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SAP ERP 6.0 (Operations)

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1 Architecture Summary

SAP ERP Operations (SAP ERP OPS) is SAP's core solution for procuring, selling, producing, stocking, shipping, and transporting of material. SAP ERP OPS is part of the application SAP Enterprise Resource Planning (SAP ERP), which embraces also SAP ERP Financials and SAP ERP Human Capital Management. SAP ERP OPS consists of the following components:

- Sales and Distribution (SD)
- Production Planning (PP)
- Materials Management (MM)
- Logistics Execution (LE)
- Quality Management (QM)

Using SD products are sold and sent to business partners or services are performed for them. Data about products, services and business partners is the basis for sales processing. The sales process is based on a set of business documents such as customer inquiry, quotations, and most important the sales order. These business documents are maintained and stored by SD. Follow-up activities are triggered based on them. The calculation of prices for material and services is based on the condition technique.

PP supports the development and execution of efficient production plans, which takes warehouse, material, and production capacity information as well as sales planning into account. When the production plan is transformed to a production order in order to trigger execution, PP reserves and procures required raw material using MM.

MM provides the functions that are necessary to deal with the inbound flow of goods and services. MM supports procurement using the business documents purchase requisition and subsequently purchase order. The arrival of the ordered goods results in a goods receipt and is handled by the inventory management. MM maintains the central inventory for the complete enterprise, which means that also outgoing material movements are communicated to MM. MM provides a pattern-based user interface implemented in ABAP Dynpro. The purchase requisition functionality is based on a framework.

LE controls and organizes the movement of material within the enterprise (warehouse management), but also transportation between enterprises. The central business documents which are maintained and stored by LE are the delivery, the shipment document, and the transfer order. They are used to trigger and control material movement.

QM allows planning and conducting inspections to check the quality characteristics of material. It is integrated in procurement, production, and sales processes.

To support reliable business processes across the different ERP OPS components based on consistent data they are closely integrated using database integration. Based on the same mechanism SAP ERP OPS communicates with SAP ERP Financials. All components share the same material master data.

The functional scope of SAP ERP OPS can be extended by integrating it with the other applications provided by SAP ERP Business Suite, such as SAP Customer Relationship Management, SAP Supply Chain Management, and SAP Supplier Relationship Management.

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2 Introduction of SAP ERP Operations

Enterprises want to provide the right products and services at the right price, to the right customer at the right time. To achieve this kind of operational excellence business processes in procurement, in logistics execution, in product development, in manufacturing, as well as in sales and service have to work hand in hand. To support end-to-end processes across these areas SAP provides SAP ERP Operations (SAP ERP OPS) as part of the application SAP Enterprise Resource Planning (SAP ERP) as shown in figure 2-1. In addition to SAP ERP OPS, SAP ERP includes the following applications:

- Corporate services
- Financials (FI)
- Human Capital Management (HCM)
- Industry-specific Functionality

All applications share one common database. However it is possible to deploy SAP ERP HCM on a separate system with own database. SAP ERP FIN, SAP ERP OPS, and corporate services run always on one system.

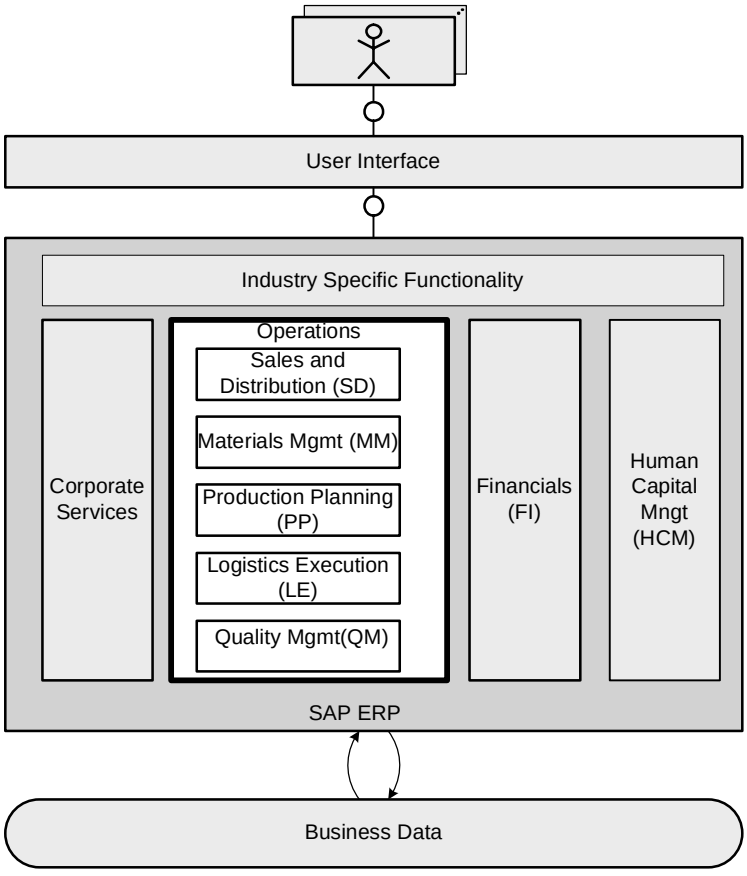

Figure 2-1 Architecture Overview of SAP ERP

The functionality of the SAP ERP OPS is bundled into the following components (see figure 2-2):

- Sales and Distribution (SD) which includes creation of sales orders, checking the availability of the requested products, price calculation, and finally delivery and billing.

- Materials Management (MM) which includes creation of purchase orders for procuring material and services from external vendors, verifying incoming invoices, and managing the inventory.
- Production Planning (PP) which includes planning the production of the materials and execution.
- Logistics Execution (LE) which controls and organizes the movement of material[1]
- Quality Management (QM), which includes quality planning, quality inspection, and quality control during sales, production and procurement.

For application-to-application-communication (A2A) between the different sub-applications - as there are SD, MM, LE, PP and quality management - database integration is used. In addition SAP ERP OPS and SAP ERP FIN are integrated in the same way. In database integration the sending and receiving application share database tables. To transfer data the sending application creates records in these tables, which triggers then follow-up processing in the receiving application. The sending application creates the records in the transfer tables within the same logical unit of work as it stores the business data processed in the transaction. This makes database integration very reliable. Data transfer only happens, when the business transaction can be processed successfully.

2.1 Master Data and Reuse

Within SAP ERP OPS the most important master data is the material as it is shared across SD, MM, and LE (see figure 2-2). The material master data has a set of attributes which are common and separate sets to cover the specific requirements of sales, logistics, and procurement. Business partner information, such as vendor or customer master data, is not shared. So MM and SD store their own master data versions of their respective business partners. Besides material master the most important master data for PP is the bill of material (BOM), which lists all components required to manufacture a certain product. Routing master data is also used by PP which has information about the operations need to be performed to produce the finished product.

Reuse components which are used across all SAP ERP OPS applications are provided either by the general functions, by the cross-application components or within the basis which is part of SAP NetWeaver (see figure 2-2).

- General functions provide additional functions to support specific processes in the supply chain. Examples are batch management, variant configuration, handling unit management, and logistics information systems (LIS).
- Cross-application components provide reuse components for all SAP ERP functions. It includes the classification system which allows maintaining characteristics of a material, and the document management system (DMS) for attaching documents (e.g. design or engineering diagrams) to objects (e.g. material master or business documents).
- The basis component provides central address management, workflow, change document functions for writing the change documents in the transactions, and archiving functions.
- Enterprises adapt the software of SAP ERP to their individual requirements by maintaining customizing settings. At runtime the customizing data influences the execution of SAP ERP OPS.

[1] In this context material is the general term. It includes products (material which is build from pieces to be sold), goods (material to be shipped), raw material and parts (material as input for production). If a dedicated type of material is intended, we use the corresponding term.

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All application data, master data, and customizing data created and used by SAP ERP OPS is stored in the central database of SAP ERP.

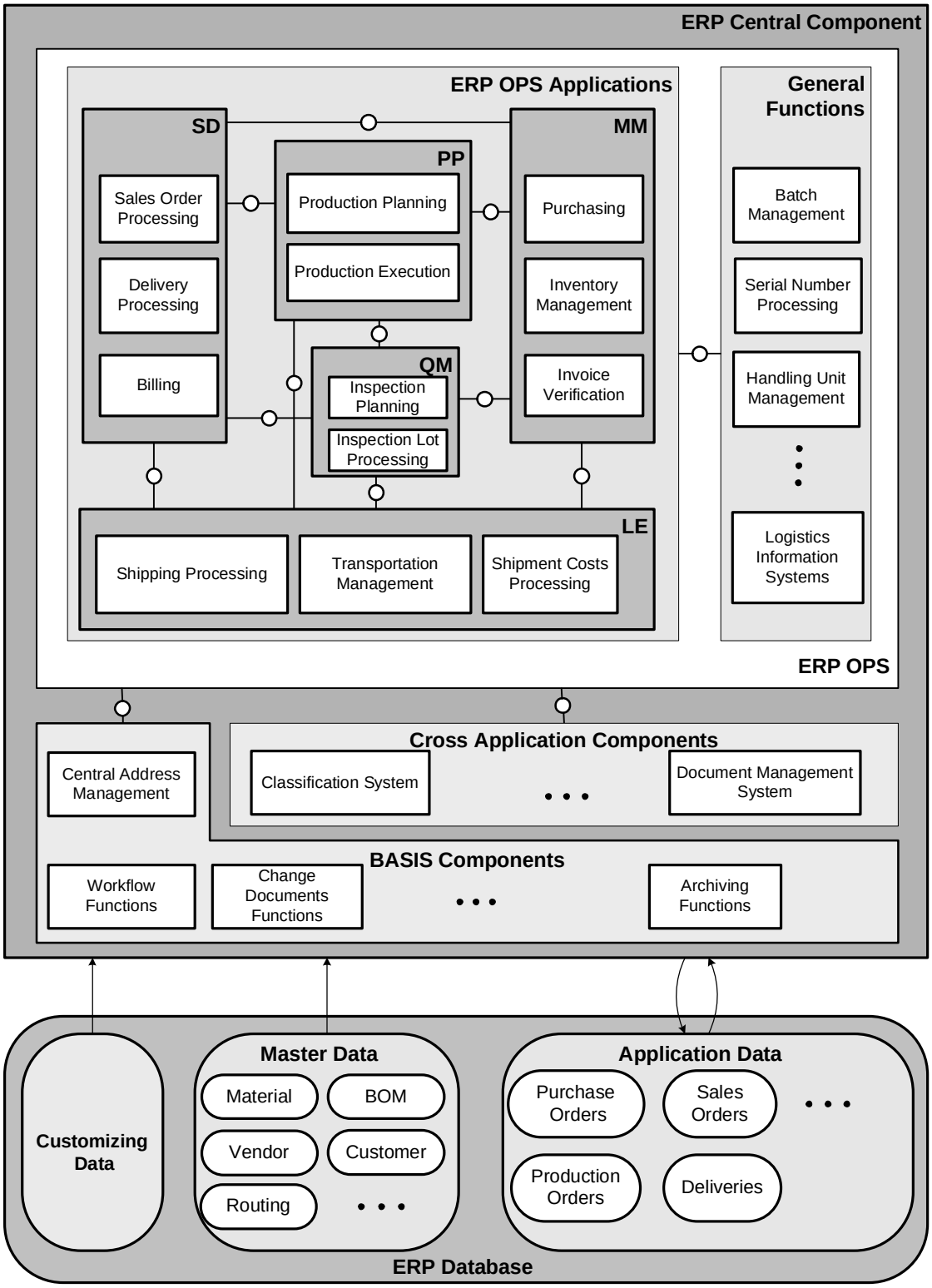

Figure 2-2 Architecture Overview of SAP ERP OPS

2.1.1 General Functions

The general functions of SAP ERP OPS provide specific functions to handle material. Enterprises can activate general functions if required. The activation is typically enabled by configuration of the material master. The most often used general functions are described below, however the details of their architecture are not covered within the scope of this book.

Batch Management

In various industries particularly in the process industry, there is a need to work with homogenous partial quantities of a material or product throughout the logistics supply chain. This homogenous partial quantity is called a batch. Managing material in batches is required for the following reasons:

- Legal requirements, for example the guidelines set out by GMP (Good Manufacturing Practice or regulations on hazardous material
- Defect tracing, callback activities, and regression requirement
- The need for differentiated quantity-and value-based inventory management, for example, due to heterogeneous yield/result qualities or varying constituents in production.
- Differences in usage and the monitoring thereof in materials planning in SD and PP
- Production or procedural requirements, for example settlement of material quantities on the basis of different batch specifications

Batch management is integrated in all applications of SAP ERP OPS to support the management and processing of batches in all operational business processes.

Serial Number Processing

Serial number processing is used to identify individual items of material by consecutive identifiers. It supplements the material master record, which contains the attributes which describe the material and are required to manage it. The serial numbers are used in various business procedures within logistics. For each material with a serial number, serial number processing creates a transaction history and tracks its status.

The serial numbers can be used within the following business processes:

Component involved	**Business procedure or operation**
Production Planning	Production order
Sales and Distribution	Sales order, inquiry, quotation Delivery and returns delivery Completeness check for deliveries and returns deliveries
Quality Management	Original value recording of inspection lots
Inventory Management and Physical Inventory	Goods movements, Entering the physical inventory count Posting inventory differences

Handling Unit Management

When using handling unit management (HUM) multiple materials are can be combined to a handling unit, which movements are tracked within the logistics processes. Goods movements

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processing deals then with the entire handling units and the materials they contain instead of tracking the movement of each material individually.

Handling unit management works together with the existing packing function in shipping and warehouse processing in the warehouse management system.

2.2 Integration with SAP Business Suite

To support end-to-end business processes SAP ERP Operations is closely integrated with the other SAP Business Suite applications using RFC (see figure 2-3).

The functionality of SD can be extended by SAP Customer Relationship Management (SAP CRM) which provides additional pre-sales functions, and supports marketing and sales order management. Sales orders created in SAP CRM are transferred to SD for further processing such as delivery and billing. In addition SD can be extended by SAP Global Trade Services (SAP GTS) which automates global trade processes in imports and exports. SAP GTS provides tools to exchange required information with government and custom authorities electronically.

MM can be integrated with SAP Supplier Relationship Management (SAP SRM) which provides additional procurement functionalities such as shopping cart, maintaining catalogs for products, contract management, and sourcing. MM and SD can also be integrated with SAP Advanced Planner and Optimizer (SAP APO). SAP APO provides additional planning functionalities such as demand planning, forecasting the requirements for materials, and global availability check for materials.

SAP Extended Warehouse Management (EWM) provided by SAP Supply Chain Management (SAP SCM) enhances LE with functionalities to effectively manage the operations in a warehouse.

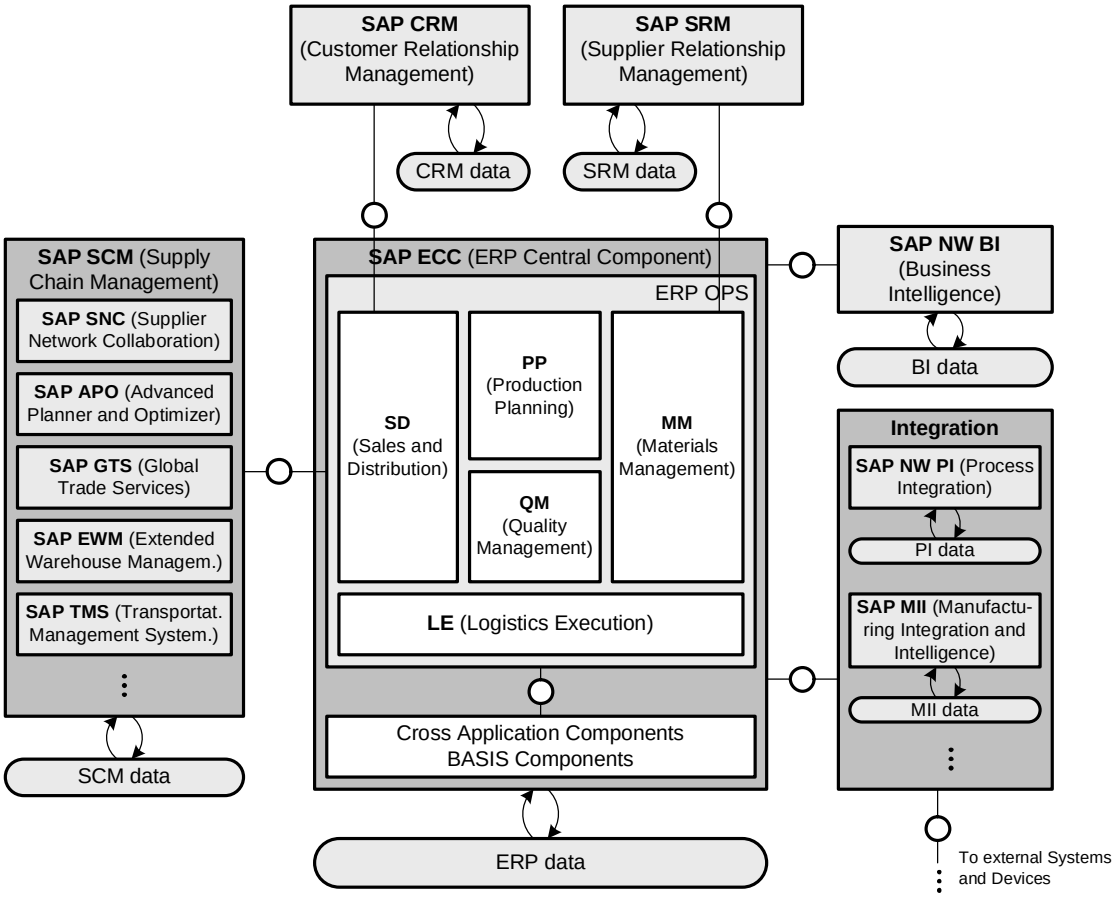

Figure 2-3 Integration Overview of SAP ERP OPS

Transportation management system (TMS) is a part of the SAP SCM solution that provides functions to support the planning and the execution of the transportation of the goods or materials from the shipper to the consignee (party who receives the goods; usually the buyer). Some of the functions include for example service provider management, transportation forecasting, freight order tracking, freight cost calculation and settlement.

Supply Network Collaboration (SNC) is a part of the SAP SCM solution that provides a platform for vendors to manage the inventory and handle special processes like subcontracting and consignment stocks. Consignment stock is any stock that the vendor has placed in the warehouse of the manufacturer without charge until the stock is used.

For analyzing SAP ERP OPS data, SAP NetWeaver Business Information can be connected to the system. Business data is replicated to the business information warehouse, where it is prepared for analysis and reporting.

SAP ERP OPS provides business application programming interfaces (BAPI) and enterprise services to access the functionality from outside. Non-SAP applications can be integrated with SAP ERP OPS using SAP NetWeaver Process Integration (formerly known as SAP NW XI) for message transfer, routing, and mapping..

SAP Manufacturing Integration and Intelligence (SAP MII) can be used to integrate external devices such as barcode scanners to track material along the supply chain.

For more details about enterprise service provisioning of SAP Business Suite please refer to the bluebook on “mySAP Service Provisioning”.

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3 Material Master

Almost all business operations in a company deal with material. Material is procured, produced, stocked, sold, delivered, and transported. As it is typically the same material which is produced, stocked, sold, and so on, it has been decided to maintain common material master data to be used by MM, SD, PP, LE, QM, and SAP ERP FIN (financials, controlling, see figure 3-1). This approach avoids redundant storage and maintenance of material data and ensures consistency within end-to-end business processes. In addition industry or company-specific extensions to material master data structure can be done at a single place.

3.1 Architecture Overview

Material master data record consists of common attributes shared by all applications and processes, such as material id, name, base unit of measure, and application-specific attributes which are used only in a certain context, for example the cost price of the material which is maintained in the material master is used by the pricing application, the country specific tax details are maintained in the material master is used by SD applications for tax calculation. Similarly production planning makes use of certain attributes of material master like goods receipt processing time and whether the material should be produced in-house during the planning phase.

In SAP ERP OPS material master is a set of database tables for storing material master data together with a set of read interfaces and maintenance transactions. The common attributes are stored in a set of tables, which are separated from the tables which store sales relevant data, purchasing relevant data, and so on.

Creation and update of material master data can only be performed using the maintenance transactions of material master. These transactions provide the necessary user interface screens, validate the input data, and manage the database access for creating and updating material master data.

In general the different applications, which make use of material master, have only read access using the corresponding interfaces. They are only allowed to update some context-specific attributes of material master data, for example MM updates the stock and price information and PP maintains the forecast and consumption data.

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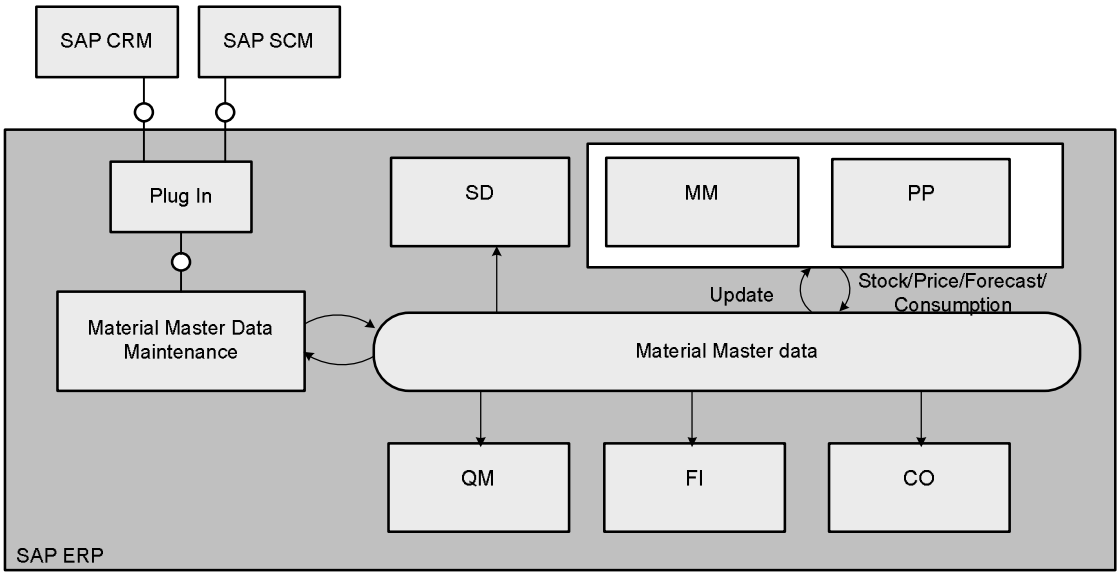

Figure 3-1 Overview of Material Master

When SAP ERP is used together with other SAP applications such as SAP SCM and SAP CRM at an enterprise, material master data is created and updated centrally in SAP ERP and data is replicated to SAP CRM and SAP SCM. The material master data in SAP ERP corresponds to the product master data in SAP CRM and SAP SCM.

In both cases the exchange of material master data is performed using the plug-in, which exchanges iDocs with SAP CRM and synchronous RFC calls to communicate with SAP SCM. When material master data is updated in SAP ERP OPS business transaction events (BTE) are called which trigger communication with the external systems.

3.2 The View Concept of Material Master

As mentioned material master data has a set of common attributes as well as application-context specific attributes. Altogether to create one material master data instance a lot of attributes have to be maintained. For displaying and maintaining the attributes on the user interface they are grouped in views. One view embraces a set of semantically related attributes, for example a set of sales-specific attributes or a set of common attributes. Every view is implemented as an ABAP Dynpro screen and displayed as a tab in a tab strip control.

3.2.1 View Sequence

Which views and also which fields need to be maintained to create a material master data record depends on the intended usage of the material, which is influenced for example by the following factors:

- Material type[2] to which a material is assigned. If, for example, the material is a raw material, the sales screens are not displayed because raw materials are not sold.
- Industry sector of the enterprise: for example in chemicals industry other attributes need to be maintained than in automotive or retail sector.

[2] Material master data is categorized by material type, for example raw material, finished good, and variant material. All material master data instances of one material type share a set of properties, for example raw material cannot be sold or finished goods are produced in-house. Enterprises can create additional material types if required.

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- Organizational level at which data is entered. If, for example, data is entered at plant level only, storage-location-specific fields are hidden.
- Used SAP application components: in case a company does not use the warehouse management component, the warehouse management views do not appear.

So, when creating a material master record the maintenance transactions need to determine which views need to be maintained. As certain attributes depend on each other, also the sequence in which the views are displayed needs to be evaluated. Both are done by the view sequence controller. It determines the next view that needs to be displayed based on the specific material type and the industry sector.

The material master maintenance transactions provide the following view sequence (see figure 3-2):

1. First the initial screen is displayed for entering basic material data, such as material type and industry sector. This information influences which additional views need to be maintained.
2. The view sequence controller triggers the display of the view selection popup. The user can select multiple views which should be maintained for the material

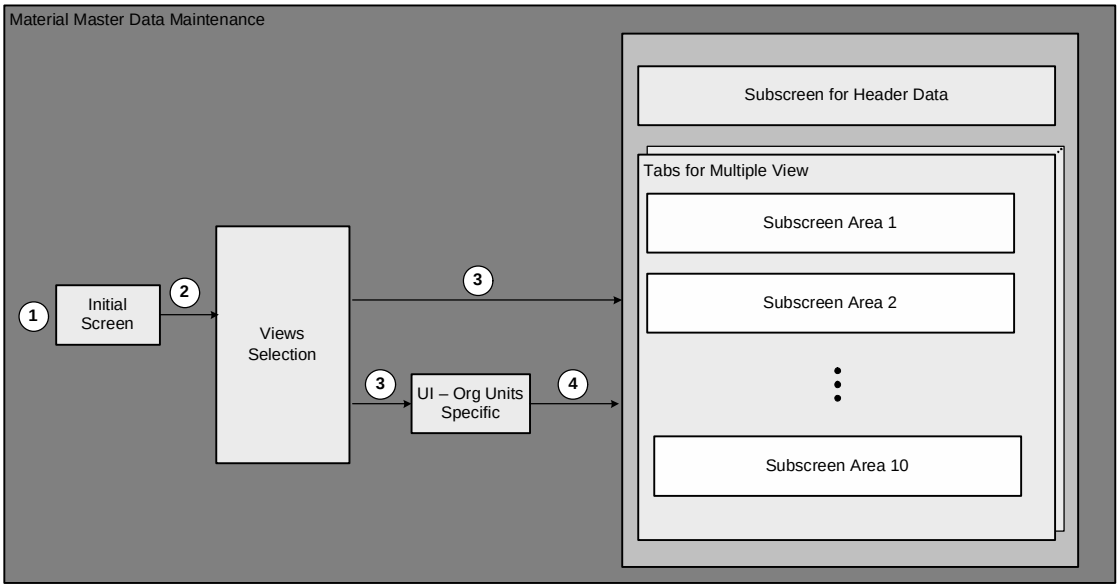

Figure 3-2 Screen Sequence in Material Master

3. The view sequence controller checks whether the selected views require the maintenance of additional organization-specific data. If yes, a corresponding maintenance view is displayed. For example if the purchasing view is selected plant data needs to be maintained and for sales views a sales organization is required.
4. Now the view sequence controller displays the main maintenance screen, which consists of a sub-screen for material master header data and a tab strip offering multiple views. Each view is implemented by an ABAP Dynpro screen, which consists of one or more sub-screens. The sub-screens are used to group fields.

The relationships between the views, screens, and sub screens are defined in customizing. The customizing also allows creating industry-specific materials, such as article in retail.

When displaying a view the field selection logic determines the properties of the fields. In customizing every field is assigned to a field selection group which defines whether the field is hidden, displayed, mandatory, optional, and so on.

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3.2.2 Authorizations

Typically in enterprises the material master data maintenance is distributed across different departments. For example the sales department is responsible to maintain the sales attributes and the purchasing department maintains the purchasing views of material master.

Thus it is required that certain views and even attributes are only maintained by certain users. To do so, all views and attributes which should be accessible altogether share the same maintenance status (see figure 3-3). For example all views which display sales attributes have the maintenance status “sales”.

Maintenance statuses are also defined for individual attributes. For example the attribute “purchasing group” belongs to purchasing and is not relevant for sales. Hence this field will not appear on a sales view. But if “purchasing group” needs to appear on an accounting view for some reason the field has the maintenance status of both purchasing and accounting.

At runtime when performing authority checks a user can only see and maintain the views and attributes which are assigned to him using the maintenance status.

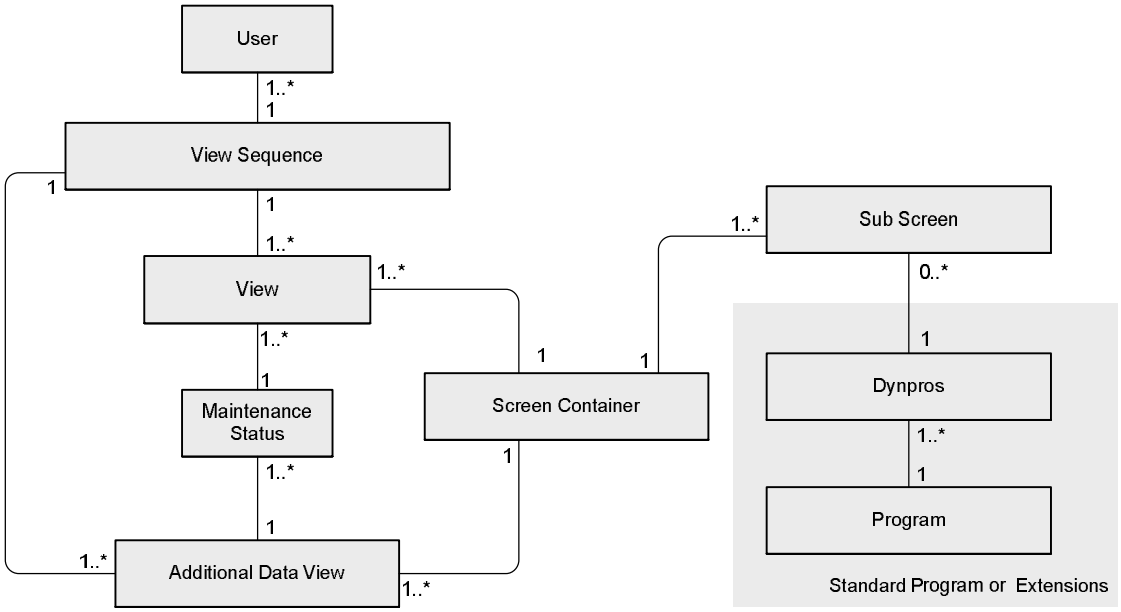

Figure 3-3 Views and Maintenance Status

3.3 Database Design of Material Master

The database design of material master reflects the view concept (see figure 3-4).

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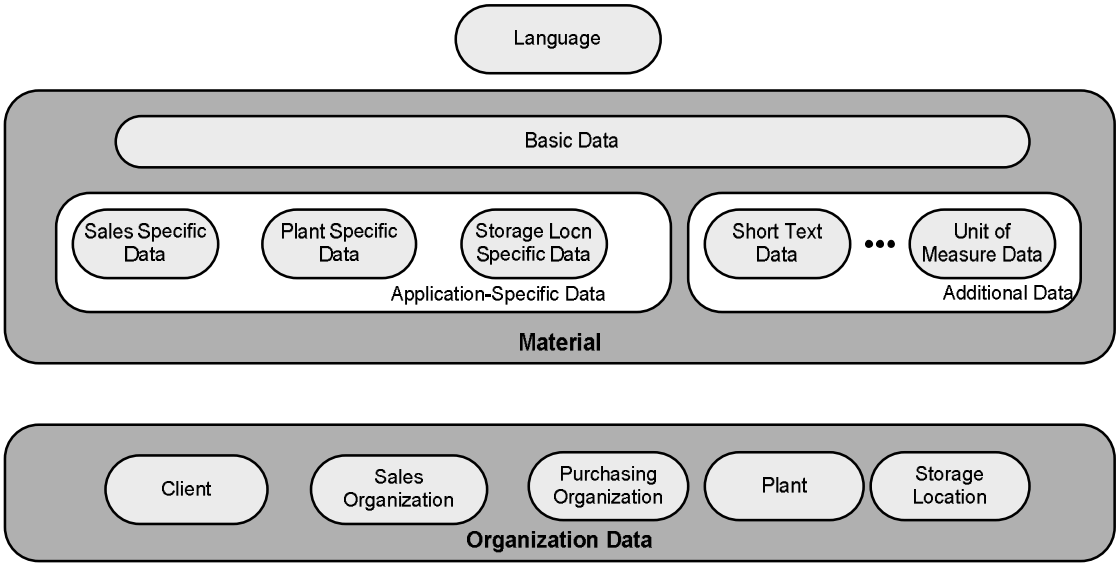

Figure 3-4 Database Table Structure of Material Master (see also Appendix 12.1)

There is one central table (MARA) which stores the material ID and references multiple tables with more specific data (see figure 3-4). These tables can be categorized in three types:

- Basic data: these tables store the header data of material master, such as material group and dimensions of the material (gross weight, net weight, volume).
- Additional data: these tables store specific common attributes, where a material has typical more than one values. For example there is a table to store all units of measures and another for storing material short texts in multiple languages.
- Application-specific data: these tables store attributes relevant for a specific application context. Typically these tables correspond to views or sub-screens on the UI. Examples are sales data, plant data, and storage location data.

In addition the organizational structure of the enterprise influences how material master data is distributed across different tables. For example the basic data and the additional data are common across all organizational units. The application-specific data is maintained based on the selection of the organizational unit chosen from the view popup (see figure 3-2). If for example the plant 0001 is entered, meaning the material can be maintained only for the plant 0001 and the plant specific tables are affected. This data however can be accessed only if the plant 0001 is used by the application. The same holds true for all other organizational units like sales organization and storage location. The view together with the organizational data determines which tables store the information of the material.

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4 Business Partner Master Data

A company has different business relationships with different business partners. In dependence of the relationship the business partner acts as a customer, vendor, employee, or contact person. Within a business transaction a specific business partner can fulfill multiple functions. For example SD deals mainly with selling products and services to the customer. The different functions of a customer in a sales process are the following:

- Sold to party
- Bill to party
- Ship to party
- Payer

In SAP ERP OPS these functions are called partner functions. They are assigned to a partner type, which is for example customer, vendor, and logistic provider.

The different SAP ERP OPS applications store the business partner master data for their partner type separately. So SD owns the customer master data, MM owns the vendor master data, LE owns the logistic provider master data, and so on. There is no central business partner storage and maintenance like for material master data (see chapter 3). However there is some central functionality which is re-used by the master data of all partner types:

- Partner determination
- Address management

Partner determination is used to determine the partner functions and their values which are required by a business transaction. For example sales order processing triggers partner determination to get the mandatory partner functions that includes sold to party, bill to party, ship to party and the payer and other partner functions (like forwarding agent) if determined and also the corresponding partner address that needs to be used.

Address management is a framework for storing and retrieving address data which belongs to business partner master data.

4.1 Partner Determination

As the partner functions vary for different business document types the superset of partner functions for a specific business document type is defined by a so-called partner determination procedure. At runtime partner determination determines the partner functions required in the specific business context.

Partner determination is called during the processing of header of business documents, such as sales order, purchase order, and delivery. In the following we use sales order processing as an example to describe the architecture of partner determination.

When a sales order is created, the customer name is entered as sold-to party. To do so, the user can select an existing customer master data record or create a new one. Then sales order processing calls partner determination, which performs the following steps (see figure 4-1):

- Partner procedure determination selects the partner procedure which is valid for sales order
- Sales order header processor triggers partner determination logic for the selected partner procedure

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- Partner determination logic evaluates customizing rules to identify which partner functions are required for the current sales process, for example ship-to party, bill-to party, and payer and what is the data source (for example customer master) to determine each partner function.
- Partner determination logic calls central address management to retrieve the address data which correspond to the address numbers.
- The data is copied to the sales order document.

The partner functions can also be passed on to pricing or output determination for further usage.

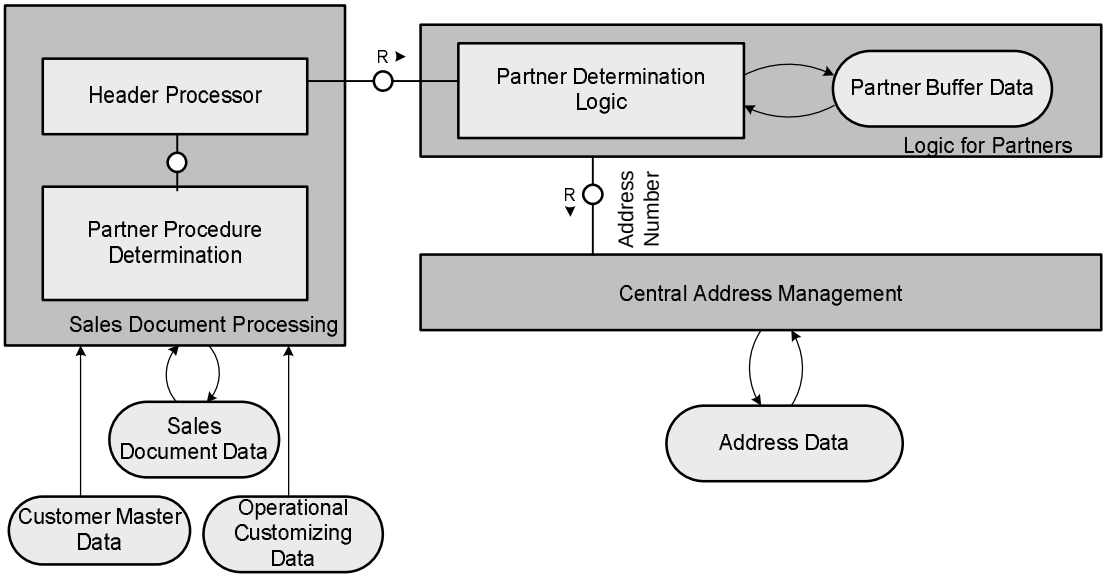

Figure 4-1 Partner Determination and Address Management used in SD

5 Sales and Distribution

The Sales and Distribution (SD) application of SAP ERP OPS provides the necessary functionalities to sell products and services to customers. This includes sales order processing, creating delivery and shipment documents, delivery monitoring, billing, and also returns handling.

5.1 Architecture Overview

To provide the required functionality SD contains four main components (see figure 5-1):

- Sales order processing
- Delivery processing
- Outbound shipment processing
- Billing

Sales order processing is responsible for creation, update, and persistence of the sales order documents. It triggers availability check and pricing calculations as well as delivery.

Delivery processing creates delivery documents for a sales order document. It triggers shipment, monitors the delivery, and finally initiates billing.

Outbound delivery processing takes care of the transportation of the ordered products to the customer.

Billing creates and sends the customer invoice. It is closely integrated with the SAP ERP FIN application, where the received payments are tracked.

All sales documents such as sales order, delivery, and invoice use material and customer master data.

In the following the SD architecture is explained by describing a standard sales process.

5.1.1 Pre-Sales Processing

SD allows sales departments to perform pre-sales activities via inquiries and quotations. If a potential customer asks for example about the details of a product or price, the sales department creates an request for quotation (RFQ) document (also known as inquiry) using the pre-sales processing component (see figure 5-1). The response of the sales department is documented as quotation with a reference to the RFQ document. The quotation contains already information such as price of the product and discounts. Output determination (see chapter 5.3.3) is used to identify the communication channel (e-mail, letter, fax, B2B message) with which the quotation is sent to the customer. In addition SD provides functions for maintaining the sales activity data, contact persons, interested parties, promotions, and competitor data.

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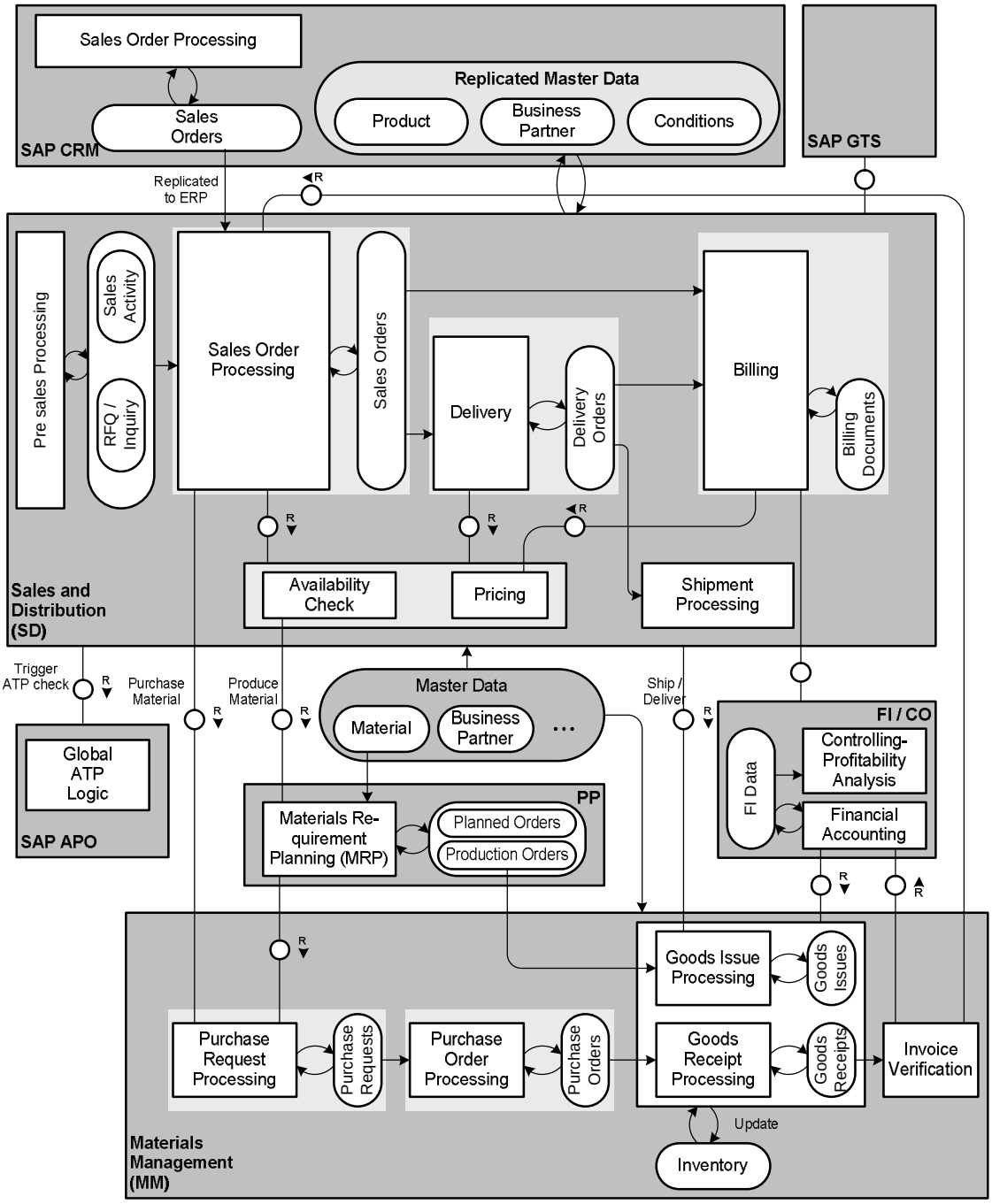

Figure 5-1 Architecture Overview of Sales and Distribution

5.1.2 Sales Order Processing

The most important activity in the sales process is the creation of the sales order document which is the first step towards the actual sale of a product. The sales order document is structured in header, items, and schedule lines which store the following information:

- Sales Order Header:
  - Sales order ID and type
  - Customer name and address
- Sales Order Item (one or more):
  - Products ordered by the customer

- Quantity of the product to be delivered
- Schedule line for each separate delivery which includes quantity to be shipped, date of delivery, and ship to location

Header, item, and schedule lines are stored in separate database tables. The header can have multiple items and each item can have multiple schedule lines. The characteristic of an item (for example standard item or third party item or a free item) is defined by the item category. Likewise the characteristic of the schedule line is determined using the schedule line category.

A sales order can be created by converting a purchase order document into a sales order or by referencing a quotation. In both cases data such as customer and product data, is taken over from the original document.

When a sales order is created, the sales order processing component triggers various functions like price determination, checking the availability check of the requested product, and partner determination to identify involved partners (see chapter 4.1).

If the requested products are on stock sales order processing informs outbound delivery processing for delivering the products to the ship-to-location. If the products need to be procured from a third-party vendor sales order processing creates a purchase requisition and sends it to materials management (MM). If the products need to be produced in-house sales order processing transfers the requirements to materials requirement planning in production planning (PP).

5.1.3 Outbound Delivery Processing

Delivery processing prepares the shipment of the ordered products to the ship-to location by creating the outbound delivery document. The delivery document is created with reference to the sales order. While creating the delivery document the shipping point which embraces the loading point and the persons responsible for delivery is determined (see chapter 8). Delivery processing triggers picking of the ordered products from stock, packing them and finally shipping them. Each step is documented in the delivery document.

If the products need to be transported to the customer, delivery processing initiates shipment. Else it initiates goods issue processing in MM to update the inventory. In the inventory the quantity of material is reduced by the products sold and delivered.

5.1.4 Outbound Shipment Processing

Shipment processing which embraces transportation planning and execution is provided by logistics execution (see chapter 8). During this process the outbound shipment document is created which contains all deliveries which are shipped together. Shipment processing determines the way of transportation, such as flight, truck, or train, the route, but also the responsible logistic provider or forwarding agent. This information is stored in the shipment document together with the references to the deliveries.

All costs that are raised by the transportation are recorded using the shipment cost document (SCD). The freight costs or the shipment costs settlement is possible only after the outbound shipment document is created. After the products have left the plant or warehouse, shipment processing initiates goods issue processing to update the inventory in MM.

5.1.5 Billing

When the customer has received the ordered products, which is tracked in delivery processing by the proof of delivery document, billing is performed. During billing invoices for the delivered products are created. A billing document is generated in this process which facilitates the payment processing by the financials. The automatic G/L account determination happened during the billing to debit the customer receivables account and credit the revenue account.

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The billing document is created either with reference to the sales order or the outbound delivery document. The invoice is then sent to the customer by mail, fax, e-mail as determined by output determination.

5.1.6 Returns Order Processing

Customers can return a product delivered in case it does not fit their expectations or is damaged. SD supports handling these returns using the returns order. The returns order is a sales order of a particular type which is created with reference to the existing sales order or billing document. Returns order processing creates then a returns delivery, where the receipt of the returned material is documented. At last a credit memo is posted to billing which pays the customer back.

5.2 Integration

5.2.1 Integration within SAP ERP

SD is integrated with PP, MM, and SAP ERP FIN using database integration. SD transfers requirements to PP in order to trigger in-house production of the material sold. PP is responsible for planning the production, monitoring the execution of the production and for reporting the produced materials to update the stocks in inventory management. The sales order reserves the quantity through the availability check functions and when the material is delivered to the customer the stock is reduced and the corresponding requirements in the PP are reduced and reflect in the stock monitors.

If the material is not produced in-house but procured from a third-party vendor, sales order processing creates a purchase requisition directly and passes it over to MM (see figure 5-1), where the purchase requisition is converted to a purchase order and sent to the vendor.

The billing document generates financial postings in FI. FI is responsible for getting the payments from the customer. The controlling-profitability analysis (CO-PA) of SAP ERP FIN is updated with the details of the revenue and the cost from SD functions for analyzing the profitability of the company.

5.2.2 Integration with SAP Business Suite

SD can be integrated with the following applications of SAP Business Suite (see figure 7-1):

- SAP CRM
- SAP SCM that includes SAP APO and GTS

SD can be used in combination with SAP CRM. In this case sales orders are created in SAP CRM and the SD functions are called in the SAP ERP OPS to fulfill the order requirement. This is done by the replication of the sales order in the ERP and the follow-on process happens in the ERP from delivery to billing. Once the billing is done the billing status is updated in the SAP CRM sales order from ERP. This is done via the CRM middleware component which is a part of the SAP CRM. The middleware is responsible for the handshake between the SAP CRM and SAP ERP OPS.

Another aspect is the master data replication, the customer master and the material master data in the SAP ERP OPS are replicated to the business partner data and the product master (which has additional fields compared to material master) respectively in the SAP CRM. In addition, the condition masters are also replicated both ways. However, a change to the conditions is only possible by the system which created the conditions.

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The SD functions like availability check (see chapter 5.4 for more details) can be triggered in the SAP APO systems as SAP ERP has certain limitations like the check is carried out in the local inventory and the system always assumes infinite capacity is available for the production of the material. The SAP APO provides additional features such as search on alternative locations propose alternative products and check against actual production plan taking into account the capacity constraints.

5.3 Pricing

For every product or service sold, as well as procured a price is required. The sales organization decides the price with which a company sells a material or service to a customer (selling price) and the purchasing organization decides the price at which a material or service is procured from the vendor (cost price).

But a price is not just a fix number. The overall price of a material (net price) consists of a base price (gross price) plus for example taxes, discounts and surcharges which may vary from customer to customer depending on the nature of business, location, and so on. In addition, the price of a material depends on the market and varies from time to time based on external parameters, for example tax regulations and seasons.

SD provides a pricing component to define, manipulate, and retrieve pricing data for day to day business operations. In pricing the different factors which influence a price are called pricing elements. These are for example taxes and discounts. When sales order processing requests a price, the pricing component first provides the base price that's maintained for the material. Afterwards it calculates the net price based on the various pricing elements, which have to be taken into account. This eliminates the manual determination of the price for a material. However the price that's automatically proposed by the pricing component can also be overridden manually.

The pricing component was originally provided for SD, but is now also reused in MM. The following explanation focuses on pricing in SD.

5.3.1 Condition Determination in Pricing

From an architecture perspective the main challenge is to offer a framework which is on one hand flexible enough to perform the different price calculations which enterprises require, while on the other hand operates accurate and with high performance. To achieve this condition technique has been developed.

Basically a condition defines a rule to determine a certain result value. The result value depends on selected influencing factors (such as customer, customer group, and material) and is valid for a specified period. An example of a typical condition is: the gross price of material A between certain dates of validity from vendor A will be 1 EUR / 1 Kg.

The condition determination technique is based on a look-search-match strategy:

- Look up which tables contain relevant conditions
- Search the identified condition tables in a predefined sequence
- Match every record in the condition tables with the input parameters

The condition technique is such a successful approach, that it is not only used for pricing, but also for other use cases where a result value has to be determined based on multiple influencing factors and rules. Examples are account determination and output determination.

The following example illustrates how price conditions are maintained and determined (see figure 5-2). In this example the requirement is to find the base price for material A provided for pricelist 01.

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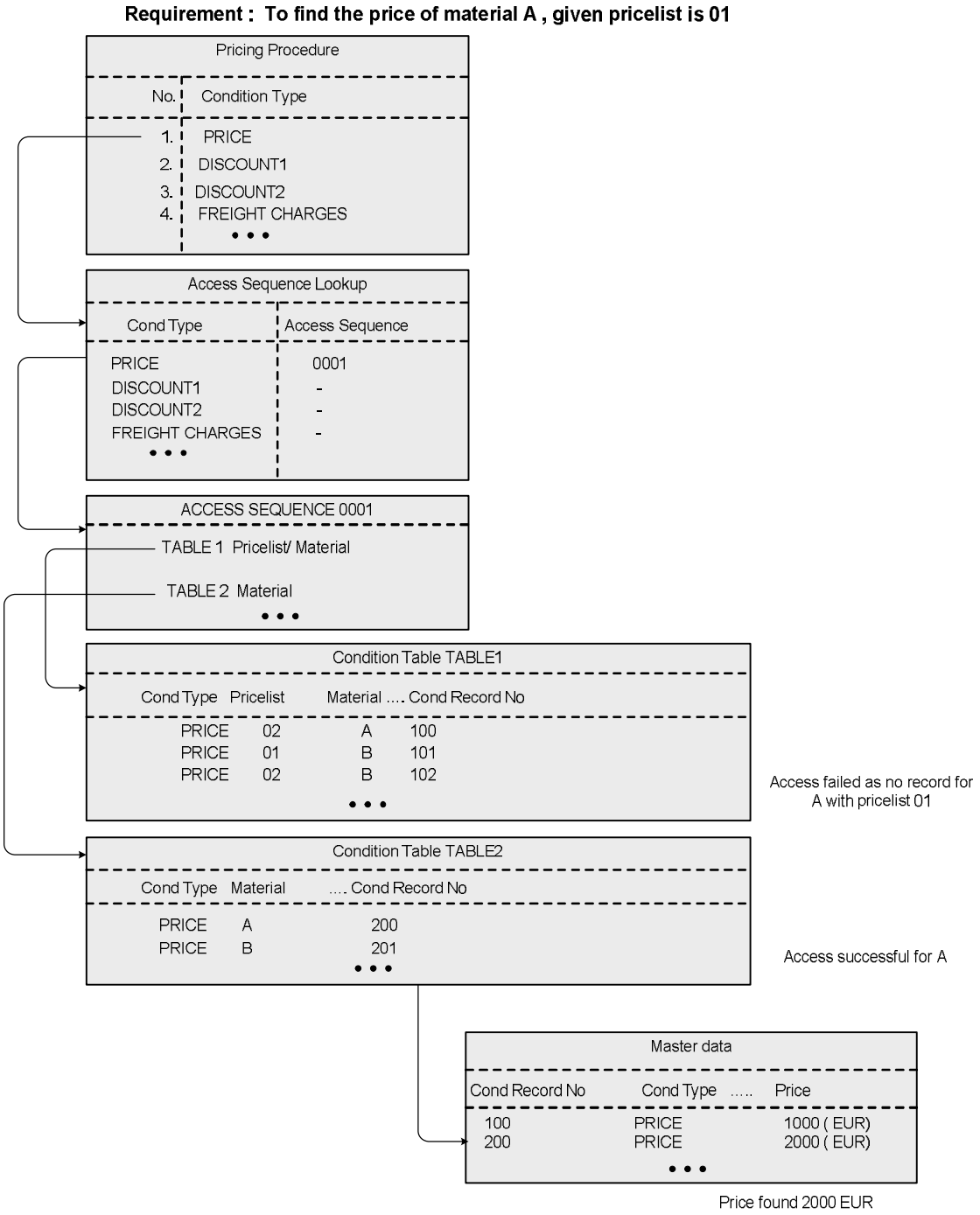

Figure 5-2 Condition Technique - Example

The requirement then has to be matched with every record in the tables defined for access, in the above example condition table TABLE1 and condition table TABLE2 are accessed.

The different pricing elements (price, discounts, freight charges etc) are stored as condition types. The pricing procedure (aka pricing schema) embraces all condition types that can be used in business transactions. The pricing procedure can be customized to the company's needs.

The condition determination technique starts with the pricing procedure (see figure 5-2). In our example the expected result value is the price (base price). So first condition determination checks in the pricing procedure table if "price" is listed as condition type.

In the next step condition determination has to identify all tables which store conditions for price. In the example there are exactly two condition tables for price: TABLE1 and TABLE2**.** The question is which should be searched first.

The sequence in which condition tables should be searched is defined by the access sequence which is stored in the access sequence lookup table. Condition determination determines the access sequence and starts to search the corresponding tables. Once a condition record is found which corresponds to the input parameters, the system will not access further condition tables.

When defining the access sequence it is important to define the tables that need to be searched in a way that the maximum number of key field combinations is searched first, followed by the next smaller key field combination and so on. In the above example material and plant have the biggest number of key combination of condition table 1 and only material is the key for the condition table 2, so the sequence in the example is first condition table TABLE1 and then TABLE2. Every record in a condition table that's used for matching is called condition record. The key fields in the condition tables are called access keys.

In our example the input parameters price and material A are met in TABLE2, where plant-independent conditions are listed. The actual price of the material is maintained as master data (see figure 5-2). When the matching is successful the condition record number is used to get the price value from the corresponding material master record. In our example 201 is the condition record number, so the price of material A at plant 001 is 2000 EUR.

5.3.2 Pricing Architecture

In SD pricing is triggered by sales order processing (see figure 5-3). When a sales order document is created, sales order processing determines the pricing procedure based on the parameters defined in customizing like sales order document type and sales organization. Each sales order document has only one pricing procedure.

Each time a material is added to a sales order item, sales order processing sends a request to the pricing engine. There the pricing pre-step logic calls the condition processor reuse layer to get the pricing relevant customizing data such as condition types used in the schema and access sequences. The pre-step logic loads these tables into the pricing buffer. The buffer is used to improve performance, especially when multiple prices need to be calculated.

The pricing logic is then responsible for getting the result values of the condition types that are required by the sales order. For each condition type the pricing logic sends a request to the condition processor to determine the actual value based on the condition technique (for details see chapter 5.3.1).

The base price is retrieved from material master data.

In pricing, the condition processor is used to determine the pricing procedure and its condition types. For condition types with complex rules, such as base price and net price, access sequences and condition tables are evaluated.

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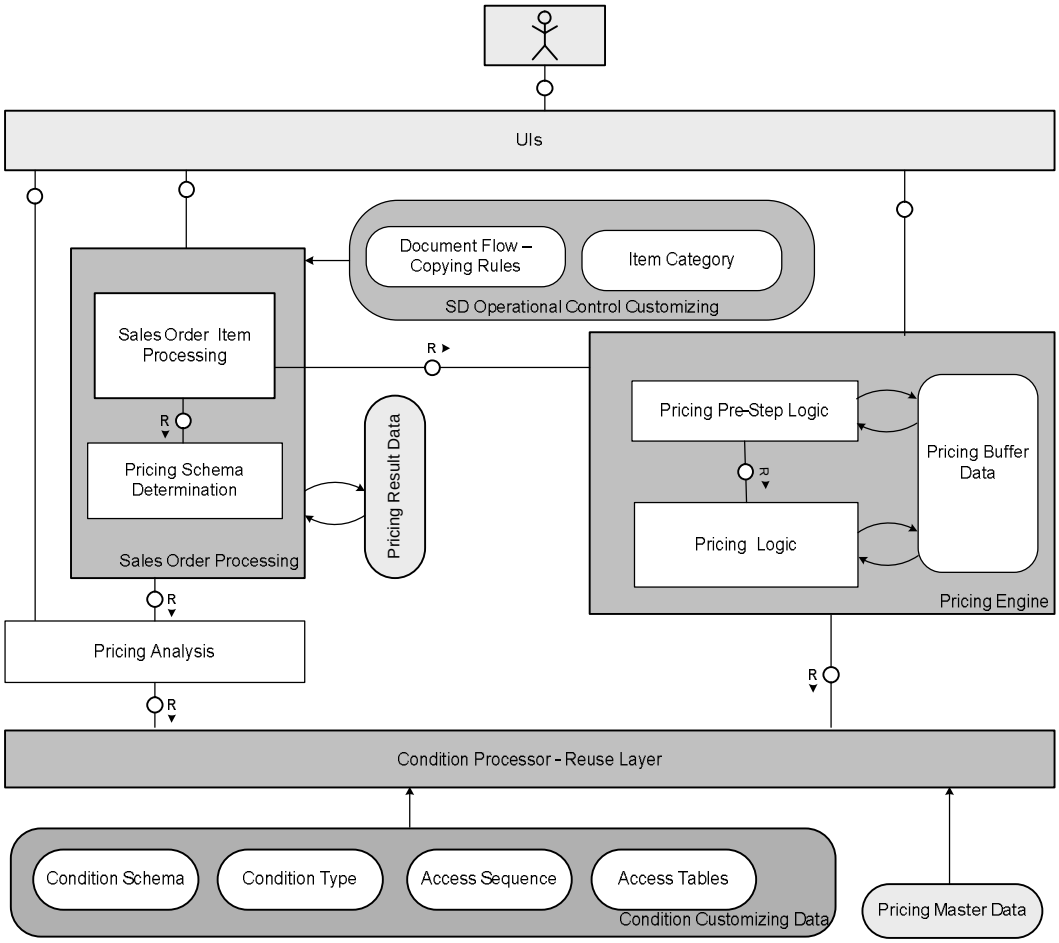

Figure 5-3 Architecture of Pricing

Finally the pricing engine sends the complete selling price together with the individual values of the different condition types (gross price, discount, etc) back to sales order processing. The result of the price calculation is made persistent within the sales order document (see figure 5-3).

The pricing engine provides ABAP Dynpro sub-screens that can be reused by applications that provide pricing functionality. In addition it provides a pricing analysis tool which is used by pricing experts for analyzing the price calculation process for the specific sales order document, such as the condition types that were used, the condition tables that were accessed at runtime, and the table from where the price was picked up.

In customizing the copy rules for pricing from source document to target document are specified. For example when a delivery is created with reference to sales order the pricing conditions are automatically copied to the delivery. In addition the item category determines if the pricing functions at all have to be triggered in the first place. For example in case of free goods pricing is not relevant.

5.3.3 Condition Determination Technique - Reuse

The condition determination technique is used in SAP ERP OPS not only for price determination, but also for other use cases, where a value needs to be determined based on defined rules.

Currently condition determination is used for the following usage (see figure 5-4):

- Pricing
- Output control
- Account determination
- Material determination / exclusion
- Taxes
- Free goods/Bonus buy

To distinguish between the different calling applications the condition determination processor requires as input the application, which sends the request, as well as the intended usage. Thereby usage defines the function which uses the condition technique for example pricing, output control, and so on. Since it can make a difference for condition determination, from which application it has been called, this information is required, too. For example pricing can be triggered from the application SD and MM, but with different condition tables. Every usage and application has their own condition data maintained in customizing (see figure 5-4): The condition determination processor can only access data that belongs to the application and usage, which sends the request.

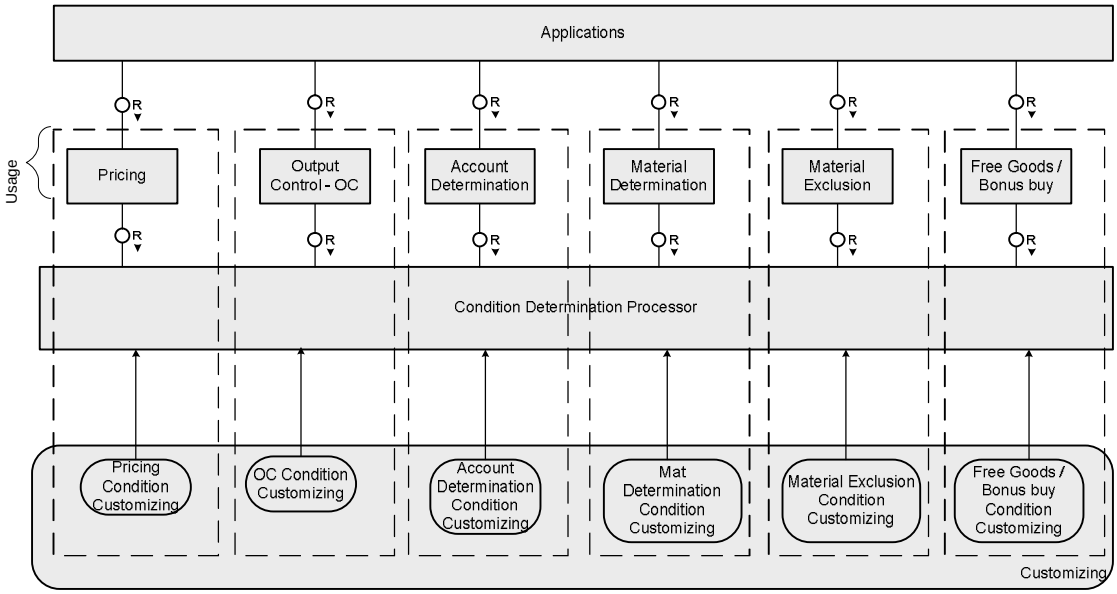

Figure 5-4 Reuse of Condition Determination Technique

Figure 5-5 shows the relationship between usage, application, condition type, access sequence, and condition tables (for details on condition type, access sequence, and condition tables, see chapter 5.3.1).

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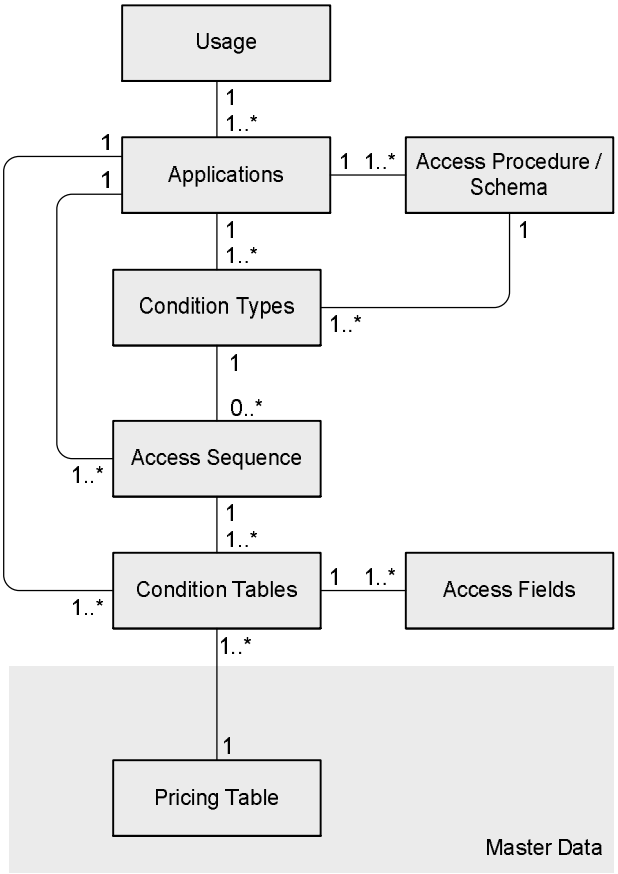

Figure 5-5 Conditions Customizing for Pricing

In the following we explain one other important usages of condition technique, which is output determination.

5.3.3.1 Output Control

In SAP ERP OPS can perform communication with business partners (Business-to-Business, B2B) using letter, fax, e-mail, or electronic message exchange. To figure out which communication medium should be used in a specific business transaction, output control is used.

Output control is based on two process steps (see figure 5-6):

- Message output determination that uses condition technique
- Actual output of the messages via EDI, print or fax

The message determination is controlled via a message output schema that every message type is assigned to an access sequence which is a search strategy to find the output record from the set of condition tables.

Afterwards message output assembles and sends messages according to the input from message determination. The following figure 5-6represents the message determination and processing.

All the applications that require performing B2B communication uses the message based communication which is based on the condition technique. The message determination reuses the condition technique to find the appropriate message type and format for the current business transaction. The first step in any of the above transaction is to determine the message output schema that is valid for the current transaction. For example the purchase order can have a schema totally different from the sales order. The schema consists of a set of

output message types for example purchase order printout, reminder, and goods receipts slip. Once the message output schema is determined the application calls the message determination logic. The message determination logic prepares to call the reuse condition technique that results with all the valid conditions for the current transaction.

The result is an output record which defines the communication medium, the number of copies, and the time at which the message should be sent. The results are proposed back to the transaction and also stored in the message status table which acts as a reference for the message processing logic.

The message processing logic is a separate program that is used to run immediately or can be scheduled for a certain point in time. This program picks up the result from the condition determination. The message processing logic constructs the application data at runtime from the entries of the message status table. Based on the processing medium like printer, EDI or fax the processing logic then calls the respective processing routines which finally dispatch the message to the recipient. The status is also updated in the message status table.

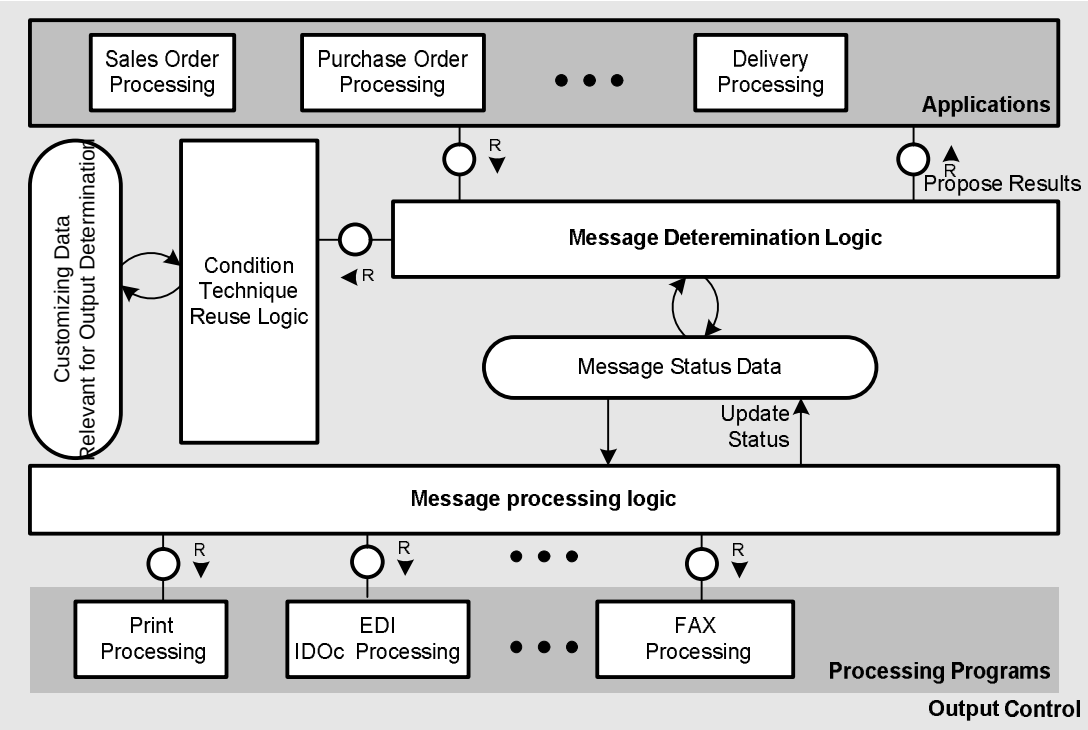

Figure 5-6 Output Control

In case of EDI processing, the output is an iDoc (Intermediate document) that is sent electronically to another SAP or a third-party system. iDoc's allow different application systems to be linked via a message-based interface. An iDoc consists of three important sections

- Control record (has details about the sender, receiver etc)
- Data record (application data)
- Status record (IDoc created, successfully sent, failure etc)

In this case the sender and receiver systems have to be set up initially for IDoc transfer. The system that sends the IDoc output is called the outbound system and the system that receives the IDoc is the inbound system. The message determination and dispatching happens from the outbound system where the message processing logic calls the outbound function modules to map the application data structure to a standard structure which the other system understands. In this case the message determination just determines the output type as IDoc and all the processing is done by the IDoc processing logic.

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5.4 Availability Check

When a customer places an order, he expects the requested amount of material to be delivered on a certain date to his destination. So the selling party is interested to check, when the requested material is available to be shipped to the customer. For this purpose SD provides the availability check, which performs basically the following:

- Check in the inventory, if the material is on stock. If not check if the material is produced or procured and when it will be available
- Check if the material is reserved for another customer or for inspection

Finally availability check calculates the date, at which the material is available in the inventory. This date is referred to as the material availability date (MAD). The final delivery date displayed in the sales order however takes also time for packing, loading, and transportation into account.

The availability check is intensively used by sales order processing in SD, but also called from MM, PP, and LE. As an alternative to the availability check provided by SD, sales order processing can also call the availability check provided by SAP APO.

SD provides the following basic methods to perform the availability check:

- Availability check on the basis of the available-to-promise (ATP) quantities

  The ATP quantity is calculated from warehouse stock, the planned inward movements of stock (receipts) documented in production orders, purchase orders, planned orders, and the planned outward movements of stock (issues), such as sales orders, deliveries and reservations.

- Availability check against planning

  The check against planning is performed against independent requirements which are usually created for an ‘anonymous’ market. These requirements result from demand planning and are used for planning expected sales quantities independent from individual sales-orders.

- Availability Check against product allocation

  Product allocation facilitates period-based distribution of products for certain customers (or customer groups) or regions. This ensures, for example, that when production is low, the first customer does not get the full amount, resulting in following sales orders not being confirmed or being confirmed far too late.

Sales order processing usually uses the availability check on the basis of ATP quantities, in short called ATP check. In the following the architecture of the ATP check is explained.

5.4.1 Availability-to-Promise Check

When a sales order is created a sales order item is added for each material the customer orders. The quantity of material requested by the customer at a certain delivery date is stored in the schedule line of the corresponding sales order item. The schedule line category defines if the ATP check needs to be carried out or not. For example for schedule lines of a returns order no ATP check is executed.

When the ATP check is performed for a schedule line, the material, the quantity, and the delivery date requested by the customer are used as input. ATP check performs now the following steps:

- Check in the inventory, if the requested quantity is available
- Check if there are planned receipts of the material by evaluating goods receipts, stock transfer orders, planned orders, production orders

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- Check if material will be procured by evaluating purchase orders
- Check if there are already requirements from other sales orders which reserve quantities of the material
- Check if the material is reserved by production planning
- Retrieve from material master how long it takes to procure or produce the material

As output the ATP check calculates the available quantity for the requirement date. Additionally the material availability date is calculated. If no quantities can be confirmed then zero quantity is returned. If only partial quantities are available then ATP check proposes the partial quantity as confirmed quantity.

When the requested delivery date of the customer can be confirmed, sales order processing reserves the amount of material by storing a requirement. A requirement describes which quantity of material is needed by a sales order at a certain point in time. So in this context requirement means a kind of material reservation.

The requirements are used by the ATP check logic to make sure that quantities that are already reserved for other sales orders are not taken into account when confirming quantities for a new sales order.

Requirements are also used by PP and MM to provide the requested material in time. This process is called transfer of requirements (TOR) and it triggers either the production or the procurement of the requested material. Once the material is available in the inventory the corresponding requirements are deleted. The material is ready for delivery.

5.4.1.1 Control Parameters to Activate ATP Check

As mentioned there are three types of availability check which are supported by SAP ERP OPS (see chapter 5.4). In order to trigger the appropriate availability check the following control parameters have to be evaluated (see figure 5-7):

- Requirement type
- Requirements class
- Checking group
- Checking rule

The requirement type defines whether the requirement is a customer requirement, non-customer requirement (independent requirement that comes as a demand) or warehouse requirement.

The requirement class defines the type of availability check. For sales order processing it ensures that the ATP check is carried out. In addition it defines, if the requirements has to be passed to production or not. The second scenario is used, when an ATP check is executed without reservation.

How a requirement is passed to production is defined by the checking group. So for example the checking group can define, that requirements should be collected daily or weekly and then transferred or that individual requirements for each sales order should be handed over.

The checking group together with checking rule determines the scope of the availability check, for example what type of stock should be considered and what type of orders should be taken into account.

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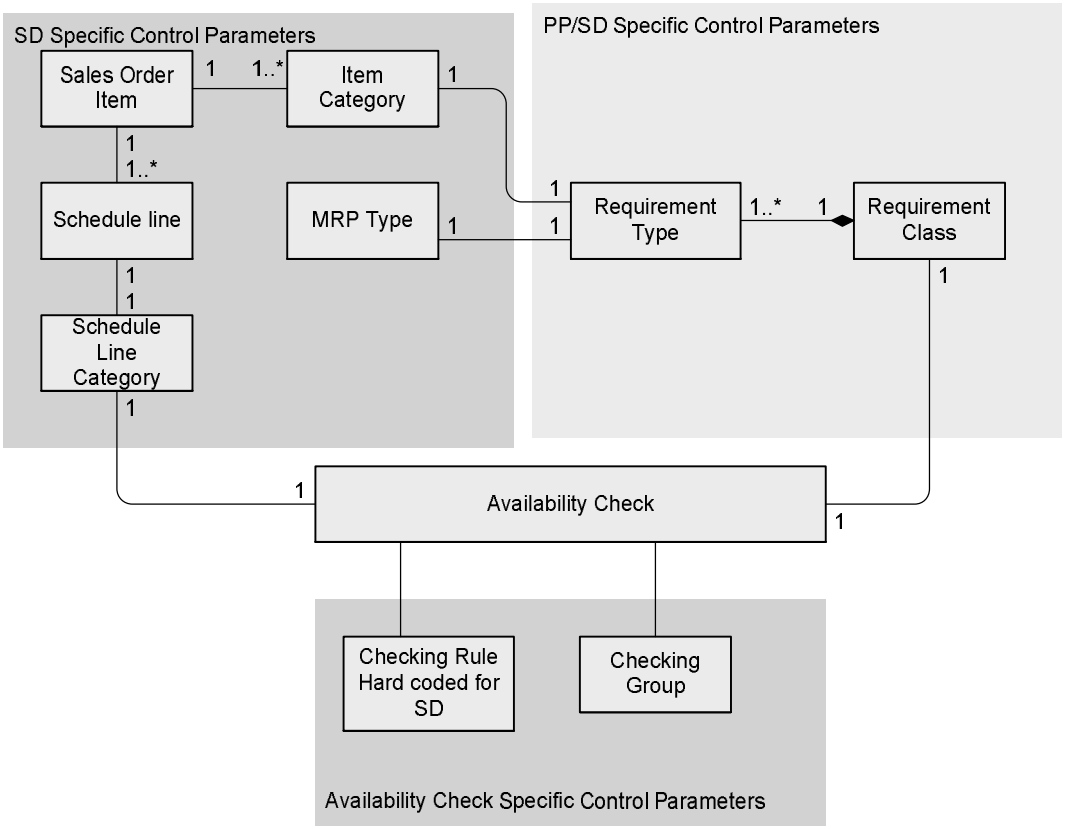

Figure 5-7 Control Parameters for Availability Check in SD

Figure 5-7 shows the relationships between the different control parameter and in addition the SD and PP components that are required to facilitate the transfer of requirements to production. Each item category together with material requirement planning (MRP) type determines the requirement type. MRP type is a procedure that determines how the material has to be planned. For example if the material has to be planned based on forecasting , reorder etc. This information comes from material master. Every requirement type is associated to a requirement class in the customizing. As requirement class is general there can be many requirement types that a requirement class contains.

The requirement class has the option to activate the availability check. Much finer control of the availability check can be obtained through the schedule line category. The other parameter that also has to be considered for the check is the checking rule and the checking group. Every material has a checking group associated to it and the information of the checking group comes from the material master data.

5.4.2 Architecture of ATP Check

The request for an ATP check can be sent from different sources for example sales order processing in SD, stock transport order processing in MM or from external requested by a BAPI (see figure 5-8). The ATP logic is encapsulated inside an ATP controller that acts as a service provider.

There are three options for performing the ATP check:

- By the local SAP ERP system
- By an connected ATP server which is called via RFC
- By SAP APO which performs a global ATP check

The server-based set up provides better performance and scalability (see chapter 5.4.2.1). The global ATP check provided by SAP APO is not in the scope of this book.

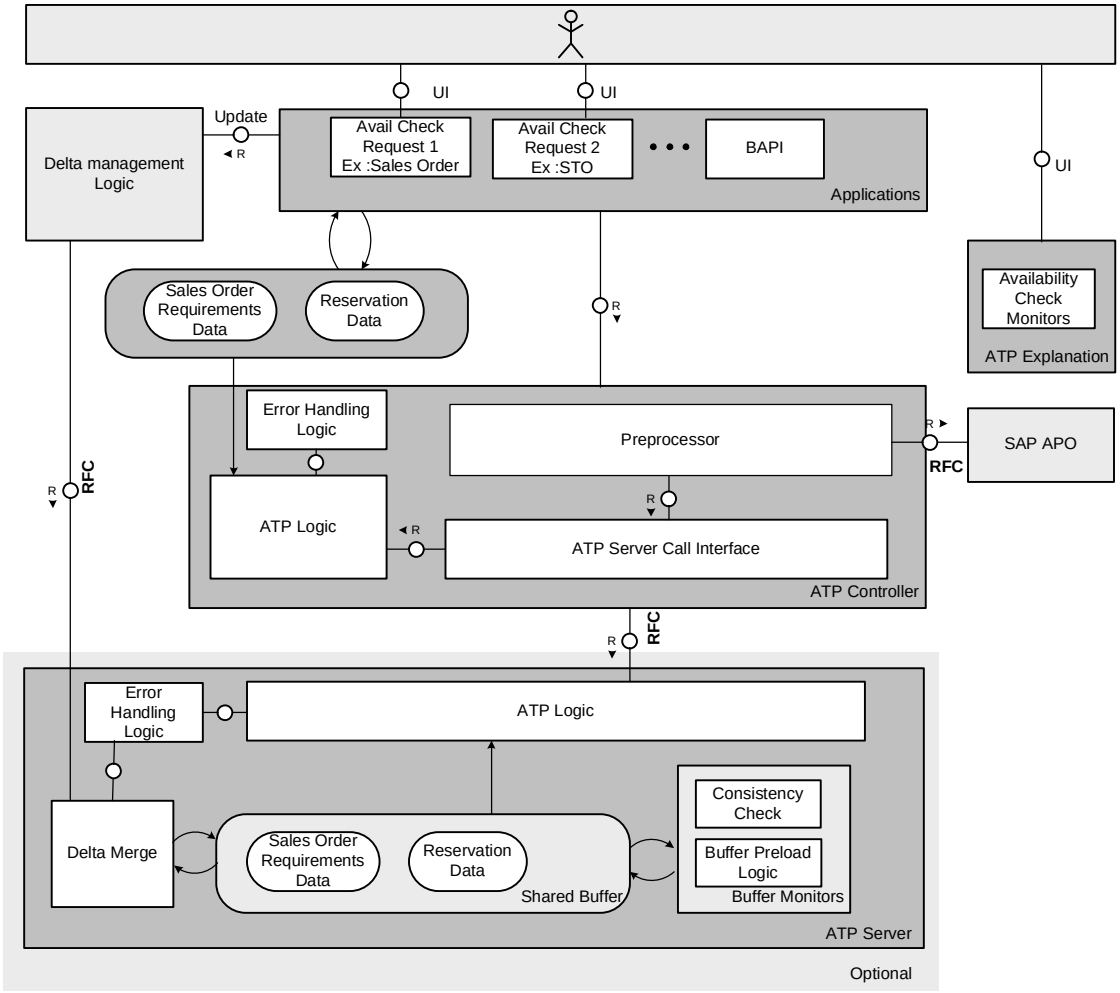

Figure 5-8 Architecture of ATP Logic

The ATP controller includes a preprocessor that determines whether the call has to be routed to SAP SCM APO. If not then the request is forwarded to the ATP server call interface. If a dedicated ATP server is connected, the ATP server call interface calls it via RFC. Otherwise the ATP logic is triggered locally within the ATP controller.

As mentioned during the ATP check the ATP logic evaluates the existing sales order requirements as well as reservations from production planning, transfer orders, purchase orders, production orders, and material master. The elements which are actually taken into account can be widely controlled via the ATP customizing (checking scope).

Based on this information the ATP logic determines if the material is available and if so confirms the quantity which is available to the proposed material availability date.

In addition the ATP controller takes care of error handling and provides transactions to monitor the results of the availability check.

5.4.2.1 Architecture of ATP Server

The ATP server is an option to improve the performance of the ATP check. It is an additional installation and configuration option of SAP ERP.

The ATP server improves the performance as a result of two features

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- **Shared Buffer**

  ATP-Server stores specific ATP relevant database information such as requirements and reservations in main memory thus eliminating expensive database reads during the ATP check.

- **Aggregation**

  When requirement records are loaded into the shared buffer they are stored aggregated by plant, requirement date, requirement quantity, and confirmed quantity.

Requests for ATP check is sent from the ATP server call interface to the ATP server via RFC (see figure 5-8). The calls are enqueued in the enqueue server (see figure 5-9). Hence it is a mandatory requirement to have an enqueue server attached to the ATP server.

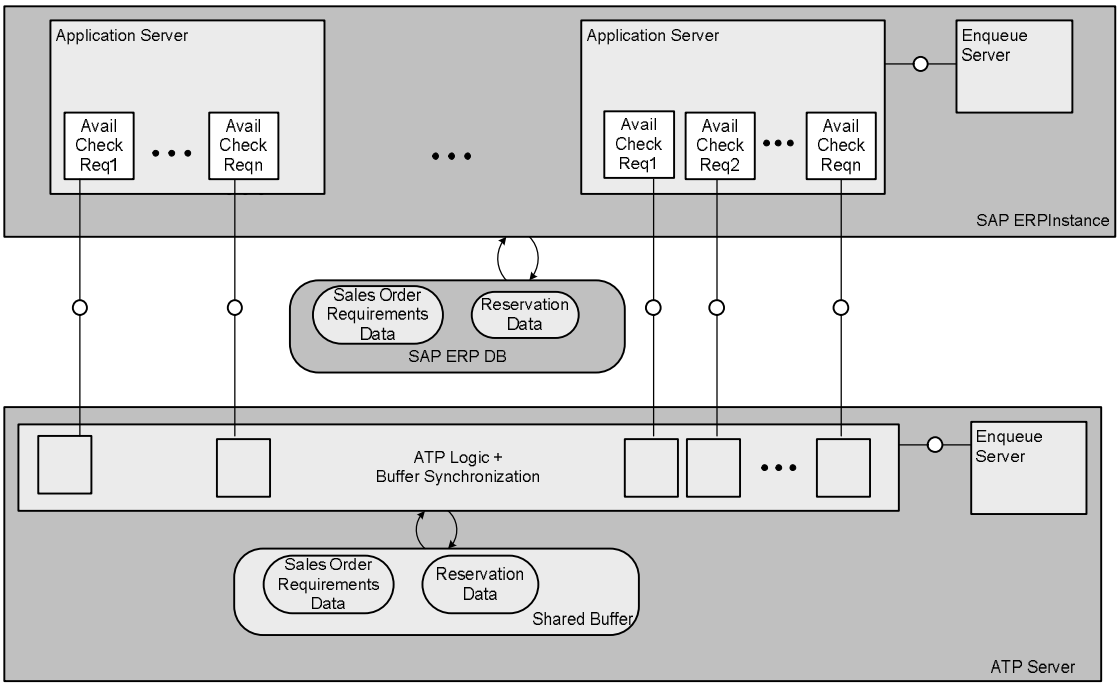

Figure 5-9 Architecture of ATP Server

The initial load in the shared buffer can happen by running certain tools already provided for ATP or as an alternative the administrator can manually load the shared buffer using the buffer monitor (see figure 5-8).When the availability check is in progress the buffered data needs to be locked so that no other application can modify the shared buffered data. The locks for buffered data are set within the ATP server's enqueue server. Once the availability check is finished the buffer is updated and the entries in the enqueue server are removed so that the next application can use the ATP logic.

The SAP ERP database and the ATP server buffer are synchronized using delta management. After sales order processing has executed the ATP check by calling the ATP call service interface it creates a requirement record to reserve the material and simultaneously updates the delta management (see figure 5-8). The delta management retrieves the old and the new data, aggregates the data and sends the information to the delta merge functions in the ATP server via RFC. The ATP server then updates the shared buffer. In this way it is ensured, that the ATP check is always performed on up-to-date data.

The ATP server takes care about error handling and provides tools to synchronize the buffer with the SAP ERP database in case of any inconsistencies.

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6 Production Planning

Manufacturing is the use of tools and labor to create finished goods from raw material or assembly parts. In SAP ERP OPS manufacturing processes are supported by the production planning component (PP) which makes sure that the sales demand is met by producing the requested materials in time. Logically PP in SAP ERP OPS can be divided into two functional parts:

- Production planning phase
- Production execution.

The basis for production planning is the sales plan, which defines the demand of a certain product over time. Production planning allows simulating and planning the production in a way that the required products are available for sale in time.

Production execution initiates and monitors the actual production. It triggers for example the procurement of raw material required for production, reserves material in the inventory for production, and initiates transfer of material from warehouse to production site. Production execution in PP does not control the assembly line or the shop-floor scheduling of the production site. But corresponding third-party applications can be integrated with PP using enterprise services or BAPIs.

Finally the produced material is listed in the inventory and put into the warehouse. For this PP is integrated with MM and LE.

Manufacturing is driven by requirements. A requirement is a quantity of a specific material that is needed on a certain date in a plant. Requirements can arise directly from a sales order (make-to-order) or from production planning (make-to-stock). In the first case the ATP-check which is initiated by sales order processing, creates the requirement (see chapter 5.4).

In different industries production planning and execution are processed in different ways. For example in process industries like pharmaceuticals the materials are produced and managed in batches (for batch management, see chapter 2.1.1).

6.1 Master Data

The master data that is required for production planning and execution is bill of materials (BOM), routing, work center, and material master. The bill of materials (BOM) is the complete list of components that make up a product or assembly. The list contains the component names, its ids and the required quantities. The BOM is required for all production planning and execution activities.

Within a plant the work center describes the place where a production operation is carried out. For each work center the production capacity (manpower and machines) is defined. Routing defines the list of the production operations to be performed, their sequence and various work centers involved in manufacturing the material.

The material master (see also chapter 3) provides separate views which include attributes required for producing the material. For example the material requirement planning view has all information related to the planning of that material like

- MRP type: is a configuration setting for the MRP planning program. This indicator differentiates whether the planning happens for the finished product or for sub-assemblies (see also chapter 6.3.4) or for all sub-components as well.
- Procurement type: defines whether material is produced in-house or procured externally
- MRP controller: person responsible to run the MRP in the plant

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The material requirement view of a material can vary from one plant to another.

6.2 Integration

6.2.1 Integration within SAP ERP

Production planning is integrated to SD and MM via database integration. SD triggers planning through the availability check in case there is not sufficient material to meet the customers demand. The planning program creates purchase requisitions or schedule lines in MM if raw materials have to be procured externally to start production.

Production execution triggers goods movement in MM (goods issue and goods receipt, see also chapter 6.4.2) to update the inventory. The production execution is also integrated to the subcontracting functions of MM for outsourcing the manufacturing operation to external vendors. In addition the financial documents are posted to SAP ERP FIN and the costs incurred during production are posted to the cost elements of SAP ERP FIN.

6.2.2 Integration with SAP Business Suite

PP can be integrated with the following applications of SAP SCM:

- SAP APO for planning
- Extended warehouse management (EWM) for execution

The SAP APO provides a high performance, memory resident data processor to perform planning and optimization. When the planning is performed by SAP APO production execution still happens in the SAP ERP system. The requirements can either be transferred from SAP ERP OPS to SAP APO or the global ATP check can trigger the planning directly in SAP APO. Planning in SAP APO takes the capacity situations into account. The planning results are then transferred to PP for execution.

EWM is used when separate warehouse management systems manage the inventory of the materials. In this case goods movement functions are triggered from EWM for posting the material movement data in order to record the material movement from warehouse to the production plant. Likewise the goods movement functions are triggered from EWM when the finished product is moved back to the warehouse.

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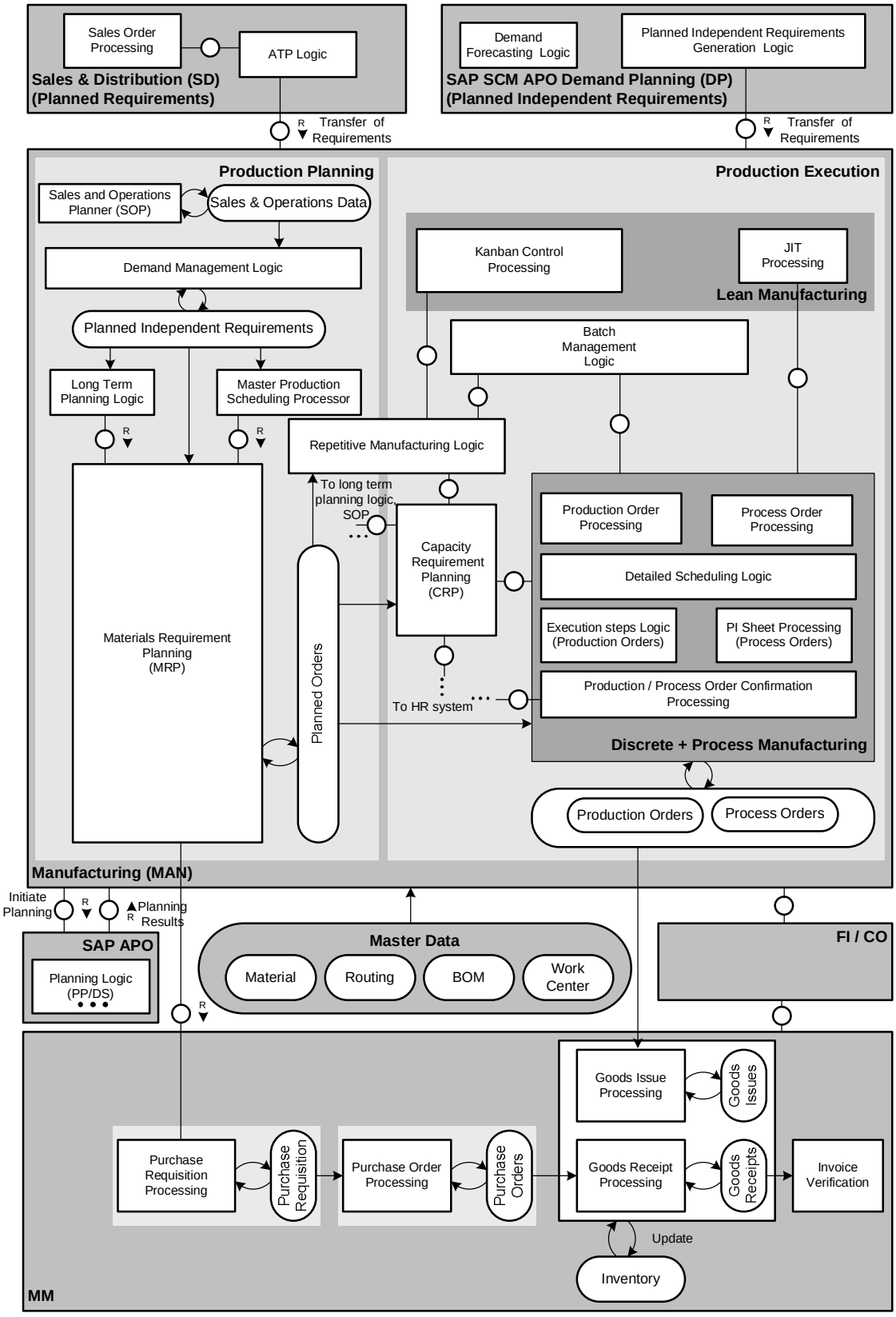

Figure 6-1 Architecture of Production Planning and Production Execution

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6.3 Planning Functions

Production planning includes multiple planning functions (see figure 6-1):

- Sales and operations planning (SOP)
- Long term planning (LTP)
- Material requirement planning (MRP)

The planning functions are performed top-down starting from forecasting the sales demand down to the planning of production orders with MRP.

6.3.1 Sales and Operations Planning

Sales and operations planning (SOP) provide functionality to create a sales plan and a corresponding high-level production plan. Within the sales plan SOP creates a sales forecast for a given planning horizon based on historical sales data such as market requirement statistics, sold products and trends. SOP proposes the quantity of products or product groups the company will sell in a certain future timeframe. When calculating this, SOP does not consider actual stocks and available production capacities.

In a next step SOP prepares a production plan, which checks if the sales plan is feasible by checking production capacities. As user interface SOP provides a spreadsheet as planning table. SOP supports the import of sales plan data from MS Excel.

A sales plan looks for example like this: an automobile manufacturer plans to sell 100 cars and 100 trucks in 6 months. In this case cars and trucks are different product groups. In the next step the product groups are planned:

60% of cars belong to variant A and 40% as variant B

50% of trucks are belong to variant C and remaining 50% variant D.

So finally the sales plan provides requirements, which say in 6 months 50 trucks of variant C need to be available, and so on. SOP transfers these requirements to the demand management logic for further planning. The SOP is performed at the product group level. For further planning they are transformed to planned independent requirements (PIR) by the demand management functions.

6.3.2 Demand Management

Demand management receives requirements from SOP processing via database integration. Demand management is used to create and maintain the planned independent requirements (PIR). The user interface for creating the PIRs is a spreadsheet where each row corresponds to the requirement quantities of the material in the day, month or week format for a plant. This is referred to as the planning period. Demand management translates the rough cut plan to the actual plan that can be used by MRP. The PIRs are stored as database records which form the basis for further planning. In doing so certain characteristics of the material like planning strategy, requirement type, consumption and plant responsible for producing the material are attached to the material information in the PIR. The planning strategy could be different for every material and is maintained in the material master.

Demand management takes requirements from sales orders in the PIR into account. Based on the requirements type, the quantity of planned independent requirements is reduced by the quantity from incoming sales orders. This is called consumption and is reflected in the stock monitor. However the physical reduction of the quantity from the database happens during the goods movement. Based on the PIR all further planning steps, such as long term planning, master production scheduling, or material requirement planning (MRP) happen (see figure 6-1).

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6.3.3 Long Term Planning

Long term planning (LTP) checks the feasibility of the sales plan created by SOP. It checks, if the available production capacities are sufficient to make the sales plan happen. The LTP forecasts also stock and capacity situation which helps users to decide early in the planning phase whether additional work centers and machines are required. The result of LTP is simulated planned orders.

Technically LTP is a simulated MRP run and the same MRP logic is reused. LTP takes into account additional parameters which are defined in a so called planning scenario. This allows the planner for example to forecast the raw materials demand and plan the procurement process well in advance, or to see how the planning is affected when there is a change in BOM by creating separate planning scenarios. Finally the best planning scenario one can be transferred to MRP, which transforms them into a planned order and initiates production or procurement.

The results of LTP are also used by the purchasing to identify the sources of supply for the material well in advance and negotiate long term agreements with the vendors. LTP does not create purchase requisitions. The LTP has an interface to the capacity requirement planning (CRP) for calculating the capacity requirements and plan the budgets required for producing the product.

6.3.4 Master Production Scheduling

Master production scheduling (MPS) is used to plan the production of material that greatly influences the company's profits or take up critical resources with extra care. The material master data differentiates whether a material is relevant for MPS or MRP.

MPS creates the master production schedule for a material and its components (first level of BOM). The master production schedule data can be changed manually to trigger different simulation runs.

Finally MPS creates planned orders according to the master production schedule. In addition MPS creates single level dependent requirements based on the BOM of the planned order. For example for the production of a car the wheels, the engine, and the steering wheel are dependent requirements. MPS considers only the components listed on the first level of BOM, components listed below are planned only by MRP.

MPS reuses the MRP logic except that only the first level BOM is exploded. Generally the MPS is done at the finished product level or for important sub assemblies.

6.3.5 Materials Requirement Planning

The final step in planning is material requirement planning (MRP). MRP is a planning tool for the raw material and assembly components which are required to produce a certain product in a given plant.

MRP goes top-down through the BOM of the material to be produced. Initially it plans the net requirement of the material to be produced. Then the planning continues on detailed level, which means all components listed in BOM are considered. For each component listed in BOM MRP creates a dependent requirement. MRP checks for each requirement, if there is enough supply of each component for the production. If not, MRP makes sure that the right quantity is available at the right time in the inventory. To do so, it creates either a planned order to produce the missing components or a purchase requisition in order to procure them. If the first level of BOM is already planned by MPS, then MRP takes only care about the rest.

In contrast to MPS, MRP does not consider the production capacity of the plant.

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MRP receives planned independent requirements from demand management or MPS. During MRP material master data is evaluated. The MRP views of material master for example define the procurement type (in-house production or external procurement) and the goods receipt processing time. In addition the routing and BOM master data is also used by the MRP logic.

The MRP logic has to make sure that the same material of BOM component is not planned again. This is ensured through a so called planning file which is an input queue for the MRP logic. The planning file is a record that consists of the materials that are relevant for planning. The MRP run happens only for the materials in the planning file. Once the material is planned the entries are deleted from the planning file.

The planning file is updated from many places by those applications that change the material planning status, for example when

- A new material is created with the MRP view,
- The MRP logic itself deletes the planning file entries once the planning is done and creates a planning file entry for the dependent requirements during BOM explosion in order to plan for all the components
- A sales order requirement quantity changes, then the planning is updated for the new quantities.

In general any application that could change the planning status of the material updates the planning file so that the MRP run is up to date.

MRP logic calculates the net requirement of material in order to satisfy current or future stock shortages and generates either a planned order (in case of in-house production) or purchase requisition (in case of external procurement). The following explains the steps in the MRP logic in more detail (see figure 6-2)

- The first operation of the MRP is to check if entries for materials exist in the planning file.
- MRP selects the first entry in the planning file and prepares internally a table to calculate the current stock situation in the warehouse for the material. To do so, it evaluates all requirements and receipts of the given component. Receipts are documented for example in production orders, purchase requisitions, purchase orders, and goods receipts. Requirements are documented by sales orders and PIR.
- The system calculates net requirements for every material. For this calculation, the system checks whether the requirements are covered by the warehouse stock and dispatched receipts from purchasing or production. If the requirements cannot be covered, the system creates a procurement proposal.
- The system calculates procurement quantities. When doing this, the system takes into account the selected lot-sizing procedure and, if necessary, scrap and rounding values
- Lot sizing determines how the requirement quantities must be handled. For example in case of the fixed lot sizing if the lot quantity is 1000 for material A, and if the MRP net requirements calculates a demand of 500 for material A, then the procurement proposal is created for 1000 units. The remaining 500 units will be consumed later when subsequent requirements are generated for material A. MRP performs lot sizing based on the lot sizing procedures which are maintained in the material master (for examples see figure 6-2)
- The MRP carries out the scheduling in order to calculate the start and finish dates for the procurement proposals taking into account the procurement lead time, production time, and the goods receipt processing time, which is maintained in the material master.

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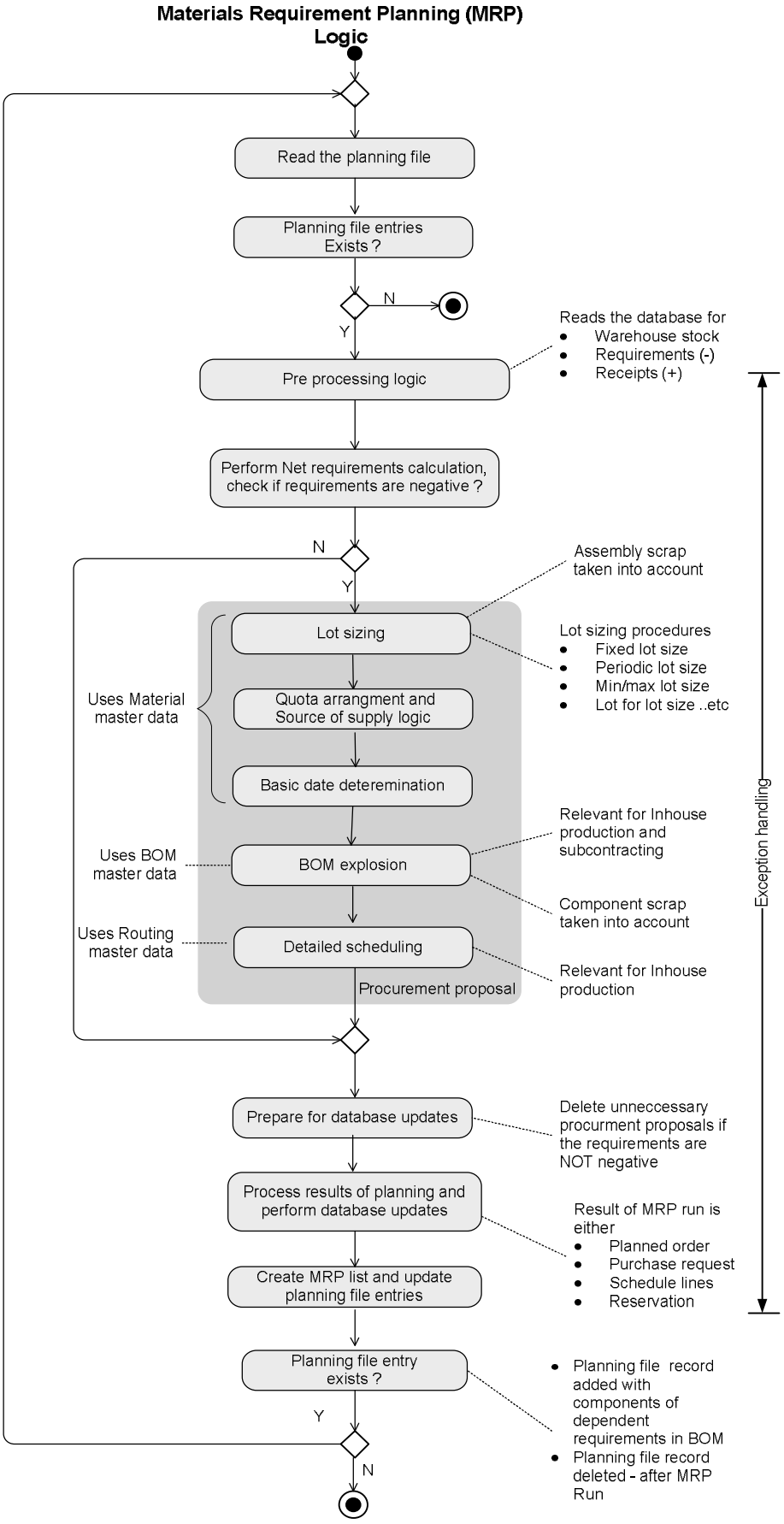

Figure 6-2 Material Requirement Planning

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- The MRP then determines the type of procurement proposal. Dependent upon the defined setting, planned orders, purchase requisitions or delivery schedules are created by the system for a material.
- If necessary entries for quota arrangements are maintained, then the system also determines the source of supply and allocates this to the procurement proposal. To do so, MRP calls the MM interfaces.
- For every procurement proposal of an assembly, MRP explodes the BOM and determines the dependent requirements.
- Then MRP Performs detailed scheduling which reads the routing data where the exact time of the operations and the average time to complete the production of a material are maintained. With this data a detailed scheduling happens and the basic start and end dates are adjusted (increased or decreased) accordingly.
- Finally MRP prepares the tables to be updated and creates a planned order, purchase requisition, schedule lines or reservations. Then the planning file is created for the planned dependent materials during BOM explosion and the material that is planned is deleted from the planning file.
- MRP reads the planning file and checks if there are any further materials or components that need to be planned. The planning run is over when there are no more entries in the planning file.

During the planning run, the system recognizes critical situations that have to be assessed manually in the planning result. The system creates exception messages that are collected and logged at every phase of the MRP run. The MRP logic doesn't react to any of the exception messages or in other words they are not handled. It is just to bring to notice to the MRP controller to decide whether or not to react to the exceptions.

6.4 Production Execution

Production is executed in different ways in different industries. PP supports:

- Discrete manufacturing
- Process manufacturing
- Repetitive manufacturing (REM)

Discrete manufacturing (aka shop floor production) describes the production of single, distinguishable products. Manufacturing manages this kind of production using production orders (see chapter 6.4.1).

Process manufacturing is characterized by batch-oriented production of products in the process industry (for example chemicals, pharmaceuticals, food). For managing this kind of production manufacturing uses a specific type of production order called process order and batch management.

Repetitive manufacturing is characterized by the interval-based and quantity-based creation and processing of production plans. With repetitive manufacturing, a certain quantity of a stable product is produced over a certain period of time. The product moves through the machines and work centers in a continuous flow. Repetitive manufacturing is suitable for a variety of industries, such as electronics, semiconductors, and packaging.

Discrete, process, and repetitive manufacturing also can be used for pure make-to-stock production. Production in this case has no direct connection to a sales order. The requirements are created by demand management and the sales orders are supplied from stocks. The material master data settings determine if a material is to be produced by means of repetitive manufacturing.

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The BOM for the material to be produced specifies how many units of which components are required for production. In repetitive manufacturing, not every goods issue is recorded at the same time as the physical withdrawal of the material from stock. The component usage is automatically posted only when the finished product is received. This is called back flushing. To do this, a storage location is specified in every BOM item, and the back flush is carried out for this location.

6.4.1 Production Order Processing

Once the planning phase is over, the actual production execution starts. To do so, production order processing creates production orders based on the planned orders from MRP. A production order can be created directly from a sales order or manually, too (make-to-order scenario). In all cases production order processing retrieves the information necessary for production from the planned order or sales order as well as from the following master data:

- Material master which for example defines the production process
- BOM which lists all the components required to produce the final product
- Routing which embraces the operations involved in producing the final product
- Work center which provides information about the tools and machines required for production

In production execution the production order is the central business document used for controlling and monitoring the production process in the shop floor. It includes the following attributes:

- Production start date
- Production end date
- Bill of material (BOM)
- Operations to be performed to produce the final product
- Capacity required for producing the material
- Status of the production (such as work in progress, completed, and so on)
- Information about costs involved in the production for later settlement
- Production resources and tools (PRT) for producing the material

The production order passes through a number of different stages. Beginning with the order creation, which is usually performed through the conversion of a planned order, it involves a number of functions like availability check on the raw materials, capacity planning, order releasing, order printing, order accounting, followed by production order confirmation and order settlement. When a production order is created, production order processing performs the following activities:

- Select appropriate routing and include operations and sequences into the production order.
- Explode BOM of the material to be produced and include components into the production order.
- Create a reservation for each BOM component kept in stock
- Calculate planned order costs
- Create capacity requirements for the work centers
- Create purchase requisitions for all BOM components, which are not on stock
- Create purchase requisitions for production operations which are performed by a third-party

The production order processing is integrated with the inventory management of MM and the warehouse management of LE for material staging (see figure 6-3). If the company uses warehouse management the production order triggers the creation of transfer requests.

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Warehouse management transfers these requests into transfer orders which ensure that the raw material and components required for production are supplied from the warehouse to the shop floor in time.

Production order processing needs to reserve in the inventory the raw material and components which are needed to execute the production order. MRP creates this reservation for the planned dependent requirements derived from BOM. When production order processing converts the planned order into a production order it creates reservations for the dependent requirements. The components and raw material, which have to be taken from stock, are reserved in the inventory for the production order. This is done by the production order processing logic.

Finally the production orders are subject to release which is the starting point for production workers. The order can also be printed and made available to the shop floor. The reserved material can be withdrawn only after the order is released.

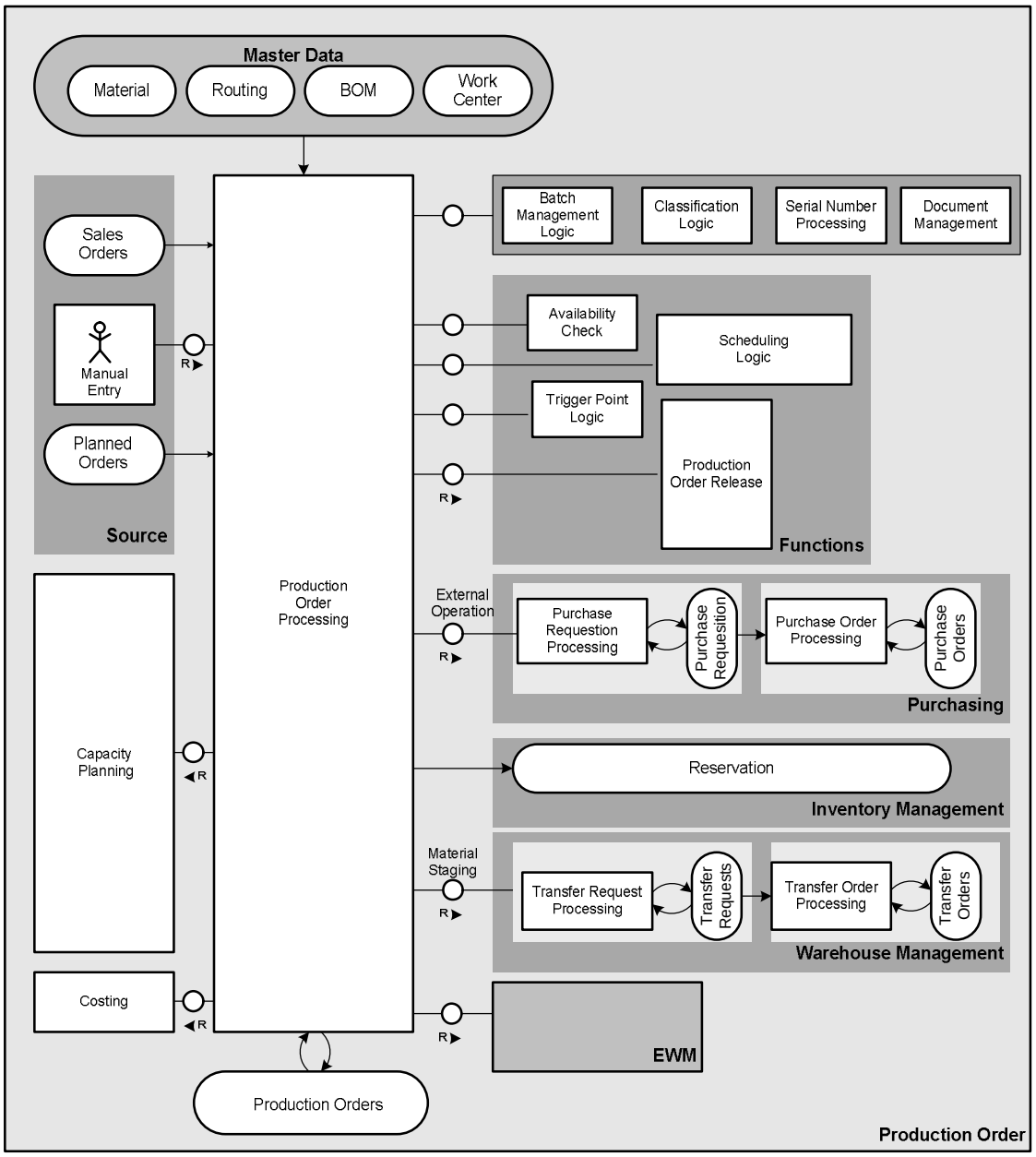

Figure 6-3 Architecture of Production Execution

6.4.2 Production Order Confirmation

Production order confirmation processing records the actual status of the production based on the production order. The status information of the production confirmation includes the following:

- Produced quantity as yield and scrap
- Activities leading to actual costs
- Work center that was involved in the production
- Person responsible for the execution of the operation

The production order confirmation is a separate document which references one production order or an operation of a production order. The master data that is required for its processing is the material master data and the work center data to record the work center responsible for production.

Production order confirmation processing triggers goods movement. The finished product is updated in the inventory via the goods receipts processing and a goods receipt document is posted. The quantities of the components that were used for producing the product are updated in the inventory via goods issue processing. This is called back flushing of materials. The FI/CO documents are posted during the confirmation.

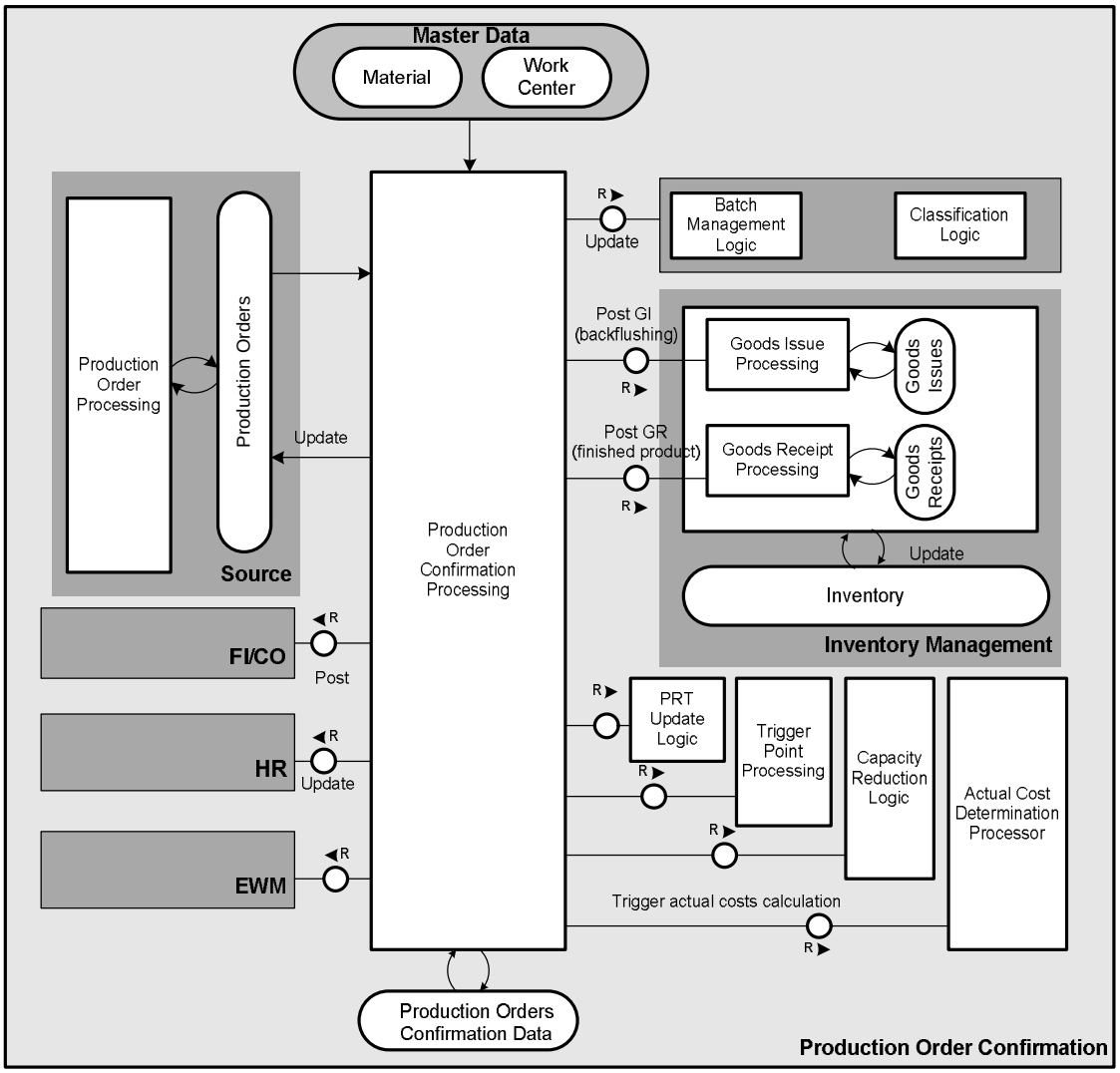

Figure 6-4 Architecture of Production Order Confirmation Processing

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The confirmation updates the following

- Production order with the status, quantities and the activities that were performed to complete the production
- Batch characteristics of material if the materials are handled in batches
- Capacity requirements via capacity reduction logic
- Production resources and tools (PRTs) equipment data
- Costing data from activities leading to cost for cost settlement
- HR data like person responsible and time taken for operation is passed to SAP HCM

Unexpected events which disturb the production for example machine breakdown calls the trigger points which initiate follow up actions such as new operations.

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7 Materials Management

Enterprises procure materials and services to run their business. Within SAP ERP OPS materials management (MM) focuses on the procurement needs of an organization. MM supports the procurement of materials as well as services, manages the inventory, and performs invoice verification to check and issue payment to the vendors. The business processes in MM affect the financial accounting of SAP ERP FIN, which is therefore tightly integrated with MM.

External procurement supports procuring material or services from an external vendor or from a supplier who delivers the goods or services. The purchasing organization holds the responsibility of managing the procurement process.

Within MM the following business documents are a part of the procurement process (see figure 7-1):

- Purchase requisition (PR)
- Request for quotation (RFQ)
- Contracts
- Scheduling agreement
- Purchase order (PO)
- Goods receipt document
- Service entry sheet (SES)
- Invoice

The purchase requisition is a document that informs the purchasing department in an enterprise about the demand to procure certain material or services. The purchasing department is then responsible for identifying an appropriate vendor. For a single purchasing transaction a request for quotation is sent to the vendor to negotiate the price. For regular purchases from the same vendor contracts and scheduling agreements are stored in MM which describes the terms and conditions with the enterprise have negotiated with the vendor.

To actually procure material or service, purchase orders are created referencing the purchase requisition (see figure 7-1) or the corresponding outline agreements (contracts and scheduling agreements.

When the material or services are delivered the goods receipt or service entry processing takes place. Afterwards invoice verification happens based on the invoice sent by the vendor. If the invoice verification is successful finally the payment is made to the vendor which is triggered by SAP ERP FIN.

Procurement of material and of services is based on the same architecture. The procurement of services is implemented as an extension to the original material procurement functionality.

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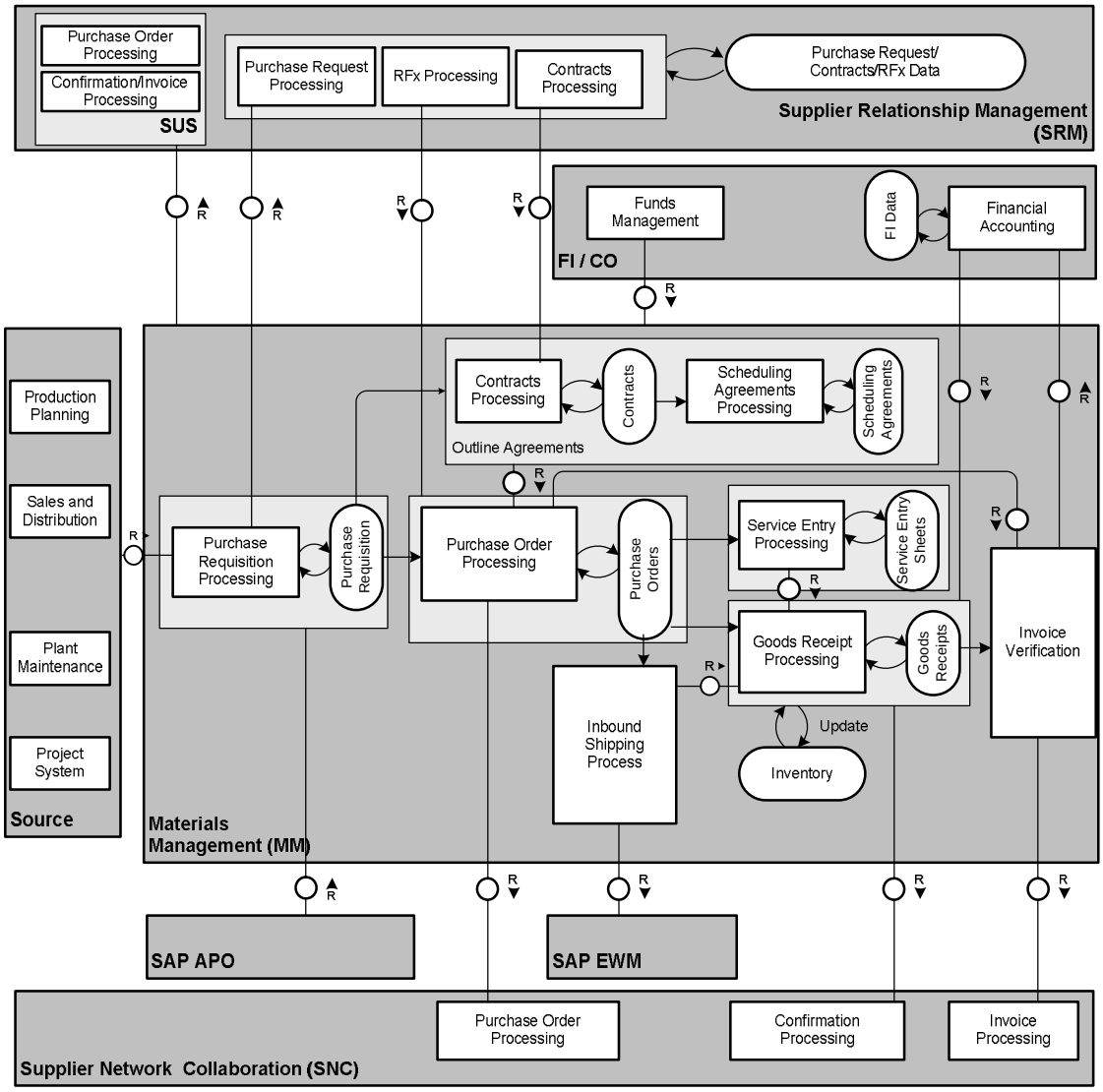

Figure 7-1 Architecture of Materials Management

7.1 Procurement of Materials

Materials owned by the company are managed in the inventory. All goods movements are monitored and updated in the inventory. When additional material is required, a purchase order is created first (see figure 7-1). The purchase order includes information about the vendor, the amount and type of material requested, and the requested delivery date.

When the material is delivered from the vendor goods receipt processing starts. Within that process a material document is created which contains all details about the material, its movement type, posting date. The material document references the initial purchase order. In this way it is tracked, if the purchase order is fulfilled. During goods receipt processing the quantity and the value of the inventory is updated, too.

The goods issue processing initiates the financial postings (financial document) to update the value of the material in the balance sheet general ledger (G/L) accounts

If the received material is damaged or of the wrong type the goods receipt process can be reversed. In this case the material is sent back to the vendor, the inventory gets updated, and the material document and the financial document are also reversed.

Once the delivery is completed and the invoice from the vendor is received invoice verification takes place. During this process the invoice is compared with the purchase order and the goods receipt document. If the check is successful payment is triggered via financial accounting.

7.2 Procurement of Services

The procurement of services, for example construction of a floor, fitting of electrical equipments, and cleaning, differs slightly from the procurement of material because for services no inventory has to be managed. First the purchase order is created and sent to the service provider. Now instead of a goods receipt an entry of services is maintained after the services are provided by the vendor (see figure 7-1). To do so, a service entry sheet is created based on the purchase order. The service entry sheet is used to track the actual services performed by the vendor. Follow-up processes such as invoice verification and financial accounting are only triggered after the complete service entry sheet is accepted. Typically this happen, when all services of the service entry sheet are provided.

Once a service entry is accepted, then internally the good receipt processing functionality from material procurement is reused. This means a material document is generated, and financial data is transferred to ERP financial accounting to trigger payment. If the services are not provided properly, the service entry sheet can be revoked, which also reverses the material document and the financial postings.

After service entry the invoice is matched with the material document (invoice verification) and then a payment process is initiated via financial accounting.

7.3 Integration

7.3.1 Integration within SAP ERP

MM is closely integrated with SD, PP, Project Systems and Plant Maintenance using database integration (see figure 7-1). All these applications create purchase requisitions together with their business documents (store them in the same logical unit of work) So when a sales order is created and the material ordered is not produced by the company itself, sales order processing creates a purchase requisition directly to procure the material. Similarly material requirement planning in PP creates purchase requisitions for material which need to be procured in order to produce the planned products.

SAP ERP FIN is also integrated using database integration. SAP ERP FIN is triggered by goods receipts processing in MM. SAP ERP FIN is responsible for the payments to the vendor. Before the payments are made invoice verification happens. To do so, invoice verification compares the invoice sent from the vendor with the purchase order and the goods receipt. SAP ERP Fin only initiates payment to the vendor is the invoice verification is successful.

Controlling and budgeting of procurement is managed by the funds management component of SAP ERP FIN. This component is linked to MM to track the cost and to make sure that the budget allocated for the procurement doesn't exceed the overall budget.

7.3.2 Integration with SAP Business Suite

MM can be integrated with the following applications of SAP Business Suite (see figure 7-1):

- SAP SRM
- SAP SCM that includes SAP APO, extended warehouse management and supply network collaboration (SNC).

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SAP SRM provides features like indirect or the self service procurement, central contract management and supplier self services (SUS). Unlike the purchasing process in ERP that's triggered by the production planning, the self service procurement offers capability for the end user or the employee in a company to purchase materials or services. This is mainly used for low cost consumable materials for example paper, pencils or services which are maintained in the product catalog. The materials or services are requested via the shopping cart is converted to a purchase requisition or the purchase orders in the ERP system. SAP ERP MM acts as a backend system and provides the necessary business functions to support the procurement process.

The central contract management of SAP SRM offers the possibility to maintain the contracts with vendor at the company level for large companies which offers the possibility of negotiating better terms and conditions with the vendor and maintaining them in the system. The contract is distributed to the multiple ERP system and local contracts are created in the ERP system. A purchase order is created for the contract and the contract statistics are updated back to the central contract which provides more visibility of the contract usage. This is achieved via integration with the MM in the backend.

The SUS is a part of the SAP SRM which offers the platform to collaborate with vendors who doesn't have ERP system. The vendor can log on to the SAP SRM system provided by the buyer and can respond to the purchase orders, perform confirmations, send an invoice which calls the MM functions in the backend to update the purchase order, post goods receipts, posts invoices respectively. SUS supports procurement of external services.

For more details on SAP SRM please refer the blue book on "SAP SRM 6.0".

MM functions are integrated to SAP SCM. The SCM APO availability check functions are triggered during the stock transport orders processing in MM. In addition the SCM APO systems can create purchase requisitions in MM when the planning is done in SCM APO system. If the EWM is used for managing the operations in a warehouse the necessary goods movement functions in the warehouse uses the Inventory management interfaces from MM. SNC provides platform for vendors to manage the inventory and handle special processes like third party processing, subcontracting process and consignment stocks. SNC handles materials and not services. This special process of materials handling is not covered within the scope of this blue book.

7.4 Framework-Based Implementation of Purchase Requisition

When a business document is created by a user, the format, correctness, and consistency of the entered data needs to be validated by the business logic. Thereby the sequence of validation checks is influenced by the dependencies between different input values.

Figure 7-2 shows an example of input value dependencies when creating a purchase requisition. Purchasing group for example depends on company code. Vendor and material is dependent on plant.

Typically these validation rules are implemented as a long block of if-statements. This made it difficult to create and maintain the validation rules, for example to change the sequence or add a new rule.

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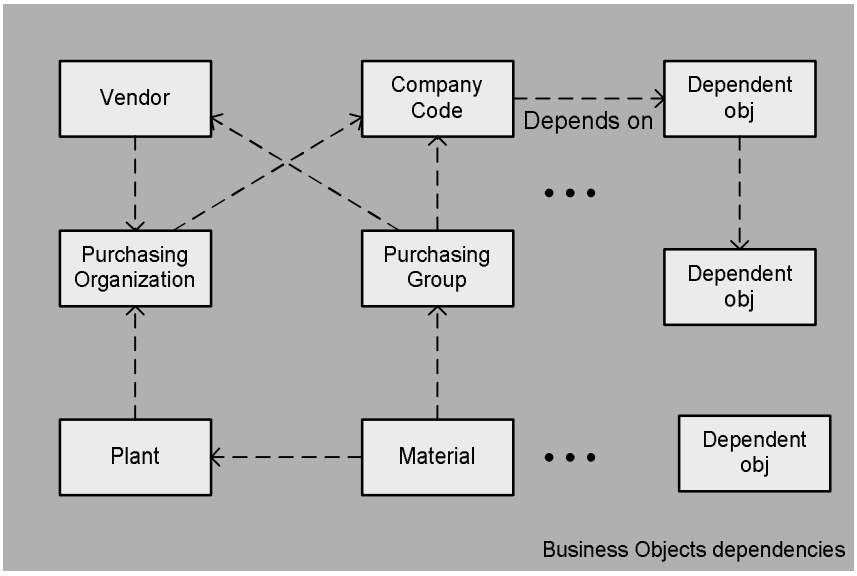

Figure 7-2 Business Entities and Dependencies

To address this problem and also to ease the maintenance of the business logic a framework-based approach is used for the implementation of purchase requisition and outline agreements (contracts, scheduling agreements) in MM. In this approach each validation rule is implemented in one local ABAP class. At runtime generic framework instantiates a rule interpreter which calls the registered rules in the right sequence.

The encapsulation of the validation rules by providing a generic framework for the execution makes the implementation of a rule an easy task. In addition this approach also improves runtime performance, since only relevant validation rules are executed. For example if the validation of the input for vendor is not successful then all its dependent inputs like purchasing organization, purchasing group is not validated.

7.4.1 Framework

The purchase requisition document is structured in header and items. Accounting information is part of the item. The business logic which takes care about header, item, and accounting is encapsulated by the corresponding manager (see figure 7-3). They handle the state and trigger the validation checks.

The business logic is executed by a generic framework. The main components of the framework are as follows (see figure 7-3)

- **Instance factory**

  This is responsible for initializing the header manager which in turn initializes the item manger. The item manager is then responsible for initializing the account manager. The instance factory also initializes the rule factory and the rule interpreter which is used later for processing the rules.

- **Rule factory**

  A collection of all rules and their interdependencies belonging to a business document. The rule factory includes all the business logic rules (header, item and accounting rules).The set of rules is further characterized by a scope. The scope determines whether the rule has to be executed immediately or later.

- **Context**

  Contains a reference to the interpreter and the scope. This provides additional information on the state of a business document at runtime.

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- **State**

  Header, item and accounting manager maintain their own state. The state holds the information like the old state, new state and before checks. For example when a price in the purchase requisition is changed the old state will have the information from the database and the new state will have the new price.

- **Rule interpreter**

  Given a context, a rule factory and a scope, the interpreter executes one rule after the other. The set of rules is derived from the scope and provided by the rule factory. The rule registry provides the information of the business rules to be executed. The rule interpreter is a generic component and can be reused by other applications.

Purchase requisition processing is integrated with other components like purchase order processing. They are referred to as foreign applications. Purchase requisition processing provides an interface to the foreign applications.

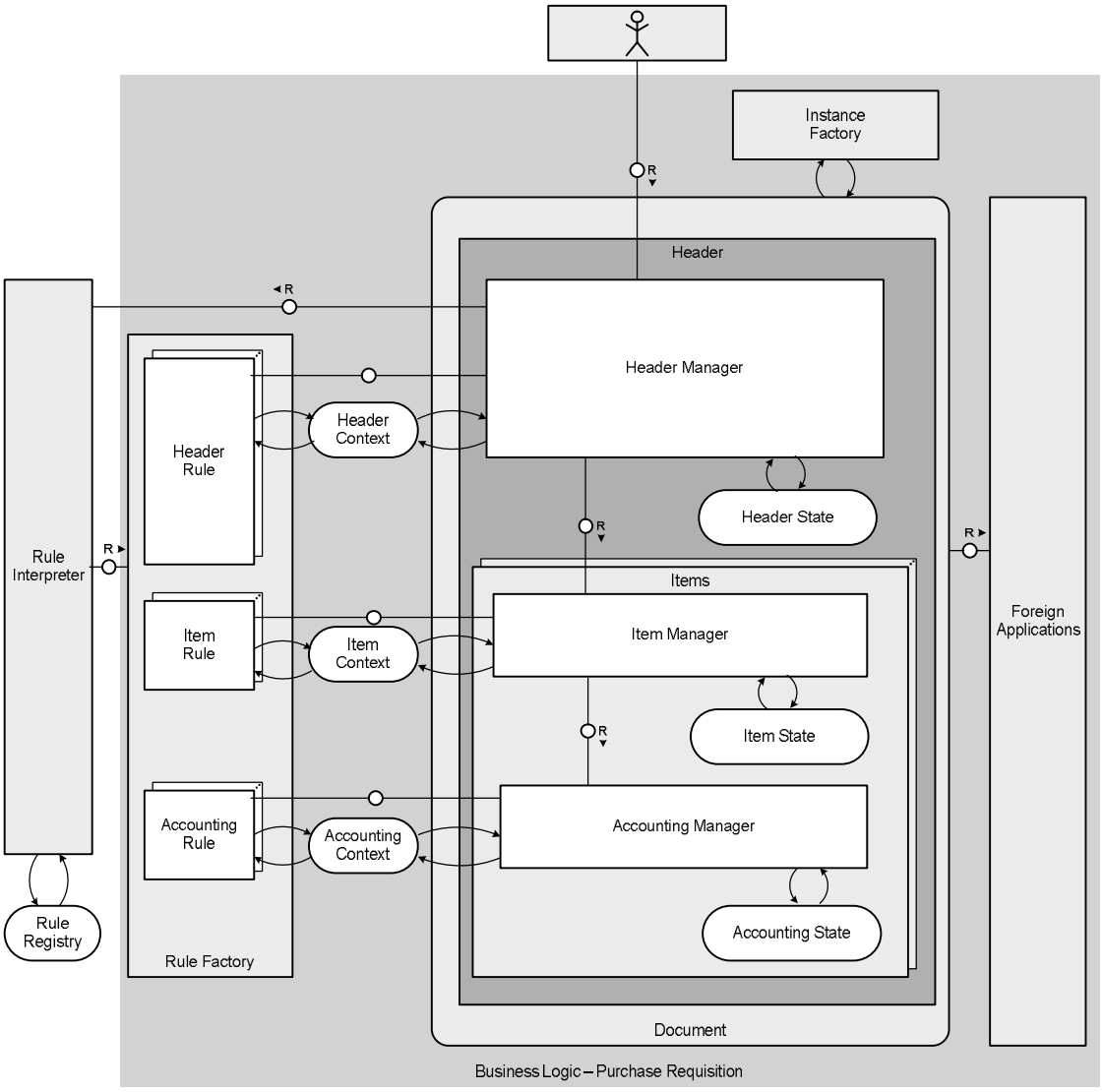

Figure 7-3 Architecture of Purchase Requisition Framework

7.4.2 Rule Execution

The validation rules are implemented as ABAP classes at design time. At runtime the rules are instantiated and executed by the rules interpreter (see figure 7-3). When doing this the rules interpreter considers the dependencies and preconditions of the validation rules.

Say for example that rule 1 is the current validation rule that needs to be validated (see figure 7-4). Rule 1 has Rule 2 and Rule 3 as precondition. This means that Rule 1 will be executed only if Rule 2 and Rule 3 are valid. The result of Rule 1 is dependent on Rule 4 and Rule 5. These rules are observers of Rule 1 and act based on the result of Rule 1 which means that Rule 4 and Rule 5 have to be executed, immediately or later.

The execution of a validation rule provides one of the following results:

- Valid
- Invalid
- Unchecked

After all rules are executed a decision is made whether the given context (or the business entity) is compatible with the rules. If all the rules are satisfied then the document is processed without errors. In case the rules are invalidated an error message is placed in the error log and requires further processing. A rule interpreter is responsible for the execution of the rules at run time.

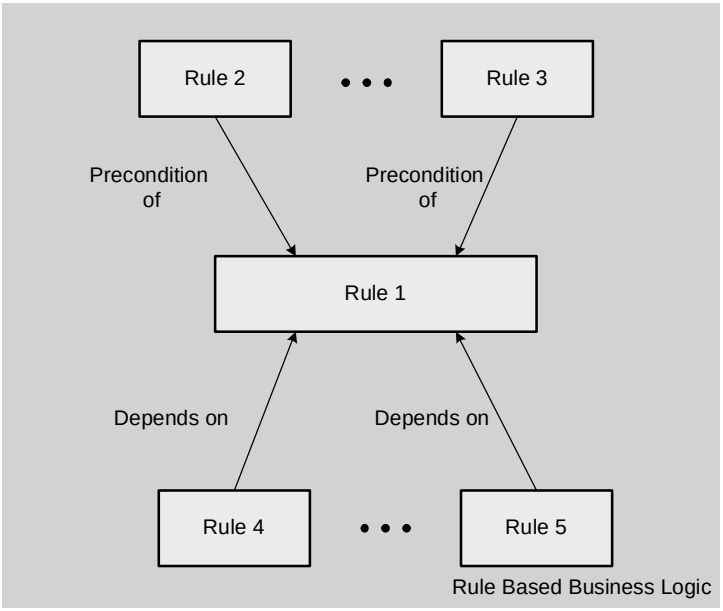

Figure 7-4 Preconditions and Dependencies of Validation Rules

The complete validation process of a purchase requisition document works like this:

1. A special header rule loops over all items and invokes the process method of each item.
2. Two copies of the item state are created – one remains unchanged (item before checks) and one is updated by some rules at the end of method for delta management purposes.
3. The context information is built from the item state and transferred to the rule interpreter together with the rule factory and the scope.
4. The interpreter determines which rules have to be carried out depending on the scope. Previously broken rules are always reprocessed.

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5. The interpreter gets all the rules from the rule factory.
6. The interpreter starts with the first rule and executes one rule after the other until all rules are executed.

The state of a rule is updated each time the rule is executed and every rule is implemented as a local class in ABAP. The rule interpreter is responsible for calling the local classes that executes the rules. The document can be saved only after all the rules are successfully executed.

7.5 Pattern-based User Interface

With the enjoy initiative for SAP R/3 release 4.6 the user interface of MM was re-implemented based on a new architecture and a new screen layout. A pattern-based approach ensures that the different user interface screens for maintaining purchase requisition, purchase order, goods receipt and invoice receipt have a uniform and consistent look and feel. Also user input has been simplified by collecting the faulty input data instead of interrupting the user after each erroneous data entry with an error message.

7.5.1 User Interface Design

The design defines a pattern for single screen maintenance of header, item and item details (see figure 7-5). The window embraces the complete screen and is implemented by one ABAP Dynpro screen that provides a placeholder for the document overview and the document view. The document overview on the left is a tree control that is used for listing the documents created earlier by the user. It has also options to select documents based on selection parameters like document date creation, and document type.

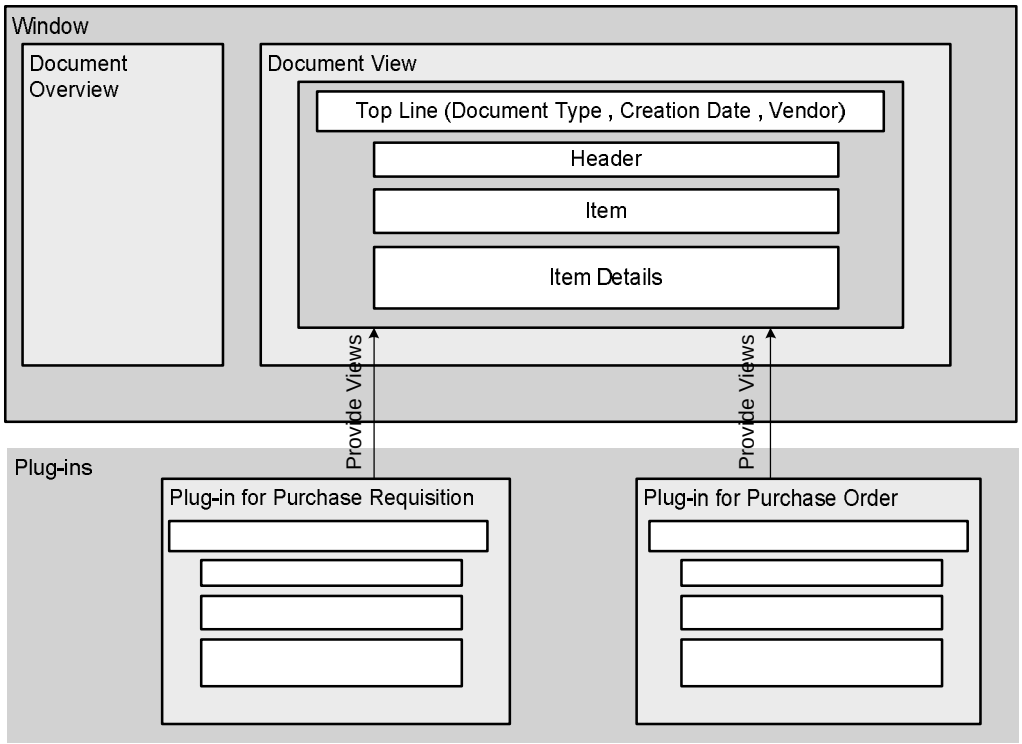

Figure 7-5 Enjoy Transaction – User Interface Layout

The document view displays the header, item, and item details of the business document. It is structured in different sub-screens where plug-ins provides the content. On top the top line

plug -in is loaded which provides general information such as document type, creation date and vendor. In dependence of the actual business document to be displayed, different plug ins are used to present the corresponding header, item and item detail data (see figure 7-5).

7.5.2 Model View Controller

The pattern-based user interface is implemented using the Model-View-Controller (MVC) design pattern. By using the MVC pattern the user interface (UI) is decoupled from the business logic. This was not the case in the older transactions. Model, view, and controller play the following roles:

- **Model**

  Models define the application data to be presented on the user interface. In MM the models represent the business documents, for example purchase requisition or purchase order. The model provides services needed by the controller. The model is responsible for triggering the business logic and provides the information back to the view for display.

- **View**

  View provides the visible screen output. Each plug-in in figure 7-5 corresponds to a view. The views are implemented as object oriented wrappers around ABAP Dynpro screens. Examples are header data screens like partners, address.

- **Controller**

  Controllers (in MM also called framework) handle the communication between model and views. The controller registers the views that have been changed by the user. Once the data entry is completed the framework informs all the registered views to send the entered data to the model for further processing.

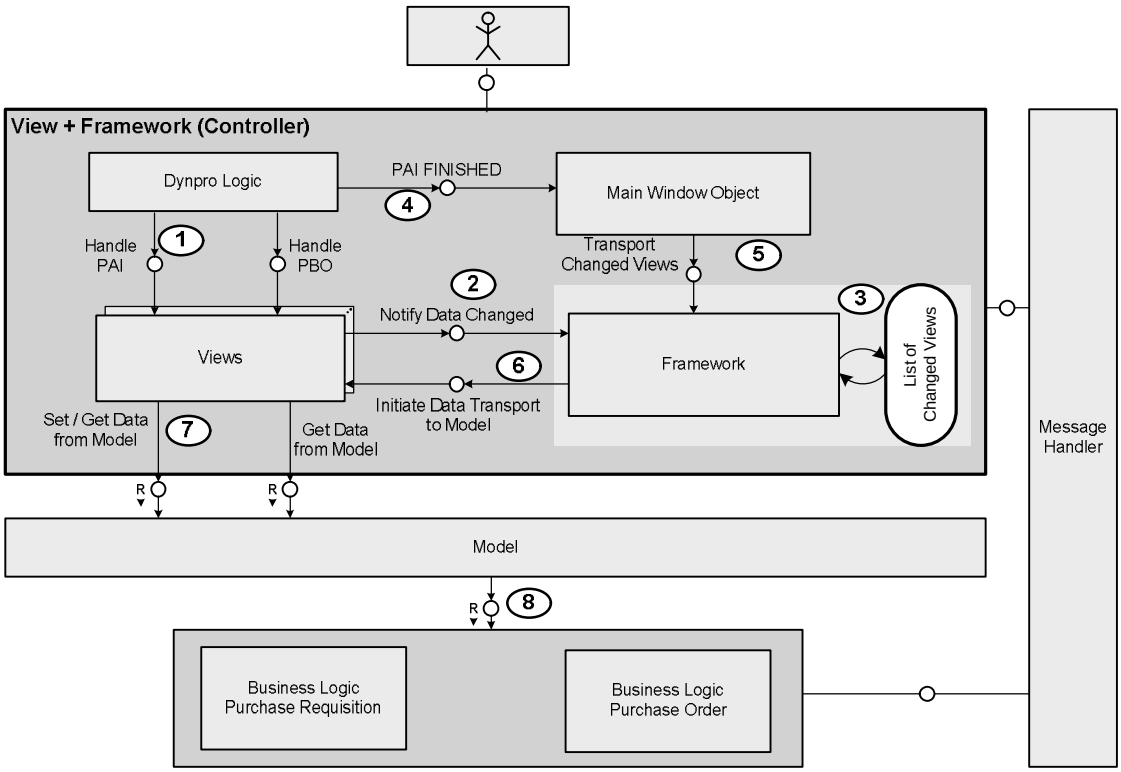

Figure 7-6 Enjoy Transaction - Architecture Overview

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Model, view, and controller (framework) is implemented as ABAP classes. The communication between them is based on class events.

For the PBO, the logic is quite simple. The Dynpro logic raises an event handle PBO and the views respond to the event. The views then check if the model is changed by using the get data method in model. If there are changes then they are displayed on the screen with changes else the screens are then displayed in the window.

To process input data models, controllers, and views work together in the following way:

1) When the user has entered data on the screen the ABAP Dynpro logic raises an event handle PAI.
2) The views that correspond to the screen know that data is changed and informs the framework to register the changed view. The event name is “notify data changed”.
3) The framework collects all the views that have been changed by the user and stores it temporarily in the buffer.
4) Once all the views have registered the changes with the framework the Dynpro logic triggers the event PAI Finished to the window (that contains all the views).
5) The window informs the framework to initiate the transport of all the changed views to the model.
6) The framework then initiates a call to the model through the view (changed views in the list) and all the views that were collected are transported to the model.
7) The view calls the get data first to check if there are any changes in the model and then sets the data entered by the user through the set data method provided by the model.
8) The model calls the business logic to perform operation on the data.

The data validation happens in the business logic. The message handler provides all necessary functions for error handling and incompletion process for purchase requisition and purchase order.

7.5.3 Business Logic Extensibility

Industry and business requirements of a company cannot always fulfilled by the standard functionality provided by SAP ERP OPS. Therefore the business logic can be extended for:

- Processing custom objects
- Processing additional data on standard objects
- Performing additional check and derivations
- Changing data in standard fields
- Changing the field selection

To ensure that the extensions are compatible with the existing business logic the BAdI technology is used. Predefined BAdIs are called when the existing business logic is executed, being it triggered by a dialog transaction or an external BAPI call.

Figure 7-7 shows the different places in document processing logic where extensions are possible. The extensions are available in the header processor, item, schedule and accounting and can be implemented based on the custom requirement. The extensions are plugged in the main business logic.

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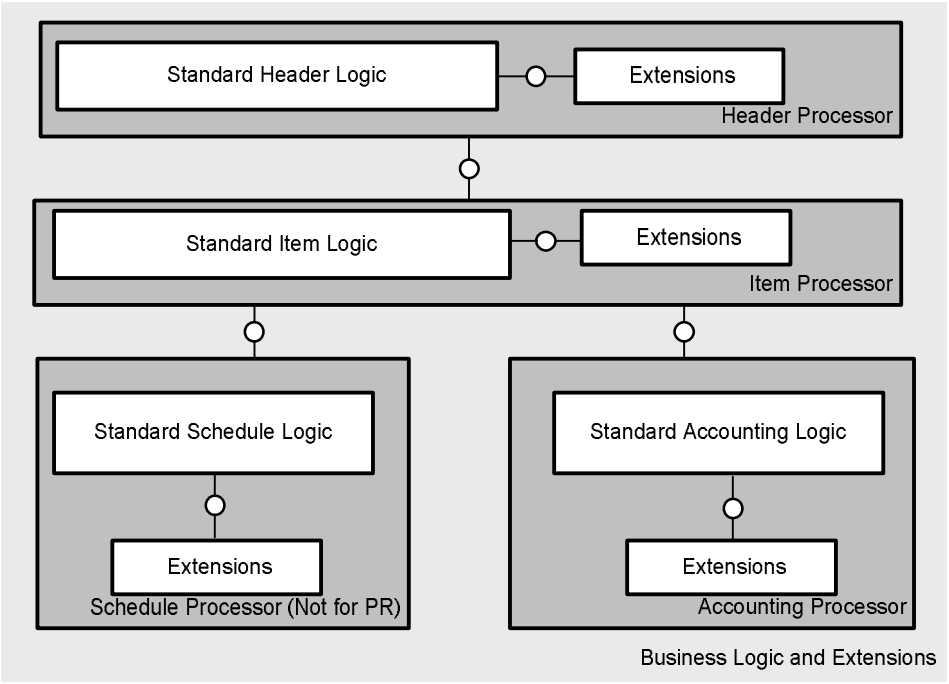

Figure 7-7 Business Logic Extensions

7.5.3.1 Extending Purchase Order Processing

As an example we explain how the business logic of purchase order processing can be extended.

Purchase order processing is structured into multiple logic parts (see figure 7-8). When the purchase order is opened the open logic is called to perform the read operation. The initialization is logic is responsible for initializing the purchase order for the usage in the transaction. The field selection logic is responsible for switching a field on or off, making field available for input.

The process logic handles all the operations related to processing of purchase order document that includes header, item, accounting and schedules. The check logic is triggered once when all the user input is made and the document is ready to save. The post logic calls the update functions to post the transaction data followed by the close logic.

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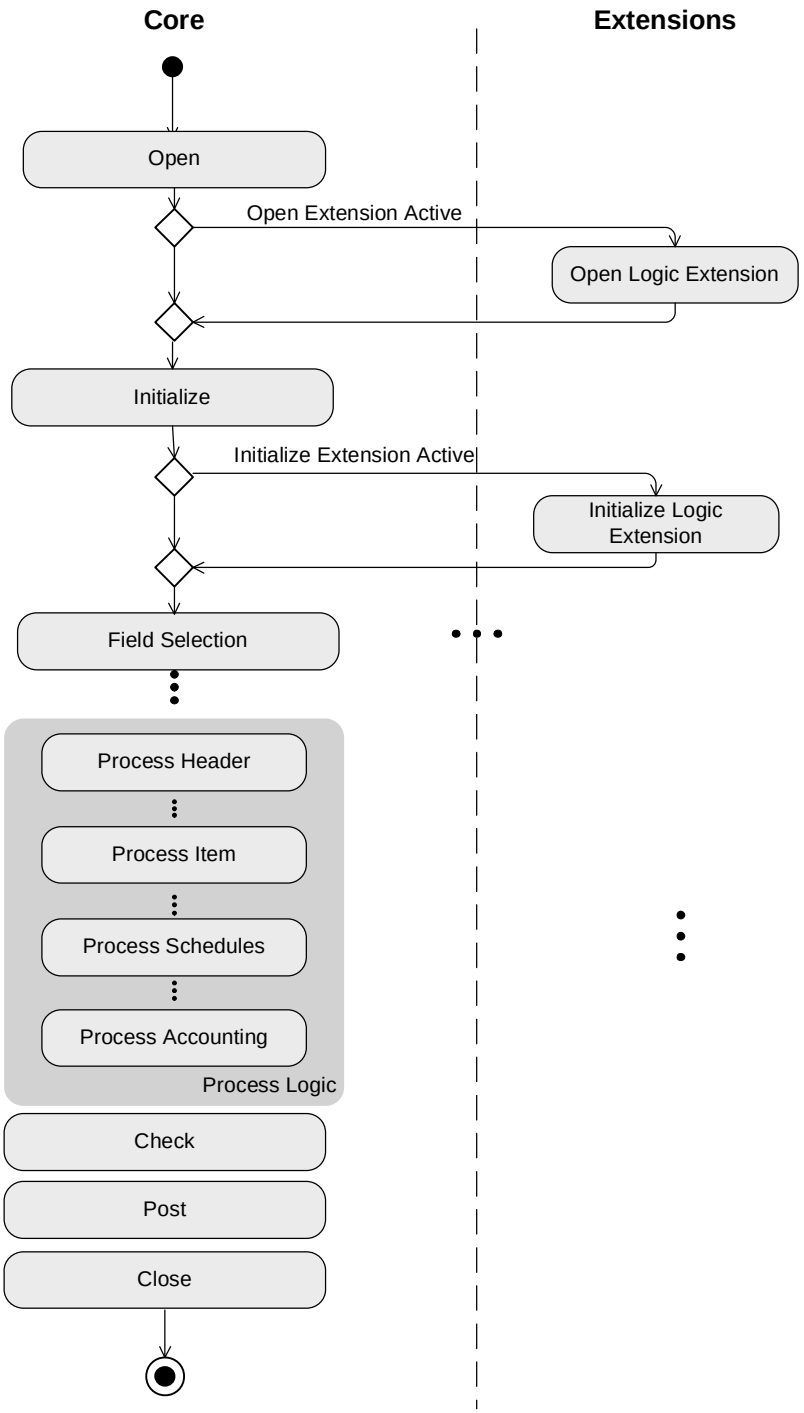

Figure 7-8 Processing Purchase Order Extensions

Within the flow of standard business logic extensions can be added to each logic part.

8 Logistics Execution

Logistics execution (LE) controls and organizes the movement of material within the enterprise (warehouse management), but also transportation between enterprises. Movement of material includes the outbound processing of sending materials to customers, the corresponding inbound processing of receiving materials from vendors, and organizing and monitoring the transportation of material.

8.1 Architecture Overview

From architecture perspective LE is divided into the following areas (see figure 8-1):

- Inbound delivery processing which covers receiving goods from the vendor and storing them in the company's warehouse.
- Warehouse management which supports stock transfer, picking and packing
- Transportation management which supports inbound and outbound shipment processes
- Outbound delivery processing which includes picking the goods and transporting them to the customer

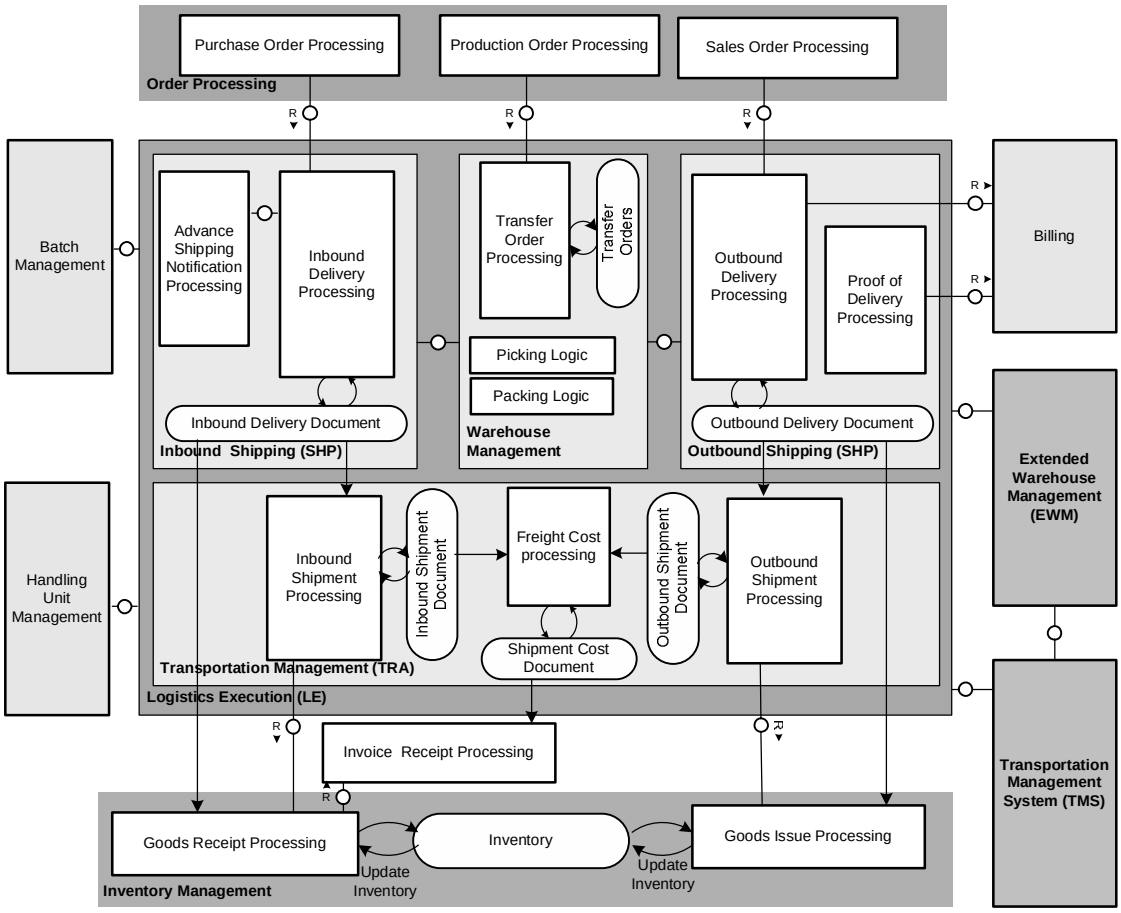

Figure 8-1 Architecture of Logistics Execution

Typically logistic execution is initiated by purchase order processing in MM or sales order processing in SD. The inventory itself is part of MM. Logistics execution processes are closely integrated with inventory management, which maintains the actual inventory

8.2 Integration

8.2.1 Integration with SAP ERP

LE is integrated with SD and MM using database integration. SD triggers LE to perform the order fulfillment process for a sales order, in especially the delivery processing. In this case an outbound delivery document is created referencing the sales order.

When material is received by a company LE creates an inbound delivery with reference to the purchase order and triggers goods receipt processing in MM.

8.2.2 Integration with SAP Business Suite

LE can be integrated with SAP SCM to extend its functional scope. Extended warehouse management (EWM) can be connected to the lean warehouse management of LE to provide additional warehouse management functions in the areas of advanced shipment notification (ASN), work assignment, and picking bin determination. Transfer order are created in LE and transferred to Extended Warehouse Management using as RFC.

The transportation management functionality of LE can be replaced by SAP Transportation Management System (SAP TMS) which supports transportation request management, transportation dispatching and execution. In this case LE forwards all transportation requests to SAP TMS using asynchronous message transfer.

8.3 Inbound Delivery Processing

Inbound delivery processing only starts after the enterprise has purchased material (raw material, goods) which the vendor has confirmed by sending a purchase order confirmation. If the procured material needs to be transported to the enterprise inbound shipment processing is performed. It is part of transportation management (see chapter 8.5)

To be prepared to receive the ordered material inbound delivery processing is initiated in one of the following ways:

- Manually an inbound delivery document is created with reference to the purchase order
- The vendor sends an outbound delivery document to the enterprise via iDoc. The received outbound delivery document is then transformed into an inbound delivery document with reference to the purchase order.
- The vendor sends an advance shipping notification to the enterprise via iDoc, which triggers the creation of an inbound delivery document

In case the vendors send both, the outbound delivery document as well as the advance shipping notification, the later just updates the inbound delivery document.

The inbound delivery document includes the following data:

- Header:
  - ID
  - Status
  - ID of corresponding purchase order
  - Vendor
  - Date of delivery
- Item:
  - Quantity and type of material to be received

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The inbound delivery document is used to track the arrival, unload, unpack, and put into warehouse of the material. When the material is received at the plant or warehouse inbound delivery processing sends a proof of delivery as iDoc to the provider. In addition the inventory is updated by goods receipt processing.

8.4 Outbound Delivery Processing

The outbound delivery processing within LE is responsible for sales order fulfillment. If the vendor organizes the transportation of the material to the customer outbound delivery processing initiates outbound shipment processing which is part of transportation management (see chapter 8.5). Outbound delivery processing is integrated with lean warehouse management if the materials are stored in the warehouse (see chapter 8.6).

Sales order processing initiates outbound delivery processing as soon as the requested material is available in the inventory (see figure 8-1). Then outbound delivery processing creates an outbound delivery documents with reference to the sales order. It includes the following information:

- Header:
  - ID
  - Status
  - ID of corresponding sales order
  - Customer
  - Date of delivery
- Item:
  - Quantity and type of material to be delivered
  - Ship-to party
  - Delivering plant or warehouse
  - Shipping point
  - Loading point
  - Route

Outbound shipment processing performs the following tasks:

- Shipping point determination
- Delivery scheduling
- Route determination
- Receive proof of delivery

If the material is not picked up directly by the customer, but transported to the customer's ship-to location outbound shipment processing is performed.

Once the goods are delivered the goods issue processing updates the inventory by reducing the quantity that was delivered. Subsequent financial documents are posted so that billing can be performed.

8.4.1 Shipping Point Determination

The shipping point is the organizational unit of a company which is responsible for a dedicated way of shipment, for example the mail depot or a plant rail station. Within LE the shipping point is responsible for delivery creation, update and monitoring as well as goods issue processing. One delivery is processed by one shipping point only.

Outbound delivery processing determines the shipping point for ordered material based on the following three input values (see figure 8-2):

- Shipping conditions, for example that the material should be delivered as soon as possible.
- Plant which delivers the material (provided within the sales order document)
- Loading group which defines the way of loading, for example that the material must always be loaded with a crane or a forklift

For each possible combination of values the corresponding shipping point is defined in customizing tables. So outbound delivery processing looks up the corresponding shipping point. The shipping point is a prerequisite for delivery scheduling and route determination.

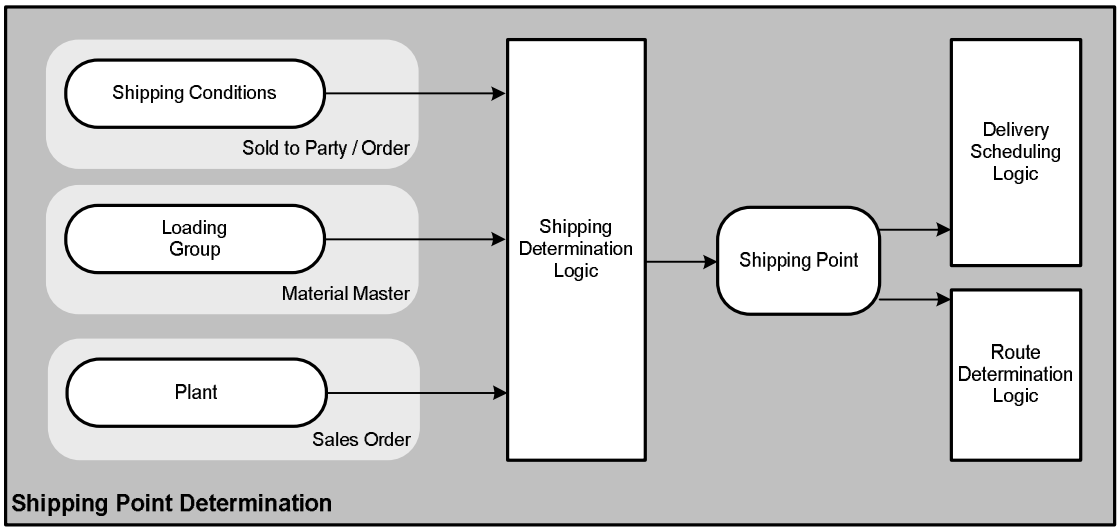

Figure 8-2 Shipping Point Determination

8.4.2 Delivery Scheduling

Delivery scheduling defines a timeline for all activities that have to be carried out before the material can be delivered to the customer, for example picking, packing, and loading the material. To do so, delivery scheduling determines the material availability deadline, at which the material must be picked from the bin and packed as well as the loading deadline, at which the material must be available for loading.

8.4.3 Route Determination

A route describes a course of travel between the shipping point and an end point. A transportation planner maintains routes which are stored in customizing tables. At run time the route determination logic checks if there is a route which connects the shipping point to the ship-to location of the sales order. The following attributes determine the route selection (see figure 8-3):

- Departure country and zone from where the materials are to be shipped (this information comes from shipping point)
- Shipping conditions which define how the materials are to be delivered (this information comes from the sales order)
- Transportation group (this information comes from material master)
- Destination country and transportation zone indicates where the materials are to be delivered (this information comes from customer master)
- Weight group (relevant for delivery) indicates how much of materials can be delivered. The weight group is determined on the basis of the total weight of the delivery.

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Based on the above input values the route is determined during creation of a delivery. Route determination is prerequisite for transportation scheduling, which defines the timelines for preparing and carrying out the transportation. Transportation scheduling determines the following two deadlines:

- The transportation scheduling deadline is the date on which transportation of the goods must be organized.
- The goods issue deadline is the date on which the goods must leave the company in order to arrive at the customer location without any delays.

To do so, it calculates for example the transit time of a foreign forwarding agent and the transportation lead time for arranging a truck.

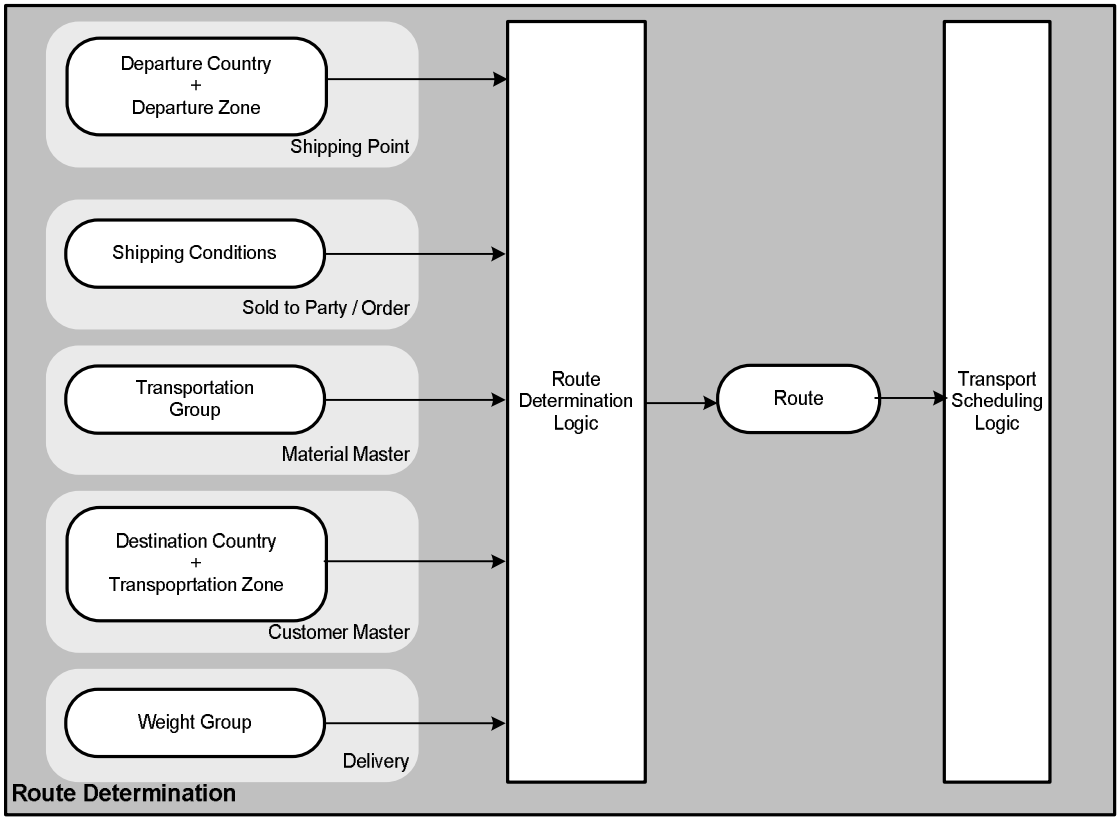

Figure 8-3 Route Determination

8.4.4 Proof of Delivery Processing

Customers can send a proof of delivery (POD) document to LE to confirm that he received the ordered material. The proof of delivery is required in business processes in which an invoice is issued only after the customer has confirmed the receipt of the delivery.

The proof of delivery includes the following attributes:

- POD date
- POD time
- Actual quantity that arrived
- Reason for possible differences in quantities if any. This is especially important for deliveries in which the delivery quantity varies because of the nature of the goods or for which the exact delivery quantity is unknown from the start.

The proof of delivery document reflects the actual delivery status thereby facilitating an accurate billing process and eliminating unnecessary credit memos. The ship-to party transfers the proof of delivery to the SAP ERP OPS via iDoc. The message is received by proof of delivery processing. Now billing is initiated based on the POD quantity.

If the customer uses SAP ERP, too, inbound delivery processing sends the proof of delivery via EDI (Electronic Data Interchange) technology. Inbound delivery processing calls output determination which determines the system address to which the proof of delivery has to be sent. Then inbound delivery processing creates an iDoc which is transmitted to the vendor's SAP ERP. For more details on output determination, see chapter 4.3.4.

8.5 Transportation Management

Transportation management embraces inbound shipment processing as well as outbound shipment processing. It is triggered by the respective delivery processing.

Transportation management includes the following functions:

- Transportation planning and shipment completion
- Service agent selection
- Shipment costs calculation
- Shipment costs settlement
- Billing of customer freight
- Follow-up and supervision of shipments
- Management of shipment costs

Inbound as well as outbound shipment processing creates a shipment document which first of all defines which deliveries is part of one shipment. In addition the following information is maintained in the shipment document:

- Service agent or logistics provider which is responsible for the transport
- Mode of transport, such as rail, truck, plane
- Shipment type
- Estimated freight cost

During shipment processing the shipment document is used to keep track of the shipment status. In addition the system does a leg determination which provides information about how the material reaches from the source to destination by calculating subsequent legs, transfer points (mode of transport: air, land, water) from the point of departure to destination. The determination is based on the simple rules maintained in the customizing and does not involve optimization algorithms and also has no geographical intelligence.

One aspect of the transportation management is to handle the freight costs or the shipment costs that were involved when the material was delivered. The handling of freights is an integral part of the LE Transportation functions and always happens in the ERP system even though an external TMS system is used. In this case the freight requests are initiated by the external system to do the freight cost settlement in ERP. The costs incurred during the freights are booked separately and a separate FI documents are generated for this purpose to settle the freights. The freights can be handled by the manufacturer or by a third party logistics provider.

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8.5.1 Shipment Costs Processing

The following explains how the shipment costs are calculated in the SAP ERP OPS with respect to the inbound and outbound point of view.

8.5.1.1 Shipment Costs: Inbound Shipment Processing

As mentioned the inbound delivery processing creates a delivery document based on the purchase order. If transportation is required an inbound shipment document is subsequently created with reference to the delivery. The shipment document specifies who transports the material when to the customer.

If the transportation cost is not included in the sales prices inbound shipment processing creates a shipment cost document. The shipment cost document stores the price of the transport, which can be entered manually or using price determination based on the customized pricing conditions. The second case is used, if the enterprise has a contract with the transportation provider.

Afterwards the goods receipt processing is triggered which calls the shipment costs interface to transfer the cost as shown in figure 8-4. Thereby the shipment cost is transferred to goods receipt processing logic which passes them on to SAP ERP FIN. The successful receipt of material is also documented in the purchase order and also the delivery costs are updated in the purchase order.

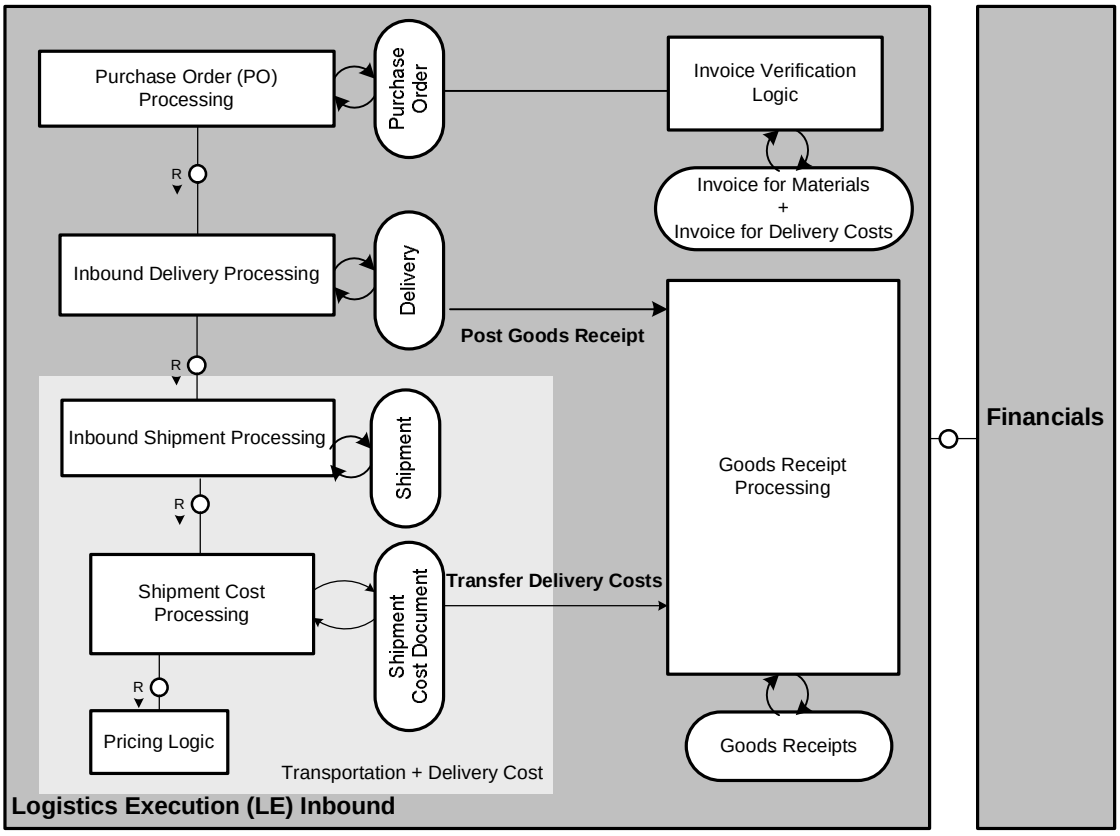

Figure 8-4 Inbound Shipment Cost Processing

The whole process ends with the invoice verification where two separate invoices are posted with reference to the purchase order. One invoice for the supplier and another for paying the delivery costs to the transportation agent. The payment is then initiated by SAP ERP FIN.

8.5.1.2 Shipment Costs: Outbound Shipment Processing

Outbound shipment processing creates a shipment document to manage the transportation of the material from the shipping point to the ship-to location. One shipment document can plan the transportation of one or more deliveries.

Shipment cost processing contains the functions for calculating and settling shipment costs which arise from material transportation. To do so, outbound shipment processing triggers the creation of a shipment cost document with reference to the original shipment document (see figure 8-5). The separate shipment cost document helps companies to effectively plan transportation with transparent cost.

Shipment cost processing calls the pricing engine to calculate the estimated shipment cost. The calculation of shipment costs is carried out using the condition technique in pricing (see chapter 5.3.1). In addition shipment cost processing triggers the account assignment logic where the appropriate accounting object for the shipment cost is determined for example cost center.

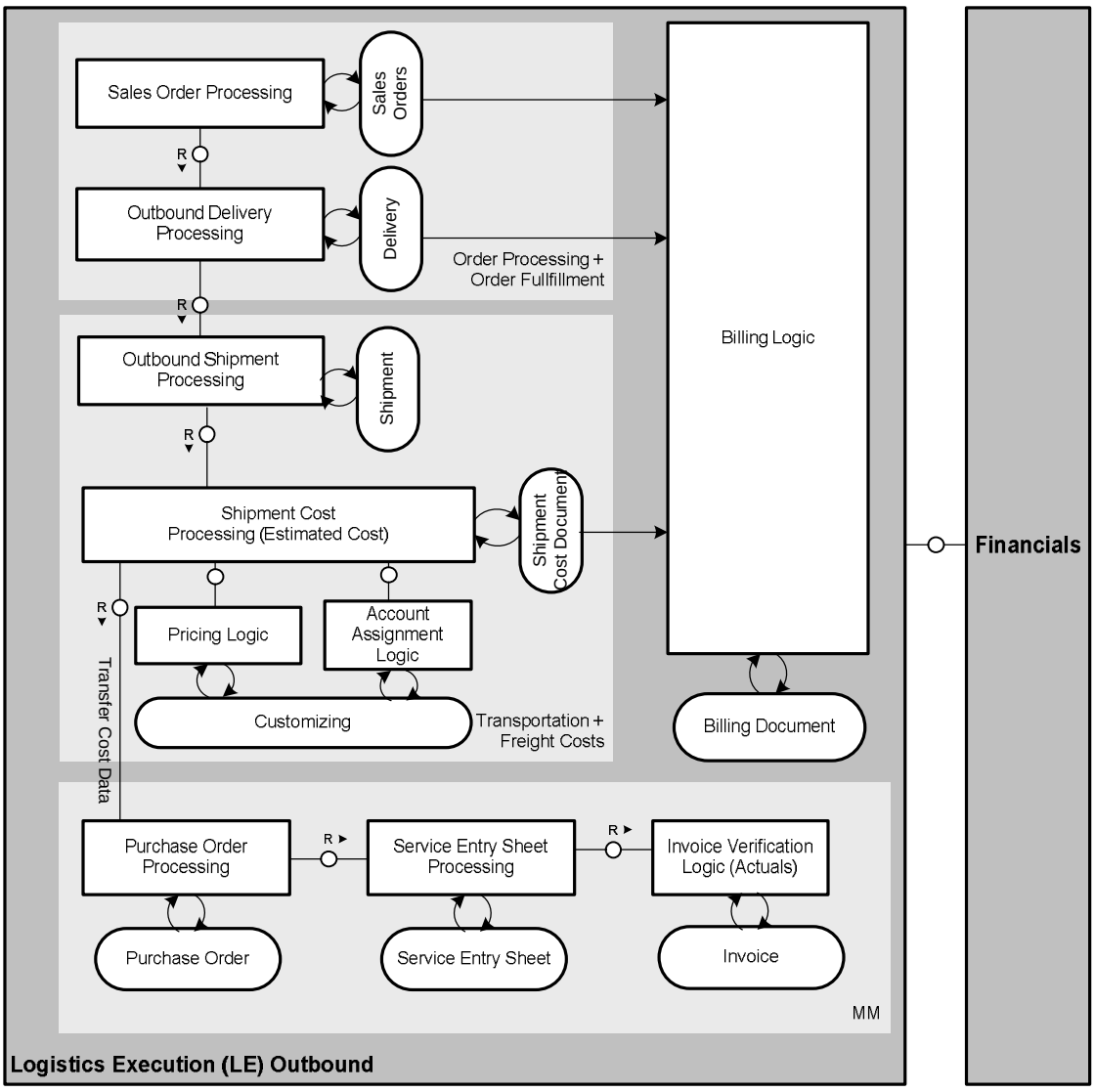

Figure 8-5 Outbound Shipment Cost Processing

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If a third party logistics provider is involved in the shipment the shipment cost processing triggers the creation of a purchase order in MM to procure the corresponding services. The shipment cost as well as the account is passed to the purchase order. Now the process continues in MM: once the materials are delivered a service entry sheet is created with reference to the purchase order. As soon as the invoice from the third party logistics provider is received and verified SAP ERP FIN is triggered, which initiates payment of the invoice and billing of the shipment cost to the customer.

8.6 Warehouse Management

SAP ERP OPS keeps track of the material stock in the inventory provided by MM. Every movement of goods into or out of the company is reflected there. Warehouse management supports controlling the movement and storage of material inside the company, more precisely within the company's warehouse. The typical operations in a warehouse include receiving, put away, picking, packing and transfer of material.

LE provides only a lean warehouse management. But SAP ERP OPS can be integrated with the extended warehouse management provides by SAP SCM.

8.6.1 Technical Representation of the Warehouse

Within LE a warehouse is represented in the following way:

- **Warehouse number**

  Each warehouse has an identifier, which allows managing multiple warehouses in parallel.

- **Storage type**

  A warehouse can provide multiple storage areas, which are defined by the storage type. Examples are high rack storage, bulk storage or fixed storage.

- **Picking area (aka storage section)**

  Each storage type has a picking area, where the material is picked.

- **Storage bin**

  Represents the storage space, where the material can be put. It is the smallest unit of space in the warehouse (also known as storage slot). Each storage type and picking area consists of a row of storage bins.

- **Quant**

  Describes, if there is material stored in a storage bin.

Having the real warehouse mapped to the LE warehouse allows monitoring the stock, locating the exact position of material in the warehouse, and plan and triggering goods movements into, out of and within the warehouse.

Warehouse management is integrated with the inventory management of MM. The inventory is still the central place, where all the material stock of the company is maintained.

8.6.2 Transfer Order

The most important document that is used in the warehouse management is the transfer order. A transfer order is an instruction to move materials from source storage bin to destination storage bin in a specific warehouse at a specified time. It provides the information about the quantity of the materials that needs to be moved.

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A transfer order is created based on delivery, transfer requirement (created from production order to the issue materials of BOM for production) or posting change notice. The transfer order is created during both the inbound and the outbound shipping process to handle all the movements in the warehouse. Once the materials are moved to the destination the transfer order is confirmed.

8.6.3 Operation of Logistics Execution

The number and size of warehouses vary a lot from company to company, which leads to different requirements regarding warehouse management. SAP addresses the different needs by offering four ways of running warehouse management:

- Central execution of lean warehouse management
- Execution of lean warehouse management on a separate system
- Integration of SAP ERP OPS with extended warehouse management of SAP SCM
- Integration with third-party warehouse management systems

In the first case lean warehouse management runs together with SD and MM on one SAP ERP system. SD, MM, and warehouse management are integrated using database integration. Warehouse management as well as inventory management happens in the same system.

But it is also possible to run the lean warehouse management on a separate system. In this case SD, MM (including inventory management) is performed within one SAP ERP system, whereas the complete LE is operated on a separate SAP ERP system. It is possible to run one or more LE systems together with one central SAP ERP system (see figure 8-6).

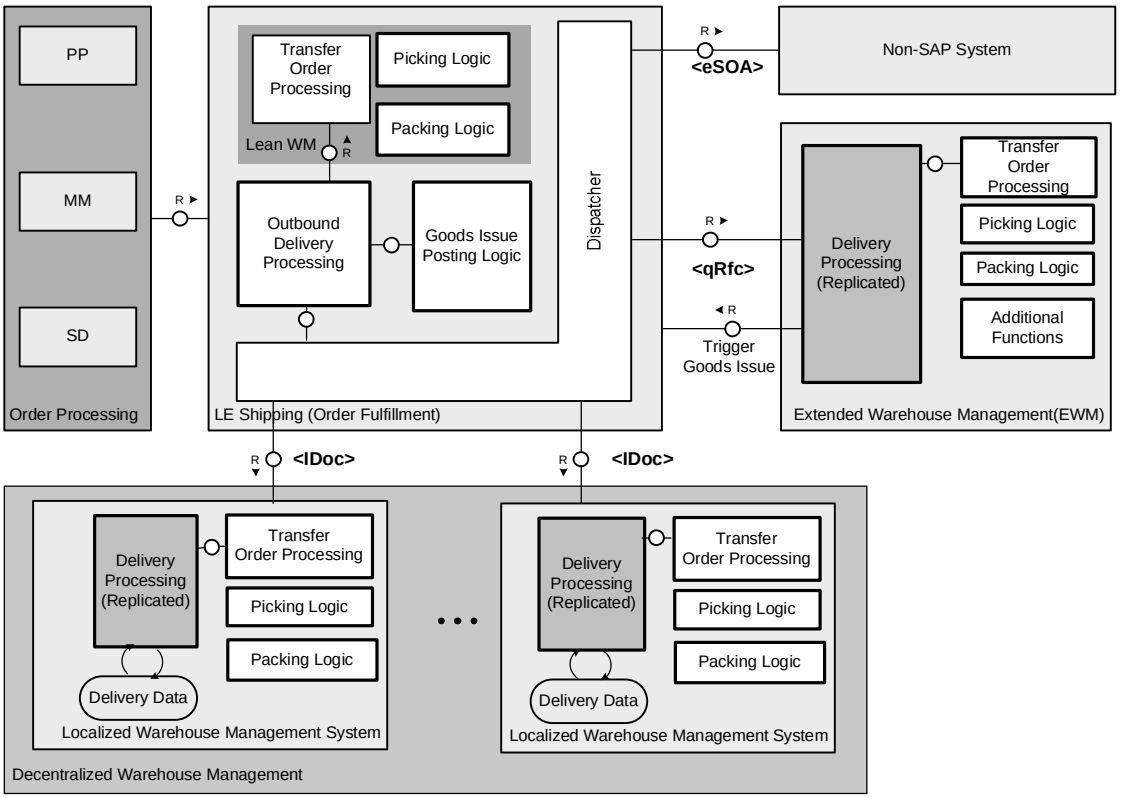

Figure 8-6 Outbound Processing in LE

In this case the delivery created by the central ERP system is replicated to the decentralized LE system using iDoc. Once the delivery is replicated the warehouse which is responsible for it performs delivery, shipment processing, as well as warehouse management operations. Once

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the LE confirms the delivery the relevant updates and postings happen in the central SAP ERP system to ensure consistency. The communication across systems happens via iDoc.

Companies prefer to run LE decentralized for example when their warehouses are in different geographical locations or the warehouse itself wants to perform the logistics execution functions to meet high demands and ensure faster delivery of goods to the customers.

The third option is to integrate SAP ERP OPS with extended warehouse management of SAP SCM which provides additional functions. In this case the delivery is sent from SAP ERP to SAP SCM using qRFC. Delivery and shipment processing is then performed within SAP SCM, but inventory management is still in the responsibility of SAP ERP.

LE provides enterprise services, which can be used to integrate SAP ERP OPS with third-party warehouse management systems and external applications which support specific warehouse processes such as warehouse control units and fork lift control systems. Enterprise services are for example available to send transfer orders and cancel transfer orders.

In all cases where warehouse management is operated on a separate system delivery processing calls the dispatcher located in the central SAP ERP system (see figure 8-6). The dispatcher determines the target system and sends the request to the corresponding system. To do so, the dispatcher reads a mapping table where the storage location, warehouse number are stored together with the destination system details. The dispatcher is called during the save operation of the delivery document.

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9 Quality Management

Enterprises have to ensure that procured, produced, and sold material fulfills certain quality characteristics. These quality characteristics are checked by quality inspections and documented using quality certificates. In SAP ERP OPS quality management (QM) provides functions for quality planning, quality inspection, and quality control during sales, production and procurement. QM complies with standard ISO 9001which defines the requirements for a quality management system. A material becomes subjected to the quality inspection process by maintaining the corresponding setting in the material master.

Quality management is divided in the following building blocks (see figure 9-1):

- Quality planning for defining which kind of quality inspection has to be performed at which point in time
- Quality inspection for performing the inspection and documenting its results
- Quality notification for triggering follow-up steps when an inspections discovered bad quality
- Quality control provides reporting functions to evaluate quality management processes
- Quality certification processing for checking as well as creating quality certification documents
- Quality in procurement logic for checking if procured material fulfills its quality requirements and certifications

Quality management processes are closely interlinked with the business processes in MM, SD, and PP.

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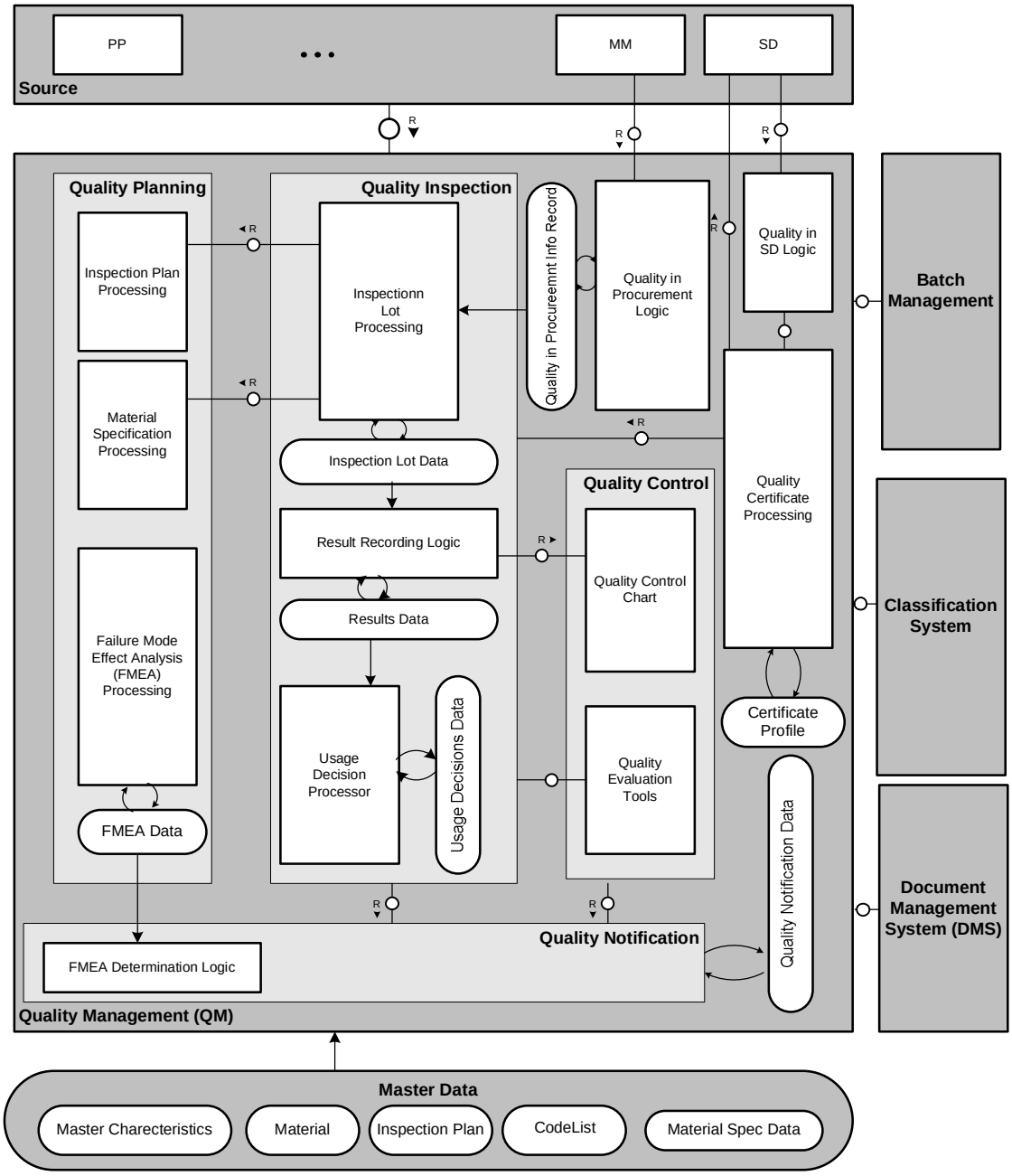

Figure 9-1 Architecture Overview of Quality Management

QM is integrated with SD to perform quality inspections of the outgoing material and issue quality certificates if required. Similarly QM is integrated with MM to check, if incoming material fulfills the company's quality requirements. The company can check, if the material is accompanied by a valid quality certificate or inspect the material on its own. If the check is not successful goods receipt or invoice processing can be blocked.

To control the quality of raw material after a production order is created and finished products after production the QM process can be triggered to perform the quality inspection on the characteristic properties of the material

In addition, QM also provides integration to the batch management when the material is handled in batches and to the classification system (see also chapter 2.1.1).

9.1 Quality Planning

Quality planning is used to define the inspections and plan their execution. The quality planning in SAP ERP provides functions to maintain the master data for the inspection process, for example:

- Master inspection characteristics
- Inspection method
- Inspection plan
- Material Specification

The master inspection characteristics provides information such as tolerances, reference to class characteristic (for example, dimension, color), and assigned inspection methods. Master inspection characteristics can be reused by multiple materials.

The inspection method describes how to carry out an inspection for a given inspection characteristic. Documents for example specific inspection instructions and drawings can be attached to an inspection method using document management system (DMS). The inspection method and the master inspection characteristics can have multiple versions.

In QM, the quality inspection is either based on an inspection plan which is at the plant level or based on material specifications.

The inspection plan defines a sequence of operations or tasks to be performed for inspection. Some of the details that are maintained at the operation level include:

- How the inspection is to take place
- The work center for the inspection
- The sequence in which the inspections are to take place
- The test equipment that is required for the inspection
- Default values (such as base quantity, unit of measure, conversion of units of measure (header/operation)

In addition it is possible to describe within which processes inspections take place, for example goods receipt process, goods issue process, or inspection of stock transfers.

The inspection plan can be assigned to multiple materials. Several inspection plans with different operations or inspection characteristics can be assigned for a combination of material, vendor and manufacturer, material and customer. During the actual quality inspection the details of the inspection plan are read and used for further processing.

A material specification defines a inspection of a specific material. It is maintained by assigning master inspection characteristics to a specific material. The material specification can replace or supplement a plant-specific inspection plan. It is used during the quality inspection especially during the inspection lot creation.

The inspection specifications defined in the material specification take precedence over the inspection specifications of the inspection plan. Material specification processing has interfaces to batch management to reference the batch characteristics in the material specification.

9.1.1 Failure Mode Effect Analysis Processing (FMEA)

Failure Mode Effect Analysis Processing (FMEA) is used to keep track of failures and trigger follow-up steps. It is used by quality managers to analyze failures. If a new failure occurs for the first time it is added to the FME data. If the failure is already known, the data is updated. FMEA processing allows to calculate the probability of a failure occurrence which is used to calculate a so called risk priority number (RPN). These numbers are part of the quality notification which is sent to the quality manager.

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9.2 Quality Inspection

The quality inspection component is used to determine whether the company's product consistently meets defined quality requirements by conducting quality inspections. In a quality inspection, a material or product is inspected, based on the inspection criteria maintained in the inspection plan.

Quality inspection has the following important functions (see figure 9-1) which are discussed in more detail:

- Inspection lot creation
- Results recording
- Usage decision logic for inspection lot completion

In addition the quality inspection is integrated with

- QM in procurement (for example, quality info record in procurement, quality assurance agreements in procurement).
- QM in production (for example, inspecting by batch, serial number processing, inspection of variant products).
- QM in SD (for example issuing of quality certificates, quality assurance agreements in sales).

9.2.1 Inspection Lot Processing

Quality inspections are processed on the basis of inspection lots, which define a specific quantity of a material or a piece of equipment to be inspected. In QM the inspection lot is a document that is created for the material at plant level. It is the first step for performing the quality inspection.

An inspection lot can be assigned to goods receipt, goods issue, and production process. The inspection lot processing is integrated with MM, PP, SD functions as shown in figure 9-1. The inspection lot has information like the inspection start date, end date, inspection quantity and lot quantity.

The inspection lot also specifies whether it is relevant for the goods movement. If the inspection lot for example is relevant for goods movement then the lot quantity will be posted to inspection stock. Inspection stock indicates that the material is subjected to quality inspection and cannot be used until the stock is posted for the unrestricted use. The postings in the inventory happens based on the inspection results and usage decision. Once the inspection is completed and the material meets the quality standards then the material is moved from the status "inspection" to "unrestricted use" and is made available in the inventory.

The inspection lot processing can happen in the following processes:

- Process inspections for goods receipts in MM
- Process inspections during production when production orders or process orders are released
- Process goods issue inspections when deliveries are created in LE

When an inspection lot is created, the following functions are executed by the inspection lot processing:

1. Inspection lot creation
2. Assignment of an inspection specification which was created in inspection planning
3. Calculation of sample size (using sampling procedures or entered manually)
4. Printout of instructions

Once an inspection lot has been created, the goods can be inspected and the results or defects are recorded and a usage decision is made to complete the inspection.

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9.2.2 Result Recording Processing

The results recording processing is used to record the results of the quality inspection for an inspection lot. The results are stored separately with references to the inspection lot.

The recorded inspection results document the quality of the inspected product and provide the basis for providing batch values and inspection certificates. The recorded result data are also used to make evaluations for quality control purposes. The result recording has interfaces to the quality control chart for statistical process control (SPC) tools.

If the inspected material does not meet the quality standards the defects are maintained in the result recording. The defects are included into the quality notification which is sent to the quality manager to take appropriate actions.

9.2.3 Usage Decision Logic

The usage decision is the last step in the quality inspection which completes the whole inspection process. Based on the results and defects that were recorded for the inspection lot, a decision is now made whether the inspected goods can be accepted or rejected for use. The usage decision logic helps document the information via the usage decision document of the decision that was taken as the result and can trigger follow-up actions if required.

To make a usage decision, the inspection results have to be recorded for all obligatory inspection characteristics

The usage decision has interfaces to the goods movement functions of MM. The quality stock which is blocked for inspection can be given free to unrestricted use or moved to scrap based on the usage decision.

If an inspection lot is not stock-relevant, then no stock postings are possible with the usage decision functions. Examples of inspection lots that are not stock-relevant include all manually created inspection lots and lots that were created for a production order

The usage decision can also influence if the materials are handled in batches. Some of the functions include

- Change the current batch status (from "unrestricted" to "restricted" or vice versa)
- Transfer the results of the batch characteristics value

If for example an inspection lot material is processed in batches and the results of the quality inspection doesn't meet the quality expectations then the entire batch status is set to restricted use. In this case the quality notification could be triggered and the quality manager can decide if further inspections needs to be planned or not.

9.3 Quality Control

The quality control provides tools for evaluating the inspection results using statistical process control (SPC). The most important tool in SPC is the quality control chart, which is a graphical tool used by quality technicians to control, analyze and document the quality issued in the different business processes. The quality control components read the data from the quality inspection components to compute the statistics. The quality control can also trigger quality notifications for example if inspection result values exceed the limits of a control chart.

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9.4 Quality Notification

The quality notification records general quality problems for example faced during the quality inspection. It records some of the information like problem, materials affected, vendor, names of partners involved in the problem.

The quality notification provides a user interface to maintain the above details and has an action box which maintains possible actions that can be triggered. The action box has predefined actions that the company can use to react to the quality situations and in addition can have own actions depending on the custom requirement. The quality notification is a separate object that is persisted in the database.

9.5 Quality in Procurement Processing

The quality in procurement processing is a separate component in QM and is integrated with procurement, goods receipt and invoice processing of MM. Through this component the materials procured from the external vendor is subjected to the incoming quality check and for the same reason this component is integrated with the inspection lot processing. The quality in procurement processing is also used by companies that demand quality certificate from the vendor for the material.

In SAP ERP OPS the quality in procurement info record is maintained for the material, vendor and plant combination that contains data such as block function (process during which the material was blocked for example goods receipt) , block reason, medium through which the quality certificate should be transferred from vendor and control data for inspection. Based on the data the quality in procurement performs certain functions such as

- Release or block vendors
- Evaluate vendors on the basis of quality
- Request that quality certificates be submitted with the delivered goods and monitor the receipt of these certificates
- Inspect vendor goods upon receipt (goods receipt inspections)
- Block the payment of invoices until the goods have been inspected and accepted

The quality in procurement info record will be required based on the setting of the control key in material master. When the inspection lot is created by the goods receipt process, the quality in procurement info record is read by the system for further processing. Then checks are made if the vendor is subjected to block for any reason or if the quality certificates should be issued by vendor. If the inspection results suggest a block then the system for example posts the goods to the blocked stock The quality in procurement results are used during the invoice verification as well, for example the invoice is blocked until the quality inspection is complete or the usage decision during the goods receipt inspection was not approved that led to the invoice block.

9.6 Quality Certificate Processing

A quality certificate certifies that a material meets specific physical and chemical properties.

The quality certificate component provides the following functions:

- Automatic creation of the quality certificates when materials are shipped
- Distribute quality certificates to a predefined list of recipients
- Print certificates, or send them for example via iDoc based on output determination technique
- Create certificates in the language of each recipient

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- Store certificates using SAP Archive Link

Quality certificate processing is integrated with SD and MM processes. The quality certificate processing component generates quality certificates that certify the inspected material. The quality certificate is an electronic document transmitted via iDoc to the customer on demand or received from vendor on request.

In case the manufacturer has to issue the quality certificate the goods issue processing triggers the quality certificate process which collects the quality data at runtime in the buffer with reference to the delivery document. The collected data is constructed and transmitted electronically using the message output determination technique (see chapter 5.3.3.1). QM does not store the quality certificates directly in the database. They are automatically stored using SAP Archive Link directly after printing.

The certificate profile is an important master data that is used by quality certificate processing. It is used to determine the selection and sequence of the characteristics whose results are to be documented in the certificate. The certificate profile is attached to material, material group, or material/customer combinations. By doing so, certificates can be sent individually for specific customers. At the same time, general certificate profiles can be used, if there is no special certificate profile for the customer. The condition technique is used to determine the right combination to issue the quality certificate (for condition technique see chapter 5.3.3)

From the MM point of view, the quality certificate processing is linked to the quality in procurement processing component (see figure 9-1). The goods receipt document doesn't supply all the quality related data for performing the incoming quality check. For the same reason the quality certificate is not linked to the goods receipt document. In LE the quality certificate is linked to the goods issue processing. The quality certificate in procurement is a separate database object which is linked to the incoming quality certificate (iDoc) from the vendor. The inspection lot is then created with respect to the goods receipt and the characteristics of the inspection lot gets the value transferred from the iDoc for performing quality inspection.

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10 Further Reading

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[Gau08] Othmar Gau, Transportation Management with SAP LES, SAPpress 2008

[SAP06] Office of the CTO, mySAP Business Suite Service Provisioning, SAP Architecture Bluebook, SAP AG, 2006

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[SAP07] SAP Masterguide: mySAP ERP 2005 powered by SAP NetWeaver 2004s, SAP AG, 2007

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11 Glossary

Term	Definition
Plant	Place where the material is procured, sold or produced
Client	Represents the legal entity for example a company, has its own master data
Company code	Its defined for financial purpose, also a subdivision of company
Sales organization	Responsible for selling the material to customers
Purchasing organization	Responsible for procuring the materials from vendors
Storage location	Location within a plant to store the material
Shipment location	Shipping points are independent organizational entities within which processing and monitoring of the deliveries as well as goods issue is carried out.
Condition technique	The condition technique refers to the method by which the system determines prices for example from information stored in condition records.
Lot Size	This refers to the quantity that is planned for production or that needs to be procured during MRP. Based on the lot size procedures the system calculates the lot size
Foreign applications	Generally in purchasing applications this term refers to the applications that are called by the purchasing functions which have their own UI and business logic. Like for example services, account assignment etc are considered as a foreign application.

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12 Appendix

12.1 Material Master

Important Transactions

MM01-MM03 Material Master Create/Change/Display
MM06 Material Master Flag for Deletion
MM17 Mass Maintenance
MMAM Change Material Type

Important Tables

MARA General Material Data **(Basic data related)**
MAKT Material Descriptions **(Additional data related)**
MARM Units of Measure for Material **(Additional data related)**
MBEW Material Valuation **(Plant related)**
MPOP Forecast Parameters **(Plant related)**
MVKE Sales Data for Material **(Sales related)**
MLGN Material Data for Each Warehouse Number (**Warehouse related)**
MLGT Material Data for Each Storage Type **(Warehouse related)**

Important Programs

Object Name	Usage	Object type
MATERIAL_READ	Read Material data	Function Module
MATERIAL_MAINTAIN_DIALOGUE	Main Program Material Master Maintenance Std	Function Module
MATERIAL_DYNPRO_SEQUENCE	Screen Sequence Control: Material Master	Function Module
RMMMPERI	Period closing program in material master	Program
GET_DATEN_BILD	Gets buffered data into main function group	Form
BILDFOLGE	Program for Screen Sequence control	Form
MATERIAL_UPDATE_ALL	Update Functions: Material	Function Module
MATERIAL_UPDATE_DB	Update Material Master Data in Database	Function Module
BADI_MATERIAL_OD	Integration of New Objects in Material or Article Master	BAdI
SET_DATEN_BILD	Put the collected and verified data into buffer	Form

Further Reading

12.2 Sales and Billing

Important Transactions

VA01 – VA03: Create/Change/Display Sales Order
VA21 – VA23: Create/Change/Display Quotation
VF01 – VF03: Create/Change/Display Billing Document
VA05, VA25, VF05: List Sales Orders, Quotations, Billing Documents
VF04: Maintain Billing Due List
VF06: Create Background Job for Billing Processing
VK31-VK33: Create/Change/Display Condition Records

Important Tables

Customer:
KNA1 Customer Master Data
KNVK Customer Contact
KNVV Customer Sales Data
KNVP Customer Partner Functions
KNVD Customer record sales request form
KNVA Customer Unloading Point
KNVI Customer Tax Indicator
KNVL Customer Licenses
KNVS Customer Shipping Data

Sales Order:
VBUK Sales Order Header Status (also for Billing and Delivery Document)
VBAK Sales Order Header Data
VBKD Sales Order Business Data
VBUP Sales Order Item Status
VBAP Sales Order Item Data
VEDA Contract Data
VBEP Sales Order Schedule Line
VBFA Sales Order Flow (also for Billing and Delivery Document)
KONV Conditions (also for Billing Document)
VBPA Sales Order Partner (also for Billing and Delivery Document)
VBUV Sales Order Incompletion Log
FPLA Billing Plan (also for Billing Document)
FPLT Billing Plan Dates (also for Billing Document)
SADR Address Management: Company Data (also for Billing and Delivery Document)

Billing Document:
VBRK Billing Document Header
VBRP Billing Document Item Data
EIKP Foreign Trade: Export/Import Header Data (also for Delivery Document)
EIPO Foreign Trade: Export/Import Item Data (also for Delivery Document)

Delivery Document:
LIKP SD Document: Delivery Header Data
LIPS SD Document: Delivery Item Data

Important Programs

Object Name	Usage	Object type
SAPMV45A	Sales document: Main program	Program
SAPFV45K	Sales document: Customer data processing	Program
SAPFV45P	Sales document: Item data processing	Program
SD_SALESDOCUMENT_CREATE	Create sales document	Function Module

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RV_INVOICE_CREATE	Create billing document	Function Module
SAPMV60A	Billing: Dialog processing	Program
SDBILLDL	Billing: Billing due list processing	Program
RV60SBAT	Billing: Create background jobs (Batch)	Program

Further Reading

See the SD Knowledge Transfer Folder for further reading:

\\dwdferp\erP_ALL\33_ERP_OPS\30_Units\DC3\SD\KnowledgeWare\SD_Know_How_Transfer

Also see the training document from course SCM600 “Business Processes in Sales Order Management” for detailed descriptions of Master Data and Processes in SD:

\\dwdferp\erP_ALL\33_ERP_OPS\30_Units\DC3\SD\Education\SCM605_DE_Col62.pdf

12.3 Production Planning

Important Transactions

MDBT, MD01 Total MRP Run (Plant level)
MD02 Single-Item, Multi-Level MRP
MD04, MD07 Stock/Requirements List
MD05, MD06 MRP List
MD61 - MD63 Create/Change/Display Planned Independent Requirements
MFBF Repetitive Manufacturing – Production Confirmation
CO01 – CO03 Create/Change/Display Production Order
CO40, CO41 Convert Planned Orders to Production Orders
CO11N, CO12 - CO16, CO1V
Production Order Confirmations
COR1 - COR3 Create/Change/Display Production Order
COR7, COR8 Convert Planned Order to Process Order
COR6N, CORK, CORR – CORT, CORZ
Process Order Confirmations
COGI Post processing of Error Record form Automatic Goods Movements

Important Tables

PLAF Planned Order
PBED. PBIM Planned Independent Requirements
AFKO, AFPO Production/Process Order Header/Item
AFVC Operation of PP Orders
AFRU Order Confirmation
AFFW Goods Movements with Errors from Confirmations
BLPK, BLPP; BLPR Document Logs for REM Production confirmations

Important Programs

Object Name	Usage	Object type

M61X	Determination of the current planning situation (relevant for MD04, all MRP runs, REM planning board, requirement consumption in PP-DEM, etc.)	Function Group
M61Y	Net-requirement calculation, lot-sizing for the MRP	Function Group
SAPMM60X	Maintenance of Planned Independent Requirement	Program
M60A	Consumption and reduction of Planned Independent Requirements	Function Group
BARM	Production Confirmation in Repetitive Manufacturing	Function Group
CO	Production Order Processing	Package
COCR	Process Order Processing	Package
CORU	Production Order Confirmation	Package
COCR	Process Order Confirmation	Package

Further Reading

Technical documentation of the PP area:

https://wiki.wdf.sap.corp/display/PSupportERPMAN/Product+Support+KB+-+ERP+MAN

12.4 Materials Management

Important Transactions

ME51N Create Purchase Requisition
ME21N Create Purchase Order
MIGO Create Goods Movement
ML81N Create Service Entry Sheet
MIRO Create Invoicing Document

Important Tables

Purchasing

EBAN Purchase Requisition
EBKN Purchase Requisition Account Assignment
EKKO Purchasing Document Header (Request for Quotation, Quotation, Purchase Order, Contract, Scheduling Agreement)
EKPO Purchasing Document Item (same documents as above)
EKKN Account Assignment in Purchasing Document
EKET Scheduling Lines (Purchase Order, Scheduling Agreement)

Inventory Management

MSEG Document Segment: Material
MARC Plant Data for Material
MARD Storage Location Data for Material
MBEW Material Valuation
RESB Reservation/dependent requirements

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MCHB Batch Stocks

Invoice Verification
RBKP Document Header: Invoice Receipt
RSEG Document Item: Incoming Invoice
RBCO Document Item, Incoming Invoice, Account Assignment
RBTX Taxes: Incoming Invoice

Important Programs

Object Name	Usage	Object type
BAPI_PO_CREATE1/ BAPI_PO_CHANGE	BAPIs to create/change Purchase Order	BAPI
MEGUI	UI for enjoy transactions in purchasing	Function Group
MEPO	Business Logic for Purchase Order	Function Group
MEREQ	Business Logic for Purchase Requisition	Function Group
MEOUT	Business Logic for Outline Agreements	Function Group
SAPMM06E	'Old' program with UI and Business logic for purchasing document	Module pool
BAPI_ENTRYSHEET_CREATE	BAPI to create a Service Entry Sheet	BAPI
BAPI_ENTRYSHEET_RELEASE	BAPI to release/approve a Service Entry Sheet	BAPI
MLSP	Function group with UI and business logic for handling of External Services	Function Group
BAPI_GOODSMVT_CREATE	BAPI to create Goods Movements	BAPI
MIGO	Function group with UI and business logic for goods movement transaction	Function Group
BAPI_INCOMINGINVOICE_CREATE	BAPI to create incoming invoice	BAPI
MR1M	Function group with UI and business logic for invoicing document transaction	Function Group

Further Reading

Wikis:
Purchasing
Services
Inventory Management
Invoice Verification

12.5 Logistics Execution

Important Transactions

VL01N	Create outbound delivery in dialog (VL02N and VL03N are the related change and display transactions)
VL10	Mass creation of outbound deliveries
VL06	Delivery monitor
LT03	Create warehouse management (WM) transfer order

LT12	Confirm WM transfer order
LS24	List of warehouse stock per material
VT01N	Create shipment (VT02N and VT03N are the related change and display transactions)
VT04	Create shipments in collective processing
VT20	Transport Execution Monitor

Important Tables

Delivery Processing (LE-SHP)

LIKP	Header data for deliveries
LIPS	Item data for deliveries
VBUK*	Header status information for deliveries
VBUP*	Item status information for deliveries
VBPA*	Delivery partners

)* These tables are commonly used by sales orders, deliveries and billing documents

Warehouse Management (LE-WM)

LTAK	Header data for WM ransfer orders
LTAP	Item data for WM transfer orders
LAGP	Storage bin (master data, describing the physical structure of the warehouse)
LEIN	Storage units (movement data, describing movable units in the warehouse which could be stored in bins)
LQUA	Quant (movement data, holds the actual stock information for a certain material in a certain storage unit or storage bin)

Transportation (LE-TRA)

VTTK	Header data for shipments
VTTP	Item data for shipments
VTTS	Stage of a shipment

Important Programs

Delivery Processing (LE-SHP)

Object Name	Usage	Object type
SAPMV50A	Modul pool to control the delivery dialog, main program for delivery processing	Module pool
SAPFV50P	FORM routines for delivery item processing	FORM routine pool

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SAPFV50W	FORM routines interfacing to inventory management	FORM routine pool
GN_DELIVERY_CREATE	Create deliveries of different types in background	Function module
RV_DELIVERY_CREATE	Create sales order related deliveries in background	Function module
WS_DELIVERY_UDPATE_2	Updates existing deliveries in background	Function module

Package VL contains most of the objects which are relevant for delivery processing.

Warehouse Management (LE-WM)

Object Name	Usage	Object type
SAPML03T	Module pool for dialog processing of transfer orders	Module pool
L_TA_HINZUFUEGEN	Function module for creating a transfer order	Function module
L_TA_QUITTIEREN	Function module for confirming a transfer order	Function module

Most of the relevant programs can be found in package LVS.

Transportation (LE-TRA)

Object Name	Usage	Object type
SAPMV56A	Module pool to control the shipment dialog	Module pool
SD_SHIPMENT_CREATE	Function module for creating a shipment	Function module
SD_DELIVERY_ASSIGN_TO_SHIPMENT	Function module to assign deliveries to a certain shipment	Function module

Package VTR contains most of the objects related to shipment processing; package VTRA contains objects related to shipment costs which is one important function within transportation.

Further Reading

Documentation in SAP Library:

http://help.sap.com/erp2005_ehp_03/helpdata/en/cb/973735ec50d33de10000009b38f889/frameset.htm

12.6 Quality Management

Important transactions

QM01 Creation of a quality notification
QA03 Display inspection lot
QE51n Result recording for inspection lot operation
QA11 Usage decision for inspection lot
CWBQM Inspection planning with engineering workbench

Important Tables

QMAT Material Data: QM inspection data (Master data)
PLMK Inspection plan characteristics (Master data)
QPMK Master Characteristic (Master data)
QMEL Quality notification
QALS Inspection lot
QAVE Usage decision

Important Programs

Object Name	Usage	Object type
IQS0	Maintenance of quality notification	Function group
QPL1	Maintenance of inspection lot	Function group
QEEM	Result recording	Function group
QAAT	Interface to other components	Function group
SAPMQEVA	Usage decision	Dialog program
CL_PLM_AUDIT_APPLICATION	Audit management application	Class
CL_PLM_FMEA_APPLICATION	FMEA application	Class
CQCL	Maintenance of inspection plan characteristics with engineering workbench	Function group
CL_RPLM_QI_API_RECORDRESULTS	Result recording API for role quality inspector	Class

Further Reading

Knowledge Warehouse documentation for core quality management

http://help.sap.com/saphelp_erp60_sp/helpdata/en/a6/df293581dc1f79e10000009b38f889/frameset.htm

Knowledge Warehouse documentation for audit management

http://help.sap.com/saphelp_auditmgmt/helpdata/EN/index.htm

Documentation on the SAP Portal under Business Suite Organization -> Products -> ERP -> ERP Corporate Services -> Quality Management

https://portal.wdf.sap.corp/irj/portal?NavigationTarget=navurl://dd276bc5aa58c19a28181e00a7c25c66

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