Framework for Web-Oriented Manufacturing System (WOMS)

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Abstract - The framework and architecture for web-oriented manufacturing system addresses the issues including innovations on smart assessment methodologies for manufacturers and customers to sustain their assets with near zero-downtime conditions. Web-oriented manufacturing system should include intelligent maintenance and performance assessment systems to provide reliability, dependability, and minimum downtime with equipment running smoothly at their highest performance.

Keywords - client-server architecture, Supply Chains, Virtual Private Networks

I. INTRODUCTION

Web Oriented Manufacturing System (WOMS) is the application of open, flexible, reconfigurable computing techniques and communications for the enhancement of efficiency of the whole supply chain. WOMS can be determined as IT-based manufacturing model with optimized resource handling over the entire enterprise and extended supply chain. Using the internet and tools that support commerce functions, one can find new customers; reduce the costs of managing orders and interacting with a wide range of suppliers and trading partners, and even develop new types of information based products, such as remote monitoring and control software and other online services.

Hence it is necessary to identify the functional elements of WOMS to exchange transparent and automated information between shop floor and enterprise. The major functions of WOMS are;

i) Transparent, seamless, and automated information exchange process.
ii) Total asset management that aims improving the utilization of plant floor assets using a holistic approach combining the tools of predictive maintenance techniques.
iii) Sophisticated customer service system that serves customers utilizing the latest predictive intelligence methods and tether-free technologies.

II. WOMS REQUIREMENTS

The real-time production information should be made available to the entire organization, including managers at the top floors and machine operators at the plant floor in order to successfully apply proactive maintenance to achieve near zero downtime of the systems and then, WOMS can target to optimize supply chain execution. Thus WOMS gives the company agility to react quickly to the changes in market, technology, and customers by operating as a virtual enterprise. Briefly, the main requirements of the WOMS can be listed as follows:

iv) Plant-floor, production processes, flow of material, etc. within the manufacturing system should be modeled thoroughly. The model should contain the entire flow of information for processes, products, equipment, people, and other assets in all plants involved.

v) Information should be more than raw data. It should be converted into a useful, understandable, and intelligent form via such information mode, complete visibility can be achieved. Status of equipments, orders, resources, products, and changes in the processes across various plants in the enterprise can be monitored and provided using such intelligent information management system.
vi) There should not be any black holes in the real time flow of information throughout the system including outsourcing suppliers, customers, plant management, machine operators, and machine itself.
vii) E-Manufacturing should include intelligent maintenance and performance assessment systems to provide reliability, dependability, and minimum downtime with equipment running smoothly at their highest performance.
viii) The entire system should be flexible enough to change with the varying market and demand conditions in a short lead-time.
ix) Standard, flexible, and enterprise-wide platforms and protocols should be used to offer such flexibility. Management of the assets both locally and remotely should be provided.

Hence, suppliers manufacturing responsiveness and capabilities need to be understood, improved and integrated fully to provide ultimate market solutions and customer satisfaction.

III. WOMS - FRAME WORK

Most of the web oriented manufacturing systems are designed to the client-server architecture. In such systems, the modules and databases are distributed at both the server sites and client sites. Contrary to the traditional client-server applications, the client programs are usually downloaded automatically from the server sites to the local computers through Web-browsers in the Web-based applications. The web-based applications are classified into two types, depending on the sizes of the programs and databases at the client and the server sites and these are:

i) Fat-client and thin-server application when the major computation is conducted on the client side.
ii) Thin-client and fat-server applications when the computation is primarily carried out at the server side.
iii) Simple client-server architecture i.e., Single server and multiple clients are adapted in most of the web-based manufacturing systems.

The server side module, implemented using Common Gateway Interface (CGI) scripts and other programming languages, is usually responsible for database modeling and database analysis, while client side module, implemented using web pages, is responsible for obtaining input from user and displaying results to the user. The web pages embedded with Java applets provide an interface for remote operation of the machine as part of the proposed prototype “Web Oriented Manufacturing Systems” shown in fig 1. As Java provides platform independence, all that a remote user requires is a Java-enabled web browser and internet connection to use the system. Using the web interface, the authorized remote clients (First tier) provide machining parameters or submit the job, which are relayed to the web server using the CGI.

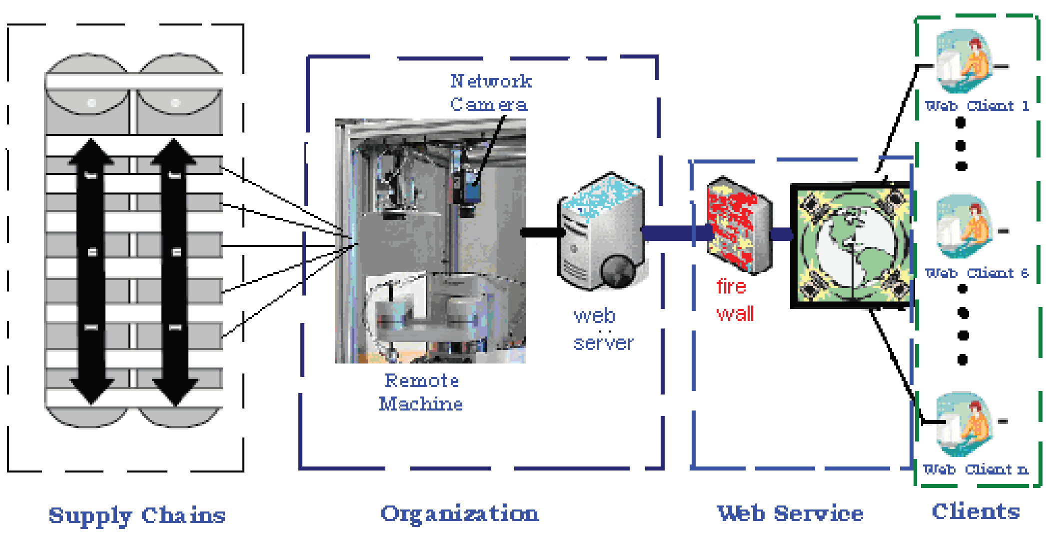

Figure1. Frame work: Integrated web-oriented manufacturing system

To address the security issues pertaining to the web oriented manufacturing system, the internet firewall (Second tier) is the first line of defense in restricting unauthorized access to the server and therefore machine at shop floor. In addition to this, the web server authenticates users prior to granting permission to submit jobs, monitor the machining process or participate in virtual discussion. The machining parameters upon reaching the server constitute a parts-program which is stored in a job file scheduled for execution on the machine. The machine centre or work centre is a representation of the machining process, which is controlled by the server via the enhanced parallel port and thus machine unit and web server together form a third tier. The machining process is monitored by the network camera, which is part of the third tier, providing real-time feedback to the remote users. Users can further collaborate on product design or other issues by means of a chat room hosted by the web server.

'Supply Chains' network is the fourth tier of web-oriented manufacturing system is an important entity, where manufacturing responsiveness to the clients depends on the fourth tier and capability of suppliers need to be improved to provide ultimate solutions and customer satisfaction. Thus the four tiers together can also be called as Four tier Web Oriented Manufacturing Systems (4t-WOMS). As each tier consists of its own characteristics and allowing bi-directional information flow while participating in manufacturing operations, the entities of web-oriented manufacturing system have been treated as tiers. In the present study, suppliers can be viewed as generalization of manufacturing facilities, with further complications due to multiple players, conflicting constraints but successfully used with adaptations. As in the manufacturing plants, one of the aims of supply chains is to meet the demands of final clients, while at the same time operate as a lean chain, by keeping inventories in the chain to a minimum.

Further sensitive communication between the clients and the server is carried over Transport Layer Security (TLS), thereby ensuring confidentiality, data integrity and server authentication.

IV. WOMS: SOFTWARE ARCHITECTURE

The software architecture is based on a set of communicating processes as shown in fig 2. On the left side, the application server is presented. It is composed of a set of permanent processes called Groom, Connection Manager, and Device Manager. They are respectively designed to receive connection requests, to manage the different users according to the control algorithm module, and to handle the machines. The connection between the Device Manager and the machines is made by specific processes called "Tool Interface" and are acting as device drivers.

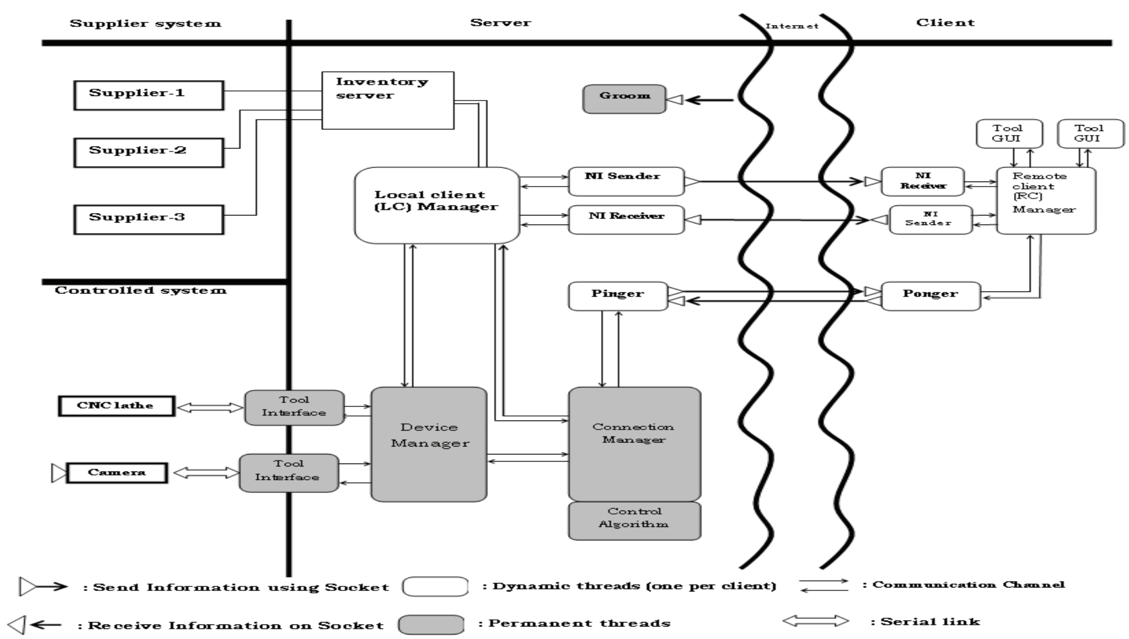

Figure 2. Software Architecture for WOMS

The Local Client Manager, NI Sender, NI Receiver, and Pinger are dynamic processes which are launched every time and new users get the right to enter the system. Communication between these processes is realized with the help of Java pipes. The right part of the figure shows the user side. NI Sender and NI Receiver are used to communicate via TCP/IP sockets with the server side. The Ponger process is connected to its corresponding Pinger process. The tool Graphical User Interface [GUI] has graphical applets used to display information coming from the remote controlled system and to get commands from the user. Local Client Manager is acting as a router between the different processes. The following sections focus on two aspects that differentiate this approach from those generally used in WOMS. The architecture and different processes have been defined to be able to control several devices called Plug and Play devices. Except “Tool Interface and Tool GUI”, everything is generic and to add a new machine, just these programs have to be re-written. A configuration file is added to the application to tell the system which machines have to be controlled, and their corresponding interface and GUI are launched.

In fact, internet is not providing quality of services, where need for WOMS’ applications have to be safe. To manage this problem, it is necessary to take quality of the network into account. A first step is to get a measurement of it. In this approach, it is realized by the two processes called Pinger and Ponger. The former sends a request to the latter, which is supposed to answer immediately and so on. The network sensor gives information about the network quality. Basically, one can decide that the connection is correct when the delay observed is lower than a limit and incorrect in the other cases. This implies two different states for the system under control and transitions between them.

V. SECURITY MANAGEMENT

To enable optimal and secure collaboration between collaborative partners, three levels of security must be used sequentially in web-oriented manufacturing system. The first level is to limit network access through hardware controls, such as creating Virtual Private Networks (VPNs) and using firewalls. This first step essentially removes the company's intranet from the public Internet, thereby creating a privatized network connection and establishing a secure infrastructure between remote sites minimizing the risks of targeted denial of service attacks.

Second level is to create security policies that use authentication and authorization controls to establish access from the VPN to the application layer. Once the security measures are in place, one can use these resources to allow data filtering, to control file transfers, and to limit and monitor or deny remote equipment operations. Moreover, the second level should provide a full data audit trail of security so a collaborating wafer knows what data is to be accessed, when it is to be accessed and to whom it is to be distributed.

Third level provides a context related security gate around a specific set of conditions that defines the content of shared information. This conditional software addresses security, such as specific data items that can be accessed, commands that can be issued and under what conditions access is allowed.

A. VPNs and Firewalls

Internet Layer Security Technology (ILST) developed a VPN solution called ServiceNet™ to address both the functional and economic factors in transporting data over the internet. Using a shared IPSec-based VPN model, shown in fig 3. which isolates the server with a public address from public reach allows the server to dedicate its time to serving customers.

In addition, ServiceNet™ permits each constituent to create a single VPN tunnel that terminates in an isolated network hub, thus enabling a secure and cost-effective network connection between each company connected. Each constituent is isolated from others using firewalls. Data sent through the VPN tunnel is encrypted, so that only the intended receiver may decrypt transmissions.

Using the shared-VPN model reduces the security risk, provides much better performance and reduces overall cost by providing access to many constituents by having only a single ‘hole’ in the firewall, e.g. ‘connect once, access many’.

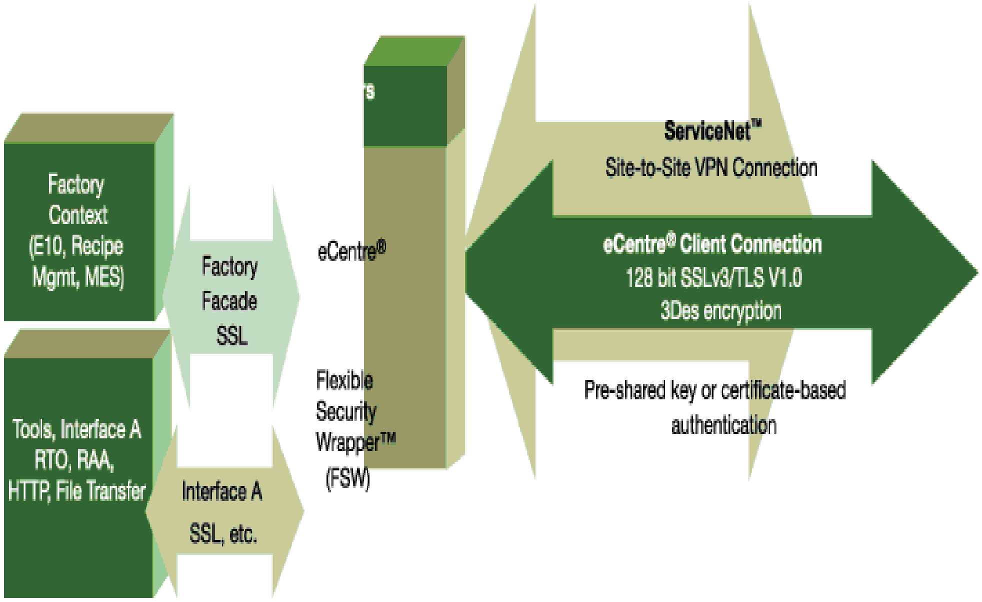

Figure 3. Network Security Management

B. *Authentication and authorization*

Once security measures are in place, they allow data filtering, control file transfers and limit, monitor or deny remote equipment operations. Securing the data is not just a concern for connections outside the firm as many firms are now placing isolation networks around their production floor and treating their own intranets as a possible security threat. Network software designs, such as ILS Technology's eCentre®, provide additional levels of security through authentication, approval and auditing functions. User authentication can range from single factor authentication, such as user identification and password, to full three factor authentication. The unique eCentre design allows a firm to handle multiple forms of authentication within the same installation. By simply defining authentication servers and linking them to specific Lightweight Directory Access Protocol [LDAP] domains, the security administrator is able to support all types of security configurations. eCentre supports all of the industry standard forms of authentication certificate, SecurID, SAML, RADIUS, registration, biometrics and integrated windows.

Once the data is collected by the web-oriented manufacturing system server, there must be assurance that the persisted data is logically separated by source. This is important to ensure that users have access only to the data that they are authorized to use and not competitors. This is accomplished by using different tables for each source or optionally different physical locations may be specified for data persistence of the different sources. The resulting security system limits access to approved users only and controls user actions based on their approved privilege levels. In addition, user actions are audited and in some cases require further approvals from within the enterprise to be allowed. An upcoming feature of e Centre will provide a layer of security that will enable communication between connected constituents in both directions.

C. *Java Technology in WOMS*

'Emation' is an industrial automation provider that leverages internet technologies to connect a wide range of manufacturing verticals to Web-based systems. Their Java based Web@aGlance software, which is part of their Device Relationship Management (DRM) solution, is installed solely on the web server. With connectivity to all major SCADA, DCS, and Data Historian software, Web@aGlance serves as the data integrator, or portal, for all of the plant's operational data. It enables the user to deploy web applications that provide a graphical view of both real-time and historical data. Users can create custom graphical displays and trend charts that deliver information specific

to the process being executed. Web@aGlance functions well in a Web-centric environment due to specific Java platform functionality. When the user navigates to a live web page with their browser, a Java applet and description file are downloaded from the web server. The Java applet reads the description file and creates corresponding animated graphics that renders displays and reports the contents of process.
Schneider Automation is embracing Java technology by using it as a core component of their transparent factory automation framework. With the development of their Web Embedded Server, Schneider is bringing Java technology-based internet-based technologies to industrial automation. The Java platform is also the foundation for FactoryCast, a Software Development Kit (SDK) intended for application engineers who want to write Java applets or applications that communicate with Schneider Automation's Quantum or Premium controllers via Ethernet TCP/IP. The FactoryCast SDK includes a communications library of class files written in the Java programming language and a graphic editor Application Program Interface (API) that describes API that is provided for developers to create graphic objects (Java Beans Components) for use in the FactoryCast Graphic Editor. Also included are FactoryCast Widgets, a set of Java applets and applications that use the set of predefined, graphic objects (Widgets) included with the FactoryCast Graphic Editor. Java technology-based applications like FactoryCast will enable Schneider Automation to implement the components of their transparent factory across the plant floor.

VI. CONCLUSION

In this paper, structural concepts of Web Oriented Manufacturing System are discussed along with the software architecture requirements. The discussion also reveals the specific nature of Web Oriented Manufacturing System. This discussion can be useful to assess the criteria to be considered for prioritization of suppliers as well as service providers.

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