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Industrial Cell Controller Classification Concepts and Selection Guide

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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IA 1

INDUSTRIAL CELL CONTROLLER CLASSIFICATION CONCEPTS AND SELECTION GUIDE

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Foreword

For more than a year the NEMA Cell Controller Group had worked to provide a structure for the classification of Industrial Cell Controllers. Until the formation of this Group, each U.S. manufacturer independently defined the key architectural aspects and interfaces of the industrial cell controller. Through this consensus document, the NEMA Cell Controller Group is attempting to provide a framework for the development, selection, and classification of cell controllers. Due to the constantly evolving technology associated with cell controllers, the Group has decided to publish this document as Authorized Engineering Information rather than a standard. Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard.

In order to ensure that this classification system will be useful over a number of generations of cell controller and computing products, the committee selected a modified data flow diagramming technique to define the various classes of cell controllers. These data flow diagrams will assist users in understanding their control and computing needs at the cell level of the manufacturing hierarchy.

Readers should note that the Group focused on the architecture for information processing devices that actually control, coordinate, and supervise manufacturing processes. Devices that monitor and report production, without the control aspect, are seen as valuable manufacturing tools; however, they are not considered as cell controllers and have been excluded from this classification document.

Because of differences between industries and applications, the Group formally avoided defining two terms: "real time" and "industrial cell." Informally, "real time" meant "fast enough for the process" and an "industrial cell" was "that area of a plant which is under the supervision of a cell controller." Readers of this document should consider their applications in this framework.

The Group would like to thank NEMA and our sponsoring companies for their assistance in this effort. It is clear that, in the future, world class manufacturing operations will include cell controller systems in their factory control hierarchies. The cell controller is the area where the information processing and control worlds come together. The cell controller is key in the implementation of factory automation systems.

In the preparation of this Standards Publication, input from users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted by contacting the:

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Abstract

This Standards Publication was written to provide industrial and manufacturing engineers, industrial purchasing departments, and manufacturing management with cell controller classifications that will aid in the selection of the appropriate cell controller for their applications. This guide is applicable to both process and discrete manufacturing operations. These classifications provide an architectural framework for users of cell controller products.

Anyone planning an implementation should contact their suppliers for detailed product information.

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Scope

The NEMA *Industrial Cell Controller Classification Concepts and Selection Guide* provides a general description of cell controllers used in automated control system configurations that supervise and coordinate plant floor operations. While the general features of these devices are listed, a thorough description of specific application functions of cell controllers is beyond the scope of this document.

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INDUSTRIAL CELL CONTROLLER CLASSIFICATION CONCEPTS AND SELECTION GUIDE

Section 1
INTRODUCTION, PURPOSE, OBJECTIVES, AND RATIONALE

1.1 INTRODUCTION

The Cell Controller Group of the NEMA Industrial Automation Division has prepared this document to describe NEMA Cell Controller Classification concepts and to provide a selection guide for users of cell controllers. This document is a result of a NEMA project to explore cell controllers, a vital link in the development of an integrated structure for factory automation. This document is classified as Authorized Engineering Information.

1.2 PURPOSE

The purpose of the NEMA *Industrial Cell Controller Classification Concepts and Selection Guide* document is to provide a set of cell controller guidelines to help educate those who plan, design, and implement industrial cells. The target audience is industrial engineers, systems engineers, control engineers, systems integrators, manufacturing supervisors, and business managers. This document also may be useful to firms that produce, or intend to produce, industrial cell control products and services.

1.3 OBJECTIVES

The key objective of this document is to provide a set of guidelines for potential cell controller users. It is intended to classify cell controller functions and attributes in order to assist users in selecting the proper architecture for their application. An additional objective is to provide consistent terminology for the users.

1.4 RATIONALE

These guidelines will help eliminate confusion in the marketplace by providing users, manufacturers, and consultants with a common basis with which to discuss cell controllers and cell controller products. This common basis will assist users in purchasing products, permit cell controller manufacturers to monitor the market, and improve overall manufacturing effectiveness using cell controllers.

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Section 2
METHODOLOGY

2.1 GENERAL

The NEMA *Industrial Cell Controller Classification Concepts and Selection Guide* uses some of the tools of structured systems design (i.e., data flow diagrams and data dictionaries) to define the interaction of the cell controller in the industrial control hierarchy. Data flow diagram and data dictionary concepts are useful tools in presenting a model that is concise, graphic, nonredundant, and logical rather than physical.

Since the purpose of this document is to describe a classification system for cell controllers, and not to write a structured specification, the tools of structured system design have been adapted for use in this application. For example, the data flow diagrams do not conform exactly to the conventions for structured analysis since a cell controller is a combination of both hardware and software. The use of data flow diagram techniques does focus on the essential elements of a cell controller and makes it easier to communicate ideas.

2.2 DATA FLOW DIAGRAM (see Figure 2-1)

The data flow diagram components depicted in Figure 2-1 is a graphic representation of active system components and the data that flows between them. A data flow diagram should not be confused with a flow chart. It does not attempt to show either control or procedural activities in any type of a time-ordered sequence.

The data flow diagrams contained in this document have four basic components:

1. Data flow;
2. Data store;
3. Data source/sink; and
4. Data transformation process.

A data dictionary is necessary to describe these items.

2.2.1 Data Flow

A data flow is represented by a line with an arrow at one or both ends, with the name of a typical piece of data written next to it. A line with one arrow symbolizes data that flows in only one direction, while a line with two arrows represents two-way communications between elements.

A specialized case of data flow is used to describe the interaction between a cell controller, the operator, and a higher level device. In this instance, data flows from two separate elements that are joined into a single arrow

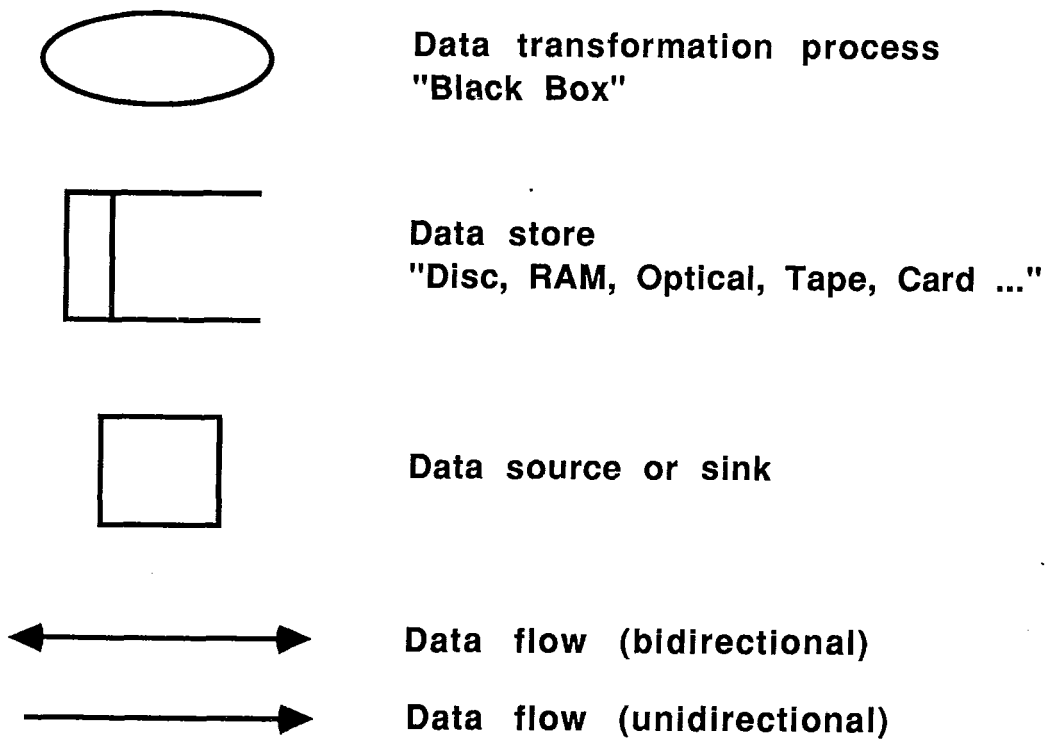


Figure 2-1
DATA FLOW DIAGRAM COMPONENTS

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as they meet at the cell controller. This represents an either/or condition.

2.2.2 Data Store

A data store is a time-delayed storage area for data. It is important to remember that a data store is simply a repository for data and is not necessarily a computer disk, file, or tape. The data store may be computer memory. A data store is represented by two horizontal lines with a small box on the left end.

2.2.3 Data Source/Sink

A data source is a provider of data that is required by the system. A data sink is a receiver of data that flows from the system. In this application there has been no attempt to show all of the possible sources and sinks – only the ones required to meet the minimum criteria for each cell controller class. A data source/sink is represented by a rectangle.

2.2.4 Data Transformation Process

A data transformation process, represented by a circle (also referred to as a bubble), transforms the data in one of two ways. It either transforms the structure of the data, transforms the information contained in the data, or generates new information. The normal procedure for naming a data transformation process is to use a phrase containing a verb that describes the transformation activity.

2.3 DATA DICTIONARY

The data dictionary contains definitions of the data flows used in the data flow diagram. It is composed of two types of data – composite data and elementary data. Composite data are data that can be broken into components and it are defined in terms of the elements from which they are composed. Elementary data, data that cannot be further decomposed, are defined in terms of the meanings they can take.

For the purpose of this document we have named the data used to describe manufacturing activities as production information. Production information has been further subdivided into these types of data (refer to Glossary B for definitions):

- Product;
- Process; and
- Device.

Further division of these data types would not add more clarity since it is not the intent of this document to design cell control software. Another factor for this generic naming is that many types of data are industry specific. An example of a data dictionary entry can be found in Appendix D.

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Section 3
DEFINITION OF A CELL CONTROLLER

3.1 CELL CONTROLLER POSITION

The cell controller occupies a position in the plant communication hierarchy immediately above plant floor production device controllers and immediately below any other high level device.

As depicted in Figure 3-1, the cell controller occupies a unique logical and physical position within the model. Because the cell controller straddles the two major environments, the cell controller may be considered as a computing element that reconciles these dissimilar domains. In other words, the typical cell controller will perform functions normally associated with production device controllers, as well as a number of management information functions. Thus the cell controller will usually exhibit some of the characteristics of both environments.

The relative position of the cell controller in its environment does not make any presumption as to the computing power of the device. A cell controller may have more computing capability than its associated higher level device and less capability than its associated production device controllers, or any combination thereof.

3.2 CELL CONTROLLER DEFINITION

MINIMUM FUNCTIONALITY CELL CONTROLLER (See Figure 3-2)

A Minimum Functionality Cell Controller processes information and, at a minimum:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and**
3. **Locally stores and retrieves production information.**

In addition, the user can modify some of the above attributes to meet changing cell requirements.

As shown in Table 3-1, a cell controller is distinguished from a cell monitor (see 3.5 and Appendix A) by its ability to perform active control.

Active Control is the ability to direct or regulate the production process without the intervention of an operator or a high level device.

Passive Control requires the intervention of an operator or high level device to direct or regulate the production process.

By implication, active control means that the cell controller is an integral part of the production process.

Table 3-1
CELL CONTROLLER AND CELL MONITOR CONTROL

	Active Control	Passive Control
Cell Controller	Required	Optional
Cell Monitor	Not Supported	Optional

Using these criteria as the definition of a cell controller, many sophisticated production device controllers may be utilized as cell controllers. 4.1 will further differentiate the role of the cell controller from other types of automated equipment.

3.3 CONFORMANCE

The conformance test for a cell controller is based upon the concept that if the cell controller ceases to function properly, the production process would be affected. Without the production control services of the cell controller, production would probably stop after some indeterminate period of time. Although systems can be designed that prevent this occurrence, this conformance test would yield the described results for a minimum functionality cell controller.

The cell controller inherently possesses some level of autonomy in performing management information services. The high level device could be disconnected from the cell controller for some period of time without affecting the production flow through the plant. Indeed, some cell controllers may be implemented without a connection to high level devices.

A cell controller may provide far more functionality than control, but the control aspect differentiates the cell controller from a cell monitor. A cell controller may

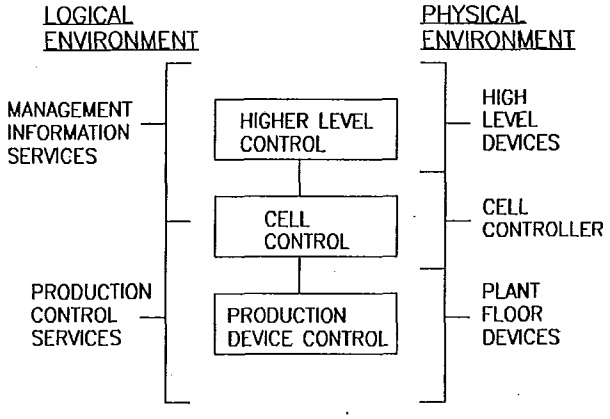


Figure 3-1
PLANT MODEL EXAMPLE

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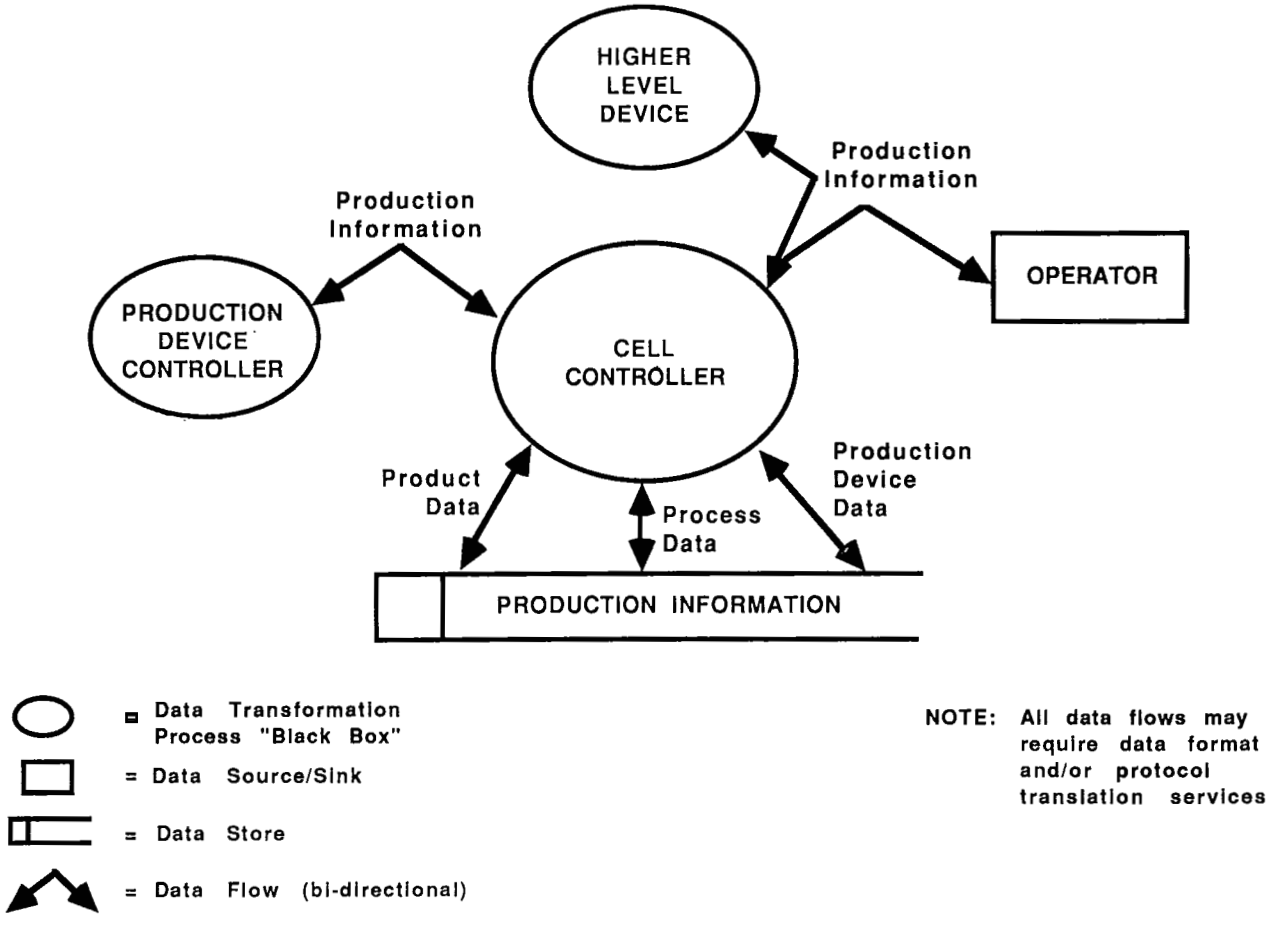


Figure 3-2
MINIMUM FUNCTIONALITY CELL CONTROLLER

be implemented as a cell monitor (see 3.5), but the method of implementation does not prevent the device from being called a cell controller. Because it lacks active control capabilities, a cell monitor cannot be implemented as a cell controller.

3.4 CELL CONTROLLER FUNCTIONS, FEATURES, AND BENEFITS

3.4.1 Cell Controller Functions

Below is a list of management information and production control services that may be provided by a cell controller (it is not a complete list).

1. Provide active control—this function differentiates a cell controller from a cell monitor;
2. Coordinate the activities of production device controllers;
3. Provide a platform, or act as a base, for additional software applications such as statistical process control or statistical quality control;
4. Supply information, such as recipes or diagrams, to the operator (This information, and also other types of information, could be resident in the cell controller or available from another source.);
5. Process and provide textual and/or graphic real time and historical information about the process or production;
6. Provide the ability to configure resources, limits, and alarms;
7. Track, collect, analyze, store, and display production data and process raw data into more meaningful information;
8. Communicate with lower and higher level devices;
9. Allow the operator to request information and perform control actions through operator instructions;
10. Calculate production efficiency;
11. Provide alarm handling and annunciation;
12. Provide database service and facilities, both historical and real time; and

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13. Provide communications and networking support.

Also, see 6.2 for a list of optional software packages.

3.4.2 Cell Controller Software Features

Many software application packages running on current cell controllers offer:

1. A standard user interface, either defined by a vendor or the user community;
2. Programmerless installation made possible by software designs that allow implementation and changes to be entered through a menu and executed without recompiling the program;
3. Ease of use by having designed-in editing facilities that are tailorable by plant engineers;
4. Self-documentation through textual output that may be produced when generating or changing the system;
5. On-line documentation through help screens and tutorials;
6. High level real time graphic displays through the use of dynamic animation, text, graphs, and charts;
7. Hard copy reports covering maintenance logs, alarms, trending, and history;
8. Software modules to compare actual versus scheduled production and/or process output;
9. Support for many different kinds of input/output (I/O) devices through software I/O drivers and symbolic naming conventions; and
10. Password and other types of software security protection.

3.4.3 Cell Controller Benefits

Benefits vary between industries and cell controller designs. Some common benefits include:

1. *Higher throughput of the production process* due to having decisions automatically made by the system and not the operator (the system could also provide information for important decisions with sufficient time to act upon them for timely changes to the process);
2. *Improved quality* due to the high availability and timeliness of information that relates to quality performance, allowing necessary changes to be made during the process;
3. *Improved safety* due to the high availability and timeliness of alarm reporting;
4. *More accurate information* since information need not go through translation by the operator;
5. *Reduced need for operator training* since there can be a shortage of skilled operators due to factors such as retirement or job changes (skill information from previous operators can be recorded and placed into the system to be available for new operators);
6. *Reduced waste* due to the ability to make on-the-spot changes; and
7. Increased flexibility in setting up new production runs due to the user-friendly design capabilities made available through software.

3.5 CELL MONITOR

A cell monitor is not recognized in the NEMA classification system as a cell controller but as a related product having many of the same attributes of a cell controller. A data flow diagram for a cell monitor is furnished in Appendix A.

Many currently advertised cell controller products are not cell controllers according to the NEMA definition, but they may be cell monitors. This is not to imply that cell monitors do not perform an important role in the factory. In fact, many current cell monitoring systems may eventually be upgraded to cell controllers. As stated in 3.2, a cell monitor is distinguished from a cell controller by its inability to perform active control on a production device controller or any other plant floor equipment. A cell monitor may collect information and may instruct the production device controller or other devices to perform specific actions, but only as a result of inputs from an operator or higher level device. The cell monitor does not perform active control functions, such as processing input data and taking corrective actions or instructing the production device controller to take certain actions, without input from an external source.

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Section 4
CELL CONTROLLER CLASSES

The following cell controller classes are based on attributes that define the position of a cell controller in a plant control architecture or address common system capabilities. The classifications are not based on the application software functionality of the cell controller. It is recognized that available commercial products may have more functionality than the minimums expressed for the individual classes.

4.1 MINIMUM FUNCTIONALITY CELL CONTROLLER (see Figure 4-1)

This section defines the minimum requirements that all cell controllers must possess. Functionality is added to this minimum to achieve other classes.

4.1.1 Definition

A Minimum Functionality Cell Controller processes information and, at a minimum:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and,**
3. **Locally stores and retrieves production information.**

In addition, the user can modify some of the above attributes to meet changing cell requirements.

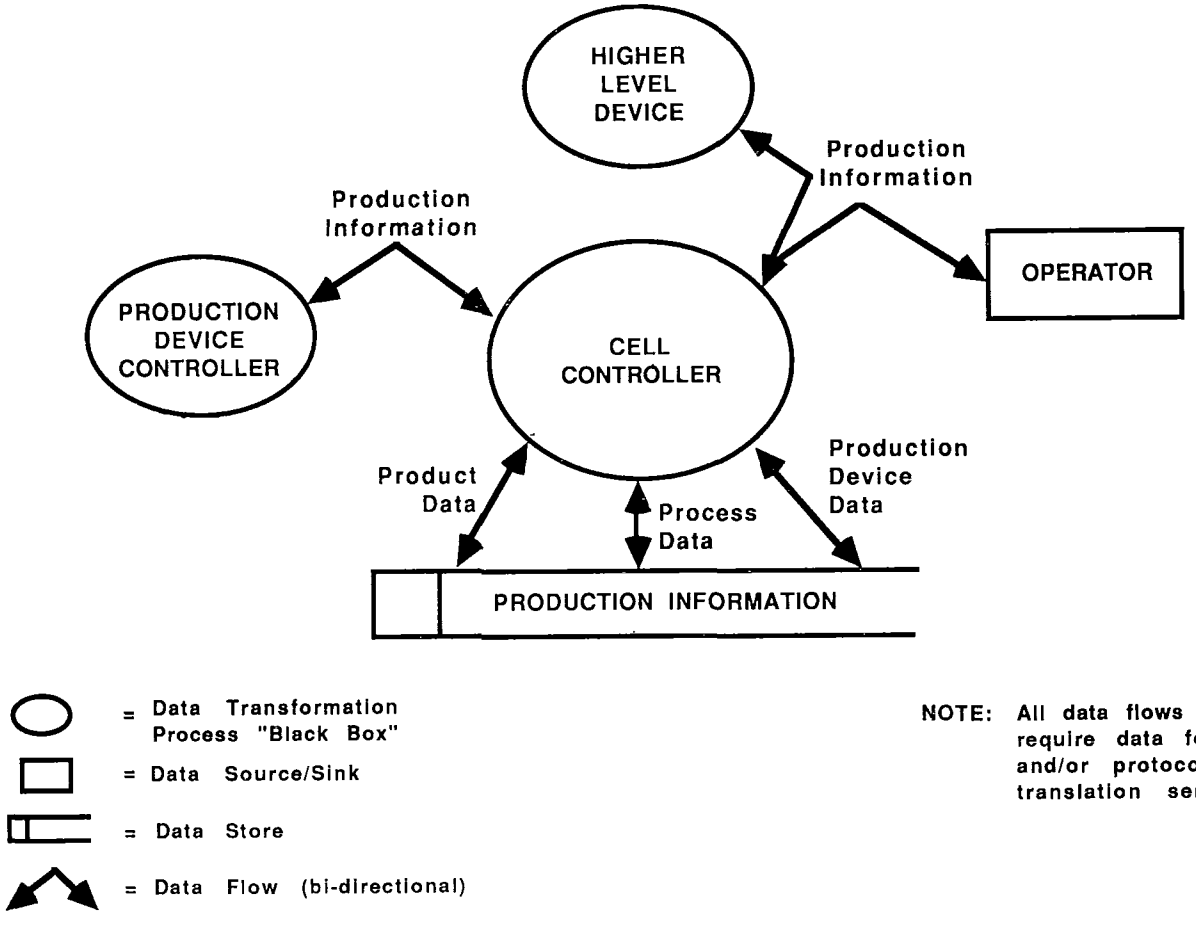


Figure 4-1
MINIMUM FUNCTIONALITY CELL CONTROLLER

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4.1.2 Description

The Minimum Functionality Cell Controller is an information processing system that is capable of communication with either a higher level device, an operator, or both. A Minimum Functionality Cell Controller is capable of coordinating and supervising at least one other independent production device controller and allows for the storage and retrieval of production information. Finally, the Minimum Functionality Cell Controller may be modified by users to support changing cell requirements.

As shown in Figure 4-1, a Minimum Functionality Cell Controller processes production information. There are a variety of sources and uses of production information. Production information consists of three distinct types of data:

1. Product data that consists of attributes of the product being manufactured (weight, color, physical dimensions);
2. Process data that consists of attributes of the collection of machinery/devices making the product (number of cycles, temperature, consumables, capability ratio); and
3. Production device data that consists of the attributes of a specific machine (program, status, condition).

A Minimum Functionality Cell Controller maintains production information in a local data store. The specifics of the data store are indeterminate (i.e., a specific media such as tape or disk is not implied). This data store should be sufficient to synchronize activities between management information services and production control services. The cell controller is capable of communicating this production information to a higher level device, an operator, or both.

The higher level device implies another computer system, whereas the operator is a human managing the activities of the cell. The human operator may add value to the control process. The presence or absence of a higher level device or operator should not significantly affect the control process.

4.1.3 Conformance

As its name implies, the Minimum Functionality Cell Controller is capable of active control functions, even if these functions are unused. For example, an implementor could use a cell controller as a cell monitor with humans closing the control loop. This implies that a cell controller is capable of performing all the tasks of a cell monitor.

A Minimum Functionality Cell Controller is also capable of communicating the results of control and monitoring actions to either humans and/or machines. The operator interface may be accomplished using video displays, hardcopy devices, keyboards, track balls, light pens, touch screens, voice synthesizers, voice recognition systems, or other input devices. The important aspect is bidirectional transfer of information.

An interface to a higher level device is typical of integrated CIM (Computer Integrated Manufacturing) applications. While the higher level device could be physically smaller and less powerful than the cell controller, it is the higher level device that provides direction and receives results. The method of communication with higher level devices may vary. Current technology indicates that networks are most likely to be used.

Most cell controllers will likely provide both an operator interface and an interface to a higher level device.

4.1.4 Examples of Attributes and Applications (See Figure 4-2)

A cell controller is often used in situations involving several operations under the control of different production device controllers. The cell controller might obtain information from one production device controller, process it, and forward the results to another production device controller. This could involve scheduling or routing information regarding the disposition of the part being manufactured. Another example may involve the interpretation and administration of a daily production schedule downloaded from a higher level device, such as a plant host computer.

Besides the routing and scheduling decisions, a cell controller may collect quality information about the process. This information could be used for SQC/SPC (Statistical Quality Control/Statistical Process Control) applications. The actual number of good and bad parts produced, sorted by reject code and hour of the day, are other examples of data that may typically be collected by a cell control system. Alarm conditions and automated process parameter tuning are further examples of control actions that may be made by a typical cell controller.

The nature and sophistication of such application examples is not intended as a comprehensive specification of the features of a cell controller. These examples are provided merely as an illustration of the basic concepts presented in the definition of a Minimum Functionality Cell Controller. In actual practice, the features implemented may be considerably different.

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4.2 DIRECT INPUT/OUTPUT CELL CONTROLLER (see Figure 4-3)

4.2.1 Definition

A Direct Input/Output (I/O) Cell Controller processes information and provides all of the functionality of a Minimum Functionality Cell Controller and, at a minimum:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and**
3. **Stores and retrieves production information locally.**

As an additional functionality, a Direct I/O Cell Controller provides for direct processing of input and output information from one or more machine or process input/output devices or subsystems.

In addition, the user can modify some of the above attributes to meet changing cell requirements.

4.2.2 Description

A Direct I/O Cell Controller is a Minimum Functionality Cell Controller with the addition of providing for the direct attachment of machine or process inputs/outputs (see Figure 4-3), which represents an enhancement to the production control services. A Direct I/O Cell Controller may accommodate, through direct attachment, any device or subsystem that does not perform active control.

Depending upon the application, a Direct I/O Cell Controller provides the following benefits:

1. Quick response;
2. Dedicated control;
3. Potential cost effectiveness; and
4. Minimal physical space requirements.

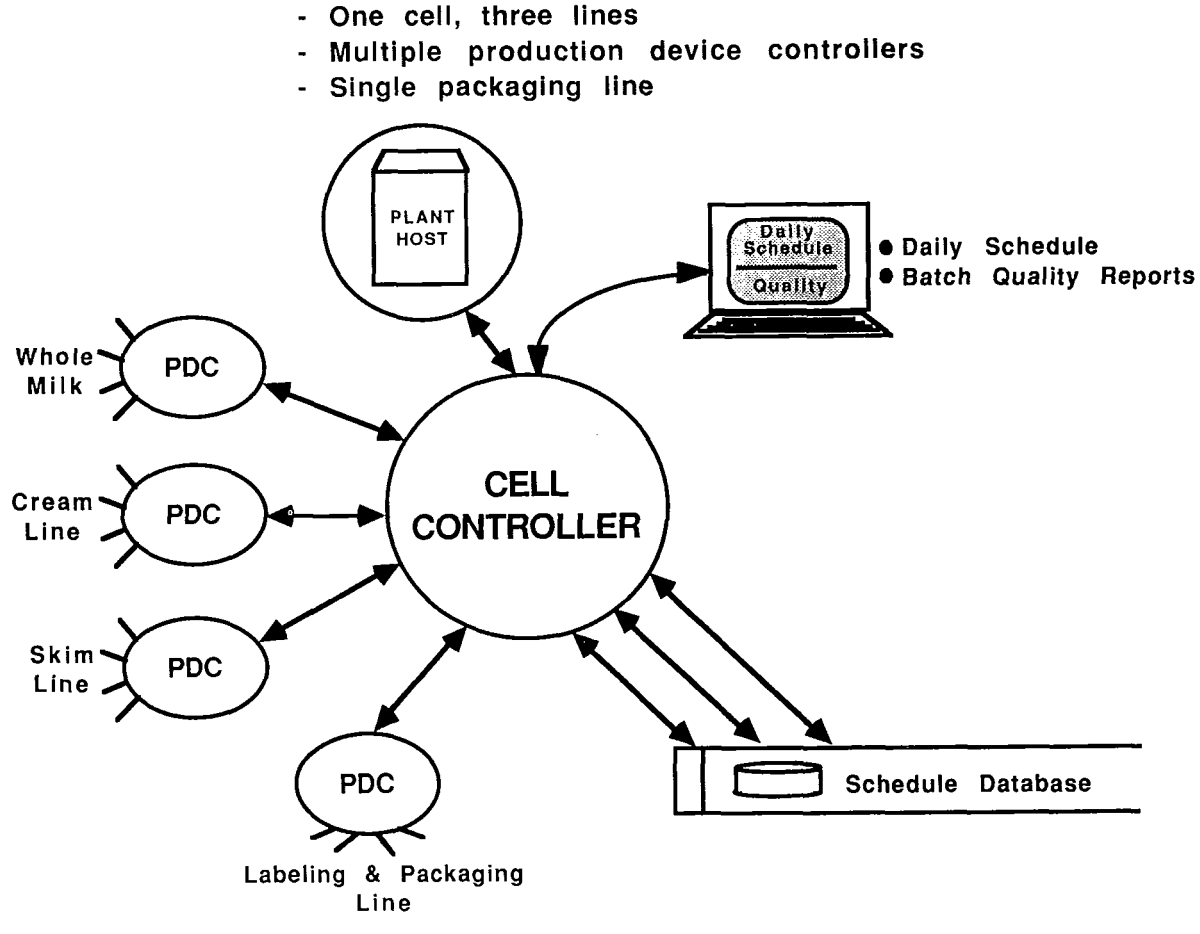


Figure 4-2
MINIMUM FUNCTIONALITY CELL CONTROLLER EXAMPLE: CONFIGURATION FOR MILK PRODUCTION/PACKAGING

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4.2.3 Conformance

A Direct I/O Cell Controller has the capability to directly sense and affect the state of the production device without the use of an intervening production device controller. The connection to the machine or process inputs/outputs often will include signal conditioning, engineering units conversion, and related processing by the interfaces between the cell controller and the process. No independent control decisions are made by these interfaces. If decisions were made, the interface would be considered an independent production device controller. In a Direct I/O Cell Controller, the cell controller is the first level responsible for making application-specific decisions based upon the inputs and outputs that are directly attached to the machines or process. This first level response implies enhanced production control services such as increased real time operation.

A Direct I/O Cell Controller can coordinate and supervise at least one independent production device controller that handles machine or process inputs/outputs. This coordination and supervision distinguishes the cell controller from another production device controller within the cell.

4.2.4 Examples of Attributes and Applications (See Figure 4-4)

The Direct I/O Cell Controller is often used where there are certain machine or process inputs/outputs within the cell that are not associated with a particular production device controller. It is also used when certain machine or process inputs/outputs are more appropriately interfaced into the cell controller, rather than into production device controllers.

For example, direct inputs/outputs are often used for coordination between production device controllers. The completion of a job at a production device is recognized by the cell controller, the next processing action

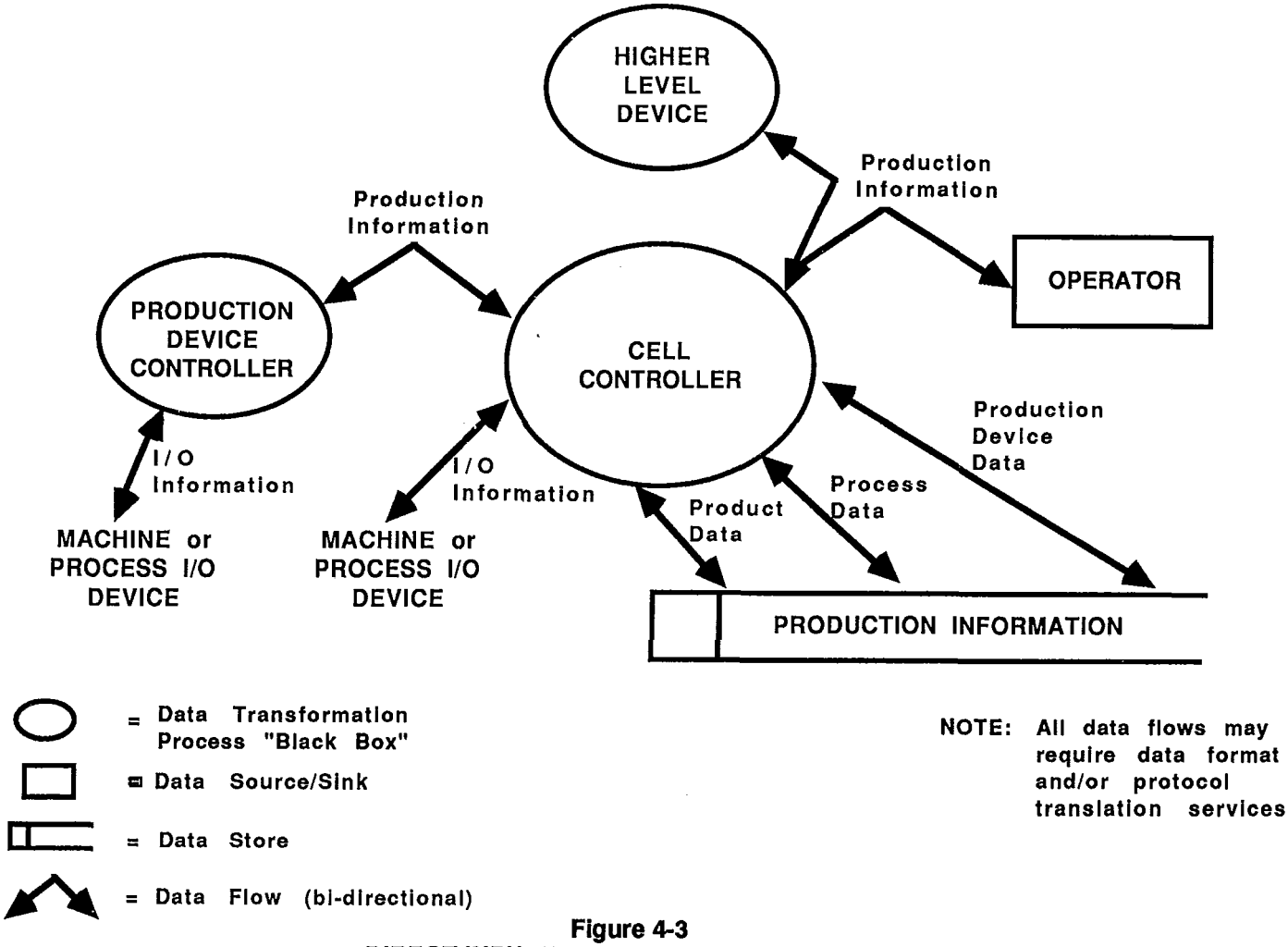


Figure 4-3
DIRECT INPUT/OUTPUT CELL CONTROLLER

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for the job is determined, the job routing is selected and performed, and the next production device controller is informed of the expected work arrival and the action it requires.

Similarly, direct inputs/outputs are often used for coordination of a cell with others. The arrival of a new job for the cell is detected, the first processing action for the job is determined, the job routing is selected and performed, and the first production device controller is informed of the expected work arrival and the action it requires.

Also, miscellaneous machine or process I/O devices within the cell can be attached directly to the cell controller. Examples include alarms, annunciators, alarm acknowledgement, and similar devices. Alternately, many of these functions can also be performed as part of the operator interface and the inputs/outputs connected to one of the production device controllers. The Direct I/O Cell Controller gives the process engineer a connectivity option.

A thermocouple, switch closure, bar code reader, R-F tag reader, vision system, or other identification system may have an interface that is more appropriate to implement on the cell controller, rather than on any of the production device controllers. These systems can be attached to a Direct I/O Cell Controller that passes the actual or transformed data (or some result of processing the data such as a recipe number) down to the appropriate production device controllers for action. In this case, the identification system is not considered a production device controller since the identification system is not making control decisions, but simply transferring data.

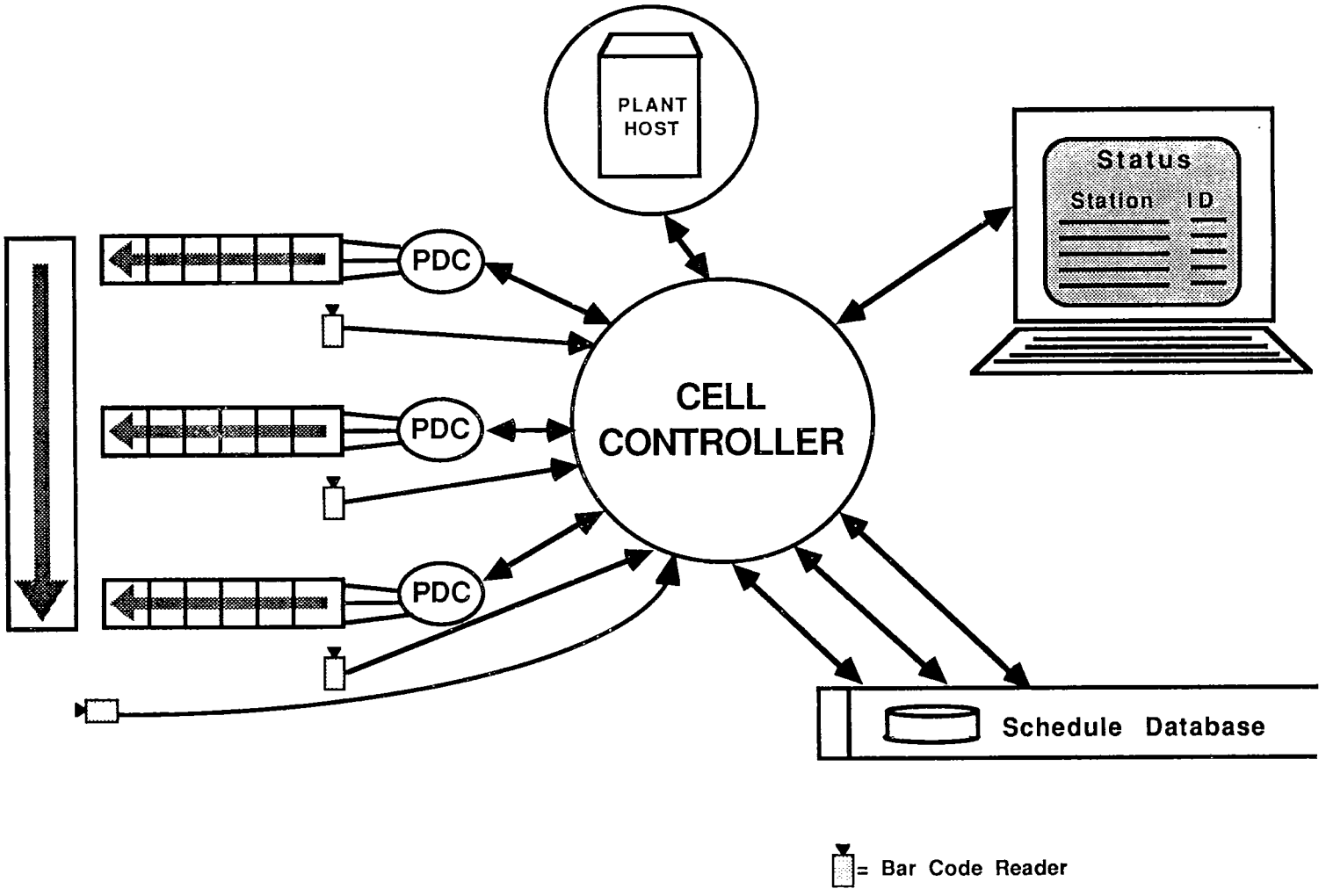


Figure 4-4
DIRECT INPUT/OUTPUT CELL CONTROLLER EXAMPLE: CONFIGURATION OF A TRANSFER LINE

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4.3 SHARED DATA CELL CONTROLLER (see Figure 4-5)

4.3.1 Definition

At a minimum, a Shared Data Cell Controller processes information and provides all of the functionality of a Minimum Functionality Cell Controller:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and**
3. **Locally stores and retrieves production information.**

A Shared Data Cell Controller also provides the following functionality:

1. **Stores and retrieves production information both locally and via remote access to a production information server;**
2. **Relies on both local and remote production information for normal operation; and**
3. **Depends in part on a remote production information server for data storage.**

In addition, the user can modify some of the above attributes to meet changing cell requirements.

4.3.2 Description

As shown in Figure 4-5, a Shared Data Cell Controller is a cell controller that has its management information services expanded to include a dependency on a remote production information server for data storage. It stores and processes production information internally, but its functional completeness is not satisfied without the con-

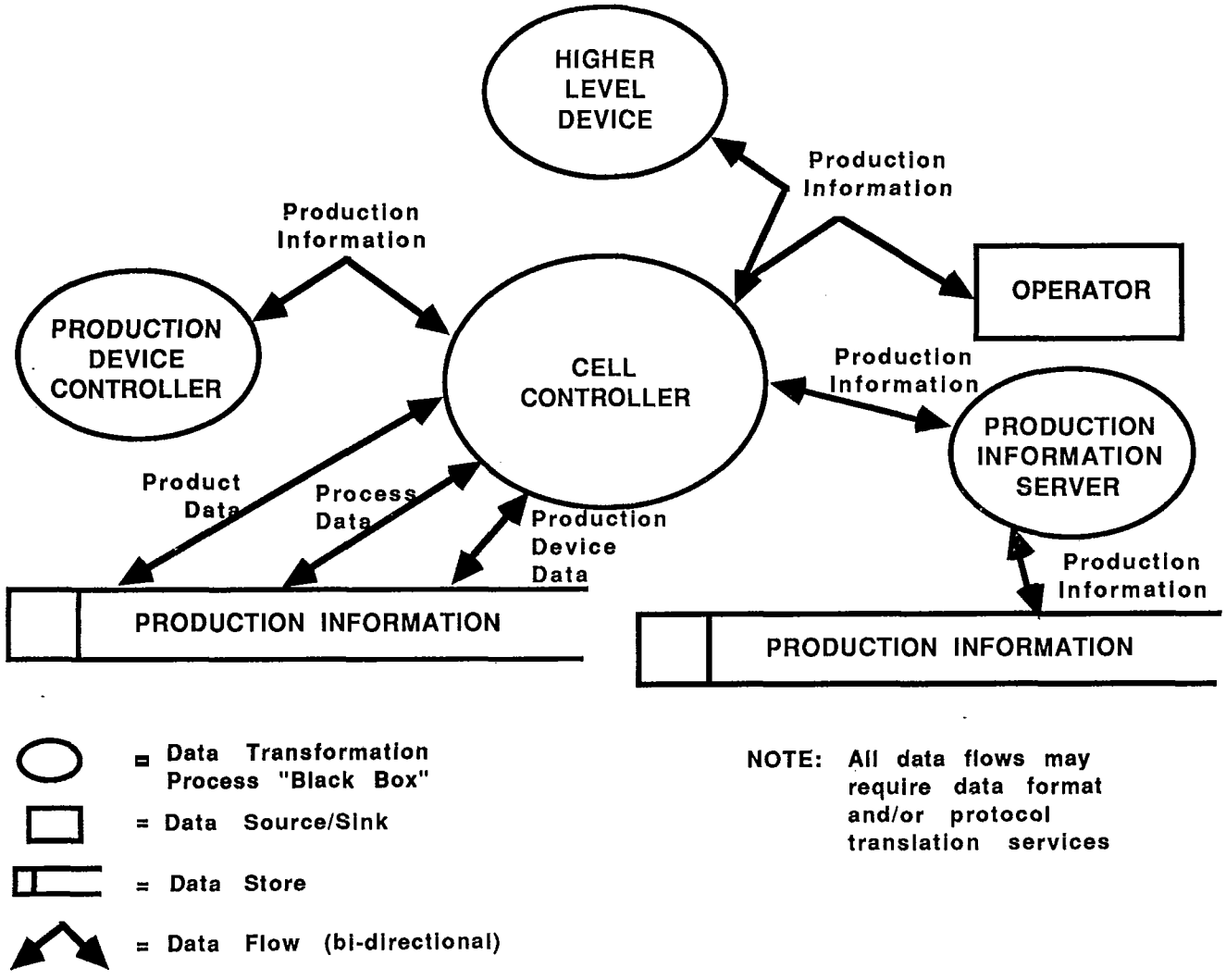


Figure 4-5
SHARED DATA CELL CONTROLLER

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nection to the production information server. Other than for the shared data dependency, the functionality of the Shared Data Cell Controller is identical to the functionality of the Minimum Functionality Cell Controller.

The physical connection and method of communication between the Shared Data Cell Controller and the production information server may vary.

4.3.3 Conformance

As stated, the only difference between the Minimum Functionality Cell Controller and the Shared Data Cell Controller is the dependency of the Shared Data Cell Controller on remotely acquired and stored production information. The Shared Data Cell Controller is not fully functional after some indeterminate period of time if the production information server is disconnected. The production information server may be connected directly to the higher level device.

4.3.4 Examples of Attributes and Applications (see Figure 4-6)

In a quality monitoring and control application, a cell controller may be required to present and utilize production data over an extended period of time without having the storage capacity to maintain that data. This data can be stored and retrieved via a production information server in a Shared Data Cell Controller.

In some applications, the data required by one cell were collected by another cell. These situations can be addressed effectively using the Shared Data Cell Con-

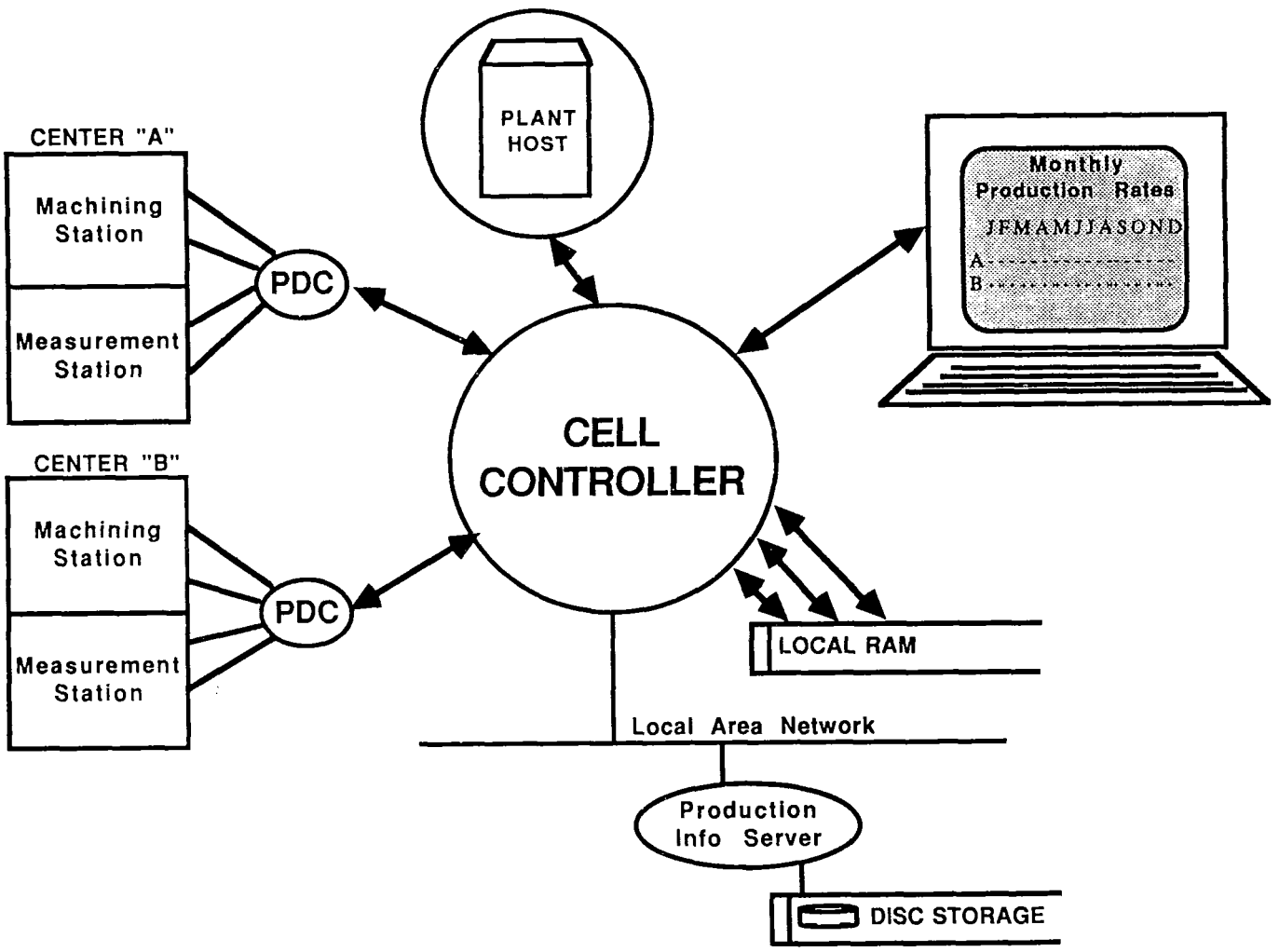


Figure 4-6
SHARED DATA CELL CONTROLLER EXAMPLE: CONFIGURATION FOR MACHINING AND MEASUREMENT

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troller, where the required data are stored and made available through the production information server.

4.4 PEER COORDINATED CELL CONTROLLER (see Figure 4-7)

4.4.1 Definition

At a minimum, a Peer Coordinated Cell Controller processes information and provides all of the functionality of a Minimum Functionality Cell Controller:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and**
3. **Locally stores and retrieves production information.**

A Peer Coordinated Cell Controller also provides the following functionality:

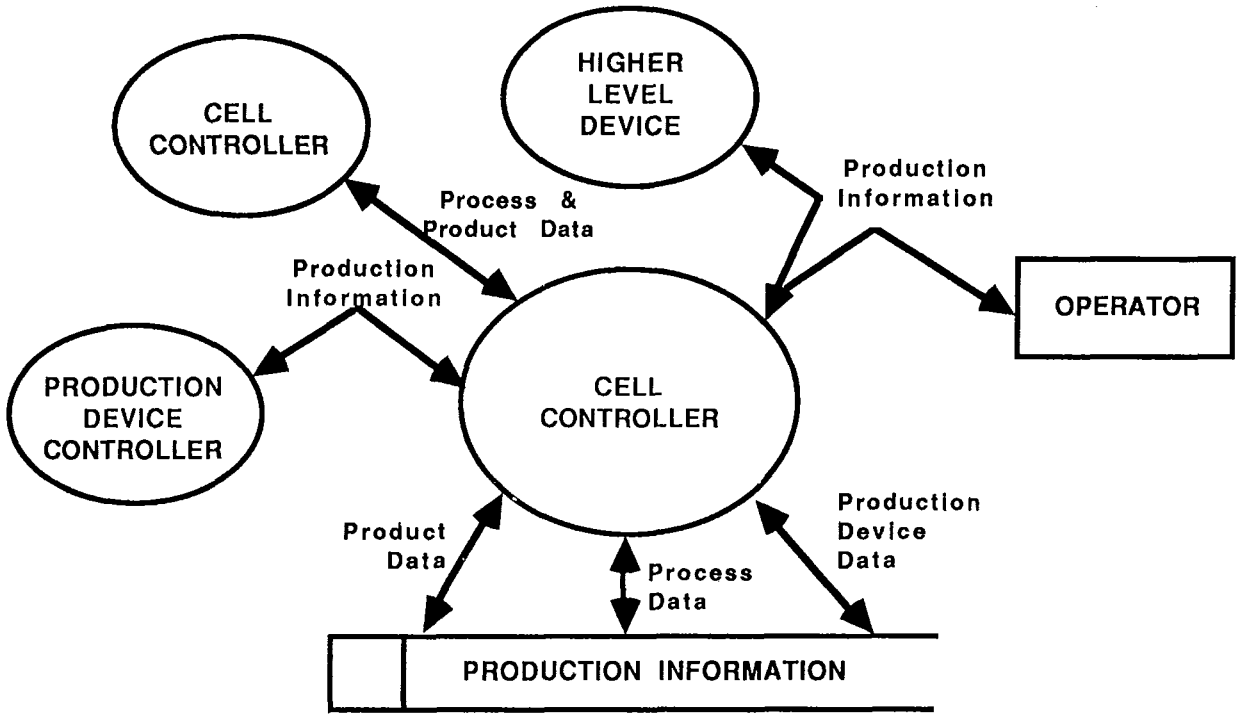
1. **Communicates product and process data to one or more other cell controllers;**
2. **Permits coordination and synchronization of activities between cells without the intervention of a higher level or other control device.**

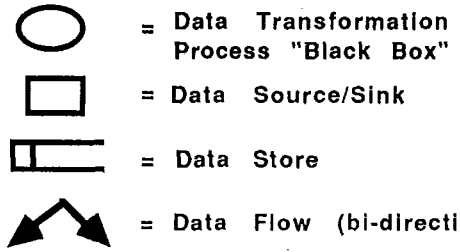
In addition, the user can modify some of the above attributes to meet changing cell requirements.

4.4.2 Description

The data flow diagrams for a Peer Coordinated Cell Controller are shown in Figures 4-7 and 4-8. The actual movement of data indicated may require use of translation devices for hardware or software. While the method of communication may vary, current technology indicates that local area networks are likely to be used.

The Peer Coordinated Cell Controller is a Minimum Functionality Cell Controller with both its management information services and production control services





NOTE: All data flows may require data format and/or protocol translation services

Figure 4-7
PEER COORDINATED CELL CONTROLLER

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enhanced to allow the coordination with other cell controller peers. In a Peer Coordinated Cell Controller environment, coordination between cell controllers can be achieved without intervention by a higher level device or through the use of a production information server.

The system being considered is peer coordinated if it can coordinate, and be coordinated, by peers. The primary advantage of this architecture is that it may make higher level control devices unnecessary.

4.4.3 Conformance

As stated, a Peer Coordinated Cell Controller conforms to all of the requirements of a Minimum Functionality Cell Controller. In addition, the ability to coordinate peer activities is essential to this category of cell controllers. A Peer Coordinated Cell Controller is capable of modifying the activities of another cell controller without the intervention of a higher level device. Choosing not to implement peer coordination functions shall not compromise the classification of a cell controller as a Peer Coordinated Cell Controller.

4.4.4 Examples of Attributes and Applications (see Figure 4-9)

The Peer Coordinated Cell Controller can be used in an application that requires a nonhierarchical system architecture. In such an application, one cell controller may have its production schedule criteria modified by another cell controller.

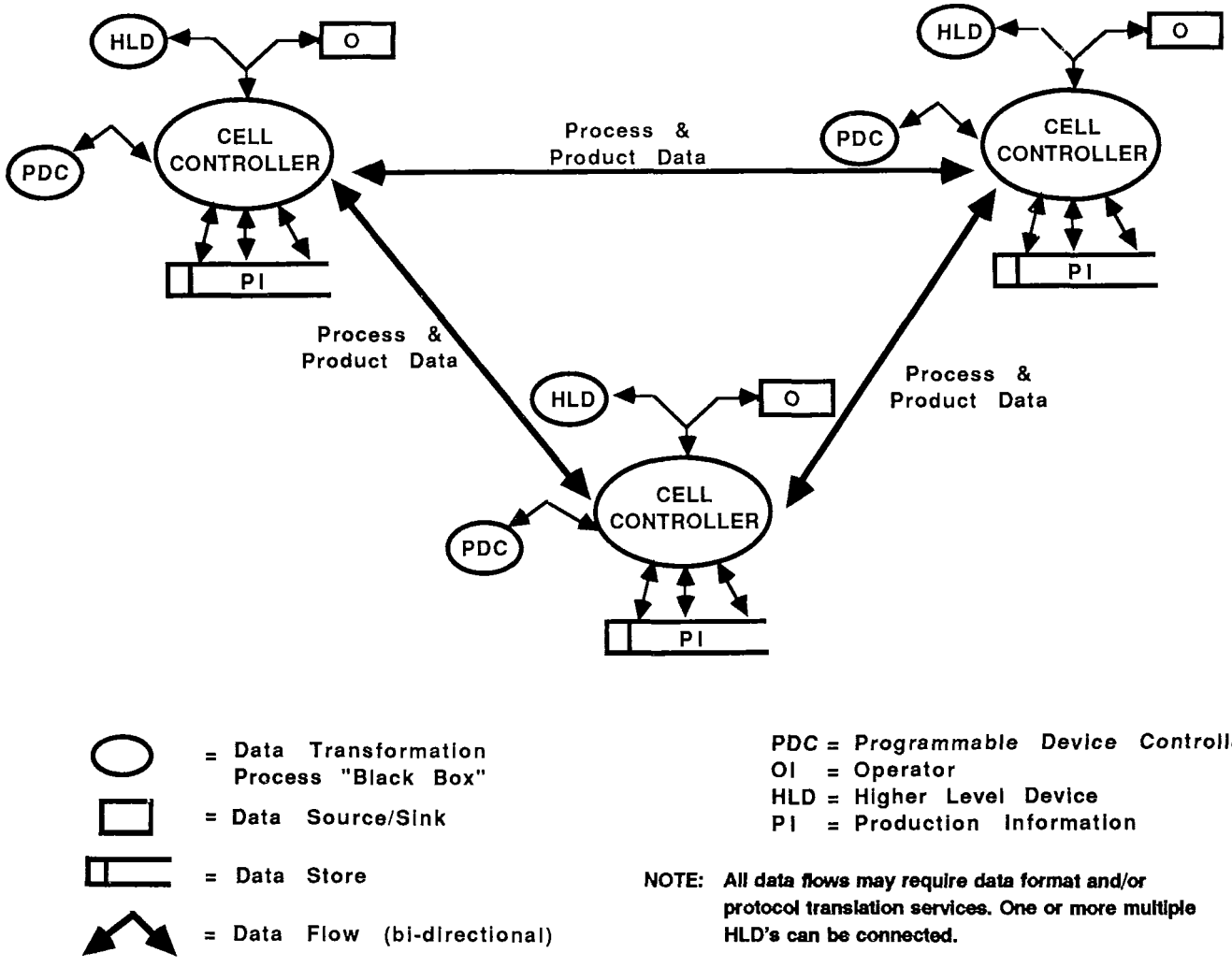


Figure 4-8
PEER COORDINATED CELL CONTROLLER EXPANDED VIEW

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A peer cell controller may make adjustments to a remote portion of the facility to implement a fix for a quality problem. For example, in order to obtain a more balanced overall tolerance, a machining center may have its tolerances modified by a cell controller supervising the subassembly of a number of components. Another example may involve a cell controller supervising the packaging and shipment of finished goods, while modifying the production schedule of several other cell controllers to eliminate the manufacture of a particular part code. This may be due to any number of reasons including the lack of packaging material or the failure of some key machine within the cell.

The important distinction between peer coordinated and other types of cell control involves the direct communication between peers to resolve global requirements (such as scheduling or adjustments). Hierarchical systems would require that this information be relayed to a higher level computer for subsequent decision making.

4.5 SHARED RESOURCE CELL CONTROLLER (See Figure 4-10)

4.5.1 Definition

At a minimum, a Shared Resource Cell Controller processes information and provides all of the functionality of a Minimum Functionality Cell Controller:

1. **Communicates production information with either an operator, a higher level device, or both;**
2. **Coordinates and supervises at least one other independent production device controller that handles machine or process inputs/outputs; and**
3. **Locally stores and retrieves production information.**

A Shared Resource Cell Controller also provides the following functionality:

1. **Communicates production information to and from another cell controller using a shared data store;**
2. **Supports data access to or from another cell controller; and**
3. **Shares one or more operator interfaces with another cell controller.**

In addition, the user can modify some of the above attributes to meet changing cell requirements.

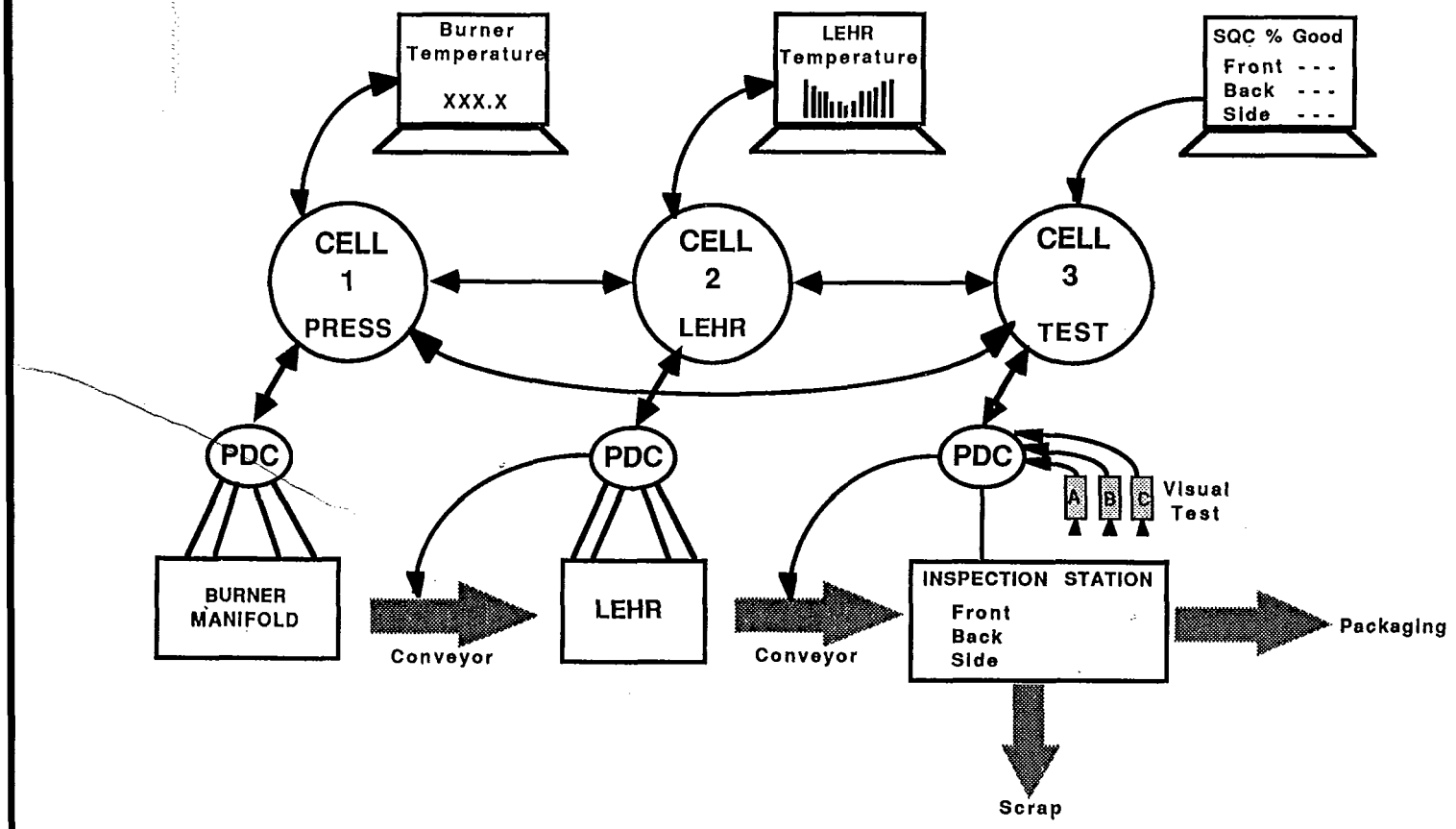


Figure 4-9
PEER COORDINATED CELL CONTROLLER EXAMPLE: CONFIGURATION FOR A GLASS PRESS

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4.5.2 Description

As shown in Figure 4-10, a Shared Resource Cell Controller is a Minimum Functionality Cell Controller with its management information services enhanced to share peripheral devices, such as operator interfaces or data stores, with other cell controllers. The result is a closely coupled cell control architecture where each cell controller has access to data in the other controller's domain. In addition, data from other cell controllers are accessible, controllable, or both, by each operator, higher level device, or both.

The shared resource architecture may include multiple operator consoles and data stores, some or all of which have access to the data from the cell controller. Similarly, the higher level device(s) have bidirectional access to the cell controller. While the production information gathered and generated by each cell controller from the production device controller(s) is accessible from either cell controller, the production device controllers themselves are not shared.

4.5.3 Conformance

A cell controller conforms to the Shared Resource Cell Controller classification if it meets one or more of the following requirements:

1. Communicates production information to and from another cell controller via a shared data store;
2. Supports data access to or from another cell controller; or
3. Shares one or more operator interfaces with another cell controller.

A Shared Resource Cell Controller also conforms to the definition of a Minimum Functionality Cell Controller.

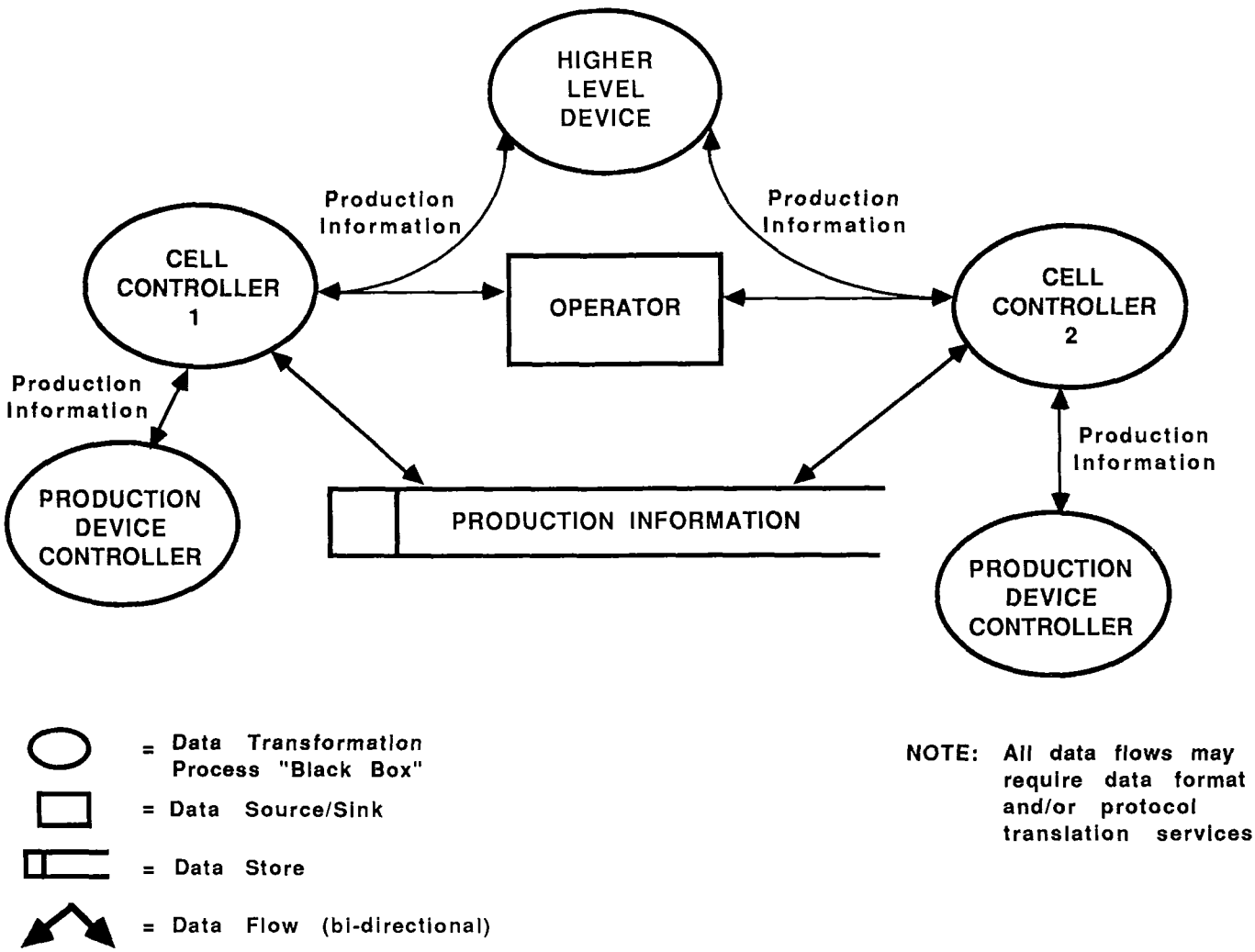


Figure 4-10
SHARED RESOURCE CELL CONTROLLER

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4.5.4 Examples of Attributes and Applications (see Figure 4-11)

An example of a Shared Resource Cell Controller application might involve the control of two adjoining manufacturing cells that can perform the same manufacturing operations and that bid for work depending on availability of inventory and free machine time. Normally the cells operate independently, but they are supervised by the same operators. A single higher level device downloads work schedules, controls the flow of materials in and out of the cells, and gathers production data.

In this example, the Shared Resource Cell Controllers provide the ability of operators to supervise both cells from the same consoles. Also, the workload may be controlled by the higher level device because it has access to the databases of both cell controllers. In addition, the cell controllers are able to communicate with each other in order to coordinate work or material flow between the cells.

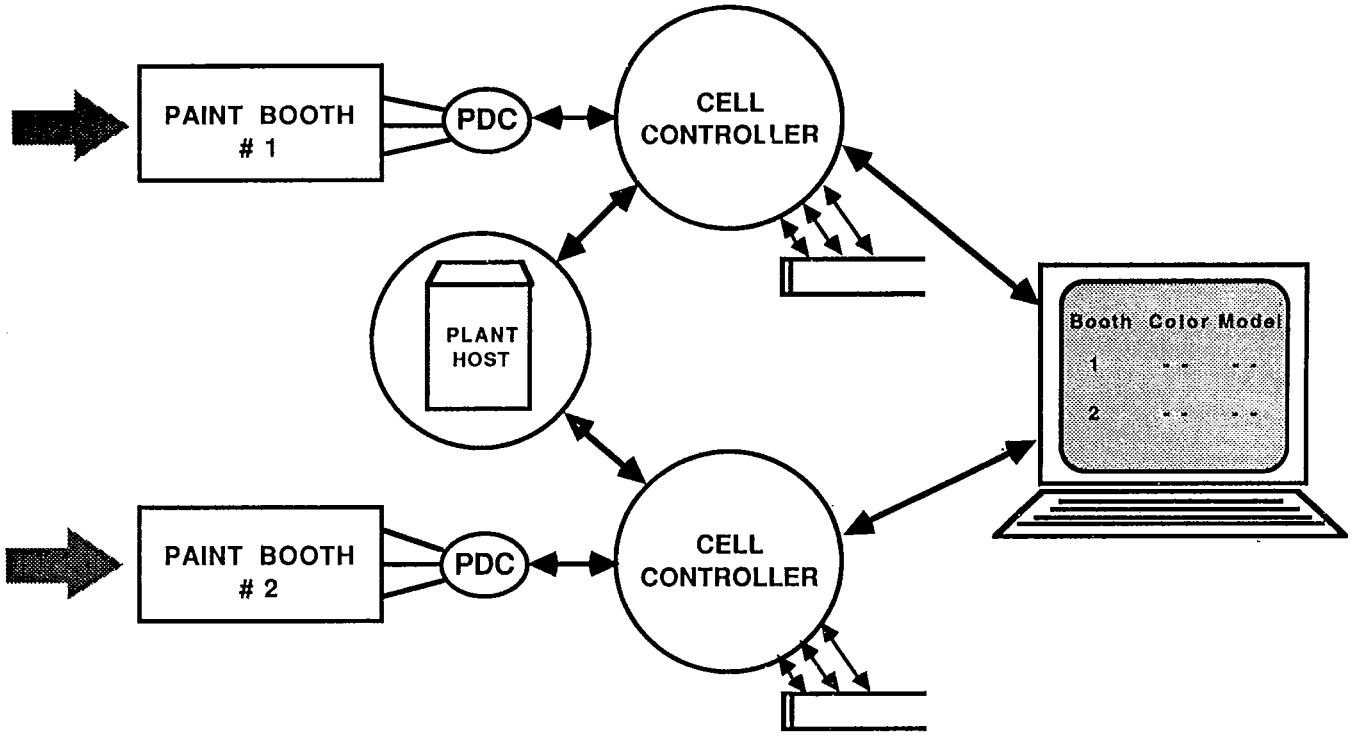


Figure 4-11
SHARED RESOURCE CELL CONTROLLER EXAMPLE: CONFIGURATION OF A PAINT BOOTH

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Section 5
SELECTION GUIDE

5.1 MATRIX DESCRIPTION

The matrix shown in Table 5-1 will assist cell controller purchasers in determining the appropriate class, or classes, of cell controller for their application. The NEMA Cell Controller Group has developed five different cell controller classes. For clarity, these classes are described as if they are discrete entities. Certain implementations may require the functionality provided by a combination or blending of two or more classes.

A single cell controller may be capable of supporting more than one class.

5.1.1 Glossary and Definitions

The following definitions apply to the cell controller matrix shown in Table 5-1:

DATA STORAGE

A local data store is an information storage device (RAM, Disk, Bubble, Optical, and such) that is directly attached to the cell controller. The local data store may be as simple as RAM that is addressed by the cell controller, or may be as complex as an attached disk subsystem. A local data store does not require disk-based memory.

DIRECT I/O

Processes input and output information from one or more machines or process input/output (I/O) devices or subsystems, without the use or intervention by a production device controller.

DISTRIBUTED DATA

Distributed data refers to a system's ability to store data elements across multiple data stores and retrieve composite records made up of data elements from these stores. A computer system analogy would be a geographically distributed data base.

HLD (HIGHER LEVEL DEVICE) COMMUNICATIONS

Higher level device communications is information transfer between the cell controller and at least one other processor located higher in the plant information processing hierarchy.

INTERCELL COORDINATION

Intercell coordination refers to the ability to order and synchronize events between cooperating cell controllers to control the operation of the cell.

MONITORING

To examine the status of a data element on an ongoing basis.

OPERATOR INTERFACE

The operator interface provides bidirectional communication with a human operator. The operator interface function may be provided by a CRT display device (color or monochrome), plasma display panel, push button, light board, or any other display technology that allows the plant operators to view and modify the cell's production process.

PEER COMMUNICATIONS

Peer communications is a mode of unmastered communication in which each participant has equal communication capabilities. The content of communications between peers is unrestricted.

REMOTE DATA STORAGE

A remote data store is a device that is physically removed from the cell controller. A remote data store may be connected to the cell controller via a data communication link (e.g., LAN). Remote data stores in many installations will be traditional file servers.

SHARED OPERATOR INTERFACE

A shared operator interface provides support for an operator interface device that has the capability to attach to different cell controllers either concurrently or serially.

STANDALONE OPERATION

Standalone operation is a mode of operation that allows a cell controller to operate without being interconnected to a higher level device or another cell controller.

5.1.2 Classification Descriptions

The primary characteristics of the five NEMA Cell Controller classifications are:

1. *Minimum Functionality Cell Controller*
   The Minimum Functionality Cell Controller will operate either with a local operator or via a connection to a higher level computing device. The Minimum Functionality Cell Controller has the ability to control and modify the associated production processes.
2. *Direct I/O Cell Controller*
   Direct I/O Cell Controllers have the capability to directly affect process I/O (input/output) without the use of another production device controller (e.g., a programmable controller). Direct I/O Cell Controllers may make the need for the lower level devices unnecessary and, therefore, may be more cost effective in some applications.

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3. *Shared Data Cell Controller*
   The Shared Data Cell Controller permits multiple manufacturing cells to share a remote data store of production information. The Shared Data Cell Controller uses a production information data server (file server) to store common (shared) production information.
4. *Peer Coordinated Cell Controller*
   A Peer Coordinated Cell Controller permits multiple independent manufacturing cells to participate in coordinated (cross-cell) production activities. This architecture is particularly useful where the manufacturing operation requires that the information from one cell be input into downline manufacturing cells.
5. *Shared Resource Cell Controller*
   The Shared Resource Cell Controller uses a shared data store to communicate production information to another cell controller and supports data access to or from another cell controller. One or more operator interfaces may be shared with another cell controller.

5.2 MATRIX APPLICATION

The NEMA cell controller matrix shown in Table 5-1 describes the functionality associated with each of the different classes of cell controllers. The matrix is intended to assist users in understanding their needs and selecting the appropriate cell controller architecture to fit their particular manufacturing cell application.

The matrix can be used as shown in the following examples. If a user requires that a cell controller connects directly to real time I/O's, the only NEMA class appropriate for this application would be the "Direct I/O" class. Similarly, users wanting peer coordination between manufacturing cells would choose the "Peer Coordinated Cell Controller." A single cell controller may be capable of supporting more than one class.

Users of the matrix should note that these cell definitions are for the minimum functionality needed for each classification. Commercially available cell controller products typically include functions above the minimums. These additional functions may be required for a particular application and industry.

Entries that are marked as "Probable Option" (O)in Table 5-1 are seen as options which are highly likely to be selected by users, but which are not required as part of the minimum functionality provided by the specific NEMA classification. For example, Shared Resource Cell Controllers frequently use a remote data store (e.g., a file server on a LAN) to share file-based production information. The shared data controller classification requires the use of a remote data store, whereas the shared resource controller classification does not.

The matrix can assist in the bounding of a user's cell controller needs and the selection of the correct architecture for a particular application. As an example, assume that in a discrete manufacturing operation two adjacent cells – Cell A and Cell B – are to be automated and that product from Cell A typically (but not always)

Table 5-1
NEMA CELL CONTROLLER MATRIX

FUNCTIONS	NEMA CLASS				
	Minimum Functionality	Direct I/O	Shared Data	Peer Coordinated	Shared Resource
Monitoring	●	●	●	●	●
Local Data Store	●	●	●	●	●
Remote Data Store			●		O
Direct I/O		●			
Peer Communications				●	
HLD† Communications	●	●	●	●	●
Operator† Interface Remote					O
or Local	●	●	●	●	O
Standalone Operation	●	●		O	
Intercell Coordination				●	
Shared Operator Interface					O

● Required Function; O Probable Option
†Either HLD (Higher Level Device) or operator communication is required for all cell controllers.

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flows into Cell B. These cells both require a cell controller under normal operation. In this instance, the user needs to decide if peer coordination is required; that is, does the manufacturing operation require that production information flow between Cells A and B without the use of a higher level device interconnect.

The cell monitor classification was excluded from this matrix so that users could focus on their control-oriented applications. This is not to imply that pure monitoring applications are not valuable in factory systems. Clearly each of the cell classes includes monitoring features. In a monitoring or a monitoring/planning specification, the feedback loop to control the production process is through the operator. Therefore, this approach differs from a cell controller in that a cell controller provides for control without human intervention.

This matrix should be reviewed prior to the functional requirements phase of project development to clarify the user's thoughts relative to cell controller features and functions. Some manufacturers have devices that span multiple classes. In these cases, a user may request a composite device, e.g., a "Shared Data/Peer Coordinated" Cell Controller. The matrix, together with the baseline NEMA cell controller classification descriptions, should be used to clearly define the cell's overall functions and features.

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Section 6
OPTIONAL FEATURES

The NEMA Cell Controller Classes may be enhanced or customized with special options, features, or design points for unique requirements. These enhancements do not change the basic classification of the system.

Some examples of unique requirements that may require different designs and features to any class of cell controller are:

1. Placing equipment near to or far from the process;
2. Interfacing with different communication protocols;
3. Predictable response time;
4. Operators-to-operator and operator interface-to-computer ratios;
5. Remote (from the process or operator) functions;
6. Notification to different kinds of higher level devices;
7. System coordination;
8. Uninterrupted operation;
9. Fail-safe operation; and
10. Allowing and/or preventing operator actions.

In classifying types of cell controllers, the NEMA Cell Controller Group found that many hardware features, software features, services, and system designs were common to all categories of cell controllers. Common options, features, attributes, and design points are summarized into the following categories:

1. Hardware Options –
   a. Networking features,
   b. Gateway features,
   c. Console and operator interface features,
   d. Operational mode features, and
   e. Hardware design features;
2. Software Options –
   a. Specific application packages, and
   b. Software design features,
3. Fail-safe operation; and
4. Service.

Appendix C provides sample questions that a potential cell controller purchaser may wish to discuss with vendors. The answers to these questions will help in determining the options that may be required for a specific application.

6.1 HARDWARE OPTIONS

6.1.1 Networking Features

Many cell controllers are tied into networks. A networked system may support the following features:

1. Remote program load;
2. Remote diagnostics;
3. Remote testing;
4. Remote recipe downloading;
5. Remote and dynamic system changes;
6. Redirecting operational messages; and
7. Remote console inputs.

(Note: "remote" means distant from the cell.)

Networking systems are further complicated by the many incompatible vendor systems and networking protocols.

6.1.2 Gateway Features

Gateways can be found in any data path. They provide protocol conversion for resolving incompatibilities between vendors' hardware, between networks, or both. Control decisions are not made by gateways; they only pass data through.

6.1.3 Console or Operator Interface Features

Consideration should be given to the various types and designs of consoles or operator interfaces. When defining the operator interface requirements, a basic question to be asked is: "Should each cell controller have a dedicated operator?" The answer to this question should be made after assessing a combination of business, technical, and personnel skill factors.

Business factors may include considerations such as personnel safety, chemical safety, and material losses. Technical factors include the difficulty of implementing an operatorless or multioperator system. Personnel skill factors are based on considerations such as the availability of operators, training requirements, union demands, risk of sabotage, and degree of decision making.

A "user-friendly" operator interface may not be sufficient in conditions where problem resolution with a short response time is required. Because of the propensity of operator error occurring due to time pressures, the interface may need to incorporate teach modes, assist modes, higher level device authorization, or expert systems assistance.

6.1.4 Operational Mode Features

It is quite probable that cell controller systems will not always run in the same mode. Contrary to many office, engineering, and drafting systems, factory systems may need to be designed to run in many different attended or unattended modes.

Examples are:

1. Operator teach mode;
2. Maintenance, debug, retool, and limited production;

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3. Different shift modes;
4. Product design and test mode; and,
5. Quality test mode.

Cells are switched between attended and unattended modes. Cells are attended for activities such as setup, process changeover, system test tune and debug, operator training, off-hour operations, and maintenance. When the system is fully operational, there is a need to be able to switch between attended and unattended modes. Operational mode requirements are applicable to all classes of cell controllers.

6.1.5 Hardware Design Features

Hardware features are dependent upon the vendor design and the unique requirements of the cell.

The selection of the cell controller hardware needs to be considered in connection with the environmental characteristics and needs of the process to be controlled or monitored.

Cell controllers may need to operate reliably, or be stored and transported, at high or low temperatures, altitude and humidity, and in environments with airborne particles, gaseous mixtures, mechanical shocks and vibrations, and ac power supply imperfections (e.g., voltage and frequency fluctuations, EMI, RFI, and disruptions). In some cases data integrity is critical, requiring such measures as parity and error correction codes. In general, cell controller hardware exhibits higher degrees of ruggedness than comparable general purpose products.

Various hardware features can be found on all classes of controllers but will not necessarily change the class of the controller.

6.2 SOFTWARE OPTIONS

The following is a partial list of application packages that may be used in a cell controller:

1. Supervisory control;
2. Archiving;
3. Batch/recipe management;
4. Distributed numerical control;
5. Document management;
6. Energy management;
7. Fault diagnostics;
8. Inspection/gauging;
9. Materials management;
10. Maintenance monitoring;
11. NC parts programming;
12. Parts/job tracking;
13. Process modeling;
14. Process simulation;
15. Program development;
16. Program library management;
17. Report generator;
18. Routing;
19. Scheduling;
20. Security and access authorization;
21. Statistical quality control/statistical process control;
22. Tools and fixture management;
23. Tools and fixtures monitoring; and
24. Trend analysis.

6.2.1 Software Design Features

Real time or predictable response times can be a requirement in many assembly or process plants. Traditional systems (systems designed from office product bases) can easily handle human input. These systems may not be able to handle data from high speed manufacturing processes or respond to human inquiries in sufficient time to control the process. The hardware needs to be designed to be capable of certain throughput, but it is often the case that the software design controls the performance of a system.

6.3 FAIL-SAFE OPERATIONS

Some cell controller systems may require fail-safe, fault-tolerant, or nonstop operation. These systems may involve multiple processors configured in special ways, and use special software. However, these systems may appear as a single system to the user.

Due to the complexity of these systems, they do not neatly fall into a single NEMA cell controller classifications.

6.4 SERVICE OPTIONS

Hardware and software products usually have warranty periods and service options. These options vary from vendor to vendor.

When designing or installing a cell controller, it is advisable to review the questions provided in Appendix C-7. This information can be used to help form a basis for generating specifications for the cell controller.

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APPENDICES

Appendix A
SPECIFICATION FOR A CELL MONITOR

A-1 DEFINITION

A cell monitor (see Figure A-1):

1. Communicates product information received from production device controllers to an operator or a high level device; and
2. May, as an option, locally store production information obtained from production device controllers.

A-2 DESCRIPTION

A cell monitor is distinguished from a cell controller by its inability to perform active control on a production device controller or any other plant floor equipment. A cell monitor may collect information and instruct the production device controller or other devices to perform specific actions but only as a result of inputs from an operator or a higher level device. The cell monitor does not perform active control functions—such as processing input data and then taking corrective actions or instructing the production device controller to take certain actions—without input from an external source.

A-3 CONFORMANCE

A cell monitor may have all of the attributes of any of the cell controller classes but does not have the ability to perform active control. A cell monitor does not provide any production control services.

A-4 TYPICAL ATTRIBUTES AND APPLICATIONS

Typical attributes of a cell monitor include:

1. Providing textual and/or graphic status display of production information;
2. Providing the ability to be configured for—
   a. Resources monitored,
   b. Production information collected,
   c. Limits, alarms, and events created,
   d. Users, and
   e. Textual and/or graphic production information displays;
3. Communicating with a production device controller and an operator (it also may communicate with a higher level device);
4. Allowing the operator to request production information, and enable or disable the request as required;
5. Allowing the operator to acknowledge and clear alarms;
6. Storing production information; and
7. Containing, or interfacing with, statistical process control/statistical quality control.

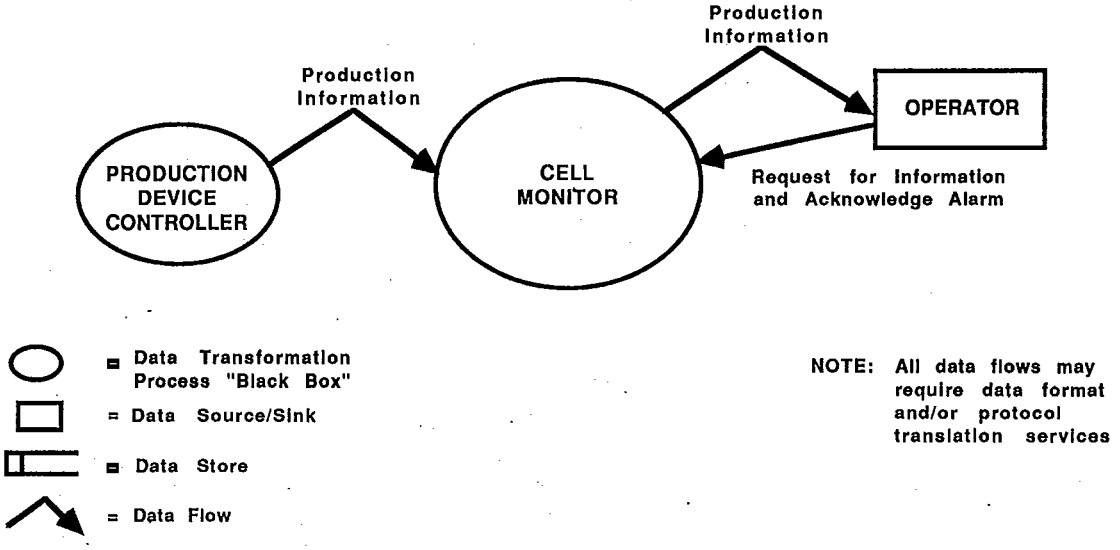


Figure A-1
CELL MONITOR

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Appendix B
GLOSSARY

CONTROL

Control modifies the operation of the production process. Control implies that a real (physical) process is affected.

CONTROL SYSTEM ARCHITECTURE

Control system architecture is the result of interconnecting with communication media the various control and computational devices located within a site. Usually in the conceptual model of this architecture the lowest level is production devices and the highest level is a site computing device, but many actual site architectures do not cover this wide expanse. The architecture may have both hierarchical (master/slave) and peer-to-peer communications. There may be more than one level of each class of communication, and more than one type of communication may be used ranging from point-to-point communication to site-wide networks. The physical architecture may not accurately represent the information flow between control and computing devices.

DEVICE DATA

Device data consists of attributes of the production device. Examples might include the current operating state of the device and the program currently executing in the device. The data is related to a specific device controller.

DIRECT I/O (Input/Output)

Directly processes input and output information from one or more machines or process input/output devices or subsystems.

HIGHER LEVEL DEVICE

An information processor that monitors and/or directs the actions of one or more cell controllers. An example of a higher level device would be an area controller or a plant host computer. The definition implies a hierarchy where the cell controller is of lower stature than the higher level device. The higher level device communicates with the cell controller. However, the control action of the cell is not predicated on response dynamics of the higher level device for normal operation. In other words, if the higher level device is unavailable, the cell controller is capable of performing its normal control task for a reasonable period of time.

HLD (Higher Level Device) COMMUNICATIONS

Higher level device communications is information transfer between the cell controller and at least one other processor located higher in the plant information processing hierarchy.

INPUT/OUTPUT INFORMATION

Data received from and sent to sensors or sensing systems, and the data sent to and received from an actuator. These data are values that are sensed or values to describe action. The data may also describe the condition of a sensor or actuator.

INTERCELL COORDINATION

Intercell coordination refers to the ability to order and synchronize events between cooperating cell controllers to control the operation of the cell.

LOCAL DATA STORE

A local data store is a memory storage device, such as RAM, disk, bubble, and optical, that is directly attached to the cell controller. The local data store may be as simple as RAM that is addressed by the cell controller, or may be as complex as an attached disk subsystem. A local data store does not require disk-based memory.

MANAGEMENT INFORMATION SERVICES

Management information services are those activities of a cell controller that are primarily data manipulation, often performed on behalf, or at the request, of the higher level device. Some examples include: (1) the semi-permanent storage of production plans when they arrive from the higher level device; (2) the generation of a production status report for the operator or higher level device; and (3) the generation, storage, and distribution of part programs for the machinery in the cell. These activities generally occur on the transaction time scale of the higher level device. Production normally proceeds independently of these activities.

MONITORING

To examine the status of a data element on an ongoing basis.

OPERATOR

A person who monitors and directs the activities of a cell. The operator is an alternative to the higher level device or may act in tandem with the higher level device. The operator's control function is supplementary in nature. The cell controller is capable of performing

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normal control functions without the interaction of an operator. This is the primary difference between a cell controller and a cell monitor.

OPERATOR INTERFACE

The operator interface provides bidirectional communication with a human operator. The operator interface function may be provided by a CRT display device (color or monochrome), plasma display panel, light board, or any other display technology that allows the plant operators to view and modify the cell's production process.

PEER CELL CONTROLLER

Another cell controller of equal stature on the factory floor. Hierarchial relationships are specifically disallowed. Relative to one another, they have equal capability; none act as a master.

PEER COMMUNICATIONS

Peer communications is a mode of unmastered communication in which each participant has equal communication capabilities. The content of communications between peers is unrestricted.

PEER-TO-PEER CONNECTIVITY

Peer-to-peer connectivity is provided by a basic communication facility between any and all computing nodes on the network. The communication between peers consists of user and system level messages, data, and executable programs. The facility is available at a user level such that data and programs may be transferred between nodes without the need to write computer programs or to understand the system software.

PROCESS DATA

Consists of attributes of the production process. Examples include the number of parts produced, the number of good parts produced, the number of defects produced, the cycle time to produce a part, and the schedule of parts to be produced. The data are related to the production facility.

PRODUCT DATA

Consists of attributes of the product being manufactured. Examples include gauging measurements, color, weight, functional test results, and defect attributes. The data are related to the item being produced.

PRODUCTION DEVICE

Equipment that either performs a value-adding or a transportation function on the product being manufactured or performs auxiliary functions for the supporting material, such as tools and cleaning compounds, and energy.

PRODUCTION DEVICE CONTROLLER

Any independent decision-making device that generates or uses production information and is interfaced to the physical production system. Programmable controllers, computers, vision systems, robots, and coordinate measuring systems are examples of production device controllers. The production device controller is usually separately configured (i.e., programmed) and may support the remote loading of configuration information.

PRODUCTION INFORMATION

Consists of product data, process data, and production device data. The data may originate from a cell control layer, a higher level device, an operator, or a production level device.

PRODUCTION INFORMATION SERVER

An independent device that stores and retrieves production information for one or more cell controllers.

REMOTE DATA STORE

A remote data store is a device that is physically removed from the cell processor. A remote data store may be connected to the cell processor via a data communication link (e.g., LAN). Remote data stores in many installations will be traditional file servers.

SHARED OPERATOR INTERFACE

A shared operator interface provides support for an operator interface device that has the capability to attach to different cell controllers either concurrently or serially.

STANDALONE OPERATION

Standalone operation is a mode of operation that allows a cell controller to operate without being interconnected to a higher level device or another cell controller.

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Appendix C
SAMPLE VENDOR QUESTIONNAIRE FOR CELL CONTROLLER BUYERS

This sample questionnaire is provided as an example of questions that prospective cell controller users and buyers should discuss with potential vendors. This questionnaire should not be construed as complete nor applicable to every intended use or implementation. Its intent is to serve as an outline to help guide the user and buyer in the topics that should be considered in the selection of cell controllers, cell controller vendors, or both. The questions below are not listed in order of importance since this may be affected by the specific application.

C-1 SYSTEM CAPABILITY

a. How many points can the system support?
b. Which of the following does the operator interface support?
   - Text
   - Graphics
   - Color
   - Monochrome
   - Video
c. Is polling of production device controllers and direct I/O supported?
d. If polling frequency is adjustable, how is this accomplished?
e. Are unsolicited messages supported?
   - From production device controllers
   - From direct I/O
   - From peers
   - From higher level devices
f. Is direct I/O supported?
g. How many communications ports are available?
h. Is the equipment maintainable by plant personnel?
i. What is the maintenance philosophy?

C-2 COMMUNICATIONS CAPABILITY

a. What physical communications medias and communications protocol are supported for the following communications needs?
   - Local area networking
     - For peer-to-peer
     - For higher level devices
     - For production device communications
     - For direct I/O communications
   - Point-to-point communications
     - For higher level devices
     - For peer-to-peer communications
     - For production device communications
     - For direct I/O communications

C-3 ALARMS AND CONDITION EXCEPTION PROCESSING

a. Does the alarm package support both analog and digital alarms?
b. How many different levels of alarm priority are supported?
c. What type of system devices can be used to log alarms?
d. Is condition exception processing supported?
e. Which of the following can invoke condition-exception processing?
   - Alarm states
   - Logic states
   - Measurement states
   - Other

C-4 SOFTWARE CAPABILITY

a. What programming languages are supported?
b. Is the software modular?
c. Are analog and digital points supported within the same data base?
d. Is the database user-configurable?
e. Can the control database be expanded?
f. Can theontrol database be modified by the user after implementation?
   - On-line/Off-line
g. How is the configuration accomplished?
   - On-line/Off-line
   - Menu driven entries
   - Graphical schematics
   - Other
h. Are internal or dummy points supported?
i. Are interfaces provided to users for extensions not provided for in the basic application package?
j. Which production device controller communication drivers are available?
k. Is the template driver available for those production device controllers not supported?

C-5 HARDWARE

a. Which of the following peripherals are supported?
   - Terminals
   - Printers
   - Plotters
   - Workstations
b. What types of operator entry devices are supported?

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- —Standard QWERTY keyboards
- —Personal computer keyboards
- —Numeric keyboards
- —Alpha keyboards
- —Special keyboards
- —Touch screen
- —Mouse
- —Trackball
- —Joystick

c. How is hardware capability expanded for the following?
- —Memory
- —Processing power
- —Communication ports
- —I/O connections
- —Other

d. What is the hardware's reliability?
- —Mean time before failure
- —Mean time to repair
- —Error detection and correction

C-6 ENVIRONMENTAL

a. To what NEMA standard does the enclosure conform?

b. What are the required power specifications and tolerances for the following?
- —AC or DC
- —Voltage
- —Amperage
- —Frequency
- —Number of phases
- —Options

c. What are the operating and storage specifications for the following?
- —Temperature
- —Humidity
- —Altitude
- —EMI/RFI

d. Does the equipment have certification from any of the following agencies?
- —Underwriters Laboratories
- —Canadian Standard Association
- —Factory Mutual
- —Federal Communications Commission
- —Other

C-7 VENDOR RELATED

a. What is the warranty period?
b. Is an extended warranty available?
c. What does the warranty cover?
d. What training is included?
e. Is additional training available?
f. What type of service agreements are available for long term support?
g. Which of the following types of documentation are included?
- —Hardware
- —Software
- —Installation
- —Operation
- —Maintenance

h. What other documentation is available?
i. What of the following types of installation services are available?
- —Supervision
- —Checkout
- —Turnkey installation

j. Which of the following application services are available?
- —Application design specifications
- —Software configuration
- —Custom application software
- —On-site software checkout
- —On-site software modification

k. What other services are available?

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Appendix D
DATA DICTIONARY EXAMPLE

An example of a data dictionary is shown below. The composite data example is listed with a brief description, followed by a list of its data elements. Individual data elements are separated by a plus sign (+).

Production Information = *information about the manufacturing process that is needed to monitor and control it *

Product Data + Process Data + Device Data

Normally product, process, and production device data would also be considered as composite data items because each can be further broken down into smaller elements. For the purposes of this document, further decomposition of these items would not be useful.

Many of the elements used to describe products are industry-specific. For example, in a precision machining environment product data might contain the following elements:

Dept ID + Area name + Line No. + Machine No. + Spindle No. + Operator + Lot No. + Quality Measure + Date + Time + ...

Some of these terms may be inappropriate for specialty chemicals or plastic injection molding operations, where a spindle number on a machine does not exist. An aerospace or pharmaceutical manufacturing operation may be extremely concerned about traceability to conform to certain government requirements and would, therefore, require these elements. Due to the range of variability at the element level, this document does not address data dictionary levels below that of composite data.

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status, are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below.

Purpose of Standards

National Electrical Manufacturers Association standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist purchasers in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard. *(Standardization Policies and Procedures, p. 1)*

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p.8)

Categories of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 7 & 16)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 7 & 16)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment, and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 7 & 16)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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CELL CONTROLLER SECTION
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