



Framework Implementation Project Quarterly Project Report

March 5, 2001



Introduction

This report describes the status of the Framework Implementation Project, which is being conducted at the Georgia Institute of Technology's Manufacturing Research Center (MARC). The initial sponsors of the project were Intel and Lucent, but has grown to include Agilent, DEK Printing Machines, Fuji, GenRAD, MAPICS, Siemens EAE and Talarian. The project follows the recommendations of the National Electronics Manufacturing Initiative (NEMI) Plug and Play Factory Project, which addressed the need for a common framework for electronics manufacturing. The purpose of this project is to build upon the work conducted by the NEMI project, address the unanswered questions posed by the NEMI project, develop specific solutions to the needs of the sponsors, accelerate the acceptance of standards, and potentially demonstrate the concepts at sponsor sites. The project makes use of the Center for Board Assembly Research (CBAR) surface mount technology lines that are located in MARC.

Project Status

On August 9 & 10, 2000 the project team met in Atlanta to review the status of the project and to recommend future direction. Representatives from about a dozen companies participated. During the meeting three major goals were put forth by the project team. They were:

- Increase the number of project participants
- Publicize the project by demonstrating at trade shows
- Develop an application that will assist in publicizing the project

Over the past few months, the Georgia Tech team strived to accomplish these goals and has met with success.

We have added several new members since the meeting including: Agilent, GenRAD, MAPICS, Siemens EAE and Talarian (125% increase) Several other companies have expressed interest such as Assembleon (Philips), Cisco, Flextronics, Motorola, Panasonic, Siemens SCR and Universal. We will work diligently to encourage these companies to join.

We also have accomplished a major goal by demonstrating in the software produced by the project in four booths (Agilent, DEK, Fuji, and GenRAD) at the APEX Exhibition Conference in San Diego, January 16-18 2001. All four companies displayed the framework portal application receiving live data from Georgia Tech equipment and simulators, as well as data gathered on the show floor. Figure 1 indicates the flow of information among the four booths and Georgia Tech, in Atlanta. Figure 2 contains photos of booths demonstrating the Framework Implementation Project software.

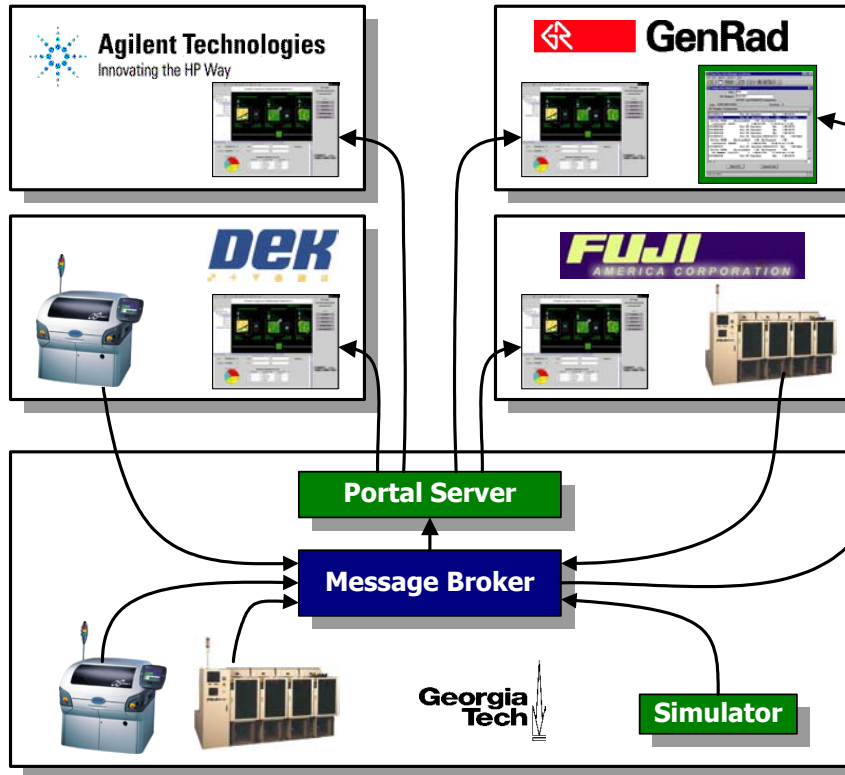


Figure 1. APEX Demonstration Diagram



Figure 2, APEX Booth Photos, showing Framework Project software being demonstrated.

The information flowed from San Diego to Atlanta and then back to San Diego during the show. Data was gathered from machines running on the show floor and was sent to a message broker located at Georgia Tech. The message broker also collected data from simulators and equipment running at Georgia Tech. A portal server received the information, processed it, and served it to a graphical interface in the participating booths. Individuals visiting the booths expressed a great deal of interest in the project. The key to demonstrating the project results was the development of a sophisticated application that could show-case the potential of a framework. The framework portal was developed for just this reason. The portal provides MES functionality and adheres to the IPC equipment communication standards (IPC254X series).

In addition to the demonstrations at the booths, two presentations were made at APEX which provided an overview of the project. Both presentations were attended by over 50 people, and a great deal of positive feedback about the project was generated.

An article was also published in the March, 2001 issue of Circuits Assembly entitled, "The Framework Implementation Project." The Circuits Assembly article provides an overview of the project and quoted many of the project members.

Technical Accomplishments

Message Broker

The current manifestation of the recommended framework for use in an electronics manufacturing environment recommended by this project is shown in figure 2.

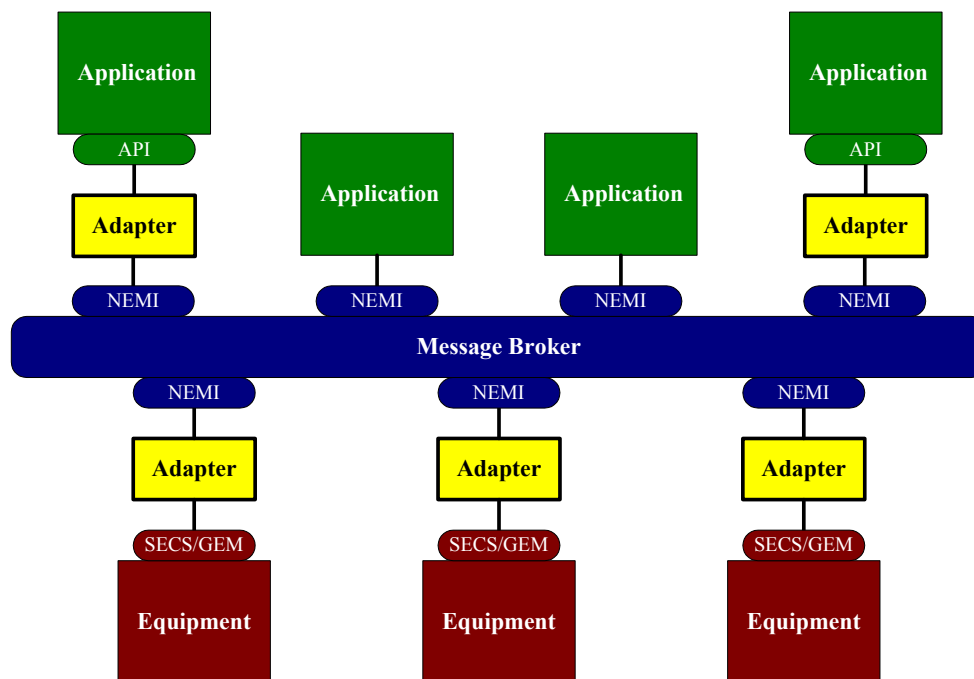


Figure 2. Framework Implementation Project Infrastructure

A message broker is used to facilitate the exchange of messages among various entities in the enterprise. The broker acts as web server and the various entities act as web clients. An HTTP connection is established between the entities and the broker, and messages are exchanged. The functionality of the message broker will be defined in the evolving IPC 2501 standard. As the broker becomes better defined, the standard will be extended.

The first version of the message broker used the Tomcat web server from the Apache Software Foundation, and the Java Message Queue (JMQ) as the middleware. The next generation of the message broker will make use of Talarian's Smart Socket middleware and a web interface that was developed by Georgia Tech. The reason for switching to Smart Sockets is because it is more robust, better supported, has a higher throughput, and contains more complete documentation. The Talarian software developers have already contributed a great deal to the development of the broker. The Georgia Tech developed HTTP interface is being used since it is more robust and stable for this particular purpose than other general purpose web servers, such as IIS and Apache.

Equipment Adapters

To connect the equipment located at Georgia Tech to the message broker, adapters have been written that translate IPC 2541 messages into SECS/GEM and visa versa. These adapters make use of Java SECS/GEM drivers and are stand alone applications. Since they communicate with the equipment and the message broker via socket connections, they are run on machines independent of other applications in the enterprise.

Framework Information Analysis

The Framework Portal consists of a JAVA-based client applet that displays factory information communicated through the FIS message broker. This real-time XML-based message data is received by a supporting system of JAVA software communicating with a SQL compliant database that parses the XML messages in real-time and maintains a persistent record of messages to permit both real-time and roll-up summary of utilization and productivity performance for a factory, line or machine. At the time of this report these general capabilities are deployed as a Framework Portal Client and a Framework Portal Server. An additional development, used for testing the client and server real-time data and reporting is a Framework Simulator.

The initial development of the Framework Portal Client identified the key forms of client information exchange in the Factory Information System Framework Architecture. These four key forms of information that are exchanged are:

- Board data consisting of the attributes of the manufactured products, including batch and product classifications;
- Machine data consisting of the states of both present and past performance in its operation
- Process information concerning interrelationships between boards and the machines producing the boards, such as roll-ups of yield for a given time period
- Subscription status to the Framework Message Broker by the Framework Portal Server.

Three typical uses of the information have been used as the user design reference for developing the Framework Portal Client, Portal Server and the Framework Simulator.

Shop Floor Surveillance

Detect, localize, track, classify, identify, and report the boards under production in the manufacturing environment and the machines producing these boards. On-site and remote surveillance will be considered.

Archival Analysis of Shop Floor Production

Detect, localize, track, classify, identify, and report boards already produced from the manufacturing environment and the machines performance in producing these boards.

Concept Demonstration and Familiarization

Training of manufacturing partners and potential interested parties in the roles they may play in the above missions.

Following the completion of the preliminary needs analyses for the Framework Portal user interface during the previous reporting period, work has continued with software deployment of the Framework Portal and Framework Server.

Framework Portal

The Framework Portal has been progressively developed with a mixture of static design placeholders and active capabilities. Each distinct area is developed as a separate widget to permit the corresponding individual information display item, for example, machine state, to first be developed as a separate stand-alone JAVA application and then later integrated into the GUI (please see figure 3).



Figure 3. Framework portal showing machine utilization graphs.

This approach supports the iterative design of individual areas separately and permits multiple team members to work on independent areas of the interface without conflict. Version control and remote checkout of software that was recently completed also supports team-based development of the GUI interface. In addition to the development of this general GUI software design approach, emphasis in this period has been for long-uptime and real-time performance. Improved performance in real-time graphics, as the complexity of the interface has increased has largely been due to threading and intelligent socket management. In preparation of the APEX show in January, reconnection logic was also added to the socket management code to monitor the connection status, in this case, to the Framework Portal Server. If the Portal Server socket connection is lost the Portal Client is cycled back to through the initialization and re-presents the logon prompt to the Portal Server. Apart from continuing optimization development we are continuing development of the GUI widgets. Designed and in software implementation are the Cycle Time Widget, Productivity Graph Widget, and Alert Widget.

Framework Portal Server

A GUI-based interface was initially developed for the Portal Server. This JAVA-based interface, initially was run on a Windows NT 4.0 with service pack 5, then later on a Windows 2000 server and currently it is running on Redhat Linux v.6.2. Performance improvements under Linux were not formally measured but showed noticeably faster server execution and increased number of possible client connections without slowdown. For example, configurations with a simulated line of 5 machines that have average cycle times of 12 seconds and 5 to 6 simultaneous running clients have been tested without noticeable decrease in server performance. General improvements in threading and socket management, mentioned for the portal are reflected here as well, given the common shared classes. These changes have also contributed to a decrease in memory usage and performance improvement. In preparation of the APEX show in January, reconnection logic was also added to the socket management code to monitor the connection status, in this case, to the Message Broker. If the socket connection to the broker is lost, the Portal Server enters a reconnection loop in which it periodically attempts to reconnect to the Message Broker. This reconnection code has reduced the problems of “cascading restarts” of all the Framework applications when a critical connection, such as that to the Message Broker is lost. The reporting capabilities for WIP, machine utilization and productivity have also been developed. Resident database collection, local to the Portal Server captures running totals for the real-time performance reporting serving real-time data and reports from the same machine. This is not a scaleable approach, however, given that with even a moderate client load, there are unacceptably long delays in receiving a report. Continuing development will redesign this capability and place report generation on a separate platform, which will be called from the Portal Server. In addition, the GUI interface on the Portal Server will be eliminated and replaced with a non-graphical interface that supports remote restarting. Planned design for the server monitoring is to distribute the monitoring onto separate machines to free the Portal Server from display of a graphical interface which will also support better remote Portal Server management and is expected to significantly improve the Portal Server overall performance.

Framework Simulator

Initially, a Framework message sequencer was developed to permit testing of individual message receipt by the Framework Portal Server and Portal Client. This sequencer was unable to

generate realistic board data that could be used to test message reports (e.g., WIP, utilization for a given time period) since the message traffic could only sequence a series of pre-defined messages, rather than intelligently track the state of each machine in a line and block/starve, for example, consistent with realistic line and machine activity. To meet this requirement for intelligent simulation of a line for testing purposes, an additional application was developed that permits the rigorous testing of the real-time Framework Portal information display of machine status, the Framework Simulator. This simulator, written in JAVA, is a signed applet that publishes a set of machines representing any line defined within our local database maintaining the line configuration to the Message Broker. Upon initialization, the cycle time for each machine in the line is set. A global error term is also set that perturbs the time-varying state changes in the machines about an error term to generate variance about the mean cycle time. The item number and product type can also be set at the time the simulation is started. With these adjustable parameters, we can test a variety of conditions within the line and expect to extend the functionality as additional requirements for Framework applications testing are identified.

Conclusion

Over the past few months, a great deal of progress has been progress has been made toward the goals specified at the August, 2000 project meeting. New members have joined, the initial development efforts were demonstrated at a major trade show, and interest is growing in the project. The next project meeting is scheduled for March 20 & 21 in Atlanta. The purpose of the meeting will be to review status, plot strategy for 2001 and plan for future activities. Some of the initiatives for 2001 that have been suggested by the project members include:

- Install the systems developed through this project at a member's manufacturing site
- Embed the adapter technology into an actual piece of manufacturing equipment
- Demonstrate the project technologies at Productronica in Munich in November 2001

Over the next few months we'll be working diligently to implemented the recommendations of the members, and to encourage additional membership in the project.