CONTROL AND MANAGEMENT METHODS FOR PREPRESS PRODUCTION IN MULTICHANNEL NEWSPAPERS

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Keywords: process control, prepress, production management, multichannel publishing, process modelling.

Abstract: Prepress production in newspapers is a complex, time-critical manufacturing process involving heterogeneous networked systems. Increasing competition and changing market requirements are making new demands on production control and management as well as on the flexibility of the production process in producing originals for multiple delivery channels, both printed and on-line.

In a research project focusing on prepress production, but with a global perspective, aiming at the integration of the entire newspaper production process, we have defined models for the production process as well as concepts and methods for control and management of systems and operations in a continuously changing environment. Some effects of an implementation of these methods are enhanced production control in multichannel publishing, flexible product design, and increased productivity.

INTRODUCTION AND BACKGROUND

The monitoring, scheduling, and control of newspaper production, from news gathering and ad marketing to customer copy delivery, is complicated by a number of methodological and practical problems [Enlund 1992]. The final product is not defined until late in the production run, changes in the product and production

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process are frequent, the production subsystems are heterogeneous, and the cost of delays are high. The problems are especially prominent in the prepress area, where the creative editorial processes are especially difficult to manage. Traditional assembly or process industry production management methods cannot easily be adapted to newspaper prepress production.

Newspapers are currently going through a period of adaptation to the increased presence of digital, interactive services in the media landscape. The strategy of most publishers is to utilize the contents assets collected primarily for the printed product by repackaging them for distribution through multiple parallel channels, some of them digital. The old concept of multichannel newspaper publishing [Enlund 1979] is becoming reality. This means that the traditional newspaper production process is becoming more complex, which leads to even higher complexity in the production management area.

The newspaper production process can be divided into four high level steps (figure 1).

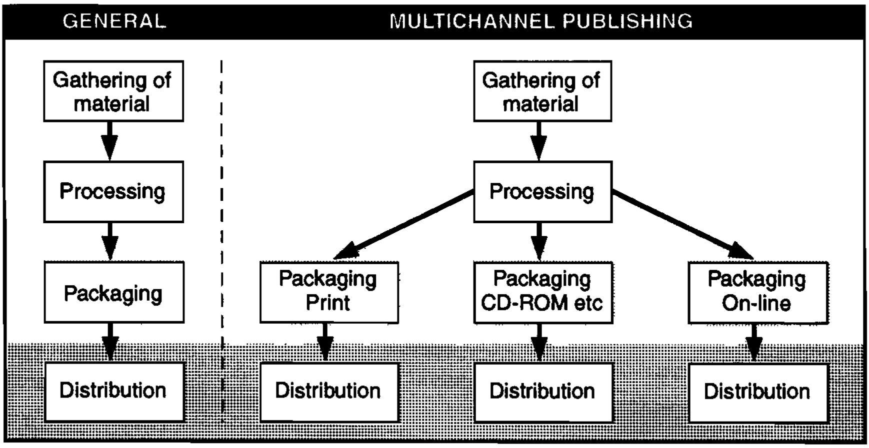

Figure 1. Four main logical steps in the publishing production process. A general view is presented on the left and a model for multichannel publishing on the right.

In this paper, we look closer on the first stage of the process, often called prepress, which is represented in figure 1 by the process phases gathering, processing, and (in part) packaging.

Earlier, during the so called 1st to 3rd generation periods in publishing technology [Seybold 1988], prepress was the production of originals, starting from the point when stories, photos, graphics and ads was ready for paste-up or electronic page make-up. This traditional meaning of the word prepress vanished with the introduction of fourth generation, distributed publishing systems. The labour and machine intensive composing rooms were substituted by integrated system that produced page films or even printing plates. Part of the work of the composing rooms was, however, transferred to the editorial and advertisement departments.

A more general definition of the concept prepress is the following.

"Prepress is a general term for all work done before the page original is transferred to a printing plate or to the imaging drum of an electronic press. Prepress includes the preparation and production of text, graphics and images."

In newspaper production, this means that we include advertisement preparation and editorial work, i.e., all activities before press and postpress. Some would argue for the use of the term pre-prepress that covers the gathering of editorial material, marketing and the selling of advertisement space. The problem with this is the difficulty in making a clear separation between prepress and pre-prepress. In the term prepress we therefore choose to include the following:

- Marketing, circulation and subscription activities.
- Advertisement sales and the reception of ads.
- Planning of the product format and product design.
- Ad production, including text, graphics, and images.
- Collection, creation and processing of editorial material.
- Page production and finishing.
- Production of press-ready page originals or originals for digital distribution.

Each of these above demands special control and management functions, but some general factors apply to all. From this point of view we will propose a common control structure.

The following important aspects of the newspaper prepress production process are worth considering, when designing production management solutions:

Common infrastructure. The necessary infrastructure for system integration consists of standardized process interfacing protocols, communication protocols, computer network systems, hardware and software platforms, and data base access protocols [Nordqvist et al 1994a]. Today, this is a reality for the prepress functions in most newspapers.

Digital production. All newspaper contents material can today be produced and processed in digital form. This pus new demands on tracking and control of the production, but at the same time creates new opportunities for productivity enhancements. One of the most important implications of digital prepress production is the possibility of multichannel publishing.

Multichannel distribution. Newspapers are by definition providers of information (news and advertisement), and since the days of Gutenberg the delivery mechanism (information bearer) has been paper. By producing and storing all content elements in digital form, the use of alternative and complementary, primarily electronic, distribution channels has become possible and viable.

Flexibility. Zoning and editioning of the newspaper has become necessary for competitive reasons [Nordqvist et al 1994b]. This requires great flexibility in the prepress production process, especially when also producing originals for multiple delivery channels. It must be possible to easily alter the production process, reallocate the resources, and adjust the schedules to meet the demands on topicality of contents while maintaining productivity.

Time criticality. The newspaper prepress process is characterized by highly parallel design and production activities under heavy deadline pressure. The production is actually well under way before the final product is specified. This is an extreme form of concurrent engineering that requires very specialized management and control methods [Enlund 1992].

All the above aspects influence the way that newspaper prepress production is configured, its functions and its data flows. They also put very high demands on the control and management methods to be used. We will present a control model for the newspaper prepress production, extended to include also the parallel production of material for digital distribution. However, before discussing the actual control and management concepts, we will specify a general model for the prepress production process and identify the main points where the progress of the process should be monitored and controlled.

A MODEL OF THE PREPRESS PRODUCTION PROCESS

Figure 2 depicts a model of the prepress production in a multichannel newspaper. The functions are grouped according to figure 1. The large grouping to the left in figure 2 represents the gathering of information as well as the processing of this material. The packaging stage is depended of the distribution channel that is chosen, e.g., print product, off line digital product (i.e., CD-ROM) or on-line distribution.

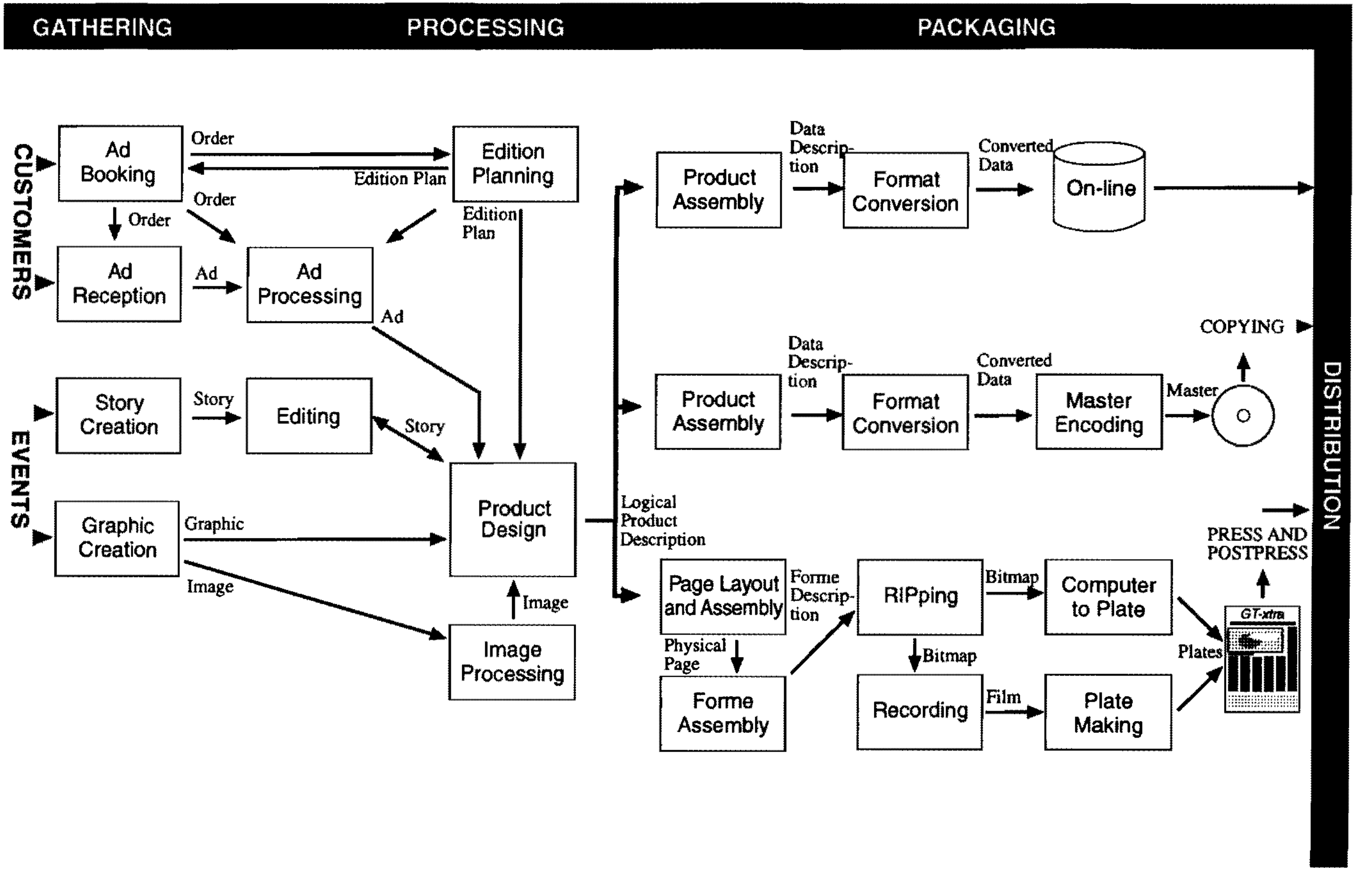

Figure 2. A functional production model for multichannel publishing.

The processes concerned with the gathering and processing of information are to a considerable extent independent of the chosen distribution channel. Herein lies an opportunity for exploiting synergy effects in multichannel publishing [Enlund 1994]. Within this area, the following functions and main data flows are represented in our model:

Ad Booking. Ad marketing, sales and space reservations are coordinated and handled by this function. The *input* to the function consists of customer contacts and edition planning information. The *output* from the function are ad orders containing space and resource booking information.

Ad Reception. Incoming external ad material is received from the customers and is checked and routed forward. The ad material can have different forms — analog or digital, complete or only partly assembled. The *input* to the function is ad material from customers and orders from ad booking. The *output* consists of ads sent to ad processing for assembly and/or preparation for production.

Ad Processing. Preparation of external ads and production of ads according to order. The *input* to the function consists of job orders, ads and ad material, and edition plans. The *output* from the function is finished ads and pages or parts of pages containing ad material.

Story Creation. Editorial text contents is generated by this function. The *input* to the function is events from the surrounding world — local and global — in a variety of formats: wire services, other media, press releases, public events, hints, rumours, etc. The *output* consists of stories for further editing.

Graphics Creation. Editorial graphics (line art, b/w and colour half-tone) are created in close cooperation with story creation. The *input* consists of events and graphics from different external sources. The *output* from the function is graphics and images for further processing.

Editing. Stories are here refined, formatted and prepared for product packaging. The *input* to the function is unedited stories. The *output* consists of stories ready for page layout/product design.

Edition Planning. This central planning function is based on general product planning objectives and on an iterative process of balancing editorial requests and ad reservations. The *input* consists of space reservations. The *output* consists of detailed edition plans, i.e., plans for the structure and scope of the publishing product.

Image Processing. Final processing of images and preparation for the packaging process. The *input* to the function comes from graphics creation in the form of images. The *output* is images ready for publishing.

Product Design. The final processing point before packaging the product for a special media. This function determines the actual contents of the products: what material will be included and with what editorial angle. The *input* to this function is edition plans, ads, stories, graphics, and images. The *output* consists of logical product descriptions, including all content material, for product assembly and page layout.

The following step in the production process is the packaging of the products. The number and types of functions necessary are different depending of the product produced. Let us start the discussion with the process of packaging print in a modern newspaper, where we have adopted the terminology used in the IFRA-track recommendations [Thoyer 1995]:

Page Layout and Assembly. The packaging of the material into fixed and numbered designed pages. The *input* is logical product descriptions and contents material. The *output* from the function is physical page descriptions in an electronic format.

Forme Assembly. The physical pages are assembled into final formes for printing, one or several pages per forme. The *input* to the function is physical pages and high resolution images. The *output* consists of forme descriptions in electronic form, e.g., PostScript.

RIPping. Converting the forme description into a bitmap of the printing plate. The *input* is forme descriptions and the *output* is bitmaps.

Recording. Transferring the bitmap onto a page film for conventional platemaking. The *input* to the function is bitmaps and the *output* is page films.

Plate Making. Optical transfer of the film image onto a printing plate. The *input* is page film and the *output* consists of printing plates.

Computer to Plate. Transferring the bitmap directly onto a printing plate. The *input* is bitmaps and the *output* printing plates.

An alternative (and complement) to print distribution is the packaging of the contents as a physically distributed, off line digital product, e.g., a CD-ROM. The packaging functions involved are:

Product Assembly. Assembling the available material in a fixed and accessible structure. The *input* is a logical product description and the output is a structured data description.

Format conversion. Formatting the contents into a pre-determined data format for one or several of the many different target reader platforms. The *input* consists of the data descriptions and the *output* is converted data in its final format.

Master Encoding. Producing a master for the product for copying, physical packaging, and distribution. The *input* is converted data from format conversion and the *output* is a master copy.

The final alternative packaging process is aimed at on-line distribution and consists of the following main steps:

Product Assembly. Assembling the content material of the product into a structure for easy access. The *input* is the logical product description with the actual material. The *output* is the final data structure description.

Format conversion. Formatting the contents into pre-determined data formats within the structure. The *input* to the function is a data description. The *output* is converted data to the on-line database.

The above general model provides an example of a possible future multichannel prepress process with a diverse product mix. It also provides a basis for defining control and management functions.

PRODUCTION TRACKING

We consider a production management system (PMS) as including the three basic functions of *monitoring*, or tracking, the production, *scheduling* the activities and resources, and the active, closed-loop *control* of the process. A PMS can be implemented in a modular, stepwise fashion, starting with basic monitoring and evolving toward production control. Monitoring methods and concepts have been discussed earlier [Enlund et al 1994, Thoyer 1995]. In this paper, using the earlier results as a basis, we address primarily the control functions of a multichannel newspaper prepress PMS.

The basis for all process control and management action is tracking information gathered by monitoring the process. The tracking points, i.e., the points in the production flow where the progress of process objects should be monitored in order to achieve a balanced view of the status of the production, can be defined on a different levels of granularity [Karttunen 1993]. In our earlier work [Nordqvist et al 1994a] we have proposed a model for monitoring and tracking production processes in general and newspaper production in particular. A working group within IFRA, the international newspaper technical association, is currently preparing a recommendation for a standard for the exchange of production tracking messages, IFRAtrack, that specifies trackable objects, tracking message syntax and a message exchange mechanism [Thoyer 1995].

The IFRAtrack recommendation specifies the following basic classes of trackable objects in the prepress area: product, logical page, physical page, element (ad, story, image etc.), forme description, forme bitmap, film, and plate. Each of these is related to a newspaper title, edition and edition version. The model does not cover multichannel publishing, but can easily be extended to include new object classes.

Our discussion of production control and management is to a great extent a continuation of the work done on newspaper production tracking.

CONTROL AND MANAGEMENT METHODS

Modular Production Management Systems

Traditionally, there has been very limited use of explicit production control tools in most newspaper operations, especially in the prepress area. Monitoring and control has been a manual function with implicit production schedules and visual inspection of the production status. This has been acceptable in times of technological and competitive stability. Today the situation is different. The need for production control and management has been strongly increased, for several reasons;

- Increased competition.
- Increased demands on productivity.
- New production technology.
- New production structures.

Operations in a continuously changing environment must be dynamically controlled and have an inherent adaptive ability in order to cope with these changes. One view of the problem is presented by Alasuvanto who discusses mutating processes and mutating process architectures [Alasuvanto 1994]. This is primarily aimed at systems development for mutating processes but can to some extent be applied to the general description of the nature of newspaper production. The most important observation is that the newspaper production process is in constant motion—both planned and unplanned—and that the control and management methods used must take that in consideration.

In order to structure the production management and control requirements, we have suggested a modular model of production management systems [Nordqvist et al 1994a]. This model includes the levels of production monitoring, scheduling, closed-loop control, and production management. Within this structure, monitoring, or tracking, is the basic, technically and conceptually the least complex level. The proposed model also includes a communications infrastructure and the decision support function of simulating the production process.

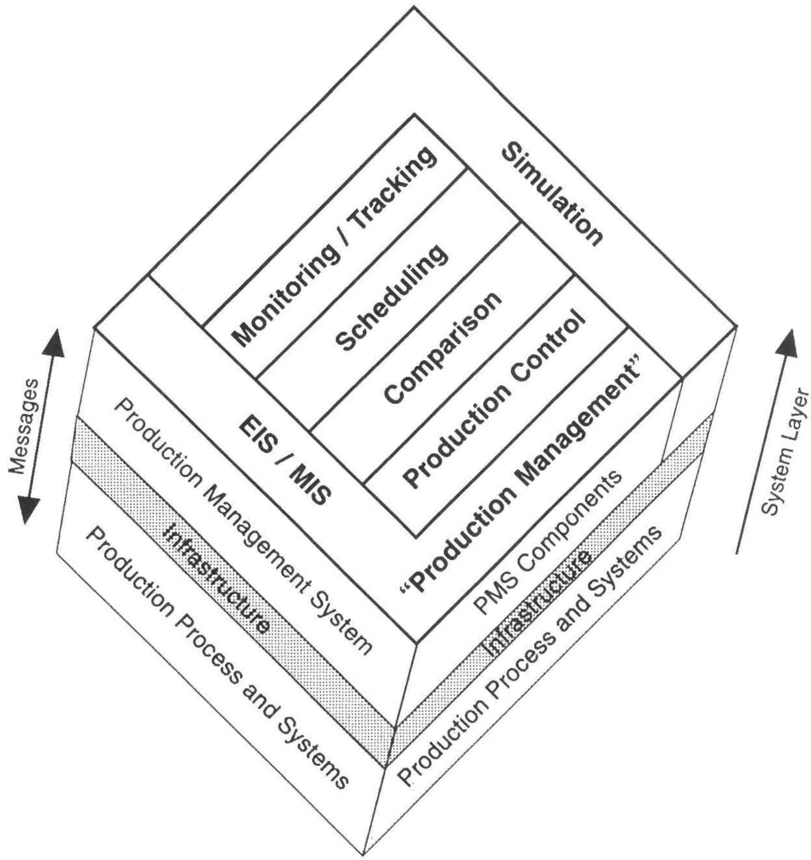

Figure 3. A proposed general structure for production management systems. The top level indicates the basic system components, interfaced to the production process through a well-defined communications infrastructure. The components can be modular, allowing the stepwise implementation of solutions with increasing functionality. The logical order of implementation would be: monitoring, scheduling, comparison, and control. Simulation and executive information systems (EIS) or management information systems (MIS) can also be included or interfaced.

A Control Model

We now propose a production control model for complex, time-critical, mutating (i.e., undergoing considerable changes during the production run), manufacturing processes. The model can utilize standardized tracking and control messaging mechanisms for communicating with the actual production process. The problems and solutions related to tracking have been discussed by the authors in several previous papers and recently also by IFRA [Thoyer 1995]. In this paper we are primarily addressing the problems of defining models and methods for closed-loop production control.

Figure 4 schematically depicts the proposed control model. The main components of the model, described in a more or less logical order, are the following:

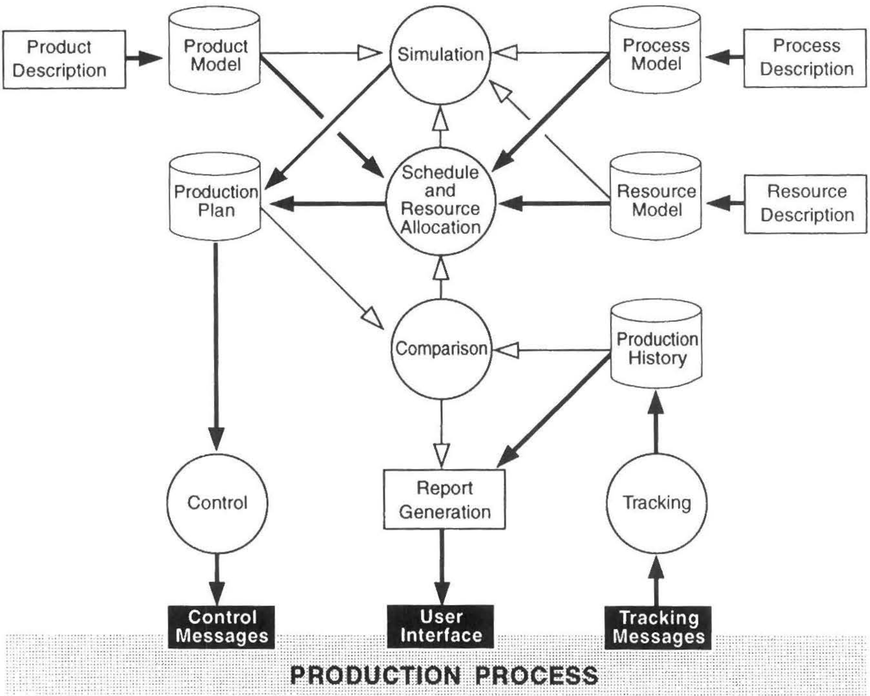

Figure 4. A control model for the newspaper production process. The four symbol types are used in the following way: white rectangles — input/output of control information, black rectangles — process interfaces, data base icons — dynamic models or plans, circles — control and management functions.

Product model. A structured description of the product to be manufactured; its objects and their relationships. Each product model is an instance of an object structure that can be described as an entity-relationship diagram. A description of a newspaper production object structure is given in the IFRAtrack recommendations [Thoyer 1995]. This data model has to be extended to cover also electronically published products in a multichannel newspaper. The product model can be implemented in a relational data base structure, but is, due to the complexity of the object structure, better expressed in an object oriented data base. The product model of a newspaper in production is a very rapidly changing and evolving data structure, and the demands on data base updating flexibility are great.

Product description. The input function of defining and describing the product model. In a modern newspaper prepress environment, the basic data for the product description is collected from edition design and ad booking systems. Additional data may have to be entered manually.

Process model. A structured description of the activities and workflows available to the production processes. The activities and their relationships can be described for example in the form of Petri nets or data flow diagrams, enhanced with information on the resource requirements of each activity. An important aspect of newspaper prepress workflows is, that several alternative workflows for the same function may be available. This makes the production flexible, but optimal control complicated.

Process description. The input function of defining and describing the process model. Since processes and workflows change and evolve rather slowly, the process description can be entered at system setup and edited manually using a process description editing program.

Resource model. A structured description of the resources available for performing the activities in the process model on the objects described in the product model. The resources can be persons, workgroups, machines, and combinations of these. With each resource is associated a set of primary and secondary capabilities of the resource, as well as information on the performance and cost of the resource in different types of activities. The resource model can be implemented as a relatively simple data structure in a relational data base. We have chosen to consider time to be a resource and production schedules to be part of the resource model.

Resource description. The input function of defining and describing the resource model. Since resources and schedules change and evolve rather slowly, the process description can be entered at system setup and edited manually using a process description and schedule editing program.

Scheduling and resource allocation. The functions of assigning processes and workflows to the product model and resources (including time limits) to the activities. Scheduling and resource allocation is handled by a sophisticated program producing a production plan optimized for time and/or cost. In a closed loop control system, rescheduling and reallocation of resources has to be made dynamically whenever there are significant changes in the product, process, or resource models and when the discrepancy between the production plan and the observed production history exceeds a preset threshold value.

Production plan. A structured description of all production activities, the objects concerned, the resources allocated, and the time limits set. The production plan can be implemented as a straightforward list of control commands to be issued to the production process, ordered in ascending time order.

Control. The function of issuing, in real time, a sequence of control commands, based on the production plan, to the appropriate, corresponding functions and their physical resources in the production process. The control commands are communicated using a well-defined control message mechanism.

Tracking. The function of collecting, in real time, status information on process objects from the production process. The status information, based on event messages, is communicated using a well-defined tracking message mechanism, e.g., IFRAtrack [Thoyer 1995], and recorded as production history.

Production history. A structured description of all events tracked and recorded in the production process. Events are defined as object state or attribute changes. Production history can be implemented as a simple list of events, ordered according to the time stamp of each event.

Comparison. The function of comparing product history with the production plan. Each command issued by the control function according to the production plan should within the given time limit result in a corresponding state change in one or more objects, recorded by the tracking function in production history. Discrepancies between production plan and production history should result in alerts and/or rescheduling and reallocation.

Report generation. The function of compiling and presenting different types of reports on production runs as well as of issuing alerts to production staff. Reports and alerts are presented using a user defined user interface.

Simulation. The function of simulating the effects of a production plan on a virtual production process. Simulation can be used as a decision support tool [Nordqvist et al 1994b], evaluating the time and cost effects of a decision prior to committing that decision to the production plan.

This general control model covers the functions of tracking, scheduling, dynamically rescheduling, and controlling the multichannel newspaper prepress process. It can also be implemented in a stepwise, modular fashion, as described earlier. The control model can be applied globally and partially to the production steps, on varying levels of control granularity.

Functions, objects, and granularity

Production tracking is concerned with objects and their states. Production control, on the other hand, must be directed at the functions, or activities, producing the objects to be tracked. The input to a function consists of sets of process objects, resources, and control signals. After a discrete time delay, the function delivers a set of output objects. More formally, the set of output objects (O) is a discrete time dependent function (f) of the internal state of the function (S), the set of input objects (I), the set of resources available (R), and the set of commands issued (C):

$$O_{t+\Delta t} = f\,(S_t, I_t, R_t, C_t).$$

Since we are interested in, and can monitor, the output objects and the time delays of the functions, we must, through the issuing of control commands, ensure that the functions deliver these objects on schedule according to the production plan, when having available the necessary input objects and resources. The correct sequences of control commands must be issued to the functions that generate the objects that we can monitor. Within the newspaper production process, these are, for example, products, page elements, pages, films or plates (as in figure 2). There is a simple one-to-one relationship between the objects monitored and the functions controlled (see figure 5). In a consistent production management system, the granularity of control must be on the same level as the granularity of tracking.

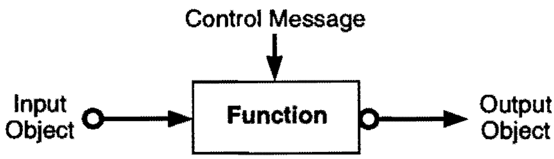

Figure 5. Relation between functions, objects and control messages.

There is therefore also a straightforward relationship between the object states and the relevant control commands. (For a discussion on object states, see [Enlund et al 1994].) Control commands are related to object state changes in the generating functions. If the state of an object is, e.g., *in process*, the relevant control commands are *finish*, *hold* and *abort*. Similarly, the expected result of the control command *start* concerning an object in the state created, is a tracking message declaring the object to be in the state *in process*. We may therefore assume a structure of control command pseudostates, as in figure 6.

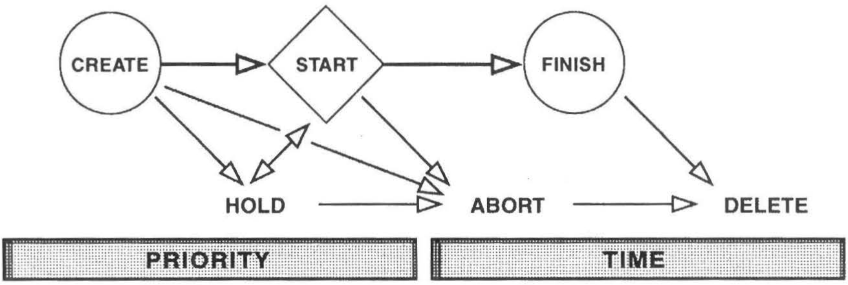

Figure 6. The basic control command pseudostates and the allowed transitions.

This model describes the basic commands and their relationships. *Create* is the command to create a certain object within a function. *Start* is the command to a function to commence the processing of a certain object. This can be followed by a command to complete the object, *finish*. These three basic control commands are supported by three supporting commands: *hold*, *abort*, and *delete*. Each command type can be associated with a priority level and a time limit.

Control Messages

A message format and exchange mechanism for tracking messages in newspaper production with heterogeneous production systems have been discussed earlier [Enlund et al 1994] and defined by IFRA [Thoyer 1995]. There is a need for defining a similar format and exchange mechanism for control messages within the same environment. A method for the interchange of production control information must be defined with respect to three aspects:

- Semantics—the contents of the information that must be exchanged.
- Syntax—the description language and structure for encoding the semantics of production control interchange.
- Delivery mechanism—the technology and methods for delivering the messages from sender to receiver.

The control command exchange method must be simple but still powerful and flexible enough to satisfy all control requirements. It should also be compatible and consistent with other production system messaging methods, especially with the proposed IFRAtrack Message Format (IMF) [Thoyer 1995].

We therefore propose an extension of the IMF to cover also control information. A control message envelope should, consist of a header, the message body, and a trailer. The control message body will consist of the following elements:

<originator>	A code identifying the sender of the control message.
<function name>	The identification of the function to be controlled.
<object name>	Identifier indicating the name of the object concerned.
<control command>	The command issued.
<priority>	An indicator of the level of urgency of the command.
<time limit>	The new deadline set.
<time stamp>	The time of issuing the control message.
<comment>	Other possible information.

An example of a control message, composed of the above elements, follows:

```
Start control message
    Edition Planning
    Page Layout
    OS 950405  ed 2  page 24
    Finish
    High
    950404–154000
    950404–152000
End control message
```

The actual message format should be modelled on the IFRAtrack message format. Additional support command types may be required in a practical implementation, e.g., a message cancelling a previously issued erroneous control command.

Delivery Mechanism and System Implementation

Control messages have to be delivered in a platform independent, standardized manner to all functions and subsystems in the multichannel newspaper prepress production process. The delivery mechanism has to be simple, fast and reliable.

When discussing the delivery mechanism for tracking messages, we came to the conclusion that a data base transfer method is preferable to a flat file point-to-point method [Enlund et al 1994]. When adding control and scheduling to tracking, the need for well structured information that is accessible from all points in the production system increases. However, control messages must be forwarded to the functions concerned immediately when generated. Data base polling from all the different functions in the production process becomes much too demanding on the system. We therefore propose a solution, where the production management system polls the data base for tracking messages, but transmits the generated control messages by file transfer directly to the functional subsystems concerned.

It then becomes logical to assign the administration of a production management data base to the production management system. Other subsystems may also access information in this data base. Control messages, however, are directly transmitted to the target subsystems, where client software modules actively listen for messages and forward them for display or action. The client software has to be specifically designed for each target system and the user interface designed for each group of users.

A global multichannel prepress production management system can be technically implemented as a subsystem in a modern networked production system. As exemplified in figure 7, the PMS together with the accompanying production management data base, can be integrated in the total prepress production environment. The PMS should also be connected to the possible Enterprise Information Systems of the newspaper company.

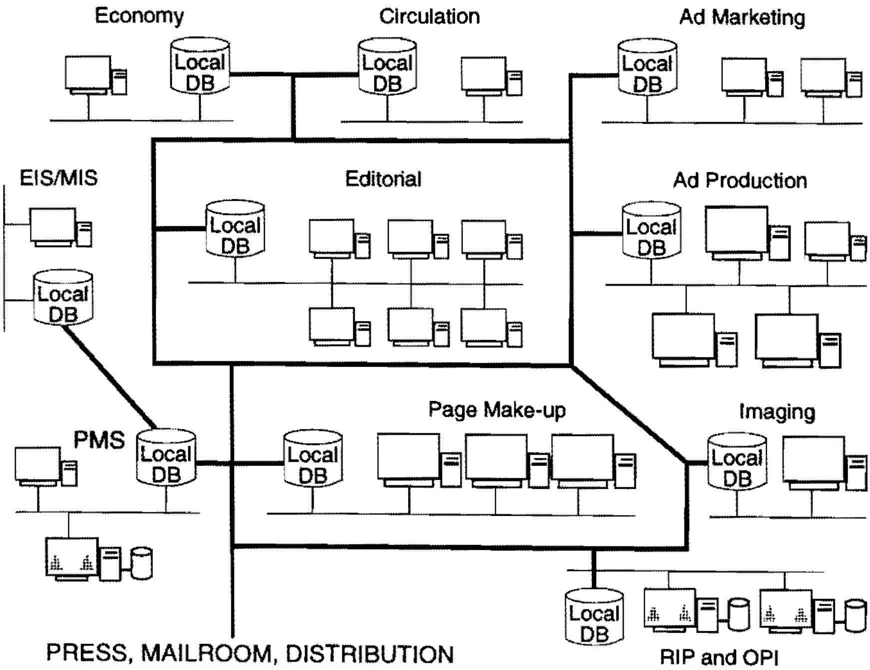

Figure 7. Example of integrating a production management system with several distributed local production subsystems connected by a local area network.

CONCLUSIONS AND REMAINING WORK

The ideas presented it this paper are results of work carried out in a research project aiming at the integration and global management of the entire newspaper production process. The work has proceeded in a stepwise fashion, from general concepts of global production management through the design of tracking methods to the mechanisms of dynamic production control.

Much work remains to be done before the objectives of the research project can be achieved. Next on the agenda are the tasks of designing a structured delivery mechanism for both tracking and control messages, defining the data structures of the production models, designing optimizing scheduling methods, developing adaptive dynamic rescheduling algorithms, and simulation methods for decision support.

In parallel to the theoretical work, prototype system solutions are being developed together with a group of newspapers. We believe that the practical construction of viable global production management systems for multichannel newspapers is rapidly becoming possible. The effects of such solutions will be of great importance to the publishing industry. Global production management systems will make possible a reduction of delays, a reduction of waste, increased flexibility in product design, and increased productivity.

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Flexible Production Planning in a Printing Shop

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Keywords: Printed products, Production planning, Scheduling

Abstract: The paper presents a concept of flexible product and production planning in a printing shop with practical implementations, and discusses in particular the issues relating to production planning. The characteristics of products and processes that must be taken into account when selecting the methods and algorithms for production planning are clarified, and the most important similarities and differences between printers are pointed out. The implementations are based on the models of processes and products, and they include inference mechanisms to manage the multitude of production alternatives during the selection of the production method and enable automatic scheduling viewed as an optimization task. Various opportunities of enhancing the scheduler are discussed.

Introduction

Concepts and systems for product and process related planning tasks have been within the scope of our research for the past three years under the VTT research programme 'Product Models in Design and Product Planning'. Our objective was to provide a fountain for systems tools to manage planning tasks that require a profound knowledge of the printed products, their production methods and production processes. The product planning concept was presented at the 1994 TAGA Conference in Baltimore (Bäck et al., 1994), and it is currently being commercialized. The emphasis of this paper is on the issues of production planning, but it also shows how the two areas should be linked together to give the printers effective tools to manage their production planning tasks.

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