THE USE OF CAD FRAMEWORKS IN A CIM ENVIRONMENT

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Abstract

CAD frameworks fall naturally into use in a CIM system because of their ability to integrate the work of design and production engineering teams. This paper describes how a CAD framework forms the backbone for supporting design and planning activities in the facility level of a CIM implementation. The data management capability of the CAD framework serves in a limited way as a product data manager for the enterprise and it plays a major role in linking the facility level to the shop floor level.

1. INTRODUCTION

Although the idea of Computer Integrated Manufacturing (CIM) is well-known, an enterprise-wide implementation is still out of reach of most, except the large enterprises. The advent of CAD frameworks and other enabling technologies has presented an opportunity to produce a lower cost solution that small and medium sized enterprises can afford.

The GINTIC Experimental Printed Circuit Board Assembly Facility (EPCBAF) was set up for the research on flexible manufacturing systems (FMS) for the electronics industry. It serves as a testbed for new technology in CIM and as a facility for the prototype production of small quantities of printed circuit boards (PCBs). It is developed to provide a showcase FMS for educational purposes, and to demonstrate and promote CIM technology to the local industry [1].

The EPCBAF has assembly lines for both inserted mount (through-hole) and surface mount PCBs. The machines on each line are connected by a unidirectional conveyor system with a magazine loader and unloader at each end. Automated Guided Vehicles (AGVs) are used to transfer the magazines of PCBs across lines.

The scale of the EPCBAF is much modest compared to, for example, the RAMP program [2]. Off-the-shelf technologies are employed as much as possible and the main effort is directed towards integration of these technologies. The control structure of the EPCBAF is similar to the reference model for Shop Floor Production Standards defined by ISO's Technical Committee TC184 (Industrial Automation Systems) in ISO/TR 10314-1 [3]. There are two main levels of control: the higher Facility and the lower Shop Floor levels (Fig. 1). Design and planning functions take place at the Facility Level, where activities are on-line, interactive, but not real-time. On the other hand, production occurs at the Shop Floor Level, where activities are on-line, interactive, and real-time. The Facility and Shop Floor levels share a common

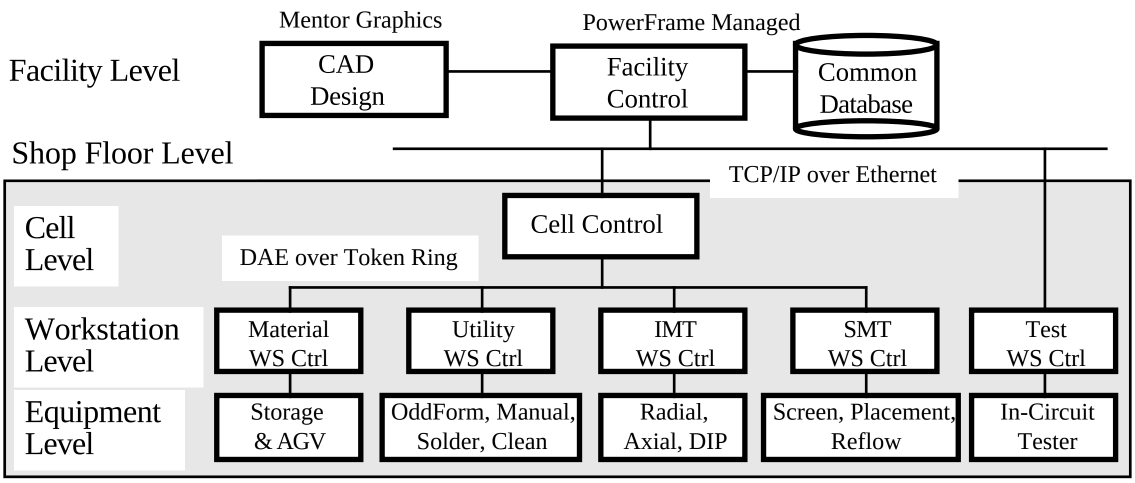

Figure 1: Hierarchical Control Structure

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database containing released design and manufacturing information, located at the Facility Level. The Facility Level control software makes the database available to the Shop Floor Level.

This paper describes the use of a CAD Framework, PowerFrame from Digital Equipment Corp., as a basis for integrating the design and planning functions at the Facility Level and for linking the Facility Level to the Shop Floor Level. In section 2, we describe the tools we use in the Facility Level and their embedment into CAD Frameworks. Section 3 discusses how the Facility Level is linked to the Shop Floor Level.

2. FACILITY LEVEL

The software tools in the Facility Level are used for design, process planning, production planning, and for serving the Shop Floor (Fig. 2).

The Mentor Graphics ECAD environment consists of tools for schematic capture, simulation and analysis, and PCB placement and routing. They are embedded within Mentor's CAD framework, Falcon Framework. In addition, we have developed an interface (PCB Design to Insertion/Placement Machine Interface) that accepts a completed PCB layout and generates NC programs that are used by the assembly machines in the Shop Floor Level [4].

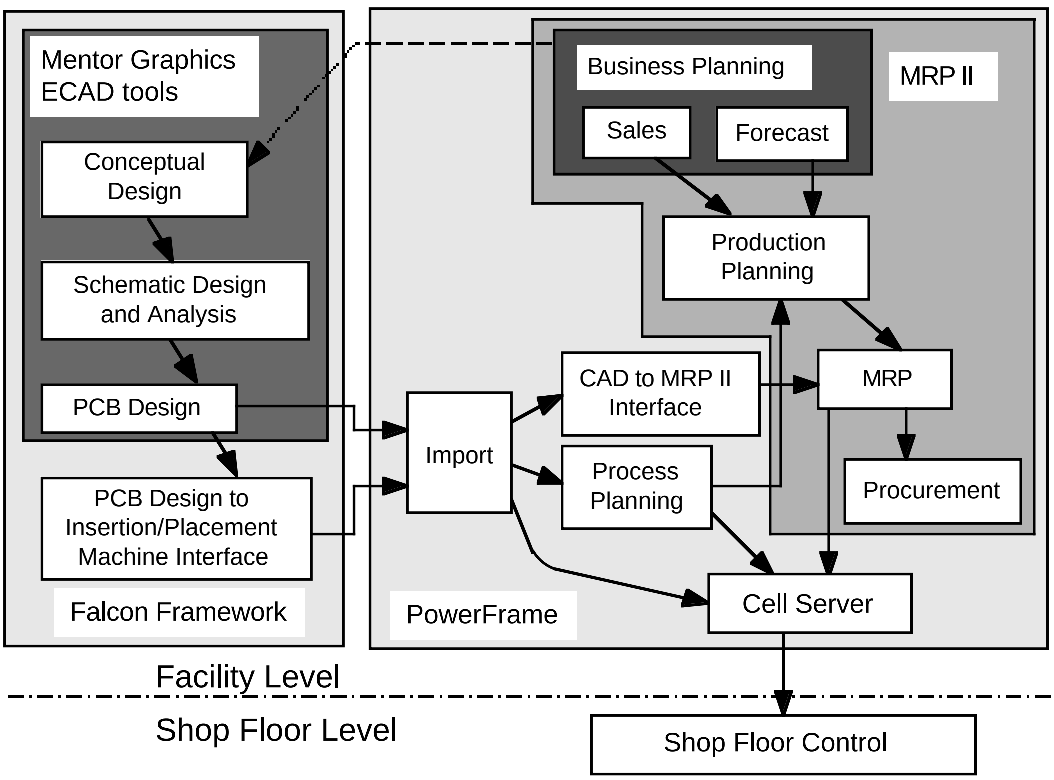

Figure 2 Software tools in the Facility Level

The Mentor Graphics tools run on a platform that is not currently supported by PowerFrame; therefore, the design and analysis work is done within Falcon Framework, and the released designs are then be imported into the PowerFrame environment. The import tool is a shell script which makes use of the UNIX remote copy command, *rcp*. The tool agent, which encapsulates the import tool into PowerFrame, provides options for selecting the remote host, directory, and file name. The import tool does not normally exist, but is built by the tool agent during each run. The tool agent then executes the newly built import tool to copy the specified design files from the remote machine. Finally, the tool agent collects the imported files and brings them into the PowerFrame environment using the *check-in* function.

Our MRP II software, MFG/PRO from QAD Inc., makes use of the Progress RDBMS. It links the MRP II system to the Shop Floor Level for automatic tracking of production.

The MFG/PRO software runs on a platform supported by PowerFrame. Since it is a third party tool where the source code is not available to us, the MFG/PRO package is encapsulated into PowerFrame. Two aspects of MFG/PRO are considered in the encapsulation, i.e. the maintenance of the MRP II database and the use of the MRP II tool. In the maintenance aspect, scripts are written in-house for backing-up, restoring and reorganizing the MRP II database. MFG/PRO is run in the client-server mode, so both client and server portions of the MFG/PRO are encapsulated separately. Additionally, a work order extract tool is written to extract released work orders from the MRP II database (Fig. 3). The extract tool is also encapsulated in PowerFrame. The extracted work orders are used to drive production in the Shop Floor Level.

We use a prototype process planning tool that is developed in-house. This CAPP tool is more than just an automatic process plan generator. It is intended to be a concurrent CAPP tool that is capable of delivering useful manufacturing process information to aid product development at the design phase [5]. It consists of two modules: one for *process definition*, and the other for *product definition*.

The Process Definition module is similar to a traditional CAPP system. It produces a detailed process plan for the manufacture of a product, based on the detailed product design, eg. machine settings, NC programs, fixturing information, etc. The Product Definition module generates conceptual process plans from the conceptual product design. Conceptual process plans could include information such as the primary process selection, design for manufacturing rules, and process operation parameters.

The tools in the Facility Level run on heterogeneous workstations. CAD frameworks are the means by which the tools and the data that they generate are managed. The main data management function in the Facility Level is provided by the PowerFrame Design Manager. PowerFrame and the information that it manages link the various tasks in the Facility Level. The details are illustrated in Fig. 3. The information managed by PowerFrame is available to serve the Shop Floor Level. In this instance, the data management function of PowerFrame has eliminated the need for an elaborate product data management system (PDMS). This is possible because the volume of data to be managed is not high, which is the situation in a small or medium sized enterprise.

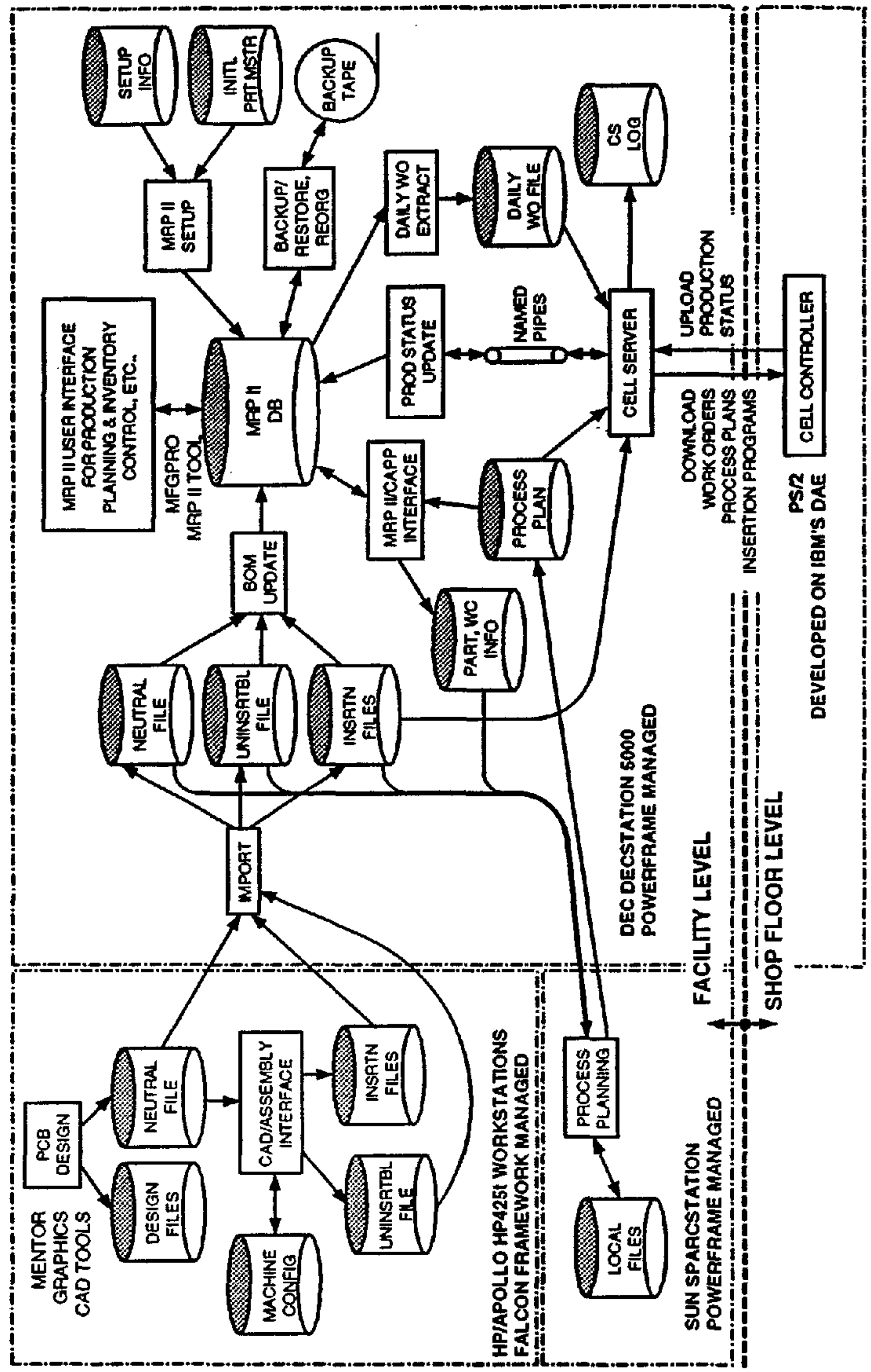

Figure 3 Information Flow in the Facility Level

3. LINKING FACILITY LEVEL TO SHOP FLOOR LEVEL

The mechanism that provides the link between the Facility and Shop Floor levels is the Cell Server system [6]. The Cell Server consists of a Cell Server daemon, a Cell Monitor, and a Cell Server Log. It serves the Cell Controller on the Shop Floor through a client-server scheme. The Cell Controller makes requests to the Cell Server for the download of data necessary for it to carry out production, and for the upload of manufacturing data when production operation is completed. The uploaded information updates the MRP II database. Fig. 4 shows the Cell Server and its relationship with the other components in the Facility Level and the Shop Floor Level and Fig. 5 is a Mascot diagram that describes the Cell Server at the activity level. Mascot is a methodology for designing complex real time software systems [7].

The Cell Controller and Cell Server communicate through the TCP transport layer using the Berkeley socket interface. On start-up, the Cell Server daemon opens a TCP socket passively and waits for connections. It also logs into the PowerFrame Design Manager which manages the Facility Level workspace. Through the Design Manager, the Cell Server obtains information requested by the Cell Controller. The version control mechanism in PowerFrame ensures that the correct version of data is being used. In most instances, the NC programs that are shipped to the assembly machines have to be fine-tuned on the machines for better performance. The modified NC programs are then uploaded to the Facility Level for storage.

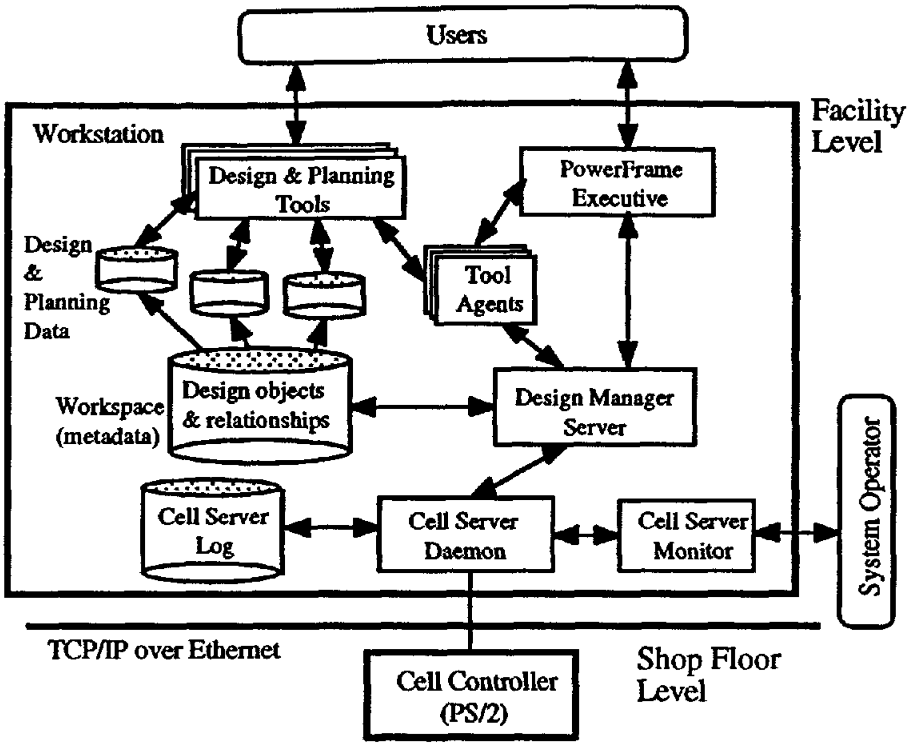

Figure 4: Cell Server and its Relationship between the Facility & Shop Floor levels

When the Cell Server receives a request to update the MRP II database, the Cell Server first makes an inquiry to the MRP II inquiry server to validate the uploaded data (Fig. 5). The MRP II inquiry server has a permanent connection to the MRP II database server and can provide very fast

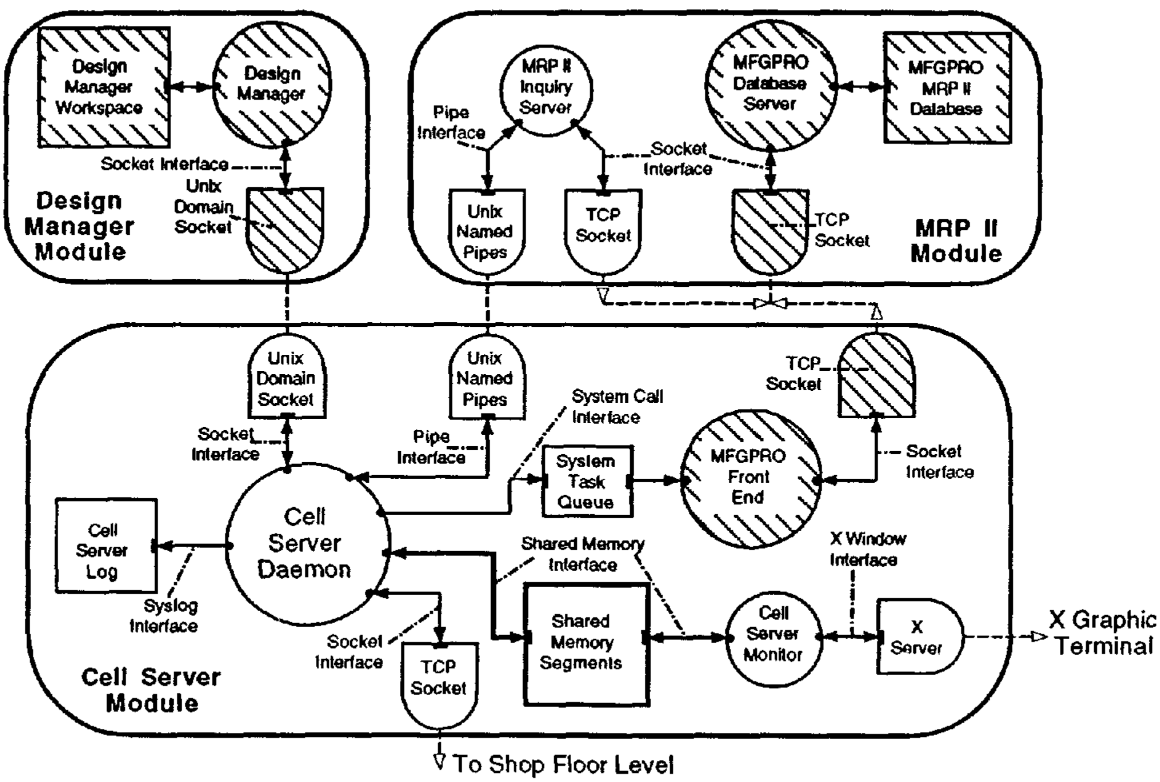

Figure 5 Mascot diagram of Cell Server System

response to such inquiries. After validation, the Cell Server invokes the MFG/PRO client program in the batch mode to update the database. The MRP II update is slow (about 40 secs.) , but this is tolerable since it is still faster than the time it takes to complete each operation in the shop floor.

The Cell Server daemon logs information on the status of its operations into the system log file through the *syslog* interface. This provides a means for diagnosing problems with the Cell Server. In addition, a Cell Server monitor is provided for use by the system operator. Through the monitor, the operator can check on the status of the Cell Server daemon and shut it down when necessary. It communicates with the Cell Server via shared memory segments.

Cell Controller

At the Shop Floor Level, the Cell Controller acts as the intermediary between the TCP/IP network at the Facility Level with the Shop Floor control network which runs IBM's DAE (Distributed Automation Edition) software. The Cell Controller's communication module is responsible for sending requests to the Cell Server. Through the Cell Server, the Cell Controller obtains the work orders as well as the process plans and NC programs necessary to carry out the production. The Cell Controller, upon receiving the work orders from the Facility Level, schedules and executes the appropriate process plan. This is done by sending appropriate commands to each of the workstation controllers, which in turn send commands to the equipment controllers for execution. On completion of a command or composite set of commands, a status signal is returned to indicate errors or readiness for receiving the next set of commands.

When an operation is completed in the Shop Floor, the Cell Controller sends a request to the Cell Server to update work order operation status in the MRP II database. The MRP II database is similarly updated when each work order is completed.

4. CONCLUSION

In this paper, we describe the role of CAD frameworks as a part of the CIM solution. They provide an information infrastructure to support the work of design and production engineering teams. The framework allows the environment to be built incrementally as and when new tools or workstations are needed. We also describe how this framework can be used to manage a database of released design and manufacturing data, and how this can be interfaced in real-time to a shop floor control system to build a Computer Integrated Manufacturing environment.

The main drawback in this CIM implementation is that the Cell Server is very tightly coupled to the PowerFrame CAD framework and the MFG/PRO MRP II database in the Facility Level and the DAE-based Cell Controller in the shop floor. A change in any of these components may necessitate a major rewrite of the Cell Server. We are closely monitoring the works of the CIM-OSA project of ESPRIT [8] and the standardization efforts of CFI and the ISO/TC 184 to shed light on a more loosely coupled implementation.

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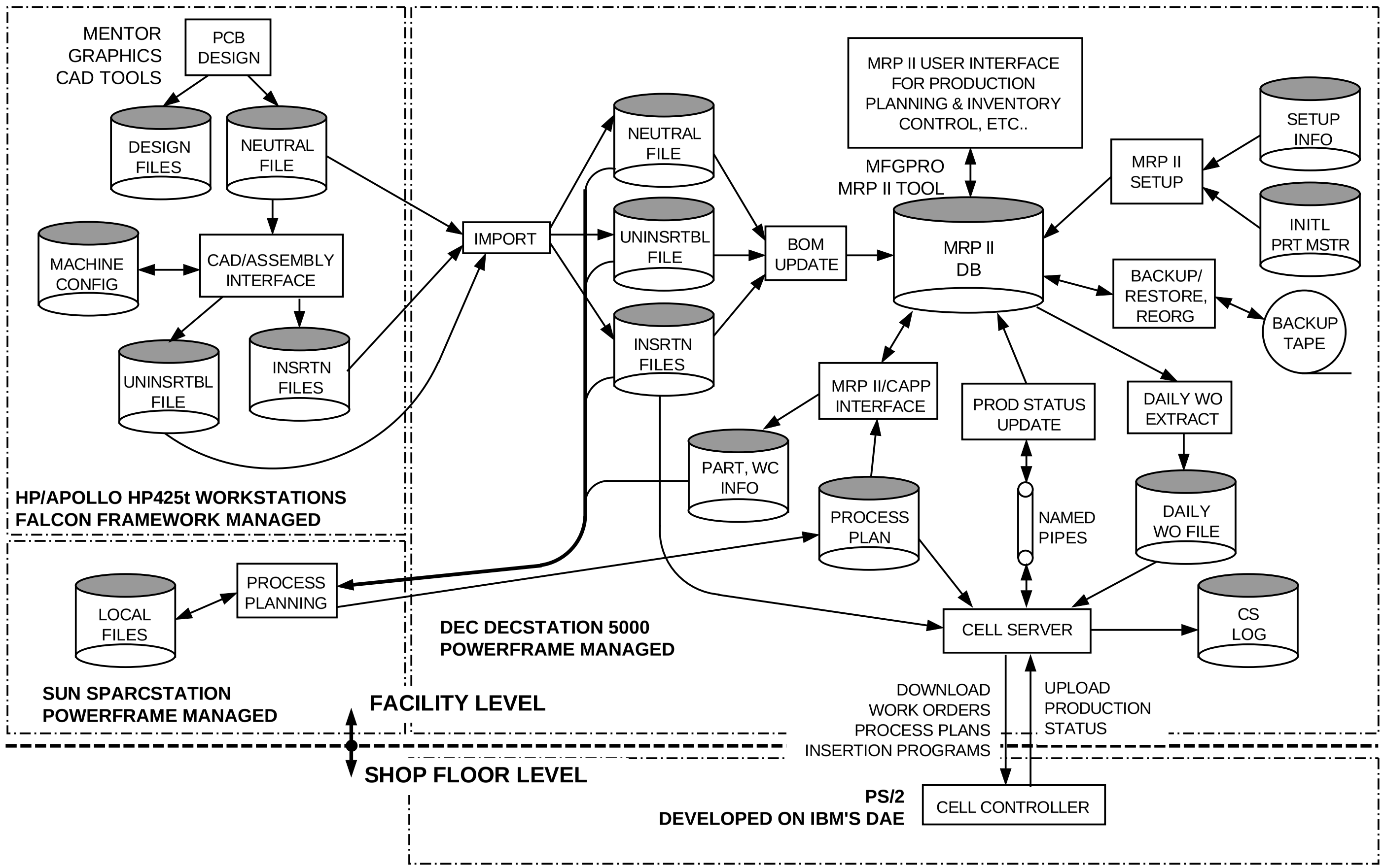

Figure 3 Information Flow in the Facility Level

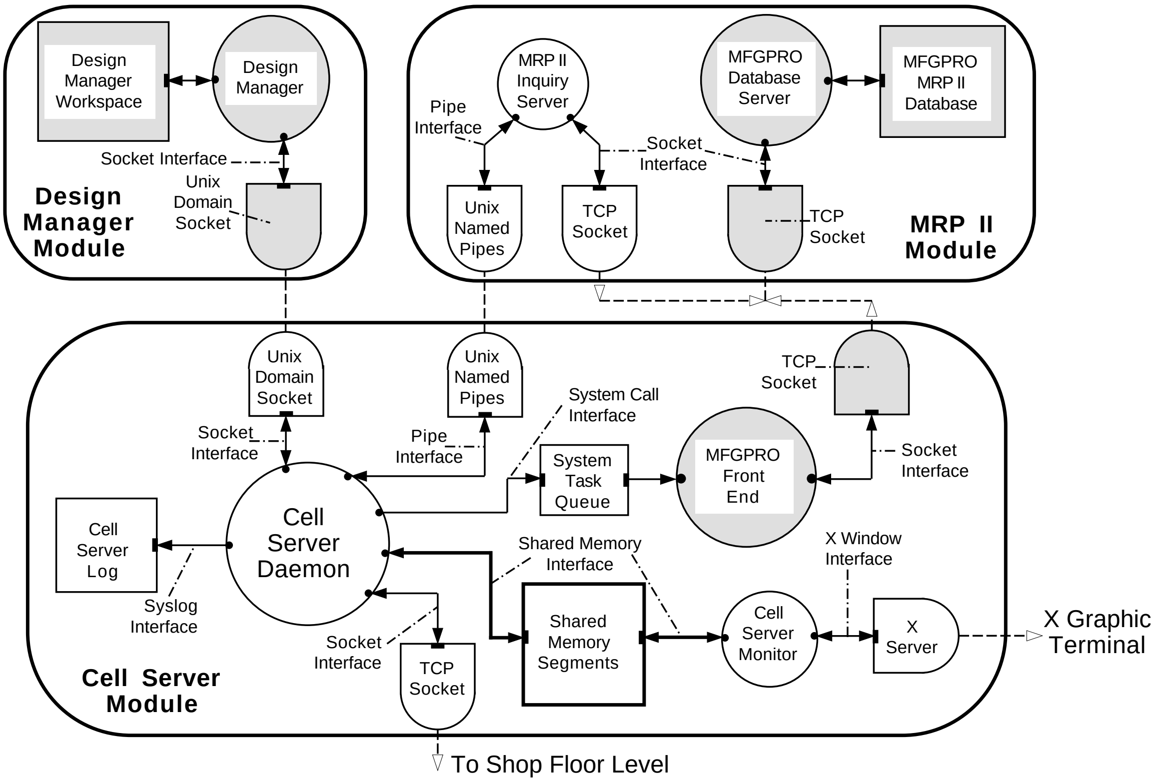

Figure 5 Mascot diagram of Cell Server System