A platform for millwide information systems

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In one typical installation, the system functions provide, capture, manage, and archive all relevant production information from each parent roll.

An effective structure for millwide information systems has been successfully installed and operated in pulp and paper mills and in other manufacturing environments. The building blocks of the structure are:

- Data acquisition
- Real-time database management
- Continuous history database management
- Event history database management
- Relational database management (optional).

Figure 1 illustrates how typical millwide applications are supported by this structure.

Data acquisition

This level of the system is directed to acquire data from the manufacturing environment and convey it into the computing environment. There are several data sources in a typical mill, including:

- PLCs
- DCSs
- Laboratory
- Bar code readers
- Instruments
- Manual terminals.

Because of the variety of equipment, interfacing costs must be considered. Established software packages should have interfaces already available for popular data sources.

Real-time database

The different varieties of the acquired data will have a corresponding variety of uses in the millwide information system. As with acquisition, the data management task is also complicated by the variety of data sources.

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Effective operation is achieved through real-time management. The real-time database manager supports the other database managers by furnishing them with the appropriate data as needed.

Functions in the millwide information and control system that are directly supported by the real-time database manager include:

- Schematic displays
- Screen reports
- Actuator supervision
- Alarms
- Run-time accumulation
- Flow totals
- Configuration of control algorithms
- Change of state processing
- Scheduling of user tasks.

The real-time database is "tag" oriented. A tag is any data source defined by the user. One "record" is maintained for each user-described tag, and it includes only the most recently acquired values. The structure of each record is fixed and includes such items as:

- Location of values on the data highways and of formulas for calculation
- Information for validating data
- Bias and span in engineering units
- Alarm limits and actions
- Filter factors for input processing
- A list of associated user tasks.

The database can be specifically configured by the user through fill-in-the-blanks screen forms. The major part of this configuration is the description of the tags. A key service provided by the real-time database manager is to give the user the ability to access the tags to either read or change them.

Other configuration efforts include the writing of descriptions for user tasks. These descriptions may be written as FORTRAN code, for instance, or in some other form. Through screen forms, the user also configures the scheme by which the real-time database manager feeds values to the history databases.

The real-time database manager, the supporting data sources, and the data acquisition technologies, are the foundation of the system. They are prerequisites for successful millwide information and control. Maximum available resources should be expended in acquiring and installing the best cost-effective technology available.

Through process schematics and reports, the real-time database provides mill operations personnel with data from all units in the mill. As shown in **Fig. 1**, the real-time database manager also supplies data to the continuous history, the event history, and the commercial database managers, and to the millwide information applications.

Continuous history

Many of the tags are measurements or calculations that provide a continual signal. Continual signals are defined to be those that are acquired on a periodic basis. The acquisition will be synchronous with the fundamental pulse of the real-time database manager. For process applications, this pulse is typically once per second.

The particular sampling frequency may vary considerably between different tags. Examples are tags for temperatures, pressures, flows, basis weight, and moisture content. Tags for basis weight and moisture content are examples of those which may also be acquired asynchronously. If so, their history data are best managed by the event history manager.

The record structure of the continuous history database manager is a set of previous values or averages for each tag. There may be several records for each tag. Examples of these records include 6- and 12-min snapshots, shift averages, and hourly, daily, or weekly averages.

For each continuous tag, the user should be able to configure the history within the system limits. The user determines the frequencies for snapshot history and average history and the number of values to keep for online histories and for archival purposes.

Trending, both graphical and tabular, off-line regression studies, and management reporting are the kinds of functions supported by the continuous history database manager.

Event history

Data that are acquired asynchronously include:

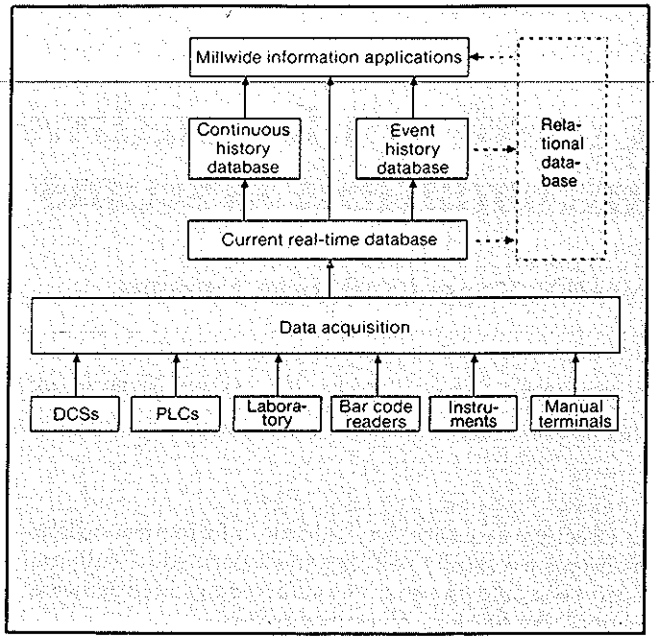
- Brand changeover signal
- Laboratory sample results
- Signals indicating that the process is down
- Signals indicating the completion of a batch or roll
- Signals indicating a change in operating mode
- Bar codes and production history for parent rolls.

When these data are acquired, the user typically wants to enter a record into the database.

The records for event history differ from those in the real-time and continuous history databases. First, each record requires a time and date stamp. Second, the list of items in the record varies widely for the different types of asynchronous data.

Third, the types of items vary widely and are the data types supported by a typical commercial database manager. These include real numbers, integers, Boolean functions (variables that are either true or false), fixed-length alphanumeric fields, date and time, and comment or text fields.

1. Architecture of the millwide information system



Examples of event data

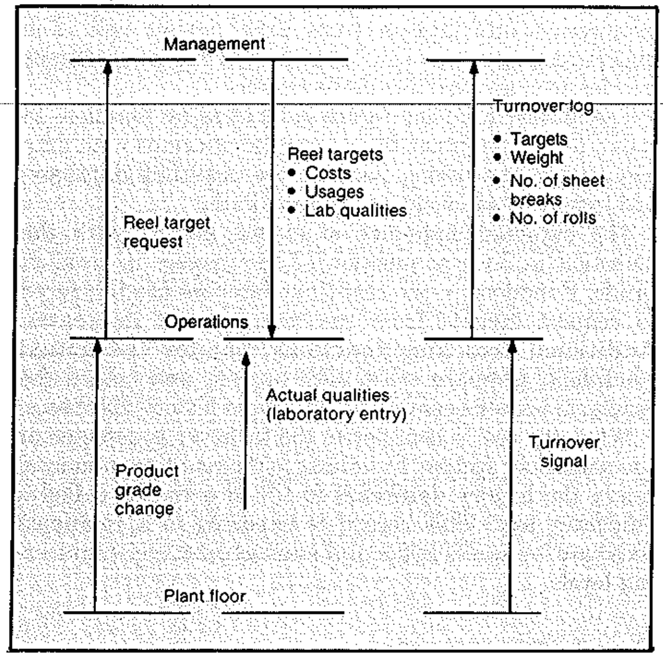
As an example, the asynchronous signal may be that of a changeover in the digester feed from hardwood to softwood. A likely source for acquiring this signal is an operator entry on a manual terminal. The record to be created in the event history might include items such as:

- Date and time
- Date and time of the previous changeover
- Snapshot of digester conditions at changeover
- Averaged operating conditions since the last changeover
- Totals of all streams used since the last changeover
- Totals of all streams produced since the last changeover
- Yields and calculated unit costs since the last changeover
- Name of the vendor supplying the wood
- Operator comments.

The record to be created for a laboratory sample might include items such as:

- Date and time
- Type of analysis (text)
- Results (varying in number)
- Name of analyst
- Number of replicate
- Source of sample
- Sample request number
- Sample number

2. Hierarchy depicting events in a typical millwide performance of the millwide system.



These examples illustrate why the record structure must be configured by the user for the specific application. Many of the items entered into the event history record come originally from the real-time database, possibly through user calculations. Others, such as the time and date stamp, are provided by the event history database manager.

Support of millwide information needs

A response to simple queries is a direct support of millwide applications from the event history database. For example, the user may wish to create a table showing data records for machine settings, but only for rolls produced from raw materials supplied by a particular vendor. For this purpose, the event history database manager can produce a table on-screen of the appropriate records for machine settings.

Another millwide information purpose supported directly from event history is that of graphs of historical data plotted against parameters other than time. These include control charts for statistical quality control, plotted by laboratory sample. Another example is a plot of the number of rejects vs. the parent roll.

Commercial relational database

Because of its record structures, the event history database manager is a natural source for records to be fed to a relational database manager. While the event history manager could respond to a simple query, complex queries require the more sophisticated relational database.

An example of a complex query is a request for data records that satisfy a set of simultaneous circumstances. Such circumstances might be described as:

- Particular vendors excluded
- A range of values for a set of processing conditions
- The date and time within specified period.

A satisfactory response to complex queries requires special database management techniques, and those used by many commercial databases are suitable. The records managed by the commercial database can be formed in the event history database and transferred. Simple file "import" and "export" may be an adequate computer utility for accomplishing this transfer of records.

In addition to the complex query function, other functions supported by the commercial database can include: spreadsheets, management reports, fourth generation languages, business graphics, and business statistics. Finally, the commercial database can serve as the main link for integrating the millwide operations computers with the business computers.

Although it is convenient, the commercial database may not be an absolute requirement to begin implementation of millwide services. The architecture in Fig. 1 has the advantage of allowing the commercial database to be added to the system at a later date.

Millwide information purposes

Implementation of millwide services involves calculations that require data from one or more of the three databases—real-time, continuous history, and event history. These services include a number of recordkeeping functions and analyses.

Real-time cost tracking and analysis begins with calculations of flows and usages from raw data. Once these flows and usages are converted to costs in dollars per unit of time, actual and target costs can be compared. Furthermore, these services can compare the costs of using different supply vendors and the costs accrued by different operating teams.

Time and event cost accounting allows us to break down expenses by the shift, day, week, or year. Expenses may also be analyzed by the costs per roll, set, case, or brand.

Downtime tracking includes the tracking and analysis of Yankee dryer uptime, machine downtime, and the number of sheet breaks. Pareto analysis is carried out by cause and by product, per parent roll, brand, and shift.

Material and inventory tracking is used to generate inventory reports from bar codes. These services can also produce an inventory map by product or by location. The status of an order can be presented, as well as the entire processing experience of a lot or batch.

Maintenance tracking is used to determine the accumulated run-time, to analyze downtime, and for online diagnosis of such problems as fouling.

Product history tracking includes cost data, downtime per unit of production, and processing data such as values for basis weight and moisture content. In product history tracking, records are kept on "geneology"—accounts of processing conditions, including information on processing lines and vendors.

Production efficiency is analyzed and reported as to trim losses, tear-off losses, inventory losses, rejects, and downtime. Costs per roll, brand, and shift are further broken down by logs/min, cases/h, and sheet breaks. Finally, the roll history is analyzed for optimum machine settings.

Statistical process control involves control charts to present the user with statistics on basis weights, moisture, tensile strength, and rejects. Pareto analysis is used to show downtime, and regression analysis can be used to study processing conditions and vendor reliability.

Modeling and simulation are important in mills today. Yield models are obtained from analysis of historical data to predict the number of tons of unbleached pulp per ton of chips to the digester and the number of tons of linerboard produced per ton of pulp. Plant network models use these yields to determine the impact of production decisions on cost, inventory, and quality.

These modeling and simulation services support "what-if" analysis, including analysis of the cost of changing specifications, analysis of the effect of production changes on inventory, and the resultant scheduling of the pulp mill, the paper machines, and converting lines. Finally, these services have the capability to support models from the real-time database, allowing decision-making to be immediately responsive to the process.

Reports are generated according to sample production or by sample usage. An example production report will contain number of tons processed, number of tons taken to the reel, and number of tons sent to the repulper. An example usage report will show usage per reel, usage per shift, and actual vs. target usage.

Sample millwide application

Figure 2 illustrates a typical application managed by a millwide information system. The system functions are to provide, capture, manage, and archive all relevant production information from each parent roll. The information can be used later to respond to customer queries or to analyze line performance.

The hierarchy in the figure is labelled by function. In rough terms, the plant floor operation overlaps with data acquisition, operations overlaps the real-time database, and management overlaps the remainder.

The depicted sequence of events begins with the detection in data acquisition of the change in product grade. Functions in the real-time database are triggered to request targets from the management databases. Additional real-time functions monitor the actual conditions, compare these with targets, and record the results in both the continuous and event history databases.

When the reel is completed, the turnover is detected at the plant floor section. Functions in the real-time manager query the history databases to fill in a record called a "turnover log." This record is exported to a relational database for access at the mill management and engineering levels.

Concluding remarks

The millwide services listed here are illustrative rather than exhaustive. Different mills will have different economic motivations for their information systems.

An organized planning technique helps to identify the needs most appropriate for a particular mill.* However, the structure can support many purposes and can serve as a platform for future growth in scope and benefits.

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*Koppel, L. B., Plantwide control: planning for organized information technology, ISA/86 Conference Proceedings, Vol. 2, Instrument Society of America, 1986, p. 41.