Integrating
Production Line Automation Systems
with Office Information Systems
by
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With the growing popularity of Ethernet Networks and the abundance of hardware and software solutions available, it is possible to integrate all components of a typical Production Facility into a tightly knit system. Office database & information systems that handle such tasks as production scheduling, data collection, invoicing, bill of ladings, certificates of analysis, order tracking, etc. can all be seamlessly integrated with the production line control system to share real-time data over common Ethernet networks. The benefits of such system integration include: automation of tasks to minimize human error, data integrity, paperless accounting, and greater accessibility through web based reporting, etc. This presentation will first look at the basic components of a typical fully integrated production facility and then it will present real-world examples of systems currently deployed in a U.S. flourmill.

What Is an Integrated System?

An integrated system is one in which the Production Automation System is linked to the Business & Information Systems over one common communications network. Typically the common network is an Ethernet network since Ethernet is the most widely used and most available computer network today. With an integrated system in place, the following information systems can share information and data with the actual manufacturing process:

- Accounting/Invoicing
- Lab/QC (LIMS)
- Production Scheduling
- Maintenance (CIMMS)

Figure 1 shows a typical flour mill prior to integration. Data is shared manually through loads of paper trails. In Figure 2, an Ethernet network has been utilized to fully integrate the production automation system with all other business information systems at the plant. Now all data is shared electronically, quickly and automatically.

Benefits of an Integrated System

Once the production automation system is integrated with the business information systems over a common network, the following benefits can be obtained:

- Labor Cost Reduction
- Paper Reduction
- Higher Quality Control / Standardization
- Better Record Keeping
- Decrease Maintenance Costs (simplify troubleshooting of production line problems)

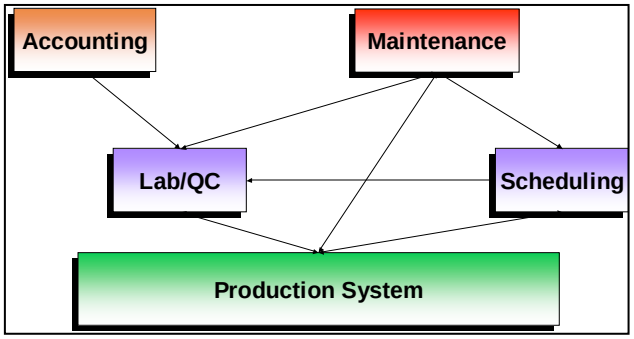

Figure 1 – Typical Plant Before Integration

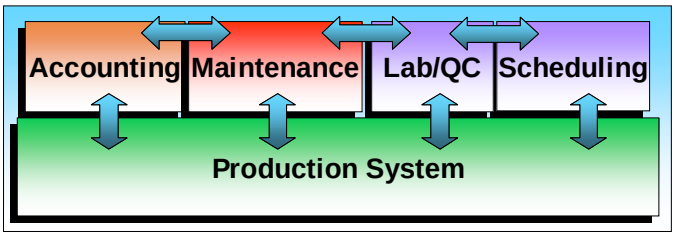

Figure 2 – Typical Plant After Integration

Basic Terminology

The following terms are commonly referred to in the Automation Industry:

- **PLC** - Programmable Logic Controller. A hardened industrial processor used to control machine sequence and operation.
- **HMI** - Human Machine Interface, a graphical user interface that provides information about a process and permits an operator to control the process.
- **SCADA** - Supervisory Control and Data Acquisition. Software that interfaces between PLC's, HMI's and the production database. Provides higher level process control and data collection.

The following terms are commonly referred to in the Information Technology Industry:

- **Ethernet** - The most commonly used network protocol. It includes specifications for media, connection schemes and data transmission protocols. Typical speed: 10/100/1000 Mbps.

- **LAN** - Local Area Network, the system of computers, media and network hardware that permits computers to share information.
- **WAN** - Wide Area Network, a network that is created by connecting two or more LANs together usually through the use of telephony technology.
- **Hub** - A network device that connects multiple computers together and passes network messages from one computer to all other computers.
- **Switch** - Similar to a hub, but learns where computers are connected and passes data only to the destination computer instead of broadcasting the message to all computers.
- **Router** - A network device used to pass messages from one segment of a network to another.
- **Firewall** - a network device that limits access from one section of a network to another.
- **Database** - A collection of data that is stored in multiple tables. Typically backed up to external storage system for data integrity. Typical Enterprise databases are: SQL Server and Oracle.
- **Web Server** - A computer that provides information or services via standard web browsers such as Microsoft Internet Explorer. Example: Windows 2000.

Figure 3 shows how the above terminology fits together into a typical Ethernet network for a typical business.

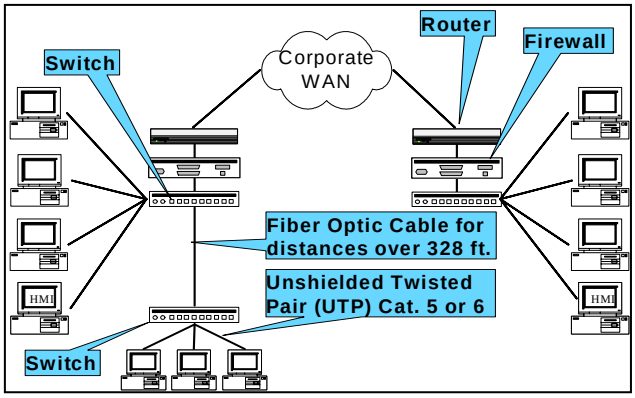

Figure 3 – Typical Ethernet Network

Typical Implementation

Most plants that have a production automation system fully integrated with business information systems follow the model shown in Figure 4. At the bottom of the model is the heart of the system – the production automation system. This consists of electrical equipment (i.e. motors, solenoids, valves, level transmitters, temperature transmitters, etc.) wired to Programmable Logic Controllers (PLC's) located throughout the plant floor. This is the heart of the system and responsible for controlling the production equipment, process interlocks, safety interlocks, sequential control, closed-loop control of process parameters and basic alarming. It is important to understand that the automation must be in place before it will be possible to achieve a fully integrated plant.

If your plant already has some automation then it is possible to retrofit the existing PLC's with Ethernet based controllers. The Ethernet backbone must be in place before all the different systems can be integrated as one.

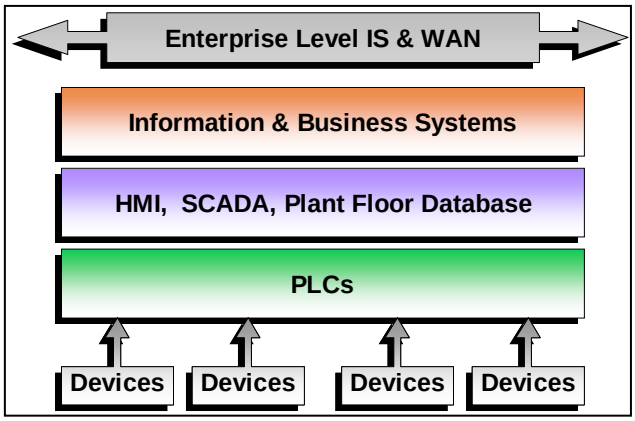

Figure 4 – Typical Architecture/Model

Implementation Phase 1 - Unit Automation

The first step in integration requires that some level of plant automation has taken place. It is important to build your automation system using highly reliable industry-hardened PLC's and automation equipment. Your automation system should be based on non-proprietary based controllers/software and the PLC's and HMI's should be Ethernet capable devices. The data received at the Business Information Systems is only as good as the devices wired to the PLC's (i.e. recording flour bin levels to a database and having this data available to management personnel is useless if the bin level transmitters are faulty and inaccurate).

Implementation Phase 2 – Process Cell Automation

Once the basic automation is in place, the next step is to install PLC's/HMI's to control different process cells. Each cell would be a logical or geographical grouping of equipment or area of the plant. For example, a typical flour mill may be broken into the follow process cells:

- Elevators/Storage
- Cleaning House
- Flour Mill
- Flour Storage/Loadout
- By-Products Storage/Loadout

Each process cell shares information with one another over the Ethernet Network. The different process cells work

together over the common network as one automated production system (Figure 5).

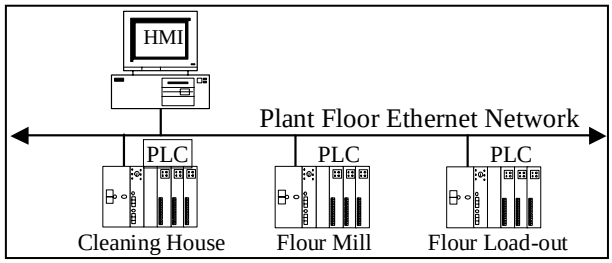

Figure 5 – Process Cell Automation

Implementation Phase 3 – Area Automation

Now that the plant floor Ethernet network is in place and you have several process cells automated/integrated into one production system, it is now time to add the SCADA system and Plant Floor Database. The SCADA system will provide for supervisory control of the entire production system as well as real-time data collection and process monitoring (see Figure 6).

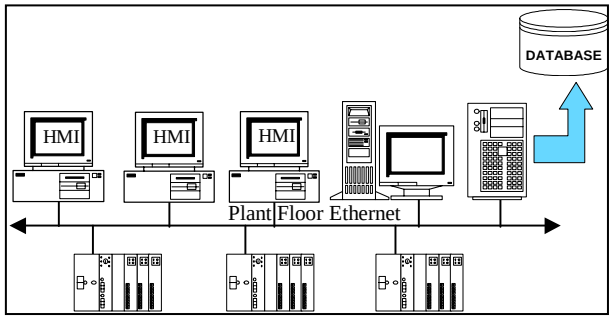

Figure 6 – Area Automation

Implementation Phase 4 – Integration with the Front Office

It is important to note that up to this point, we have been dealing strictly with the production automation system which we refer to as the Plant Floor Ethernet Network. This network has PLC's, HMI's, SCADA system and its own Database. The plant floor Ethernet network must be a highly stable and reliable industry grade network This network must remain secure from the outside world to insure data integrity and plant up time.

The Plant Floor Ethernet Network is linked to the Front Office Network or other Business Information Systems through a series of routers and Fire Walls. This combination of network equipment helps to protect the Plant Floor Ethernet Network from accidental or malicious tampering. Figure 7 shows a network diagram of a fully integrated plant.

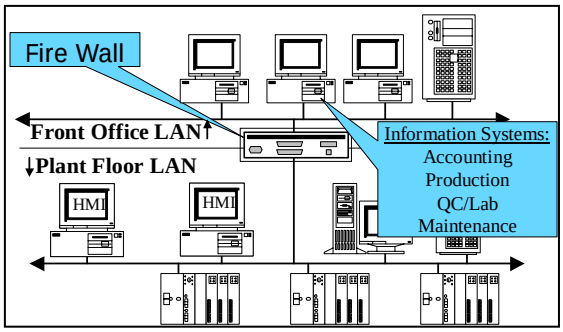

Figure 7 – Integration w/ Front Office

Implementation Phase 5 – Enterprise Level

Once the local plant is fully integrated, then it is possible to link the plant's information systems with enterprise level information systems. This is done again by using a series of routers and a Fire Wall to insure security data integrity (Figure 8).

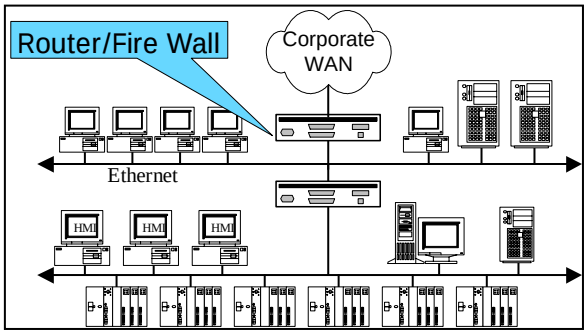

Figure 8 – Integration w/ Enterprise

Real World Examples

Now that the Production Automation System has been integrated with the Business Information Systems, we can accomplish the following business tasks more seamlessly as we will see in the examples that follow:

- Production scheduling
- Material management
- Order fulfillment

Example 1 – Data Logging & Web-Based Reporting

Data logging and reporting is the simplest function that can be accomplished once the architecture is in place. This involves simply logging data (real-time) to a central database and then making this data available to clients via reporting software/tools. Examples include: real-time inventory, 7 a.m. production reports, rail/truck load-out histories, on-line sampling histories, magnet cleaning reports, etc. Reports can be web-based where the users need only have access to

Internet Explorer to access the reports just like any other website.

A typical example of data logging in a flour mill would involve real-time monitoring of the levels of wheat in each storage bin/silo, logging the levels to a database and then making the inventory reports available via the web. Figure 9 illustrates how this is done with a fully integrated plant. Remember that none of this is possible without the proper automation in place. In this particular example, continuous level transmitters were installed and wired to the Ethernet PLC. The SCADA system then retracted the information from the PLC and inserted it into a table in the database. A web-based report was made to access this data from any computer in the plant using Internet Explorer.

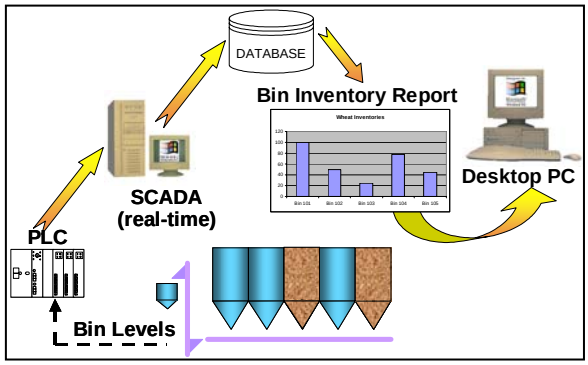

Figure 9 – Data Logging of Wheat Bin Levels

In this example and in any other basic type of data logging, an event in the PLC triggers the SCADA system to retrieve data from the PLC and log it to the database. The data can be date/time stamped when it is logged. This time of logging provides for a handy maintenance tool for troubleshooting when a problem occurs in the system. It is also much easier to sit at your desk at view the data than to actually be physically on the production floor trying to determine the problem.

Example 2 – Real-Time Inventory Control

Before Integration, operators manually kept track of the type of wheat (Wheat Code) in each bin and the date/time each bin was filled. This was done via dry-erase board or by typing the Wheat Codes into the HMI and constantly changing them as the bins were emptied and refilled. Operators were responsible for ensuring a "First in First Out" inventory to avoid spoiled wheat.

After Integration, Wheat Codes and Bin Information are stored in the Plant Floor Database. Wheat codes are only entered one time at the beginning of the wheat's journey through the system. From that point forward, the PLC/Database keeps track of the wheat codes.

When a bin goes empty, the PLC queries the Database for the next oldest bin of wheat with matching wheat code and brings this bin on-line. This automated approach guarantees a "First-in, First-out" bin filling/emptying sequence. Figure 10a shows how the Wheat Code is automatically assigned to each bin and how each bin is date/time stamped when it is filled.

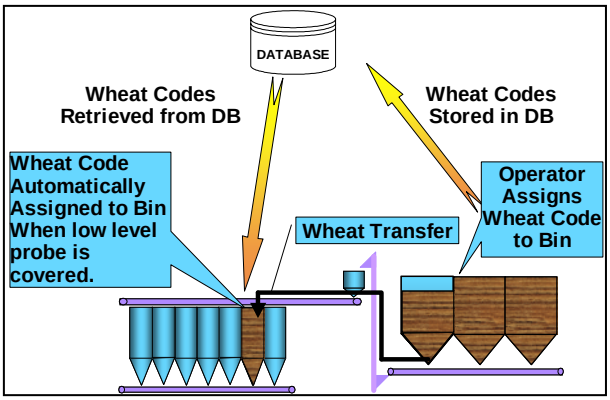

Figure 10a – Real-Time Wheat Inventory Control

Figure 10b shows that when a bin goes empty (based on signal from low level probe) the PLC automatically finds the next oldest bin of matching wheat and opens that bin.

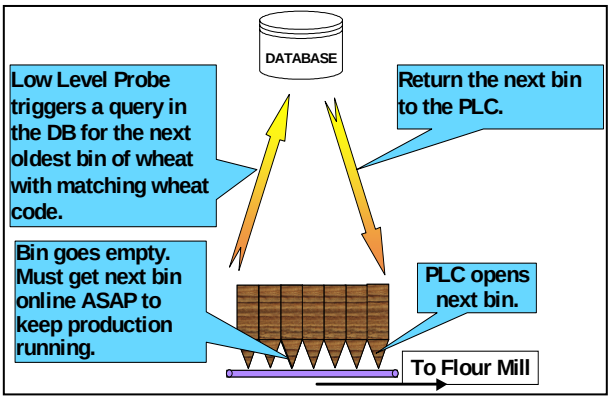

Figure 10b – Real-Time Wheat Inventory Control

Because of the high speed of today's databases, PLC's and Ethernet, it is possible for the above interaction with the database to actually be used for real-time production control. Transactions to the database occur under 1 second. The longest delay in the entire process is in the amount of time it physically takes to open the gate under the next bin to be brought on-line.

Other Real-World Examples

The list is endless as one can imagine, but some other major examples of what can be done when the Production

Automation System is integrated with Business Information Systems are:

- Production Scheduling
- Rail/Truck Loadout Scheduling, Invoicing & Automatic Bill of Ladings
- Quality analysis through on-line sampling
- Blending Control based on results of Lab Analysis
- HACCP compliance
- Product Safety/Sealing through the use of bar coded product (or rail car) seals.

Conclusion

With the availability of Ethernet technology, it is possible to fully integrate the Production Automation System with the front office Business Information Systems. There are multiple cost savings benefits to having an integrated system:

- Can be phased in step-wise as finances allow over time.
- Improved Product Quality.
- Easier Troubleshooting & Maintenance
- Paper Reduction.
- Meet HACCP and other regulatory requirements.

Biography of the Author

Michael J. Goslak, P.E. is Owner and President of THOR Engineering, LLC. Thor is a private electrical engineering firm with expertise in the design and automation of industrial and commercial facilities. Mr. Goslak is a licensed electrical engineer with over 15 years of engineering experience. Prior to forming Thor, Mr. Goslak was the manager of the Ann Arbor, MI office for River Consulting, LLC (RC). During his career at RC, he was intimately involved on a daily basis with ongoing automation projects at the largest flour mill in the U.S. In addition, he has successfully engineered and commissioned many other industrial/commercial projects in a wide variety of markets. His past experience includes 5 years working in Design Engineering at Davis-Besse Nuclear Power Station (Toledo Edison Co.). Mr. Goslak holds a Bachelor's of Science degree in Electrical Engineering from GMI Engineering & Management Institute, Flint, Michigan.