BUSINESS CHAINS AND NETWORKS IN DIGITAL PRINTING

Tapio Lehtonen, Helene Juhola, Asta Bäck, Timo Siivonen[1]

Abstract: The switch from the conventional mechanical printing production to new methods of digital printing entails profound changes in the production technology. The physical distribution of printed products will be partly replaced by information dissemination through networks and digital printing, and the information will be retrieved directly from computer databases. These are but some major changes brought by the new technologies. VTT Information Technology in Finland has launched comprehensive research activities to help the printing industry to analyze the risks and opportunities of the change-over to the new technologies.

This paper discusses the aims and first results of our research, with special emphasis on potential markets and products. Mathematical models and computer simulations shall be used to assess production performance and the economic possibilities of the new business chains. We also look into the verification of the results of theoretical computations by carefully selected laboratory demonstrations and experiment. This is the first progress report on the project that will continue at least three years.

Introduction

There are three main players in the playfield of the information industry:

- The service-intensive networks industry,
- The equipment and system intensive electronics industry,
- The contents-intensive publishing industry.

The change-over to electronic publishing and digital printing means closer and more intensive cooperation between these parties. They all need each other, no one is able to work alone. This development is indicated, among other things, by

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[1] VTT (Technical Research Centre of Finland) Information Technology, Printed Communications.

the strategic alliances and large corporate agreements of recent years. The trend in Finland is more or less the same. But characteristic of this country is that the market is rather national and domestic enterprises dominate the scene as yet. The market share of digital printing is today about 5%. This is estimated to double in the next five years. The most optimistic forecasters say that digital printing will make up 20% of the total in ten years' time.

The progress of digital printing can be described by the number of digital printing equipment. The investments made in this type of equipment so far are lower in Finland than in the other Nordic countries. In May 1995, the total number of Xerox Docutech equipment in Scandinavia was 270, including about 100 in Denmark and 20 in Finland, which translates per capita (per 100,000 inhabitants) to 5 in Denmark, 1 in Sweden and Norway, and 0.4 in Finland. Many small express printing shops have been set up in Denmark with Xerox Docutech, while in Sweden the byers are mainly in the public sector. One reason for the sluggish investment activity in Finland is the deep recession in the past few years. 70 % of the units installed in Finland are connected to data networks, compared with 50% in the other countries. In spite of the small investments in digital printing as yet, the communication industry in Finland is very interested in the possibilities of electronic printing. This can be explained to some extent by our good telecommunication facilities. The graphic arts industry and the public health services are pioneers in the application of telecommunication facilities including broad-band connections.

It is important to define and analyze the business possibilities and to specify the products before investing in digital printing presses, especially in new four-color digital printing presses. Many attempts have ended up in a fiasco. The production functions that precede actual printing must be planned carefully and solved technically before the full capacity of the press can be used. The lack of the post-press equipment, the high prices and the control of the entire process from the information producer to the final customer are problems which have to be answered in our industry. Also the required telecommunication capacity and the economic feasibility of decentralized or on-demand printing, which largely depends on the costs of the telecommunication, should be estimated.

New production technology

The huge progress of electronic publishing technologies, and more specifically, that of digital printing, is the result of the development in various communication technologies.

The *prepress technology* is close to a complete change-over to computer technology. This process must of course be completed before any business chains by means of digital printing are reasonable.

The increasingly powerful *communication networks* serve large parts of the population: In the next few years the 128 kbyte ISDN network service will be available to households at a very reasonable cost. At the same time a wide-band network, called ATM (Asynchronous Transfer Mode), which is based on optical cables, will connect densely populated areas and large business organizations. About ten years are still needed for a wider coverage. Television and radio broadcasting are changing over to digital technology, which increases the number of transfer channels and speed up the transfer. This makes it possible to distribute magazines and newspapers to the consumers electronically. They can read the papers on the video screen or, more likely, browse and print the interesting pages with on-demand printers.

Networked production allows a new type of production strategies. In the communication industry the products, or at least the semifinished products travel from one production point to the next by electronic networks and the production processes are carried through on computer platforms.

Very powerful information handling and storing capabilities are needed for digital processing and storing four-color graphic information. Platforms are developing very rapidly and their capacity does not pose a problem, but more effective software is required to handle and to control large *multimedia databases*. To make the information portable by data networks, commonly used standardized and general *mark-up languages* are needed with the text, images and video materials.

To edit and process the information is one thing, to *package and distribute* the information products is another. In addition to on-line publishing, the new digital printing methods allow - at least to some extent by both networks and on-demand printing.

Digital printing methods have been coming for more than a decade, first in b/w office printers and main frame computer printers. In recent years several manufacturers have offered full-color electronic printers which might be called digital printing engines. Thousands of Docutech and hundreds of CromaPress, Xeicon, DigiPress and Indigo (180 at the end of 1994) have already been installed for more or less centralized short-run printing. New solutions are still needed for on-demand printing, for example, in bookstores, libraries and in households. Ink-jet printing is one of the most potential options for these purposes.

Also the new packaging methods, like CD ROM, open more possibilities to package and to distribute information. But a new generation of CD ROM's is needed to store high-quality multimedia information efficiently. It will take four or five years to achieve this.

The main goal of our project is to study new business chains based on new digital printing methods and the integration of these methods with electronic media.
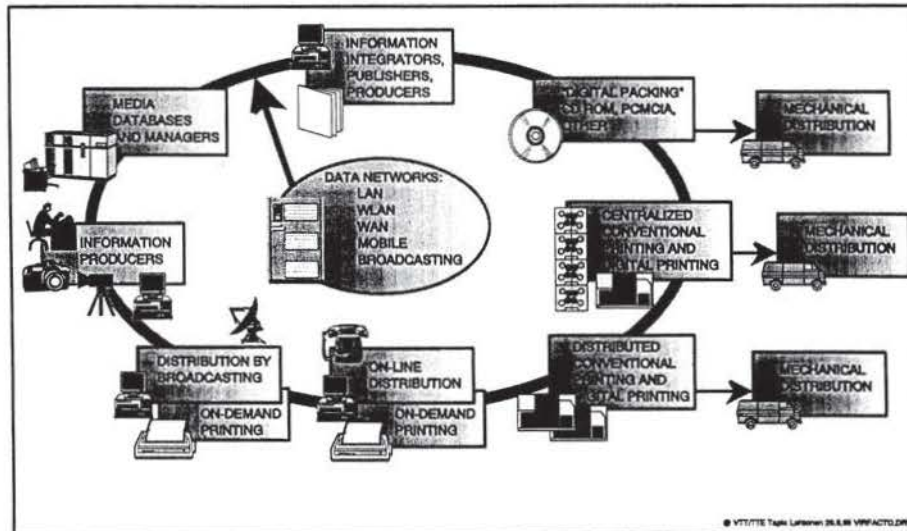

Figure 1. Virtual production of publications in networks.

New printed products

A much talked-about question is whether electronic media will replace printed media. Opinions differ, depending on whether the person is a specialist in digital or printed media. We feel that the printed media will continue to grow in absolute terms. *Electronic distribution with digital printing* opens up new horizons to the printed publication business. Especially the print quality and production costs of short-run printing have developed very favorable. Short delivery times and flexible on-demand production are other advantages. The totally personalized production of prints with a reasonable production speed is still a matter of the future. Today the profitable run length for the run in digital printing is somewhere between 1,000 and 2,000 impressions, but it is easy to see that the figure will grow up in the near future. Furthermore, *the integration of printed media with the new electronic media* to form new hybrid media combinations, is the most potential trend in new communication products. Table 1. gives some of the most probable distribution techniques and digital printing methods for the principal new communication products. Also the electronic media likely to be integrated with the printed media are listed. As a matter of fact Xerox Corp. Has already introduced a new glyph technology /1/ to integrate printed and electronic media.

Interactive communication is also one of the rapidly developing trends in the near future, produced by electronic media, through networks or mobile communications. Digital printing plays an important role there, too, providing e.g. for on-demand printing.

Product function	Typical digital printing technique	Primary digital printing processes	Primary integrating electronic media
Promotion	Centralized DP Distributed DP On-demand DP	Electrophotography Electrophotography Ink-jet	CD-ROM, broadcasting, networks
Transactions	Distributed DP On-demand DP	Electrophotography & magnetography Electrophotography & Ink-jet	Networks
Information	Distributed DP On-demand DP	Electrophotography & magnetography Electrophotography & Ink-jet	CD-ROM, broadcast-ing, networks
Education	Distributed DP On-demand DP	Electrophotography & Ink-jet Electrophotography & Ink-jet	CD-ROM, networks
Entertainment	Distributed DP On-demand DP	Electrophotography & Ink-jet Ink-jet & thermography	CD-ROM, broadcast-ing, networks

Table 1.   Hybrid products integrating digital printing and electronic media.

Problems of changing the technology

But, these fascinating new technologies and potential communication products entail a lot of problems to the publishers and vendors who link up new production processes and networks to their production chains. These problems may first be tackled at national level but sooner or later international cooperation and common standards will be necessary.

New *standards are needed for information portability as well for boundary and user interfaces*, proper for the production and distribution of communication information. The *compatibility of the software* handled by different subvendors in the different stages of production must be absolutely guaranteed. A huge storage capacity, more *effective media managers* and media data bases and fast information processing are urgently needed to store, search and handle digital multimedia information.

The decision on whether the printed product is produced by conventional or new digital printing methods requires verifications and estimations by new *computerized process description and simulation tools.* The models also give information to help find the right digital printing method and production type. Later on these computer models also provide the basis for *the management information systems and production control systems* needed for the new business chains of digital printing based on networks. Spreadsheet calculations to estimate the productivity of the digital methods compared with the conventional techniques in short-run printing have been reported previously /2,3/. We also made such calculations, but decided that more effective computer and simulation methods are needed to valuate the viability of complete business chains in the very rapidly developing conditions.

From the commercial printer's point of view the most serious problems in the digital printing process are the unsatisfactory or lacking technologies of paper feeding, paper delivery and *post-press processes,* and the high price of the existing solutions. The supply of the available paper grades could also be larger.

In Finland, we have started several comprehensive research programs in the publishing industry to get some answers to the above problems. The most important programs launched recently are listed in Table 2.

Programme	Duration, years	Estimated budget, USD million
Digital printing	3	12
Data network for publishing industry	2	4
Multimedia program	3	30

Table 2. Ongoing research into new publishing technologies in Finland.

In addition to those programmes which serve the publishing industry directly, there are several technology programmes which also contribute to the communications industry; e.g. the programmes to develop the ISDN and ATM technologies as well mobile communications.

The project discussed in this paper is a part of the first mentioned programme for the developments of digital printing.

National research programme in electronic printing

Digital printing methods deserve a large research programme because they are not just new printing methods but will dramatically change many of the areas in which publishers, other information providers and printers are operating today.

These industries may eventually have to reorganize their processes and reposition themselves in future markets to stay in the business and to remain competitive. Digital printing links up the two conventionally separate sectors - the production of the contents and the production of the physical structure. The manufacture of the printed products can be integrated into a networked, digital communication environment, which opens totally new possibilities.

The task of the national R&D programme in digital printed communications is

- to promote the development of key production processes for future products;
- to promote the development of application based on different functional processes;
- to promote the development of printing paper for digital printing;
- to support the introduction of applications and knowledge into companies and to open respective business opportunities in Finland

The business areas are the manufacture of equipment, the development of systems and application, digital print production and the production of paper and other materials.

Research project for digital printing as a part of the business chains

The business chain of digital printing includes all the companies and their operations, from the information provider to the manufacturer of the printed product to the enduser, together with the delivery operations needed to reach the enduser. In many cases the information processing, and especially the digital printing, can still be done in the networked graphic arts production environment. When we talk about short runs, quick and flexible production and tailored products, digital printing has great possibilities. Besides, the different combinations of digital and printed communications may add new value to the process. The research and development of these new chains and products is still at the beginning. Finding new ways to operate, introducing new technologies and teaching customers and suppliers the new ways of operation are never easy tasks but these risks can be reduced by joint research.

A project has been launched at VTT to make these tasks easier and manageable. New tools and methods will be developed and applied to model digital printing chains in order to describe and simulate structural, productional and economic factors affecting the capacity and profitability. The development of management systems for the entire business chain, including a study of hybrid products and development of postpress technologies, is also an important part of the project.

The basis is provided by estimating the market potential and future products in certain defined areas.
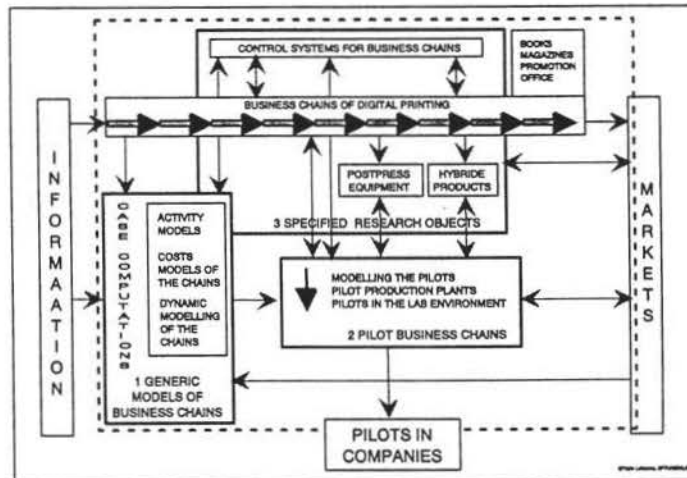

Figure 2. Research project for digital printing as a part of the business chains.

The subtasks of the project are as follows:

1. Estimating the market potential and trends in digital printing

The goal is to estimate the short and middle term market potential in various conventional and new products made by the different digital printing methods. The tendency is analyzed against the background of the generic trends in the electronic publication industry and the advances in the information technologies.

The results of this subproject steer the other subprojects and allow to focus the whole research project more accurately.

2. Business process modeling

The concept of Business Process Reengineering was introduced by Hammer and Champy /Reengineering the corporation/ who define it as 'the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed' /4/. Setting up new ways of operation often requires clever application of advanced information technology. We see that modern information technology, such as communication networks combined with electronic printing, makes reengineering possible in this field. For the first companies it is an option, but eventually it will become a must.

A formal description of processes by visual techniques such as flowcharts or activity models, is not a new approach. In the TAGA '92 Conference in Vancouver /5,6,7/ we reported on the use of the SADT method as a tool for analyzing production processes. These methods will be applied in this project as well. We are now choosing a business process modeling method and a software package that supports this method. Modeling as such is an author-dependent view of the actual processes and its correctness depends on the author's ability to understand and describe what he or she sees and hears of the process. These models can naturally be drawn using pen and paper, but software tools make it easy to create and update models with several hierarchical levels and they guarantee the integrity of the model. Activity-based costing combined with this kind of a model allows to evaluate the economy of the process: the costs of the new process can be estimated and comparisons made between alternative solutions. Some software products make it possible to simulate the modeled processes, pinpointing possible bottlenecks of the process.

We would like to have the following characteristics in the software tool that we choose for this project:

- it must be user-friendly
- models must be illustrative and understandable also to those who have no in-depth knowledge of the method or the notation
- both the data flow and the material flow must be modeled and illustrated
- it must be possible to create hierarchical models
- it must control the integrity of the model
- it must be possible to relate the costs and the capacity information to the resources
- it must be easy to modify the model and to reuse parts of it to model new processes

The tool will not be ready as such. We shall have to determine and develop the metrics that we want to apply to compare different alternatives. We shall need several figures to reveal the characteristics of the modeled process in order to take the different aspects, such as costs, quality, service and speed into consideration. Some comparisons will be made with the existing processes to verify that we will achieve significant improvements with the new processes. The comparisons of old and new processes must include the whole process, from the creation of the information to the moment when the final user gets the printed product and pays for it /5,6/.

3. New methods for the in-line finishing of the digital printing

As mentioned above, the in-line finishing of digitally printed products is still quite limited. The most commonly applied technologies are booklet binding equipment. The operations equipment manufacturers supply tailored solutions for more demanding finishing. There is an obvious need for highly automated, flexible in-line finishing to produce different kinds of products. On the other hand, there is also a lack of equipment for on-demand printing and office printers. The purpose of this subproject is to define the optimum finishing processes for the most acute needs of the industry and to develop, together with some commercial manufacturer, practical solutions.

Good use will be made in this research of the basic knowledge achieved in the three-year project of automated bindery processes /8,9/.

4. Business and production pilot chains

The business chain models and simulations are an excellent tool to verify the possibilities of the new digital printing systems, but they cannot give answers to all the problems of the real production environment. That is why we need to have *pilot production chains*. This is especially important with quite new chain components, like new wideband communication networks, new printing engines, or new postpress systems. The pilot chain shows the real problems and makes it possible to try out new solutions. It is obviously better to make the experiments in the pilot environment than with the printer's clients.

We plan to have two different pilot production chains in our project: some pilots are installed *in the printer's facilities and the other pilot production lines are constructed in the lab*, which also allow us to test new production components and materials, the paper in the first place. Setting up *pilots in laboratory environment for processing of new types of integrated products* in the laboratory environment is one type of activity. Under development is a broadcast newspaper using networks as an interactive tool. Some new product ideas, such as *integrating conventional or digital printing with some electronic media*, - a network or a CD ROM - are also developed.

5. Management of the business chains

The actual implementation of the new processes with digital printing methods requires new software to make *the management communication* between the information providers and printers quick and accurate. From the information provider's point of view it is necessary to define the final printable product, using the most suitable methods and materials that meet the requirements set to the final product. The printer will need tools to offer the customers their selection of materials and methods. The customer information system has to be well defined, easy to use and standardized enough. The printer must be able to control the

flow of incoming jobs in the electric form and to keep the schedules as required by the customer.

Quality control is another important issue; both the customer and the printer need to be sure that the quality of the final product will be as expected, without any rework or manual corrective measures, after the data is received by the printer.

We have several years' experience in the research of the model-based product and production planning, and production control in conventional printing shops /10,11/. The idea now is to develop new applications and systems for the digital printing environment.

Summary

One reason why we announce our new research activities at this early stage is that the research programme runs for several years and we want to report on the progress of the project from time to time. Another reason is that we want to inform scientists in other countries who may be doing research in the same field. We would like to find partners in other countries who are willing to work with us to find solutions for international networking of integrated communication businesses.

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