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Planning in Virtual Enterprises

Ortner W., Stary C.
University of Linz, Austria, Department of Business Information Systems, Communications Engineering
Freistädterstrasse 315, A-4040 Linz, Austria,
phone: ++43 (732) 2468-7108, fax: ++43 (732) 2468-7111,
email: Wolfgang.Ortner@ce.uni-linz.ac.at

Abstract

This paper deals with a case study in utilizing workflow-modeling techniques in the domain of tele-planning. It introduces concepts for distributing tasks to develop a production plan within a distributed organization. The requirements for modeling this type of organization for planning tasks are categorized. Traditional constructs for modeling workflows are checked against the acquired requirements. An approach for migrating modeling constructs for telework is utilized to capture essential planning tasks. Major benefits from this approach are to be expected when implementing concepts for globalization for enterprises.

Keywords

workflow, planning, virtual enterprise, teleworking

Organizing the Extended Enterprise P. Schönsleben, & A. Büchel (Eds.)

1 INTRODUCTION

Planning for production requires the coordination of human experts, material, machines, and orders to be produced (e.g. Fox et al., 1990). The ultimate goal is the mutual tuning of humans and resources, in order to meet several requirements simultaneously, such as quality constraints concerning the product, continuity of production etc. Planners need to be supported with relevant data that have to be related for setting up a production schedule. In case of distributed and geographically isolated planning workplaces and production lines, as we have to assume for virtual enterprises, the correlation of materials, machines, organizational units, and humans becomes more challenging, due to the geographical and probably temporal dispersion of the agents and planning elements to be coordinated.
The result of a planning process is considered to be a production plan that requires steady monitoring and control. The crucial activity in planning is the acquisition and integration of all constraints for the production process (Dorn et al., 1992). A planner has to take into account constraints that can be specified explicitly as well as those constraints that are the consequence of explicit constraints or cannot be expressed explicitly (in advance, i.e. in the course of prospective planning). The latter are related mainly to human factors and unexpected events, such as unforeseen problems of supply with resources. The set of constraints to be handled is basically composed of several types of constraints (e.g. Schmidt, 1996):

- Constraints concerning resource-demands and supply with resources: These are the characteristics of the materials, intermediate results, humans, and machines to be scheduled for production.
- Temporal constraints, such as processing times, and precedence constraints: They affect the quality of the product, due to the state of the humans, material and other resources, predefining a certain sequence for task accomplishment.
- Work load constraints: Humans perceive tasks and events differently, and have certain capabilities and capacities to capture situations mentally. Production planning support systems should adapt to individual and global workloads.
- Spatial constraints: This type of constraints may lead to consideration of possible delays due to space problem in production, in particular when time-critical concepts, such as just-in-time should be implemented.

Workflow systems are considered to support scheduling (planning and control), supervision, and execution of business processes in a distributed setting. Planning support is expected through meeting the constraints mentioned above. It should lead to improved performance measures and reduced failure costs. However, there does neither exist a conceptual framework nor a methodology for development. Current approaches towards a mutual tuning of workflow-driven production and concepts for teleworking, such as (Dangelmaier, 1995), are limited to first experiments with the tool perspective, namely workflow engines to support

distributed processing. However, these approaches clearly identify a lack of semantic concepts for integrating production modeling with workflow modeling.

In this paper we discuss the migration of telework concepts for production planning into traditional workflow models. We consider workplaces in distributed enterprises as tele-workplaces. First, we give the requirements and particularities for modeling telework (section 2). Then, we present the results of checking traditional workflow-specification languages against the requirements for modeling telework (section 3.1). Finally, we propose a solution on how to integrate the previously isolated concepts to support planning in production processes. We exemplify the traditional as well as the enhanced model along a case study (section 3.2). A summary of achievements and issues for further research conclude the paper (section 4).

2 VIRTUAL ENTERPRISES AND WORKFLOW MODELS

Virtual enterprises contain a set of locally distributed workplaces (e.g, Gray et al., 1993). In order to cope with production management the use of telemedia, such as video-conferencing, is required. This demand leads to a high-bandwidth connection of the involved workplaces. Due to the use of telemedia we term these distributed workplaces tele-workplaces. For this type of workplaces an adequate representation for organizational development has to be identified. The static and dynamic elements for modeling teleworking are, e.g. according to (EU, 1995):

- place and time of task accomplishment, due to the possibly loose coupling of processes for task accomplishment
- involved business processes, in order to determine organizational and technical, if not social modifications and changes
- communication facilities, in order to enable the interaction of the teleworker with other members of the virtual enterprise
- role of teleworker from the business process point of view
- synchronization requirements for timely task accomplishment in locally and temporally distributed business processes
- management of business processes involving teleworking
- work assessment, comprising monitoring, controlling, and sanctioning
- training and help for teleworkers and managers
- additional integrity and security requirements.

The particular structures of enterprises in case they are arranged in a dispersed way, and the way telework becomes part of workflows and part of employees' life style require the treatment of several features in the course of workflow models:

Distribution of Communication: A synchronous and synchronous communication has to be possible according to the temporal dispersion of resources and users. In

case dispatchers (this is the term for the functional role of planers) are distributed in the enterprise, they need channels for communication to exchange planning data and releases of plans in an asynchronous and synchronous manner. Fundamental services are email and talk-facilities that enable both types of interaction.

More complex interaction features are required in case multi-media data have to be exchanged and/or the dispatchers have to have communication quasi face-to-face although they are geographically dispersed. In this case, video-conferencing and globally accessible white-board facilities are required to support synchronous communication.

Sharing of Data: Data sharing may require sophisticated transaction management due to the requirements for planning. In case dedicated functional roles of agents allow to restrict write-access to one dispatcher, the virtual enterprise may rely on a simple client/server protocol. In case several dispatchers are working concurrently on a particular plan, simultaneous access to the current plan release has to be provided. Detailed functional role modeling as well as access plans according to time constraints and functions to be performed may ease the task of complex transaction management.

Simultaneous Interaction: For tuning different strategies and in case of immediate actions, e.g., due to alarms, simultaneous interaction may be required through several agents, e.g. monitoring systems providing the latest data and dispatchers providing the best of their knowledge to decide in the shortest possible period of time. In these cases work in parallel does not lead to improvements to performance, since conflicts have to be resolved immediately and in a straightforward way. In addition, all data available to solve the problem have to be accessible for all agents involved in that process.

From the technical point of view transaction models, such as the ACID-model have to be enhanced with features for concurrency modeling. The workflow representation requires also some constructs to indicate the technological requirements for synchronizing processes and access to commonly available data.

Workflow models hence have to provide concepts to distinguish geographically and temporally dispersed interactions from those that occur without physical separation. According to the identified items above the concepts have to comprise elements for:

- synchronization requirements concerning organizational units, functional roles, access to data, and common activities
- sharing of data, enabling the concurrent access to data by several dispatchers at the same time from different locations.

In the following we are going to detail these requirements and develop a concept to embed corresponding features into modeling constructs of traditional workflow-specification languages.

3 PLANNING IN VIRTUAL ENTERPRISES

Production planning and control works along the following line of activities: Search for the best production plan that can be achieved with the (partially) known pieces of knowledge. In the course of planning all decentralized information should be integrated after tuning, in particular when conflicting objectives have to be handled. Tasks can be distributed over teams. Dispatcher have to solve organizational and technical obstacles (Scheer et al., 1995), and therefore need support to coordinate this type of business processes. For production planning and control dispatchers need to be provided with a consistent, actual and complete picture of more or less autonomously acting components of a virtual enterprise. Planning in virtual enterprises is actually a task of coordination probably inconsistent and incomplete constraints and views of all sub-processes and elements relevant for the production process.

The subsequent sections first introduce the commonly acknowledged perspectives and constructs for modeling workflows (section 3.1), and secondly utilize and enhance them with particular constructs to model distributed planning (section 3.2).

3.1 Traditional Workflow Modeling

Traditional workflow models implement business processes along different perspectives, e.g. (Grabowski et al., 1996):

- *Dynamic view:* Process definitions detailing work tasks, temporal and causal relationships between activities.
- *Static views:* Organizational units (departments), data structures, roles of people, employees, functions, resources and tools, including hard- and software.
- *Mutual assignment of static elements*, such as roles to employees, functions to roles, data structures to functions, resources to functions.
- *Assignments of static elements to dynamic ones*, such as organizational units to tasks, functions to processes, data structures to tasks.

The following example (Figure 1 & 2) shows a traditional workflow comprising production planning. Figure 1 details the workflow with the notion of flow diagrams and assignment relationships for roles and data. The roles of people are production manager and dispatcher. The assigned data are orders, materials, machines, and schedules. Figure 2 details part of the corresponding organizational units and human resources.

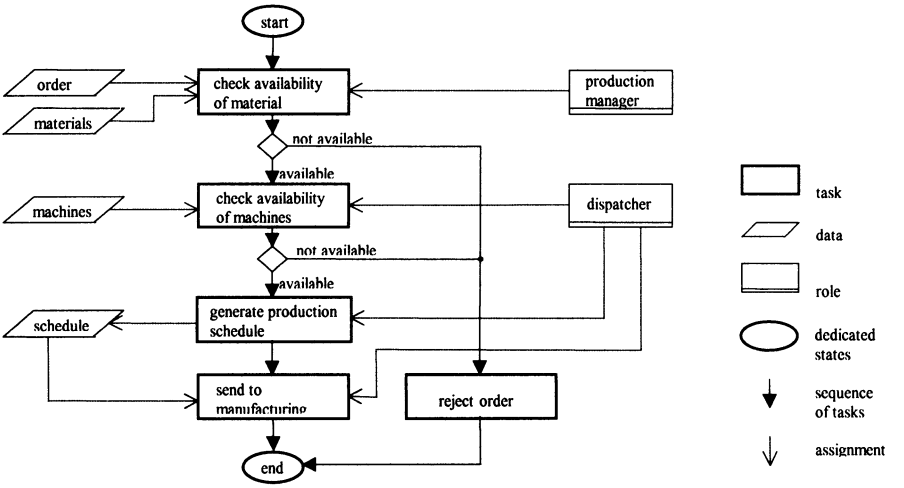

Figure 1 Example of a (high level) business process for production planning.

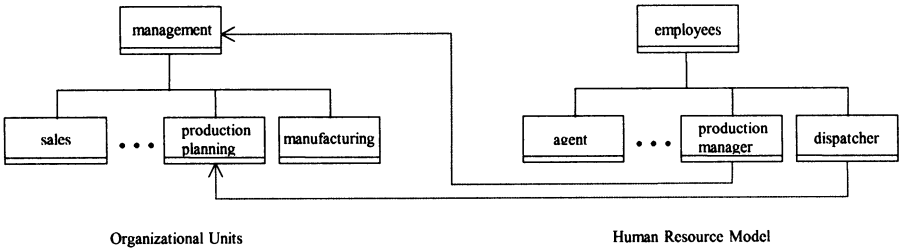

Figure 2 Part of the Organization and Resource Model according to Figure 1.

The concepts and notations utilized for specification of workflow models (EER-diagrams, Petri-nets, OSA-diagrams, etc.) do neither support different types of tasks and employees, nor allow to identify space and time constraints allocated to tasks and/or workers - a requirement set up through teleworking. In a workflow model comprising telework the organizational, individual and social constraints have to be reflected, in order to enable organizational development in the sense of introducing local and timely distributed employees and task accomplishment. Hence, the traditional concepts and notations for workflow modeling have to be extended to capture the introduced requirements for modeling teleworking.

3.2 Workflow Modeling Comprising Tele-planning

In this subsection essential constructs to model telework within workflow modeling are introduced. We first extend the example presented in section 3.1 with particular concepts and give then those conceptual elements that we suggest for a more complete migration of telework constructs into workflow models in general.

Figure 1 does not indicate the locally and temporally dispersion of employees to set up a production schedule. For instance, in a company producing at distributed locations within a single virtual enterprise the production manager is responsible for all of the distributed production processes. However, s/he can only be present at one location at a time. The only way to keep her/him continuously involved in the distributed production processes is to install and configure a tele-workplace. This step requires conceptual and notational changes. Figure 3 reflect these changes from the static point of view, namely extending the role concept with a type concept for the type of work. It shows that a production manager has to be provided with a tele-workplace in order to perform the assigned tasks. Due to the assignment of roles to organizational units (and the consequent assignment of organizational units to tasks) no further activities for migration of teleworking are required initially from the static point of view.

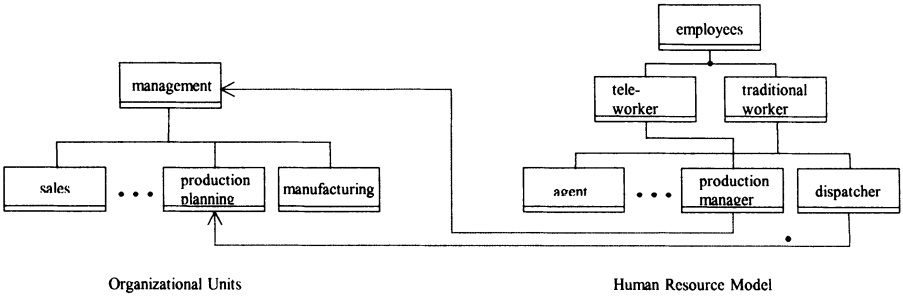

Figure 3 Static Migration of Teleworking Concepts into a Workflow Model.

From the dynamic (process) point of view the set of constraints for task accomplishment has to be specified along the sequence of the production manager's tasks. Figure 4 shows a high level view of the required synchronization, i.e. the availability of the teleworker (production manager) before an order can be processed.

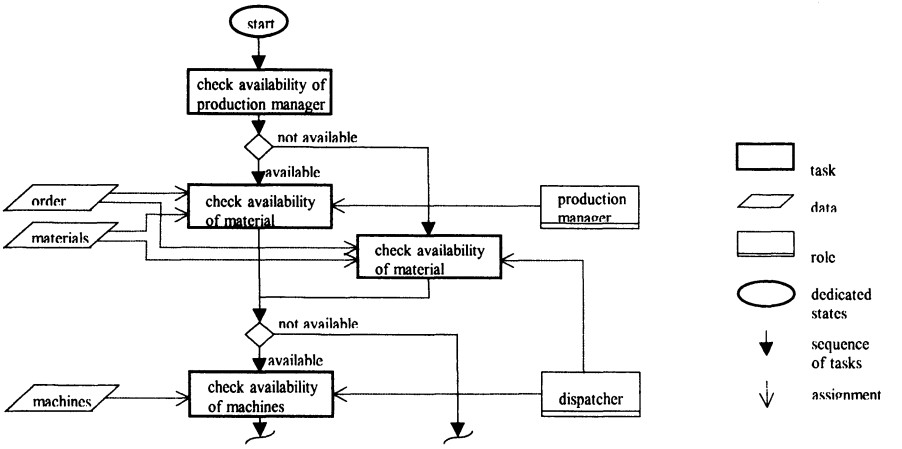

Figure 4 Dynamic and Assignment Migration of Teleworking into a Workflow Model.

Finally, the assignment relationships between static and dynamic elements of business processes have to be adapted to the previous modifications. In case the teleworker is not available, e.g. because of transmission problems, the business process has to be started anyway, in order to keep the production running. To achieve that the responsibility for the entire planning process is taken over by the dispatcher - in Figure 4 this alternative to the assignment of the production manager is added.

In order to meet the general requirements for tele-planning for production, namely the coordination of human experts, material, machines, and orders to be produced, we have to enhance the traditionally used constructs as follows:

- Dynamic view
  (a) Process of plan development, i.e. the treatment of different releases of plans, since dispatchers usually create a variety of plans, and only one of them is actually selected for production - this requires also enhancements for the static views.
  (b) Conflict management among dispatchers, in case a production plan is developed by a group of dispatchers - again, modification of features related to the static views are required (see below).
- Static views
  (a) Organizational units: The traditional partitioning of organizations into locally available departments has to enhanced, in order to provide insights which workplaces are actually tele-workplaces.

(b) Data structures: They have to assigned to two different categories: those that cannot be accessed by several employees to accomplish one and the same task, and those that have to be access by more than one user to accomplish a particular task.

(c) Roles of people: Similarly to data structures they have to assigned to two different categories: those that comprise activities that can be accomplished through teleworking, and those that comprise activities that cannot be accomplished through teleworking.

(d) Employees have to be identified according to their role they are playing with respect to teleworking (see roles of people).

(e) Functions: They may have to capture meta-information to coordinate the work with respect to teleworking.

(f) Resources and tools, including hard- and software, have definitively to capture all communication features required for teleworking.

- Mutual assignment of static elements, namely

  (a) Roles to employees: The assignment procedure have to be enhanced with the role of teleworkers, in order to reflect the geographic and temporal dispersion of employees.

  (b) Functions to roles: With respect to the modification of the role concept for workflow modeling including telework the mapping of functions to roles have to be reconsidered: each organizational function has to be analyzed whether it can be handled in a distributed way.

  (c) Data structures to functions: This assignment requires the discussion of safety and security aspects and may influence the transaction management on shared information. However, after the clarification of the mutual assignment of functions to roles this assignment should be derived in a consistent way.

- Assignments of static elements to dynamic ones, namely

  (a) Organizational units to tasks: Similarly to the mutual assignment of static elements, with respect to the modification of the role concept for workflow modeling comprising telework the mapping of organizational units to tasks have to be reconsidered: each organizational unit have to be analyzed whether it could become a virtual one.

  (b) Functions to processes, and data structures to task: These assignment require the discussion of stable processes as well as safe and secure data for task accomplishment. According to the results of mutual assignment of organizational units to tasks the assignments can be performed consistently.

One of the major requirements, namely ensuring the production in case of non-availability of tele-workers, is handled implicitly. The responsibility that tasks are accomplished in any case is modelled by passing the control to another role (in our examples the dispatcher - see Figure 4 above).

4 CONCLUSIONS

In this paper first steps for a conceptual migration of concepts of teleworking into workflow models have been performed. We have provided insights in the requirements that have to be met for an accurate representation of teleworking concepts into workflow models. We also have reviewed traditional means for workflow models and identified those elements that are able to capture modeling constructs required for a particular application domain, namely planning . We have addressed particularities concerning the

- synchronization of organizational units, functional roles, access to data, and common activities, as well as the
- sharing of data that is required to coordinate several tele-planners to accomplish their task, although they stay at different locations.

The designer of workflow models, however, is not relieved to capture one essential feature of production-related workflows: to keep the production running, even when tele-workers are not available. These cases have to be handled through extensive exception handling. For these cases we have suggested to define functional roles with identical capabilities. For instance, parts of the tasks to be performed usually by the production manager, have to be handled by dispatchers in case of non-availability. This type of exception handling seems to be appropriate to meet the requirement of maximal performance of machines.

The proposed migration strategy ensures the utmost compatibility of traditional workflow models with upcoming developments in organizational engineering, namely the integration of tele-working places. Further research has to be performed, in order to develop a notational framework that allows a consistent mapping from the workflow model to the data model, with particular respect to

- sharing of data, since conventionally utilized models, such as ER-diagrams do not reflect this constraint, and
- concurrent access to data, that require the use of high-level mechanisms for synchronization, such as proposed in Petri-nets.

Once these mappings can be achieved, high-level views, as they occur in business process models, can be transformed to requirements for implementation (e.g., in workflow engines), in a straightforward and accurate way.