Chapter 1
Conceptual definition of APS

Industrial background

Industrial needs for which APS is applicable are addressed in this section. These needs are the starting point of our motivation for developing new standards. But first, we need to take into account three critical aspects of the market environment:

(1) Unexpected demand behavior and uncertainty of the manufacturing environment

Since demand forecasting doesn't necessarily correspond to reality, it is hard to establish a balance between demand and supply, even if planners use state-of-the-art software. This is caused by greater market segmentation and by the huge variety of product choice now available to customers. Manufacturers may also experience sudden tremendous increases or decreases in their sales due to technical or social factors.

(2) Shortened product life cycle and agile manufacturing

The market continuously seeks new products. Manufacturers need to synchronize their release of new products with market dynamics, otherwise risk losing sales. Synchronization with the market and keeping up-to-date with technological improvements become the most important factors in developing and maintaining competitive advantage for manufacturing industries. Consequently, product lifecycles become shorter and it is difficult to make predictions for the next period in advance.

(3) Changes in business processes for supply chain management and EDI requirements

In terms of supply chain management, old and sustainable alliances with suppliers have to change to take account of global optimization of procurement. Web-based purchase order transactions are replacing EDI (Electrical Data Exchange) transactions. The new style of supply chain requires flexibility and agility. Internal planning information should be provided to partners to enable collaborative manufacturing.

However, current manufacturing IT systems are not necessarily geared to provide solutions for the environment noted above. In fact, we believe that the current information systems have the following three weaknesses:

(1) Lack of functional capabilities and applicability of conventional ERP systems

Most manufacturers developed MRP or MRP II enterprise information systems in the late 1970s or 80s. Some of these were replaced with ERP over the last ten years. Yet, whether they have MRP, MRP II, or ERP, the basic algorithm employed in these systems is 1970-vintage and is hard to follow the current dynamic environment. It cannot provide accurate information for plant managers.

(2) Limitation of client-server architecture for information systems

Conventional databases in mainframe computers and in client-server systems need to be precisely designed with high-level attention given to ensuring that there is consistency between all related schemas. These databases refuse extensional information that does not match their schema. However, this extensional information is the source of knowledge on plant floors, and needs to be shared among different individuals in different divisions. So far, this can only be achieved via face-to-face communication.

(3) Less flexibility and robustness for continuous improvement

Both business processes and engineering processes need to be continuously improved in manufacturing industries. On the other hand, information systems implemented by manufacturers cannot be changed every time there is a process improvement. Sometimes, manufacturers may hold off modifying their business processes because of the huge investment and potential risks involved in revising IT systems. Furthermore, migration of data from previous systems to a new system is always a work-intensive and complicated exercise, and some critical information cannot be inherited.

The aim of PSLX Consortium is to provide new solutions based on the APS concept and emergent technologies, such as the Internet and object-oriented modeling, taking the current manufacturing environment and the functional limit of conventional information systems into consideration.

Significant features of APS

APS is defined as a system and methodology in which decision-making, such as planning and scheduling for industries, is federated and synchronized between different divisions, within or between enterprises, to achieve total and autonomous optimization (PSLX technical specification 05, PSLX common dictionary, 2003). The original concept of APS was launched in the US in the 1990s, defining advanced techniques of production planning or supply chain planning with detailed scheduling and optimization algorithms. The techniques developed since then have been partially employed as the engine of planning systems in some ERP and SCP (Supply Chain Planning) software packages.

The concept of APS proposed by PSLX Consortium has many new features, which improve on the conventional concept to meet the concerns of advanced manufacturing enterprises. PSLX's APS is not a part of the planning system in ERP, but rather the entire planning and scheduling system within an enterprise.

(1) Data-centric management with an abstract data model

Enterprise information systems have a data schema for representing information handled in each business process. The data schema and business processes are closely related, and changes in business processes need to be revised in the corresponding data model. Data stored in enterprises is a heritage and needs to be inherited by new systems. APS has an abstract data model that is completely independent of the system implementation view. Enterprise data is therefore protected from the lifecycle of IT systems.

(2) Extensible system for following real business changes

Manufacturers face huge market uncertainty and need to have a competitive business model along with well-designed products. The decision-making system in enterprises is the mainframe of business models. APS enables easy design and modification of an enterprise-wide decision-making system based on actual business changes because of the flexibility of its system architecture.

(3) Close relationship between design and manufacturing divisions

To cater for shortened product lifecycles and frequent releases of new products, or for changes in existing product designs, manufacturing management needs to prepare new technical documents, new equipment, and new instructions for workers, often without much advance warning. This means that planning and scheduling systems have to deal with the complications of creating or revising master data for the new products. APS manages technical data such as BOM (Bill of Materials) and production routing data by enabling collaboration between the manufacturing and engineering divisions. The information includes not only formal and approved data, but also informal data that may not be consistent with the formal data.

(4) Real-time performance analysis and KPI (Key Performance Indicator) support

All activities on plant floors affect the cost of products. Therefore, performance management becomes a very important issue. However, undertaking a performance analysis for each activity to determine which activities contribute to the final company benefit is very difficult. APS has a mechanism for collecting cost information from the performance data of each work center, and for immediately calculating and translating it into any of several parameters defined as KPIs (Key Performance Indicators), which are valuable for future planning decisions.

(5) Reliable and accurate Master schedule for enterprise-wide collaboration

In most ERP systems, the MPS (Master Production Schedule) does not correspond to the reality of plant floor operations because of a lack of two-way communication. Compared to this, the MPS managed by APS is defined as a pacesetter in enterprise-wide operations, and all enterprise activities can participate in the creation of the MPS. Detailed scheduling for each plant floor can be incorporated into the MPS in order to make it feasible for realistic applications.

(6) Synchronous manufacturing along the supply chain by detailed scheduling

Supply chain management deals with the long-term inter-enterprise relationship and with the short-term operational synchronization between the detailed manufacturing schedule and the supplier schedules. Since detailed scheduling collaboration with suppliers calls for high-level management, there are very few cases in which this integration is established. In fact, even within an enterprise, such scheduling integration requires considerable effort. Current SCP systems generally make plans based on aggregate level information. APS can provide a framework for collaboration with suppliers at the detailed scheduling level by sharing the schedule information, and by notifying those suppliers of schedule changes that may affect them.

(7) Autonomous automation support through system visualization and fault detection

One important feature of TPS (Toyota Manufacturing System), or lean manufacturing, is autonomous automation (autonomation), in which humans in a manufacturing line are always thinking about system performance and act voluntarily to make improvements. In manufacturing information systems, autonomation means human involvement with the information systems by means of visualization of information flow in order to detect and fix problems. Sometimes, the system itself needs to change. The decision-making process and logic embedded in APS are not permanent. They can be continuously changed, not only by business process designers, but also by personnel on the production line.

(8) Manufacturers' strong initiatives in system design and development

Information systems are key enablers of a business model whereby manufacturers can gain competitive advantage. Technologies for information system implementation are becoming more complex, so that only IT specialists, system integrators, or package vendors are able to understand the details. However, the leading roles in system development projects are taken by individuals within manufacturing enterprises. Projects that do not involve the users of the system always fail because of gaps between the final outcomes and the user's requirements. APS has a system architecture and framework that can be easily understood, even by non-IT specialists. Guidelines for implementing APS allow individuals in manufacturing enterprises to concentrate on their own business processes.

APS state-of-the-art technologies

Some advanced manufacturers have already implemented APS and its relative technologies. This section introduces some of the available technologies in current APS implementations. These are the starting point in achieving the final goal of APS.

(1) Operation-centric Bill of Materials (BOM)

The conventional BOM represents the product components, directly connecting a parent to a child. This is useful for calculating the quantity of each material needed to produce the required quantity of final product. On the other hand, routing information for producing the product is managed using independently represented data, while scheduling systems use the data to calculate the load of each resource. APS integrates the conventional BOM and routing data via a new data structure referred to as an operation-centric BOM, focusing on operations that can connect both items in the old BOM and resources in the routing table.

(2) Detailed data and constraint modeling on plant floors

Detailed schedules for final dispatch require high levels of accuracy. In order to achieve this, the scheduler has to be aware of the many different constraints existing on the plant floor and has to apply them to the schedule. Conventional schedulers can deal with very simplified constraints, such as resource constraints and precedence constraints. In addition to this, schedulers in APS can represent more detailed constraints, such as material constraints, changeover constraints, sub-resource (labor and tools) allocation constraints, multi-task constraints, and so forth.

(3) Finite capacity and inventory scheduling (FCIS) algorithms

Finite capacity scheduling (FCS) deals with resource constraints and calculates a schedule that does not exceed the resource capacity. One of the best advantages of scheduling logics in APS is the finite capacity and inventory scheduling (FCIS) capability, in which an operation is never scheduled on a Gantt chart if the materials necessary to produce a product do not exist. FCIS explicitly deals with inventory, which is consumed by downstream production and produced in advance by upstream production.

(4) Bottleneck optimization and synchronized scheduling

If the performance of a single bottleneck process significantly affects the performance of the entire system, APS can provide a schedule for the process and let the other processes synchronize to the bottleneck. In other words, APS first takes care of optimizing the bottleneck process, then, backward and forward scheduling algorithms are applied to the upstream and downstream processes, respectively. According to the theory of constraints (TOC), time buffers in the schedule protect against any disturbances to the bottleneck.

(5) “What-if?” simulation of the master production schedule (MPS) based

on plant reality

The master production schedule (MPS) contains important information for collaboration between the sales and manufacturing divisions. In APS, the date on which each product is shipped to customers is always elaborated upon, taking into account detailed production information from the plant floor. Feasibility of the schedule is evaluated by detailed scheduling, which functions as a “what-if?” simulator. Simulation results may be approved as part of the future MPS.

(6) Dynamic full-pegging technique for dispatch orders and manufacturing lots

The MRP system generally cannot detect a direct effect on final customer orders when delays or problems occur for a particular dispatching order or manufacturing lot. This is due to single-level pegging information. On the other hand, production on a direct pegging system allows plant operators to determine the final customers for each operation. This is flexible and allows requests to be easily changed, but it is inefficient because of uneconomical lot size. Dynamic full-pegging in APS is a technique that shows the relationship between final customer orders and actual work orders or lots in the plant, even for an economical lot production. At the same time, the relationship can be revised when urgent, high priority orders come in.

(7) Optimization methods using meta-heuristic algorithms

In order to create an optimum planning solution for manufacturers, APS has several optimization algorithms, such as the GA (Genetic Algorithm) and Tabu-search techniques. Planning and scheduling problems have many different constraints and many decision variables, which can result in an explosion of combinations. However, these optimization algorithms, called meta-heuristics, allow planners or schedulers to find sub-optimum feasible solutions within a practical period of calculation time.