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WORKFLOW-INTEGRATED ERP: AN ARCHITECTURE MODEL FOR OPTIMIZED COORDINATION OF INTRA- AND INTERORGANIZATIONAL PRODUCTION PLANNING AND CONTROL

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ABSTRACT

Although coordination deficiencies in production planning and control (PPC) systems, which are a subset of enterprise resource planning (ERP) systems, still exist and even increase with progressing intra-organizational cooperation, workflow management systems (WfMS) could not yet be successfully established in PPC processes. This can be attributed to the complex structures of PPC tasks and the data they process, posing significant conceptual and technical problems to coupling ERP/PPC systems with other coordinating systems. Nevertheless, coordination mechanisms provided by workflow management technology and PPC functionality can complement each other. To that end, a workflow management system must fully "comprehend" the planning and control logic of industrial processes. This includes domain-specific knowledge on interdependencies of planning tasks, resources and capacity. On the other hand, PPC systems must cede some of their coordinating functions to the WfMS. Starting from a comparison of coordination in PPC systems and in WfMS, the paper suggests a model of integrated coordination of PPC processes by means of workflow management. The model is presented both on architectural and on detailed level, and is exemplarily applied to an order scheduling process.

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1. WORKFLOW POTENTIAL IN PRODUCTION PLANNING AND CONTROL

Enterprise Resource Planning (ERP) systems have significantly contributed to progressing in enterprise-wide information system integration. In ERP systems, industry-specific solutions for managing order logistics (such as Production Planning and Control Systems) have been coupled with functionality for non-logistics and administrative tasks. These tasks include financial and cost accounting and personnel management (Hansmann and Neumann, 2001).

In these functional areas, ERP systems typically provide a sufficient degree of coordination by a high degree of data integration. In contrast, the "core" component of current ERP systems, the Production Planning and Control (PPC) system, still suffers from a number of coordination deficiencies. PPC systems coordinate the material flow in input, throughput and output processes by managing the accompanying information flow for materials management, capacity management and scheduling. The complexity and dynamics of logistics management exceed the potentials of structural ERP integration concepts. In particular, the following inadequacies of PPC systems must be cited as examples (Schütte et al., 1999; Kurbel, 1999; zur Mühlen and Hansmann, 2001; Neumann and Wiechel, 2001):

- Planning and control processes are rigidly determined by system design because current PPC systems are mostly based on the MRP II concept (Scheer, 1994a). They cannot easily be modified according to a company's needs, neither to support general company-specific features, nor to dynamically address individual order requirements.

- In most cases, there is no feed-back of fine-tuned control results to higher-level planning functions. PPC systems typically "assume" that planning results are generally met during the production process.

- Derivations from planning results not only occur within the production process, but also have external sources. Customer order changes, suppliers' delays, or unplanned rush orders of high priority may as well have an impact on the feasibility of plans. In such cases it often impossible to re-iterate the complete planning process, and the required changes are manually determined and coordinated.

- Pre-defined products are often modified according to customer-specific demands. Process details and involved people are thus not known in advance. For a coordinating system, this requires modifications of the process specification at run-time.

- Large portions of business processes are not coordinated by a PPC system, but are either controlled manually or by external programs. This results in coordination deficiencies not only regarding the sequence of performed activities, but also the interdependencies of the data processed by different applications.

- Combined with the fact that industrial order processing consists of a large number of activities and transactional data (documents and data objects), this leads to a relatively low transparency of business processes. PPC systems do not offer an integrated, process-oriented view on customer order processing for monitoring and control purposes.

Coordination requirements in industrial production arise from the composition of the complex task of order processing into several interdependent sub-tasks performed by different organizational units (Malone and Crowston, 1994). The trend to intensified multi-site and inter-organizational cooperation within the supply chain impose additional coordination requirements due to a larger number of involved entities and interdependencies. These additional requirements can often not be met. Benefits of supply chain collaboration, like reduced stocks or the elimination of verification and data entry tasks, make the system more susceptible to perturbations (Christopher, 1999). If failures or other unplanned events occur, in a distributed environment with autonomous units it is less likely that feedback information is timely propagated in order to adjust planning in other affected units and take appropriate control measures. Data interdependencies that can nowadays be successfully managed

within a company by integrated PPC system, constitute new challenges across organizational boundaries.

One solution can be the addendum of a specific type of coordination system, so-called workflow management systems (WfMS) (Loos, 1998; Becker et al., 1999; Hansmann et al., 2001). WfMS control the execution of activities of a business process in the temporally and logically correct order (*activity coordination*) and by the correct actor (*actor coordination*). With the start of an activity, the WfMS automatically provides the actor with the required data and application system functionality (*data and system coordination*). This requires a sometimes complex and expensive technical coupling of the WfMS with the ERP system and other relevant application systems (Loos, 1998; Wodtke et al., 1997; Becker and zur Mühlen, 1999).

The interdependencies between data elements (and the activities processing them) are manifold and complex, and there is a concurrency of coordination mechanisms in PPC systems and WfMS (v. Uthmann et al., 1999; Rosemann et al., 1999; Neumann et al., 2001). Attempts to usefully couple them have hardly succeeded in production processes so far.

2. COORDINATION MECHANISMS IN PPC SYSTEMS AND WFMS

Coordination can be defined as the process of managing dependencies between activities (Malone and Crowstone, 1994). Coordination mechanisms are the rules defining how the coordination goal is achieved (e. g. personal instructions). Generally, two main types of coordination can be found (Kieser and Kubicek, 1992):

- *forward-coordination*: anticipatory adjustment of activities ("top down")
  - personal instructions (vertical communication)
  - self-reconciliation (horizontal communication)
  - programs / guidelines (vertical communication, e. g. standard procedures, process instructions)
  - plans (vertical communication; result of an institutionalized planning process)
- *feedback-coordination*: response to exceptions ("bottom up", "management by exception")

PPC systems, before all, *plan* activities related to material flow. *Planning* in PPC systems mostly consists in scheduling the use of resources to fulfill the demand for products and the necessary materials. The results of a planning task constitute conditions for subsequent planning tasks (Scheer, 1994b). The resulting conditions can either be regarded as invariable input information for a subsequent tasks (*directive-oriented* interdependency) or as a request that can be fulfilled or not, which may necessitate an adjustment of the original planning (*negotiation-oriented* interdependency) (Schütte et al., 1999).

Mechanisms such as self-reconciliation (negotiation-oriented) and personal instructions (directive-oriented) are not directly supported by PPC systems. Coordination by programs can be found in PPC systems in the form of routings that become production orders when instantiated. If additional systems like control stations and production data acquisition terminals are used, PPC systems can also exert feedback-coordination. Feedback-coordination is based on information on the current status in order to detect and reduce derivations from to the original plans. Whereas derivations can often be automatically detected, appropriate measures must generally be determined and coordinated manually (Stadtler, 2000).

PPC systems particularly focus *production* processes, i. e. they plan and control material-processing activities. Information-dominated *planning* processes, which often consume the larger portion of cycle time and costs, are not systematically coordinated. PPC systems typically control these processes by *order status sequences*. In addition, *integrity constraints* can ensure the correct sequence of activity executions (for example to prevent posting of supplier invoices without previous posting of goods

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receipt). Customizing PPC systems to a company's processes mainly comprises the modification of given status sequences and integrity constraints. Nevertheless, the possibilities of defining processes within a PPC system remain limited to linear, coarse-grained sequences of activities (except for routings in production control). Alternatives in process execution that are principally determined at run-time or parallel branches are not supported. In addition, only standard processes and no exception-handling procedures are defined (Strong et al., 2001). The allegation of inflexibility and coarse granularity can be made regarding the definition of organizational assignments, too (Neumann et al., 2001; Becker et al., 2000).

Controlling the execution of *information-dominated* processes is the primordial goal of WfMS. Coordination by programs is supported via creating workflow models at build-time that represent a detailed process definition, which allows a very comprehensive specification of the control flow with alternatives and parallelism. At run-time the current status of a workflow instance and its work items can be controlled using the monitoring component. Thus, in concern with the specification of process owners and time-out values for workflow activities, WfMS can extensively support feedback-coordination.

Planning is supported only to a certain extent by additional attributing of the workflow models (e. g. setting the requested delivery date as a time-out value of a workflow instance at run-time). Furthermore, the modeling of workflows can be regarded as a planning activity in terms of process planning. Thence, coordination by plans is still a core competence of PPC systems rather than of WfMS. Additionally, personal instructions and reconciliation mechanisms are implemented by using ad-hoc workflows and by integrating CSCW-components or other non-procedural workflow paradigms as the Negotiation Workflow approach (Krcmar and Zerbe, 1996).

It becomes evident that the integration of the coordination mechanisms provided by PPC systems and WfMS enables the realization of synergetic effects. However, recent research has shown that current approaches to integrate the coordination mechanisms do not meet the essential requirements of systematically exchanging planning and control information distributed between these systems (Neumann et al., 2001). Instead, a new kind of ERP system architecture of a higher degree of integration between production planning, non-logistical resp. administrative functions and workflow control functions is required. This cannot be achieved by system interaction standards as offered by commercial workflow management systems today. This holds true for embedded workflow functionality of ERP and PPC systems.

3.   ARCHITECTURE OF A WORKFLOW-INTEGRATED ERP SYSTEM

We propose an architecture model that comprises both standard workflow management and production planning components as well as additional integration components. As the non-logistical and administrative processes to be coordinated by the ERP system do not make special demands on the coordination components, the additional integration components are needed exclusively for the coordination of PPC processes. For the same reason, the architecture components concerning non-logistical or administrative processes (e. g. for accounting or human resource management) remain unconsidered in this paper.

The architecture depicted in figure 1 represents the functional aspects of a workflow-integrated ERP system. It abstracts from technical interoperability issues. In this work, interoperability problems are regarded as solved by existing middleware solutions like the Common Object Broker Request Architecture (CORBA).
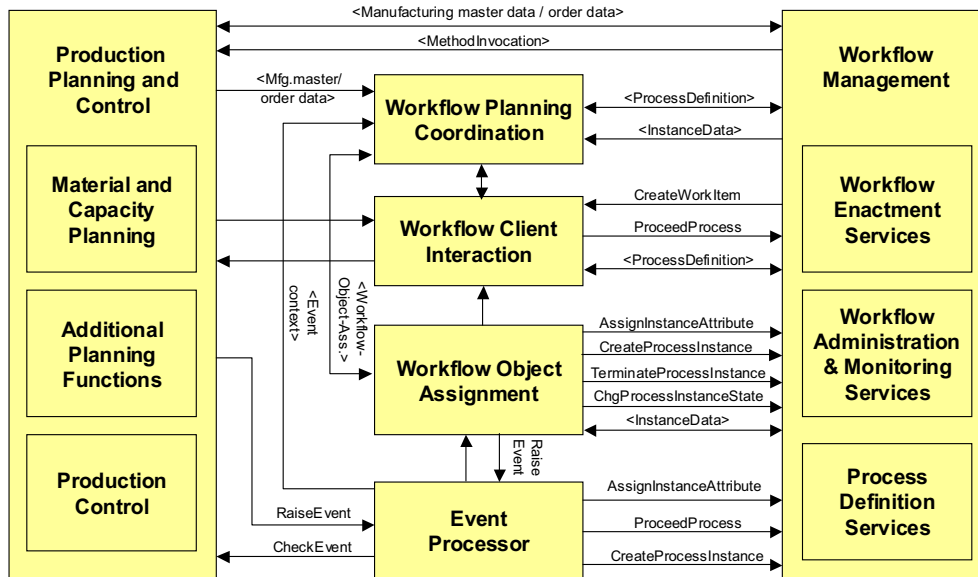
figure 1: architecture of a workflow-integrated PPC system

3.1. Workflow Management

The Workflow Management component provides basic functionality to execute processes based on underlying workflow models. This implies management of process definitions and run-time data, activity coordination in terms of selection and execution of relevant activities at process run-time, and actor coordination by determining and informing suitable actors for an activity. The component thus offers typical features of a workflow engine and additional methods for accessing or modifying process definitions. By interacting with the other architectural elements, the Workflow Management component exerts comprehensive, high-level control of the business process by activating subordinate planning and control functions and reacting on their feedback information.

3.2. Production Planning and Control

The production planning components comprise tools in the form of business objects (methods and data) for all planning tasks relevant for the order processing workflow. Planning tasks are, for example, material requirements planning and capacity scheduling as parts of the MRP II concept. They also include other functions with different planning horizons, like production plan generation or short-term machine scheduling. These functions are either provided by standard PPC systems, or implemented in specialized or individual software tools.

Although the overall process control is assigned to the Workflow Management component, it depends on control information and control tasks provided by other sub-systems, e. g. components for production data acquisition (PDA). It is important to note that we do not pursue an approach of centralized control as one of our premises assumes a distributed, heterogeneous environment in which certain sub-systems cannot be accessed from outside and need to execute specific control functions. The decentralized approach appears to be particularly suitable with regard to external companies or manual tasks involved in the overall business process.

3.3. Workflow Object Assignment

The Workflow Object Assignment (WOA) establishes a link between workflow instances, business objects and planning tasks. This function is based on a build-time relationship model of workflow

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activities, capacity units and parts needed for manufacturing the products. The concrete orders that have to be processed by a work item are determined at run-time. By this information, consistency of executed workflow structures and object structures can be controlled. When new object instances are created as a result of a planning task (e.g. the derivation of production orders from a customer order), the WOA-component creates the required workflow instances processing production orders and manages their relationships to the higher-level customer order workflow instance. If several objects of the same type are processed together as a lot, WOA manages the synchronization of the respective workflow instances.

If re-planning of certain activities becomes necessary (e.g. after a machine defect requires the assignment of orders to other resources), the component supports the identification of affected workflow instances and propagates the changes to the workflow execution facility. This may lead to the creation, termination or suspension of workflow instances, or to changes in super-/sub-workflow assignments (if, for example, a delayed production order is assigned to a different customer order of lower priority, and the more urgently required part is procured from a supplier instead).

It could also be helpful to provide the roles/persons which have processed the work items that originally created the planning result with the information that a problem concerning their area of responsibility has occurred. This could be done by automatically putting a work item, which has to be processed to solve the problem, in the work list of these roles.

3.4.   Workflow Planning Coordination

The WPC-component allows modeling of planning tasks, resources (parts and capacity units on different aggregation levels), and their temporal and logical interdependencies at build-time as the basis for the WOA-component. By using the resulting model of the company-specific *planning structure*, a link between planning, resources and workflow activities can be established. Automated management of this relationship conveys the following functional benefits:

- PPC systems normally do not support regulation processes in case that planning results cannot be implemented (due to missing resources, e. g. a machine failure) or that a planning task cannot create a feasible plan at all. The processes to compensate these types of events can be complex and are mostly manually coordinated in an ad-hoc style. However, the structure of these processes is based on planning and resource interdependencies determining the sequence of necessary re-planning tasks with modified parameters. Starting from the missing resource or the unsuccessful planning tasks, WPC enables the identification of required measures by traversing the planning structure. A set (or sequence) of tasks and the responsible workflow actors is suggested and incorporated in a dynamically created workflow model. The execution of regulation processes can thus be controlled by the workflow engine.

- In a similar way, workflows can be dynamically generated to handle orders that can not be processed by the "standard" planning process (like MRP II). This refers to rush orders or uncommon product variants requiring specific production resources or processes. Whereas the automatic derivation of a production schedule from the bill of material (BOM) is generally provided by standard PPC systems, order-specific ad-hoc workflows for production *planning* can now be created semi-automatically as well on the basis of a planning structure model.

- Planning and control tasks are usually assigned to responsible persons according to the concerned type of part (e.g. model range) or capacity unit (e.g. plant, assembly line, or group of suppliers). This knowledge is used for dynamic role resolution, so that work items can specifically be addressed to actors by order attributes.

3.5. Event Processor

The Event Processor detects relevant events in the application system environment and selects suitable action to handle them. An event can either be reported by an external system via a standard method invocation, or autonomously detected by the Event Processor component itself. The occurrence of autonomously detected events is detected by scheduled polling mechanisms such as software agents (Wooldridge and Jennings, 1995; Judge et al., 1998) querying the database state. Besides the event type and data access information required to detect it, event handling requires information on the relevant *context*, which may be determined by: the affected business object, the action causing the event, the "before" and "after" image of a state change etc. The Event Processor identifies the workflow instances affected by an event and triggers the appropriate action on them. It also provides information on the business object affected by an event for the WOA.

3.6. Workflow Client Interaction

This component manages the user interface for human actors. It informs potential workflow actors on current activities (work items) according to their roles. An actor can accept a work item, which is then locked for others, and later confirm its completion. This is done in two alternative ways:

- Work items are either displayed in a work list client enabling user interaction, including the provision of relevant application data, or

- Work item information is passed to another system in the user's working environment (e. g. a groupware client) to be further processed there.

The Workflow Client Interaction facility may also provide additional information on workflow history and ratios, organizational assignments, knowledge resources etc. In addition, it allows limited modifications of work item assignments and process definition at run-time (*ad-hoc workflows*).

3.7. Architecture Prototype

A prototype of this architecture has been implemented within the research project PROWORK[1] using a commercial ERP system, PSIPENTA, that is typically applied by make-to-order or engineer-to-order SME's. The Workflow Execution component has been newly developed in the course of the project, but is comparable to standard workflow management systems and can be addressed by WfMC interfaces 1 - 3. These subsystems currently interact with the additional integration components and external planning systems in an Windows NT environment using the COM/DCOM standard for interoperability purposes.

4. COORDINATION MODEL FOR WORKFLOW-INTEGRATED ERP

The conceptual fundament of the architecture explained above is represented by an integrated model of workflow-based coordination of ERP- and especially PPC processes. The model describes the relevant PPC- and workflow-objects and their relationships that have to be regarded in case of using integrated workflow coordination mechanisms for the coordination of planning tasks, actors, data and applications used for processing tasks. The coordination model can thus be taken as a basis for a more detailed requirements definition for the development of an workflow-integrated ERP system implementing the architecture presented above.
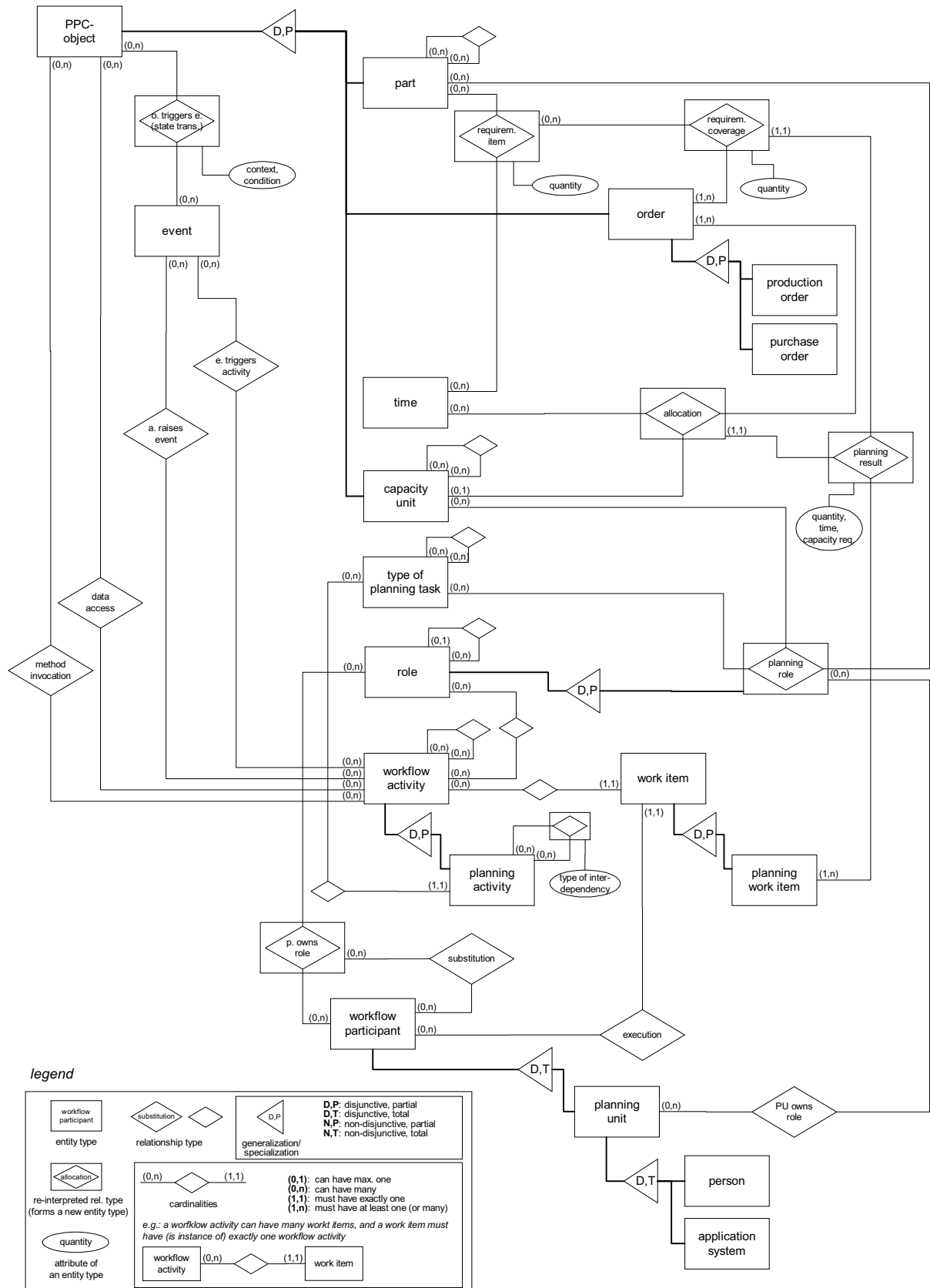

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figure 2: workflow-based ERP coordination model

The elements of the PPC coordination model and their relationships are pictured in figure 2 by means of an extended entity-relationship model (eERM) (Chen, 1976; Hars et al., 1991; Becker and Schütte, 1996). On the basis of the architecture components already specified, the eERM can be divided into several (non-disjunctive) clusters which are described below.

4.1. Workflow Management

The coordination model contains several entity types which also can be found in a typical workflow meta model. In this context only the elements which help to clarify the characteristics of PPC coordination problems are considered.

Workflow activities represent the tasks within a workflow or a workflow itself, as they are parts of a hierarchy resp. a structure. The sequence of workflow activities can also be expressed by the reflexive relationship type found in the eERM. As it can be necessary to create several instances of subsequent activities (e. g. for several positions of a production order) or several instances of sub workflows at a lower abstraction level, this relationship type helps to synchronize all the instances relevant for a certain PPC object. In the case of lot processing the merging and splitting of workflow instances has to be managed.

One or many *role*(s) can be assigned to an activity. They represent a qualification or competence necessary for undertaking the task and can also be arranged in the form of a hierarchy (e. g. to model the release of a purchase order by a superior role). A *planning role* represents a special variant of a role and is described as part of the following cluster.

When a workflow is instantiated the activities (build-time) become *work items* (run-time). Work items are displayed in the electronic work list of the persons that own the appropriate role (*workflow participants*). In addition, a *substitute* can be named for each role assignment.

A *planning work item* is a specialization of a work item representing the instance of a planning activity. The output of a *planning* work item in particular is the *time*, *quantity* and *capacity requisition* for a set of *orders*, which results in the allocation of capacity units at a certain time for the purpose of requirements coverage (see next cluster description). This fact is expressed by the relationship type *planning result* (see also description of cluster 4.3. "workflow object assignment"). Other work items (e. g. for engineering or administrative tasks) don't generate an output comparable to a planning result.

4.2. Production Planning and Control

The central object of the coordination problem is represented by the entity type *planning activity* (e. g. "schedule production orders") which is a specialization of a *workflow activity*. It makes great demands on coordination because of the interdependencies with numerous PPC-objects such as orders, parts, capacity units and other planning activities. This also results in interdependencies between the corresponding workflow activities. For example, the result of a planning activity can lead to the need of rescheduling some of the orders, which is done by initiating an appropriate workflow instance or terminating some related workflow instances already running. For this purpose, it is necessary to be able to determine the workflow instances that process the corresponding orders (or determine the planning unit that owns a role suitable for planning the corresponding resources etc.), which can be accomplished by implementing the eERM presented in figure 2. These examples show that it is necessary to define an integrated coordination model which enables the workflow mechanisms to obtain information on PPC-specific inter-object-dependencies.

The *type of interdependency* is an attribute of the relationship type between planning activities. Possible values could be "*instruction-oriented*" or "*negotiation-oriented*", which either means that one planning activity can set objectives resp. demands for another activity, or that planning results can be the output of a negotiation between different planning units that process the corresponding work items (e. g. the person who is responsible for scheduling sends a request to different autonomous production

planning units and negotiates on the completion dates of the orders he has to schedule, which depend on the capacities available in each unit).

Moreover, planning activities have a relationship with a more general *type of planning task*, e. g. "demand scheduling". Types of planning tasks can be arranged in a hierarchy which corresponds to the structure of the PPC-related business processes. The relationship between *capacity unit, part* and type of planning task can be re-interpreted as a new entity type *planning role,* which means that a role assigned to a person can consist of the qualification or competence for processing a certain type of planning task only for a certain set of parts and capacity units. If the role is unrestricted regarding parts and/or resources, the top element of the part-/resource-hierarchy can be assigned. Accommodating inter-organizational planning processes it is conceivable to define roles with members not only from one company but also "mixed" roles or workflows with roles assigned to different partners in the supply chain (technical issues of heterogeneous, distributed workflow environments are not discussed in this paper).

In addition, the coordination model regards the relationships between *parts* and *orders*. As there can be a demand for a specific *quantity* of a part (e. g. a component or finished product) for a certain date, the model contains a relationship type *requirements item*, which is re-interpreted in order to illustrate the *requirements coverage* by means of a *production, assembly* or *purchase order*. The fulfillment of an order requires the *allocation* of *capacity units*, which can also be external suppliers.

4.3.   Workflow Object Assignment

This cluster comprises entity types and relationship types that are used to establish the link between workflow activities resp. roles and the related PPC-objects.

In the first place, the relationship type *planning result* already described can be mentioned, which is necessary to store the information on which PPC-objects have been affected by the output of which planning work items at run-time. The planning result can concern several parts or orders in case of lot processing. This is the basis for the implementation of an effective exception management because in case of problems that occur during order processing resp. production planning the workflow-integrated ERP system can automatically determine the relations between the problematic objects (as a defective machine) and the workflow instances and corresponding roles that are just processing or have lastly been processing the objects (problems can be detected by using the Event Processor – v. 4.5.).

Secondly, the workflow participants should be provided with the PPC-functionality needed to process the work items. This is done by *invoking methods* of the business objects available in the ERP/PPC system. *Attributes* of PPC-objects can be read or changed by the workflow engine via method invocation or direct *data access*, depending on the implementation of the PPC-functionality. A subset of this data can be used by the workflow engine to manage the control flow, e. g. decide about alternative branches in the workflow model.

4.4.   Workflow Planning Coordination

The reflexive relationship type attached to the *type of planning task* and the one attached to the *planning activity* can be used as a basis for providing the functionality of modeling the company-specific planning structure and its interdependencies. The link between planning activities and the affected resources (capacity units and parts) can be determined at build-time via defining the PPC-specific *planning roles* and assigning them to planning activities. Thus it is possible to find the appropriate workflows, workflow activities or persons (via role resolution) for the relevant PPC objects for the means of exception handling and semi-automatic workflow creation.

In addition, the specification of events that are used to trigger planning resp. exception handling workflows is part of the build-time model of the planning structure.

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4.5.   Event Processor

Workflow activities can be triggered by PPC-specific *events* and events also can be raised by workflow activities. This fact results in the need of storing information on the essential attributes of events that can occur during production planning. This enables the PPC system to detect events automatically and respond to them by initiating workflow instances, resuming instances waiting for a certain event, stopping instances or informing workflow participants etc. The exceptions / problems mentioned above can thus be mapped to events detectable by the PPC system, e. g. by the means of workflow agents. Events mainly can be characterized by the changes of *attributes* (*state transition*) of *PPC-objects* such as the stock of inventory of a certain component needed at a certain time or the requested delivery date of a final product. These object attributes constitute the PPC context of an event.

4.6.   Workflow Client Interaction

See cluster description of "Workflow Management" (4.1.).

5.   APPLICATION SCENARIO: WORKFLOW-ENABLED DISTRIBUTED ORDER SCHEDULING PROCESS

The use of the mechanisms enabled by the implementation of the integrated coordination model can be exemplarily demonstrated with an application scenario, which has been developed on the basis of the company-specific process analysis undertaken at four companies within the PROWORK research project. The planning structure underlying the scenario is depicted in figure 3. We assume a manufacturer of products with variants and of unique products.

The activities within the process can be described as follows: The receipt of a customer order (*event*) triggers the order scheduling (*planning activity / work item*). As, in most cases, the master data for the desired product is not yet complete, the quantity and delivery date can only be prognosed. Before the order can be scheduled some of the components needed for manufacturing still have to be engineered. This is initiated by sending a *work item* to the engineer who owns the appropriate *planning role*[2] for the task and the parts that have to be engineered (in this case, the role is unrestricted concerning capacity units).

The information on the components of the product and the planned completion dates are input for assembly planning, which is the central planning activity because the assembly hangar is a permanent bottleneck. Therefore, order scheduling cannot make directives to assembly planning; the *type of interdependency* found here is *negotiation-based*, because the order scheduling work item has to wait for the acknowledgement of the proposed completion dates. The procurement planning for externally produced components is also handled by negotiation-based workflows and *planning roles* that are composed of the designated *capacity units* (in this case: suppliers), *parts* and *types of planning tasks* (e. g. lot size planning, vendor selection etc).

Assembly planning, however, can mandatorily (*directive-based*) give the resulting material requirements and dates to scheduling and capacity planning (for components produced in-house, where no other bottlenecks are expected). A feedback is only necessary in case of *exceptions*. When an exception *event* is detected by a *workflow agent* within the workflow-integrated PPC system (e. g. a material produced in-house is not available at the date required), the system can then determine the *roles* and *planning activities* that are affected (e. g. assembly planning) and start workflows the event

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[2] Although engineering tasks are originally not accounted as planning tasks, the planning role construct can also be applied here.

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is assigned to in the build-time workflow model (*trigger*) or automatically propose a *regulation workflow* at run-time, which could comprise the external procurement of the needed material and the rescheduling of orders resp. the revision of the assembly planning on the basis of the delivery dates promised by the supplier. It could also be requisite to *suspend, cancel* or *modify* some of the already instantiated purchasing workflows that are based on the old requirements dates. This could be achieved by informing a person who has the role as *process owner* of a workflow.

A definite delivery date can not be acknowledged to the customer until the assembly planning is complete.
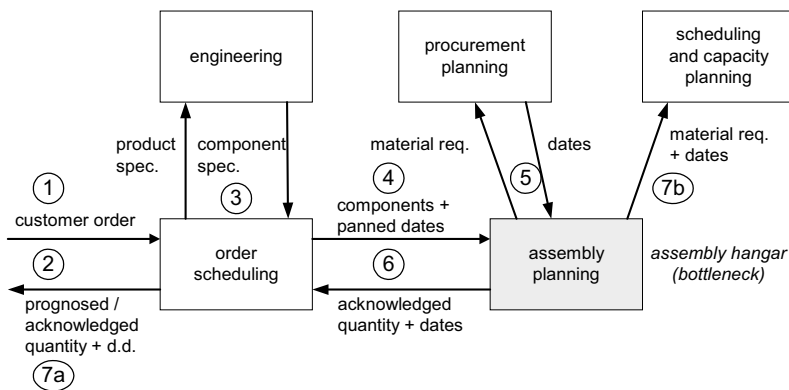

figure 3: application scenario

6. CONCLUSIONS

As the process illustrated above doesn't comply with traditional MRP II, standard ERP systems are not capable of coordinating it properly. Finally, a workflow-integrated ERP system based on the principles introduced in this paper provides all the required mechanisms for individual process definition (MRP II or non-MRP II) and coordination. It helps to increase efficiency in process execution via actor, activity, data and system coordination and supports an effective exception management due to its knowledge of the PPC-specific interdependencies between planning activities, roles, resources and orders.

Therefore, the architecture and underlying coordination model proposed can be considered as the basis for eliminating the coordination deficiencies in PPC mentioned in the first chapter, enabling a holistic and integrated PPC coordination, increasing the quality of the intra- and interorganizational planning results and thus the quality of the products and services provided to the customer.

In a further step, additional ERP components have to be adapted to this architecture. Special interest must then be given to the integration of value-based activities, such as financial budgeting, with PPC tasks dealing with quantities of material and capacity. We propose that the notion of workflow-coordinated planning tasks introduced in this paper is a suitable basis for this and can be extended to achieve more flexible and efficient Enterprise Resource Planning processes.

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