18 Architecture of Selected APS

Herbert Meyr[1], Heidrun Rosič[2], Christian Seipl[3], Michael Wagner[4] and Ulrich Wetterauer[5]

[1] Technical University of Darmstadt, Department of Production & Supply Chain Management, Hochschulstraße 1, 64289 Darmstadt, Germany
[2] Vienna University of Economics and Business Administration, Institute for Production Management, Nordbergstraße 15, 1090 Vienna, Austria
[3] University of Hamburg, Institute for Logistics and Transport, Von-Melle-Park 5, 20146 Hamburg, Germany
[4] Paul Hartmann AG, Supply Chain Systems, Controlling & Consulting, P.O.Box 1420, 89504 Heidenheim, Germany
[5] J & M Management Consulting AG, Willy-Brandt-Platz 5, 68161 Mannheim, Germany

This chapter will introduce the APS used in the case studies from *AspenTech, i2 Technologies, Oracle and SAP*: aspenONE, Six.One, EnterpriseOne, and Advanced Planner and Optimizer (APO). As these tools regularly consist of a multitude of software modules and special add-ons, only a brief survey without claiming completeness can be given. Furthermore, different lines of business can use different modules of an APS. It is also possible to use an APS only partially, e. g. without modules for scheduling or only using modules for demand planning and demand fulfillment. For each individual case the composition of modules has to be evaluated and selected (see Chap. 16).

18.1 AspenTech – aspenONE

AspenTech (AspenTech 2007) was founded in 1981 with the objective of commercializing technology that was developed as part of the Advanced System for Process Engineering (ASPEN) Project at the Massachusetts Institute of Technology. Headquartered in Cambridge, Massachusetts, AspenTech is one of the leading providers of software for process industries. Its focus has been on applying process engineering know-how to modeling the manufacturing and supply chain processes that characterize the process industries. In 1994, the company went public and in the years afterwards it grew mainly through acquisitions of small companies like Chesapeake Decision Sciences Inc. Due to this acquisition strategy AspenTech incorporated technologies in the four areas, engineering, process simulation, plant operations, and supply chain management. Today, AspenTech offers integrated solutions for chemical, pharmaceutical, petroleum, oil and gas, and engineering and construction companies which are all sold under the name *aspenONE*. aspenONE provides a single platform that integrates AspenTech's core products, one of them being As-

pen PIMS for planning and scheduling in the process industries, especially in petroleum (and oil and gas) industries.

18.1.1 AspenTech's Software Modules

AspenTech offers separate aspenONE packages for several industries. Each of these packages consists of various modules especially suited to its industry. With respect to the case study of Chap. 21 in the following we will focus on the aspenONE solution for the petroleum industry (see also Fig. 18.1).

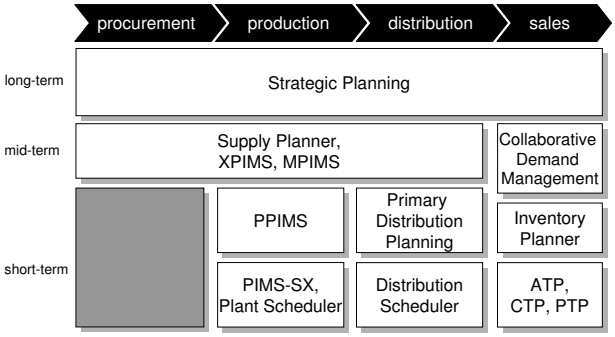

Fig. 18.1. Software modules of AspenTech's aspenONE

Strategic Planning provides the tools necessary to assess the economic and operational impact of long-term strategic plans for multiple scenarios. It is used to evaluate the impacts of new markets and new government regulations, as well as the effects of modifying physical assets and downstream networks. This assessment can include adding or removing terminals, tanks and transportation modes, developing financial budgets and operations models, and performing capital investment analysis.

Collaborative Demand Management is a solution, applicable across all of the vertical industries served by AspenTech, offering the functions demand planning and collaborative forecasting. The resulting consensus demand plan is a primary input into downstream functions such as master planning. It supports history conditioning, forecast generation, reconciling forecasts with firm orders, reviewing forecast accuracy, creating an annual budget, and comparing year-to-date projections. The collaboration capability allows for marketing and sales data, customer data, and point-of-sale (POS) data to be incorporated into the process to improve the forecast accuracy. Forecasts, sales history, budgets, and constrained forecasts can be aggregated to any brand, family, region, market or custom grouping required by the business. This module is based on statistical methods augmented with real-time collaborative data.

Supply Planner offers mid-term planning functionality for use of labor and equipment, raw materials or feed stocks, inbound/outbound transportation, storage capacity, and other constraints that may affect the decision of what to make, when, and in what quantity. *Supply planning for petroleum* includes a set of capabilities that are targeted specifically for the petroleum industry. It offers multi-plant operational planning, multi-plant blend optimization, inventory balancing of crude and semi-finished products, and capital investment analysis. It is built on *Aspen PIMS* (Process Industry Modeling System). Optimization techniques include non-linear and successive linear programming, non-linear recursion, mixed integer modeling and further heuristics. AspenTech integrates the CPLEX (ILOG 2007) and XPRESS (Dash Optimization Ltd 2007) algorithms as solvers. Furthermore, it offers simulator interfaces that link to process simulator models.

Aspen PIMS runs on an installed Microsoft IT base and its single-period base formulation provides the foundation for other functionality. The base Aspen PIMS system, which solves up to 1000 model constraints, is enhanced by *Turbo PIMS*, which enables the user to build larger, more complex models (up to 16,000 constraints). *Aspen PPIMS* allows the user to solve multi-period problems, with the help of periodic-specific data that is added to the base model. The system can be used for production planning applications where inventory considerations are important. PPIMS models can consist of up to 36 time periods of user-defined length. *Aspen MPIMS* is the global model that allows the user to link together a number of single-plant Aspen PIMS models to form a complex multi-source, multi-plant, multi-market supply/demand/distribution network. It consists of up to 100 single-plant PIMS models plus an additional global model, which defines the supply/demand/distribution implications. *Aspen XPIMS* solves multi-plant and multi-location models with interplant transfer, distribution to market demands, and distribution of feeds to plants. MPIMS and PPIMS are prerequisites to XPIMS. *Aspen PIMS-SX* enhances the multi-period model by adding scheduling capabilities for tank operations.

Plant Scheduler generates detailed plant production plans, creating an optimal short-term schedule of operations. While minimizing changeover, production and inventory costs, Aspen Plant Scheduler determines the precise timing and sequence of production activities throughout the plant. It works in finite capacity in order to generate production plans that are feasible from both a capacity and material flow perspective. The optimized schedule is readily viewed and manipulated via an interactive Gantt chart called the Planning Board. Based on a simulation engine, drag-and-drop manual schedule modifications are accompanied by inventory projections and exception reporting to assist the scheduler in visualizing the impact of changes. *Aspen Orion* is a petroleum-specific scheduling module which provides event-based coordinated scheduling and enables

generation of optimal recipes for individual blends on an event-driven time period basis.

Primary Distribution Planning for Petroleum generates distribution plans, optimizes multi-commodity and multi-period transport of several modes of distribution, and analyzes economics of the buy versus make trade off and export/import alternatives.

Distribution Scheduler plans replenishments while minimizing transport and handling cost. It creates distribution schedules for bulk shipping (focusing on mode selection and sourcing as e.g. necessary in chemical companies) and for packaged goods shipping (focusing on load consolidation as e.g. necessary in consumer packaged goods companies).

Inventory Planner allows process manufacturers to calculate inventory levels and targets of safety and cycle stocks in complex distribution networks. It calculates target minimum and maximum inventory levels.

ATP/CTP/PTP — Available-To-Promise, Capable-To-Promise, and Profitable-To-Promise — refer to the ability to commit and fulfill customer requests for product delivery quickly and reliably. ATP evaluates whether there is inventory available for the customer order or when inventory will be available, given the current production schedules. CTP is an extension to this capability, where the model attempts to reschedule production in order to fulfill the order. PTP takes this to another level where the profitability of taking the order is determined. Aspen Capable-To-Promise links Order Fulfillment systems directly to scheduling and/or planning applications. Orders can be promised to customers interactively based on existing inventory, already-planned production, available but not yet scheduled capacity, or any combination of these sources.

18.1.2 Coordination of Modules

AspenTech's APS modules are built on a relational database model which allows the relevant data to be shared across several modules without unnecessary duplication. This database also transforms and manages the master and transactional data required to maintain a timely and accurate representation of business and manufacturing functions.

18.1.3 System Integration

AspenTech provides system integration through its integration infrastructure which is an open, standards-based publish/subscribe approach to integrate applications and data from AspenTech and other systems. The integration infrastructure includes *Aspen Supply Chain Connect*, which provides additional capability to move large quantities of real-time data from multiple sources to and from APS applications. The solution reduces implementation time by including pre-configured data integration templates for SAP R/3 and other leading ERP systems.

18.1.4 Collaboration Modules

AspenTech provides a set of web-based modules that support collaboration within and among APS business processes. These modules are typically accessed through a portal. Examples include *Aspen Collaborative Forecasting*, *Aspen Sales and Operations Planning Analytics*, and *Aspen Scheduling Insight*.

18.2 i2 Technologies – i2 Six.Two

With US headquarter in Dallas, Texas, and with European branch offices in the UK, Holland, France, Germany, Finland and Belgium i2 offers a broad range of APS solutions to synchronize and optimize activities involved in successfully managing supply and demand. i2 was established in 1988, when it offered its first solution called *Factory Planner*, initially successfully used in the high tech and metals industry. Over time i2 developed decision support solutions to solve complex customer supply chain and transportation challenges, which reflected the shift in focus from isolated decision support to integrated SCM solutions, collaborative and continuous planning. i2 offers a comprehensive solution package. The current release i2 Six.Two covers the entire value chain for all kinds of business in all major industries including aerospace, automotive, industrial, metals, high-tech, consumer industries, retail, and transportation. i2's core competencies include solutions for the five group optimization areas: Supplier Relationship Management; Demand and Supply Management; Retail Solutions; Execution, Collaboration and Visibility; Transportation and Distribution Management and the underlying i2 Agile Business Process Platform.

i2 has partnerships with large consulting companies such IBM, Accenture and Tata Consultancy Services, in addition to more regional partners such as ROCE Partners, TruEconomy, i2 CIS and Logis. i2 has more than 1350 employees with a large R&D operation in India (see e. g. i2 Technologies Inc. 2007).

18.2.1 i2's Software Modules

i2 new generation supply chain solutions are designed to enable an enterprise to take control of their extended supply chain horizontally with trading partners and vertically within the enterprise. In traditional SCM, process had to adapt to the software; in the New Generation, the software adapts to the process, allowing for continuous process improvement and greater focus on operational excellence. Built and deployed according to requirements of real-time enterprises, i2 new generation supply chain management solutions feature:

Service-Oriented Architecture: The service oriented architecture increases flexibility and speed, while facilitating assembly, integration, and extension of IT-based business processes to meet competitive needs.

Business Content Library (BCL): i2 new generation supply chain solutions are built from a library of business content. This library is a set of supply chain management components which are both i2 traditional modules and optimizers (such as planning engines) that have been "componentized" through a service oriented approach for integration as well as workflows and processes built within the business process platform.

The Business Content Library provides the building blocks that enable customers and partners to quickly compose specific, highly-focused supply chain processes (see Tab. 18.1). Hence, Fig. 18.2 shows only a partial survey of modules deployed in the BCL. In the following, we will focus on the the core SCM optimizers and planning engines in more detail which are referenced to a large extent in the case study part of this book (Chap. 20).

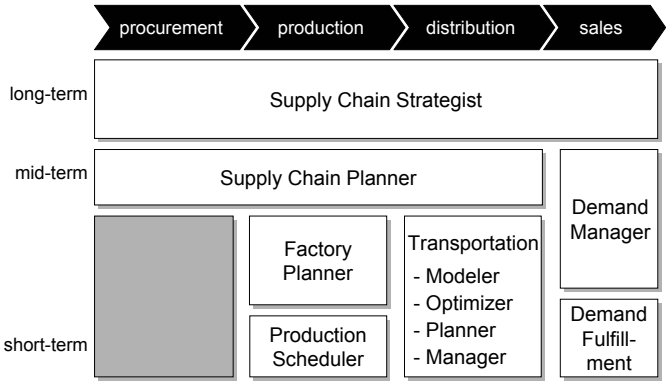

Fig. 18.2. Software modules of i2 Technologies Six.Two

Supply Chain Strategist can enable enterprises to analyze and design their supply chains to best meet business objectives. The solution is designed to support key strategic decisions (such as what-if analysis) at each stage of the supply chain: from raw materials procurement to finished goods distribution. The solution can provide insights into the tradeoffs between alternative strategies regarding site location, facility missions, product mix, transportation strategies, inventory deployment strategies, and supply chain operations.

Demand Manager is designed to provide a comprehensive closed-loop approach to the development of accurate and profitable demand plans and demand-influencing price and promotional activities. It can synchronize supply, demand, and financial objectives in a 'one-number' demand plan.

Tab. 18.1. Business Content Library categories

BCL Category	Category Description
Total Plan Management	Planning at strategic, tactical and operational levels, supply chain diagnostics and control, and global execution
Total Inventory Management	Enabling true visibility and alerts, timely point-of-sale (POS) analysis, inventory segmentation, multi-echelon stock optimization and adaptive learning cycles
Supply & Demand Collaboration	Collaborative planning for forecast, capacity and replenishment as well as short-term order execution, and shipment and inventory tracking
Plan & Order Execution	Synchronize planning with execution, manage multiple replenishment modes, control order management costs while meeting customers' demands for shorter lead times and higher service levels
Retail Planning & Allocation	Execute a closed-loop, top-down, middle-out, and bottom-up planning process at the right level of detail, profitable market-specific assortments, and synchronizing the planning process with supply chain
Total Logistics Management	Manage transportation procurement, planning and execution, carrier contract negotiations, asset management, order planning, execution and monitoring, inbound and outbound visibility and financial freight management
Product Sourcing & Cost Management	Enable collaboration among design, sourcing, and supply operations for part selection including reuse; procurement using preferred parts & suppliers; contract negotiations; supplier collaboration and spend analysis
Enterprise Data Management	Manage core enterprise data - customer, product, and vendor at enterprise level through data synchronization and cross-referencing to facilitate processes such as new product introduction

The solution supports the forecasting process through statistical methods, inclusion of causal factors and management of multiple inputs from different organizational units. POS (point of sales) data can be integrated and different views on demand data can be offered. Furthermore, OLAP tools enable efficient access to relevant data. Forecast data can be aggregated and allocated across sales hierarchies, product hierarchies and time, or can be segmented into further definable hierarchies as for manufacturing locations, packaging or financial measures. So-called "attach rates" support the creation of dependent forecast. This functionality is

used in industries like the high-tech industry where a forecast on component level is derived from the forecast on finished goods level to drive purchasing decisions (see Chap. 20).

Supply Chain Planner can help companies achieve a high degree of customer satisfaction with the best possible margins while working within the constraints imposed on their business. The solution is designed to provide visibility into exceptions that inevitably occur and to help solve these exceptions in a manner that is eventually executable by the company. It generates optimized, feasible plans across several factories and independent ERP systems and spans different divisions within the company such as procurement, manufacturing, distribution, and warehousing. The *Strategy Driven Planning* (SDP) allows planners to define types of problems and strategies to solve them. Furthermore, it is possible to apply appropriate algorithms like Linear Programming, heuristics and genetic algorithms.

Factory Planner is designed to enable companies to quickly react, synchronizing factory production plans and schedules to meet business challenges. This detailed visibility over the production plan and reduced manufacturing cycle times are key benefits. It generates optimized production plans by scheduling backward from the requested date, as well as scheduling forward from current date while considering material and capacity constraints simultaneously. After a first infinite planning step where demand and supply is matched, a finite capacity plan can be determined by i2's proprietary *Constraint Anchored Optimization*. However, the planner can manually interact by analyzing capacity shortages and performing what-if-analysis. In the last planning step a detailed schedule can be generated for the factory. It also can assist buyers in performing efficient material planning by providing extensive modeling capabilities to solve a breadth of problems in the entire material planning process domain.

Production Scheduler supports complex manufacturing environments requiring detailed scheduling and sequencing. The solution is designed to generate feasible and optimal manufacturing schedules for execution based on complex shop-floor constraints. The decoupling of constraint definition and optimization algorithm allows the handling of a large number of complex constraints. These constraints include shop floor capacities, workload balancing, material availability, resource-down etc. Additionally, an interactive schedule editor allows manual changes.

Demand Fulfillment is a order-promising solution that is designed to deliver benefits including increased order capture, delivery confidence, full supply utilization, and good customer service. In other words, the solution provides functionality to assign scarce supply to customers and to quote feasible delivery dates for customer orders. Allocation of supply can be based on current and projected inventory positions or available capacities. It respects customer priorities modeled in a sales hierarchy, fair share and profitability based strategies with the assignment of sup-

ply to particular customers. Orders are promised in real-time based on the current status of inventories and capacities in the supply chain network. It typically is integrated to existing order management systems and respects all supply and its allocations.

Transportation Modeler, Optimizer, Planner and Manager are tools for support of distribution planning processes. Transportation Modeler helps to improve the efficiency of the transportation network. Real world data are used to perform what-if-analysis. Transportation Optimizer automatically builds and routes loads and determines pick-up and delivery times with respect to delivery, equipment and personnel constraints. Furthermore, cross-docking opportunities can be selected dynamically and grouping constraints can be accounted for. The third tool, Transportation Manager, supports activities to execute and manage the transportation process from order management through customer service and financial settlement. i2 Transportation Planner can enable procurement, planning, execution and monitoring of freight across multiple modes, borders, and enterprises

18.2.2 Solutions and Collaboration Modules

In the following examples of i2 New Generation Solutions with respect to optimization and collaboration are given:

Inventory Optimization can enable companies to improve service levels, minimize inventory costs, and reduce lead times. Inventory optimization is a discipline of continuously managing inventory policies to optimize supply chain performance against business objectives, changing market conditions, risk and supply chain constraints. The solution can help companies determine what inventories to carry, where, and in what form, and how much across the procurement, manufacturing, and distribution network.

Collaborative Supply Execution enables companies to manage their supplier interactions. It is a comprehensive solution that allows companies to address three major business objectives: consolidated procurement, supply collaboration/lean replenishment and collaborative material management.

Supply Chain Visibility allows companies to respond more quickly and effectively to a wide range of unplanned and potentially disruptive supply and demand events. Supply-related events can include production bottlenecks or supplier shortages. Demand-side events could include customer orders that are greater than forecasts or changes to orders that have already been placed. The solution help manage these events, assess the impact, and orchestrate a rapid and practical resolution.

New Generation Planning leverages current planning investments and provides a comprehensive planning solution to improve customer service

levels, improve asset utilization, and reduce order to delivery cycles and operating costs by profitably managing global demand and supply. It empowers organizations to do plan-do-check-act and rapidly realign supply chains to meet changing customer demand and counter supply variability.

New Generation i2 for Retail Solutions provides solutions especially for the retail industry including Merchandise Financial Planning, Buying and Assortment Management and Allocation and Replenishment Management.

18.2.3 Coordination of Modules and System Integration

The i2 Agile Business Process Platform supports new generation solutions by providing the following resources:

Core platform services provide distributed process modeling, execution, and monitoring where distribution allows for high scalability; they include business rules definition, as well as web and rich-content UI generation.

Data services provide extensive supply chain management data models and related data processes (validation, synchronization, staging, aggregation).

Integration services provide complete integration services from bulk data transport and mapping to web services support with combined support for messaging and generic EAI use.

Studio provides an integrated development environment for modeling, testing, deployment, and maintenance.

18.3 Oracle – JDEdwards EnterpriseOne Supply Chain Planning

Oracle, founded in 1977 and headquartered in Redwood Shores, California, started as a specialist for relational database software, but has in the meantime extended its portfolio to a broad range of software packages on business intelligence, business applications, collaboration, and middleware. In 2005, Oracle took over Peoplesoft, a software company traditionally offering ERP software for non-productive and manufacturing industries, which again had acquired J.D.Edwards, a Denver–based provider of ERP and Advanced Planning software for medium-sized companies, in 2003. Due to these acquisitions Oracle now offers two streams of advanced planning software, *Oracle Advanced Planning* as part of the Oracle E–Business Suite and *JDEdwards EnterpriseOne Supply Chain Planning* as part of the JDEdwards EnterpriseOne Supply Chain Management suite (see e. g. Oracle 2007). With respect to the case study of Chapt. 24 we will only concentrate on the latter one.

18.3.1 Oracle's JDEdwards APS Modules

In the following, the APS software modules of JDEdwards EnterpriseOne Supply Chain Planning are briefly introduced. An overview is given in Figure 18.3.

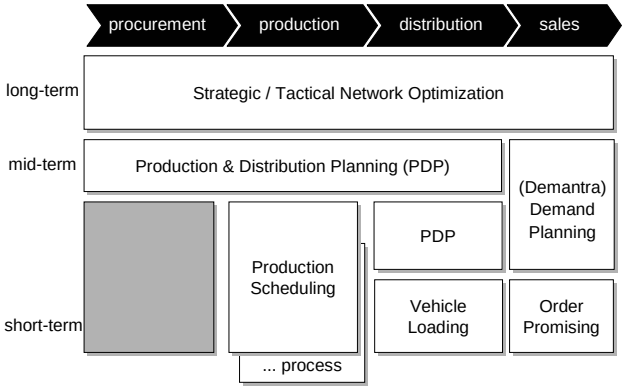

Fig. 18.3. Software modules of Oracle's JDEdwards Supply Chain Planning

Strategic Network Optimization (SNO) is intended to be applied on the strategic planning level. Optimization methods of Linear and Mixed Integer Programming (CPLEX; see ILOG 2007) and special purpose heuristics (e. g. for capital asset management and single sourcing) support the choice of appropriate supply chain structures. The most striking feature of SNO is its visualization. Even complex supply chains can be "designed" graphically without any knowledge of mathematical modeling being necessary. The case study of Chap. 24 will show that SNO is not restricted to strategic planning, but can also be used for Master Planning. Tactical Network Optimization is a "light" version of SNO where the strategic features of SNO, like capital asset management, have been disabled.

Production & Distribution Planning (PDP) and Vehicle Loading PDP is a versatile tool. Its major focus is the mid-term Master Planning and the shorter-term Distribution Planning. For this, Linear Programming and some heuristics are applied. Here, ATP (see Chaps. 9 and 12) quantities can be computed which serve as an input for order promising (in the form of so-called "supply events").

Deployment and shortage planning functionalities are also addressed by further components of the PDP module. Moreover, multi–stage matching of anonymous supply and customer orders (*"pegging"*) and component/material substitution are supported. The current version features a modern graphical user interface, offers additional manufacturing planning

capabilities and provides a heuristic called "Supply Planning" in order to execute an in–memory MRP run.

The *Vehicle Loading* module adds capabilities for optimizing the usage of the storage space of vehicles.

Demand Planning (DP) is a module that originates from Oracle's acquisition of Demantra in 2006. It uses a mixed–model Bayesian approach to forecast multi–dimensional data hierarchies. Mixed–model means that causal forecasting is applied (see Chap. 7) and that several possibly fitting causal models are weighted with probabilities in order to get an overall forecast. Even though causal factors like seasonality, prices and promotions can already be respected by DP, in consumer goods industries DP can be supplemented by *Demantra Predictive Trade Planning*, which is further specialized on analyzing and predicting the effects of trade promotions.

Production Scheduling (PS), Two alternative software modules for the short-term production planning are offered. The newer one, *Production Scheduling*, is dedicated to multi-stage production processes with floating bottlenecks and complex BOMs which can frequently be found in discrete parts' production. As solution method *texture–based programming* (Beck et al. 1997) is used. Texture–based programming builds on similar principles as constrained programming does (see Chap. 31). Though, as opposite to constrained programming no problem specific knowledge is needed because the algorithm is self–configuring. During the last versions a number of functionalities were added to PS in order to extend its footprint also to process industries.

Production Scheduling Process (PSP), however, is one of the rare software tools that are especially designed for continuous production processes, common in consumer goods industries or the process industry in general. Its main focus are parallel continuous production lines with up to two stages of production. As opposite to most other scheduling modules which pursue time-based objectives like minimizing the lateness, PSP aims at minimum production, inventory and changeover costs. Such monetary objectives fit better to supply chains having a deliver–to–order decoupling point where products are made to stock without the knowledge about definite customer orders.

Order Promising. Besides ATP and CTP checks, *Order Promising* provides also "*Profitable To Promise*"(PTP) functionality, i.e. different fulfillment options can be assessed by their profit margin. *Order Promising*, in the meantime equipped with a completely new web-interface, promises due dates automatically using predefined business rules.

Execution-oriented components of both the former JDEdwards and the former Peoplesoft ERP system like *Warehouse Management, Requirements Planning* or *Sales Order Management* intend to supplement the above APS modules. SNO and PS are also integrated with the Oracle E–Business Suite.

18.3.2 Coordination of Modules

Oracle provides rather general workflows (see Chap. 5) for different kinds of industries in order to give some advice how to design the information flows between software modules. As an example Oracle's workflow for process industries is shown in Fig. 18.4. When comparing it with Fig. 4.4 (page 97), one can see that this workflow also fits well the planning requirements of consumer goods manufacturing supply chains. Thus, instead of describing the information flows in Fig. 18.4, the reader is referred to Sect. 4.3.1.

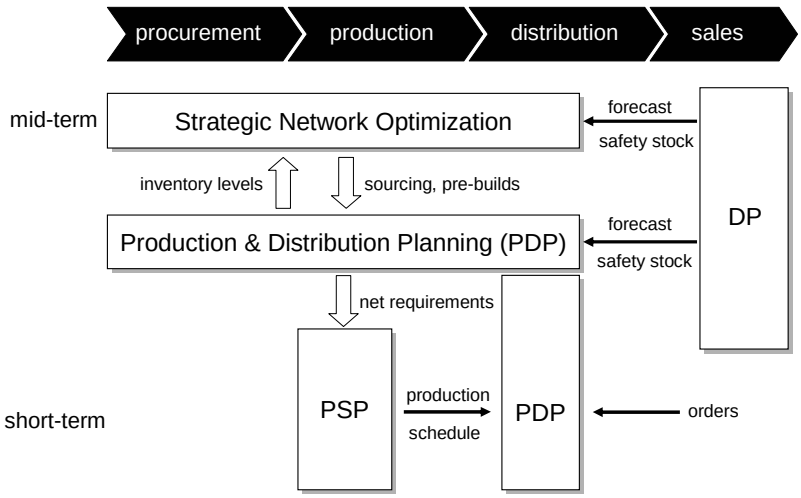

Fig. 18.4. Oracle's workflow for process industries

18.3.3 System Integration

The *Advanced Planning Agent* (APAg) software component, as implemented in the case study of Chap. 24, is a graphical tool to constitute and control the data flow between different software modules and to start batch execution of the respective software components. Usually, a common repository of databases is kept by APAg for consistent data storage. Both, vertical (e. g. between mid-term PDP and PS) and horizontal (e. g. between DP and mid-term PDP) information flows are supported.

In the meantime, Oracle recommends the more modern *Supply Chain Business Modeler* (SCBM). It provides data to APS modules at the required level of granularity and enables batch integration to ERP, CRM and other legacy systems. The real–time integration with the ERP system is implemented by web services. This functionality is of particular interest for the *Order Promising* module in order to guarantee an on–line response to customer requests.

18.3.4 Collaboration Modules

Demand Planning already offers a basic functionality for web–based internal and external collaboration. This can further be enhanced by *Demantra Real–Time Sales and Operations Planning*, which is specialized on consolidating information of several functional departments like finance, sales, marketing, logistics and production in real–time. The goal is to obtain a consensus forecast or to release a committed (production or) deployment plan, which all participants agree on. External supply chain members can also be integrated in this process. For example, point–of–sales data of retailers can improve the forecasts of a consumer goods manufacturer in a CPFR–like collaboration process (see Chap. 14) this way.

Concerning mid– to short–term planning, PDP provides the infrastructure for collaboration of different users in several locations. This PDP functionality is built upon the Oracle *Distributed Object Messaging Architecture (DOMA)*. It allows several users to work on synchronized data by continuously propagating data changes. The most important features of DOMA are:

- multi-user mode and user specific profiles,
- decision-making distributed across the whole supply chain,
- real-time information sharing,
- database surveillance and event–oriented triggering of data changes and
- alert monitoring and messaging.

Furthermore, PDP features a DOMA–enabled Excel client and a web interface ("Collaborative Web Client").

18.4 SAP – SCM

SAP AG (Walldorf/Germany) has been active in the APS market since 1998. The *Advanced Planner and Optimizer* (APO) was originally intended and sold as an independent software suite. Until 2007 it was part of the mySAP suite and it is now sold as *SAP Supply Chain Management* supplemented with different modules like *Inventory Collaboration Hub (ICH)* and *Extended Warehouse Management (EWM)*.

The technology for this applications is based on *SAP Netweaver*, which provides an application and integration platform for all SAP applications. *Netweaver* hosts several components and the *Business Intelligence* including the *Business Information Warehouse* (SAP's Data Warehouse). This section will provide an overview of selected APO components. For more information, see the current SCM documentations (e. g. SAP 2007 and Dickersbach 2004).

18.4.1 SAP's Software Modules

APO is a fully integrated APS. All modules can be accessed through the *Supply Chain Cockpit* and have an identical look-and-feel. The paragraphs below give a brief description of the individual APO modules illustrated in Fig. 18.5 based on SCM 5.0.

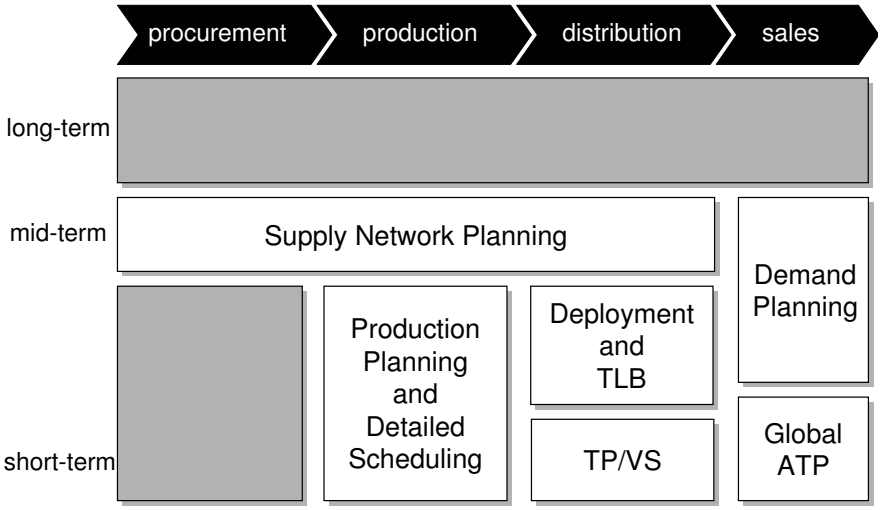

Fig. 18.5. Software modules of SAP APO

Demand Planning offers – in addition to conventional statistical methods – promotion planning tools, life cycle concepts, what-if-analysis, phase-in planning for new product initiation and collaborative forecasting methods. Reports on forecast accuracy can be generated and alerts can be raised. Furthermore, this module provides OLAP tools for Data Warehouse integration. The current version provides a functionality called *characteristics-based-forecasting* having special aggregation and disaggregation procedures for components of configurable products and material availability constraints.

Supply Network Planning serves planning and optimization functionality that take into consideration capacity and material availability constraints and costs. Optimization is based on automatically generated *Linear and Mixed Integer Programming* models (see Chap. 29) which use

ILOG CPLEX (see ILOG 2007) as a solver. Decomposition rules regarding time, resources and products can be applied to speed up the solution process. Additionally, proprietary heuristic approaches are used, such as *Capable-to-Match* (CTM), a rule based approach. Simulations of different supply chain configurations as well as matching of supply and demand with respect to alternative production sites, substitution of products, prioritizing customers, shelf-life etc. are supported. Alerts can be raised in case of late deliveries and violation of bottleneck capacities. Supply Network Planning contains the modules Deployment, Safety Stock Planning and Transport Load Builder (see below). Supply Network Planning provides functionality to manage different planning scenarios, and thus, can be used for evaluation in strategic planning. A new explanation tool for the optimizer communicates the reasons for a solution to the user (e.g. capacity constraints led to an stock out).

Global ATP performs a rule based multi-level component and capacity check based on current data. It provides product substitution methods, alternative site selection for production and purchasing, and methods for allocating scarce products and components to customers, markets, orders etc.

Production Planning and Detailed Scheduling (PP/DS) provides methods for optimizing detailed capacity and material planning simultaneously. It can perform multi-level forward and backward scheduling. Different constraints can be considered in simulations and interactive scheduling using gantt-charts is provided. Current, short-term data can be integrated into optimization runs. Production Planning and Detailed Scheduling uses proprietary evolutionary algorithms (see Chap. 30). These approaches can be combined with decomposition approaches regarding time and resources. An explanation protocol can be used to understand and analyze the solution.

Deployment and Transport Load Builder (TLB) allocates inventory by allocating actual supply (produced quantities) to planned supply. This allocation is controlled by *push* and *pull* strategies, predefined quotas and priority rules. For example, results from the Supply Network Planning optimization run can be used for defining such quotas. Inventory and allocation plans are displayed graphically. Transport Load Builder ensures that vehicles are loaded within a specified minimum and maximum range. Iterations are used to derive a feasible deployment plan respecting vehicle loads (see SAP 2007).

Transportation Planning and Vehicle Scheduling (TP/VS) is SAP APO's planning module for the transportation processes. On the basis of shipment requirements optimal vehicle loadings and routings can be derived. A proprietary evolutionary algorithm (see Chap. 30) and additional heuristics supplement TP/VS's solution process. TP/VS allows to model e.g. multi-pick, multi-drop scenarios, the inclusion of hubs, compatibilities and time windows.

18.4.2 Coordination and Integration of Software Modules

APO offers a graphical user interface, the *Supply Chain Cockpit*, that gives an overview of the supply chain being modeled and from which all APO software modules can be accessed. The Supply Chain Cockpit also provides the *Supply Chain Engineer* to graphically build a macro-model of the supply chain. This model can be shown in detailed views, and special information can be extracted for each entity. The *Alert Monitor* is also part of this module. APO planning modules use a common database. To enable fast access for all software modules this database is kept memory resident (the so-called *live*Cache).

APO's *Plan Monitor* provides predefined Key Performance Indicators (KPIs) to observe the performance of generated plans. With calculation rules, additional user defined KPIs can be generated from existing predefined KPIs.

SAP *Supply Chain Event Management* provides automated collection and tracking of information such as order status, shipments and inventory using Internet and mobile technologies. In response to exception-based events activities in planning and execution system can automatically be triggered.

18.4.3 System Integration

APO provides two different options for integrating OLTP systems. The *Core Interface* (CIF) allows direct access to SAP ERP data objects and vice versa. Integration to non SAP systems is achieved through so-called *Business Application Programming Interfaces* (BAPIs). By using BAPIs the objects of APO can be accessed by a kind of programming language. Thus, it is possible to map, for example, ASCII-files to APO data objects. SAP also provides the *Business Information Warehouse* for storing historical data. APO is able to receive these data, which are particularly relevant for Demand Planning, using predefined queries and OLAP tools.

18.4.4 Software Modules for Collaboration

SAP uses Internet and associated technologies, such as XML, to enable the collaboration between business partners. Using conventional Internet browsers APO can be accessed online. The SAP APO *Collaborative Planning* modules enable this collaboration. They support consensus based planning processes for collaboration on shared plans within demand planning, procurement planning etc. (e. g. Inventory Collaboration Hub, web-interfaces of Demand Planning). They further provide read-write data access as well as access to planning activities for authorized users using Internet browsers, user specific negotiation processes, user defined screens and workplaces, visualization of alerts, the connection to multiple systems, and links to partner systems.

References

AspenTech (2007) *Homepage*, http://www.aspentech.com, date: July, 19th 2007

Beck, J.; Davenport, A.; Sitarski, E.; Fox, M. (1997) *Texture–Based Heuristics for Scheduling Revisited*, in: *Proceedings of the National Conference on Artificial Intelligence*, AAAI, AAAI Press, Menlo Park, California

Dash Optimization Ltd (2007) *Homepage*, http://www.dashoptimization.com, date: July, 19th 2007

Dickersbach, J. (2004) *Supply Chain Management with APO*, Springer, Berlin, New York, 1st ed.

i2 Technologies Inc. (2007) *Homepage*, http://www.i2.com, date: July, 19th 2007

ILOG (2007) *Homepage*, http://www.ilog.com, date: July, 19th 2007

Oracle (2007) *Homepage*, http://www.oracle.com, date: July, 19th 2007

SAP (2007) *SAP Help Portal*, http://help.sap.com/, date: July, 19th 2007