single process flow line. GT cells are normally defined by a fixed physical grouping of machining workstations that produce a particular class of parts. A shop based upon virtual manufacturing cells provides greater flexibility than existing GT shop configurations by time sharing machining workstations. Virtual GT cells are not identifiable as fixed physical groupings of machinery, but as data files and processes in a control computer. Functions performed by these processes include analysis, reporting, routing, scheduling, dispatching, and monitoring. At a higher level, the shop control system schedules cell activation and allocates workstations and other resources to these cells. Workstations are at all times under the control of either a particular virtual cell or a pool cell composed of idle workstations.

Keywords. Production control; Hierarchical systems; Group technology; Artificial intelligence; Manufacturing processes; Management systems.

INTRODUCTION

The AMRF Project

A new type of Group Technology (GT) manufacturing cell, called a virtual cell, is being developed at the National Bureau of Standards to address specific control problems encountered in the design phase of the Automated Manufacturing Research Facility (AMRF). The project is investigating the automated production of small batches of machined parts. A portion of the NBS Fabrication Technology Division machine shop is being converted to a small testbed system that will be used for experiments in precision machining, automated process metrology, and manufacturing interface standards. For further information on the project, see Simpson, Hocken, and Albus (1982).

Implementation Techniques

This section identifies control and data processing methodologies that will be employed in the construction of the virtual cell. These techniques have been selected because they appear to provide the greatest overall system reliability and potential for real-time adaptive control. Detailed discussions of most of these techniques can be found in other NBS papers: Albus (1981); Albus, Barbera, and Nagel (1981); Albus and colleagues (1982); Barbera, Fitzgerald, Albus (1982).

Hierarchical control. This organization is equivalent to the line or tree structure found in many conventional manufacturing systems. Each system takes commands from only one higher level system, but may direct several others at the next lower level. Long range goals or tasks enter the system at the highest level and are decomposed into sequences of subtasks to be executed as procedures at that level, or output as commands to the next lower level. Guidelines for the design and implementation of hierarchical, multi-level systems can be found in Mesarovic, Macko, and Takahara (1970).

Local intelligence. At each level in the control hierarchy this processing capability enables the system to decompose tasks, analyze feedback, and respond to problems at that level. It also ensures that only major tasks, having a global impact, will be handled by the decision making systems at the higher control levels. Guidelines for using local intelligence in the automation of managerial control can be found in Beer (1982).

Finite state machine. To ensure that the control system is deterministic, it will be defined as a network of finite state