The Integration of E-Commerce Enabled Expert Systems for Automated Printing Control Networks in Printing and Publishing

Henry B. Freedman*

Keywords: E-Commerce, Networks, Printing, Expert Systems, Economics

Abstract: The application of expert systems technology incorporated within automated printing control networks is here today and changing the printing and publishing process. This paper addresses the emerging integration of the printing requestor with the manufacturing operations for printed products and how expert systems software engineering makes this possible. In addition, an "Economic DNA" metaphoric model is presented whereby each individual printed work being produced can automatically report basic cost building blocks from the manufacturing process that are unique to that work being produced. This Economic DNA in turn communicates with the expert systems in the network, offering a cybernetic system for print production control. Some examples of off-the-shelf emerging technologies in this area are discussed. The impact of the technology on people is also mentioned.

Integration of Print Requestor with Producer

Several levels of automation exist for the integration of the printing requestor with the printing process. Today everyone is their own Gutenberg and we have seen that the personal computer evolution has provided a great population of electronic printing devices to print cut sheets on-demand for personal consumption. Auto-setup and configuration tools allow the PC to interrogate the printing device attached to the PC, verify and initiate connection, and troubleshoot if so needed. The image quality from desktop printing is exceeding the quality of the conventional offset printing process. The quality is high but the volumes are low and the format size limited.

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*Inventor - This paper originally accepted for TAGA Stockholm, Sweden's "Future of Information Systems in Printing & Publishing Conference."

The need for commercial volume printing from industrial production centers remains. The communications links between the requestors of commercial volume printing and the production facilities have been evolving to the point where the customer is now an integral part of the production process. Files sent to be imaged are being reviewed or "preflighted" with diagnostics approaching the ease of use of spell checkers in word processing software. Printing is produced at a remote location and sent to the requestors the next day. Salespeople and printing estimators have been eliminated from the process. In some cases, traditional materials and processes along with their vendors are eliminated from the process. In many cases, one-on-one human communication has been eliminated from the process. The first functioning printing expert system to do this is detailed in United States Patent 4,839,829 for an "Automated Printing Control Network" circa 1986. The following sections of this paper will describe how developments in the field are making this true for the production of complex large volume commercially printed products.

Definition of the Application of Expert Systems and Cybernetics in Print E-Commerce & Production

Print Expert Systems and the "Turing Test"

A print "estimating expert system" as defined in this paper is "a non human communications system" that includes software that produces the same or better results just as if a trade or craft knowledgeable human printing expert had produced the results. One method for testing this is to have a printing requestor enter specifications into, for example, an Applications Service Provider (ASP) browser based screen. Then have both a human participating from a typical printing production facility and the ASP based estimating expert system produce the results. The reader is referred to the now infamous "Turing Test" problem described here as an "imitation game" in Turing's own words from his book *Computing Machinery and Intelligence* (Mind, Vol. 59, No. 236, pp. 433-460):

"The new form of the problem can be described in terms of a game which we call the "imitation game." It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either "X is A and Y is B" or "X is B and Y is A." The interrogator is allowed to put questions to A and B."

Modified Print Expert System Turing Test

An expert system test for the production of print has been similarly constructed. With the elimination of conversational requests such as “what is your favorite color” and subjective questions, (which by the way could be programmed in to respond to the requestor), complex printing production order processing has been done. The test is between a printing requestor, a human estimator, and an expert system. This was accomplished with the development of rule-based systems from the knowledge of expert trade printing estimators. Error trapping for errant inputs not only corrects such errors but also teaches printing requestors about their errors. Since graphic designers can transmit entire image files for a given printing job as a digital model version of the actual content, automated interrogation and extraction of specifications without human assistance is possible. Intelligent processing besides and against the requesting individuals inbound materials provides automated feedback and queries by the system. A human cannot do this.

Test criteria were not just based on what produced a “winning price.” A human could certainly make a mistake and loose money if the printing was to be produced to their calculations. Testing was conducted for calculating the break-even point for annual report printing with a sheetfed cover for the reports and web printing the inside with two types of paper stock.

Print Estimating Expert System Test Results

The end user was not able to tell the difference. The expert system repeatedly defeated the human estimator. What gave it away was the fact that the communications network with the print expert system was nearly an instantaneous response. So, a delay had to be programmed into the system so as not to tip-off the human tester. Once this occurred, in nearly all cases, the print estimating expert system won the estimate over the human.

The fact that the print estimating expert system could also store in memory multiple plant equipment configurations made it possible to compete simultaneously with multiple printing plants in a competitive procurement. A human cannot do this but an E-Commerce Enabled Expert Systems can.

Predictive Systems Underlying Key Principal - Ashby’s Law of Requisite Variety

With e-commerce based expert system technologies, sales and estimating staffs will be radically reduced as well. This impact is evidence to the fact that automation continues to be successful. What makes this possible is taking the knowledge from both estimators and equipment manufacturers and then simulating the entire manufacturing process in software. Manipulation of print

pricing requirements is then instantly fed back to the print requestor entering the information. Such systems are interactive "predictive systems."

In order to tell a requestor what the real cost for printing is, the system software must be able to encompass and simulate the full variety of complexity that the process encompasses at a given printing producer. If the system cannot encompass and simulate the full variety of the print production process, it cannot make or repeatedly make, correct responses. The underlying requisite principal for this was defined by Ross W. Ashby's as his "law of requisite variety" as defined in Ashby's *Introduction to Cybernetics* pp. 202-211, London, Chapman & Holland LTD, 1957.

A simple example of this is a web offset press with a finishing system. If the software can only simulate the setup and running waste from the printing units on the press and not simulate the setup and running characteristics and waste of the on press finisher, chopping and folding signatures of a printed work, then speed and paper waste cannot be calculated since the software is missing the "requisite variety" of the press. Since time cannot be calculated the system also looses the labor cost calculations for the press.

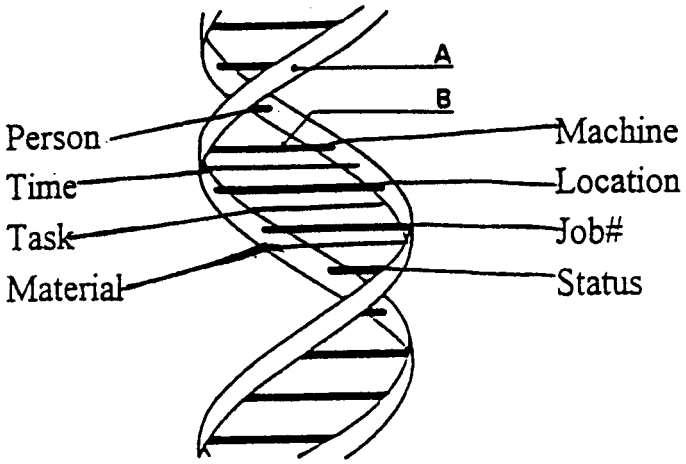
Ashby's work is fundamental and includes many other principals, a few worth a quick mention here. Ashby states a machine variety reduces over time. Look at today's use of cylinder letterpress equipment. It is not used to print but to score and diecut as off-line finishing equipment. There are many, many more of Ashby's laws of variety that are not able to be discussed here such as "variety can destroy variety", the application of possibility tables, the rules of regulation, and the transmission of variety. Combining Ashby's work with Claud Shanon's Nobel Prize winning Theory of Communication provides the foundations for E-Commerce Enabled Expert Systems for Automated Printing Control.

Defining, Measuring, and Controlling the Variety in Print with Event Economic DNA

Printing (as well as any other form of manufacturing) production is comprised of steps and tasks that take place in time and herein for the purposes of this discussion are defined as events. An event is a step or individual task performed which uses "resources." Resources are made up of eight elements: people, time, location, task, machine, material, job number, and status. These eight elements make up the microeconomic "genes" of the event.

Economic DNA

Eight Basic Constituents of an Event's Economics



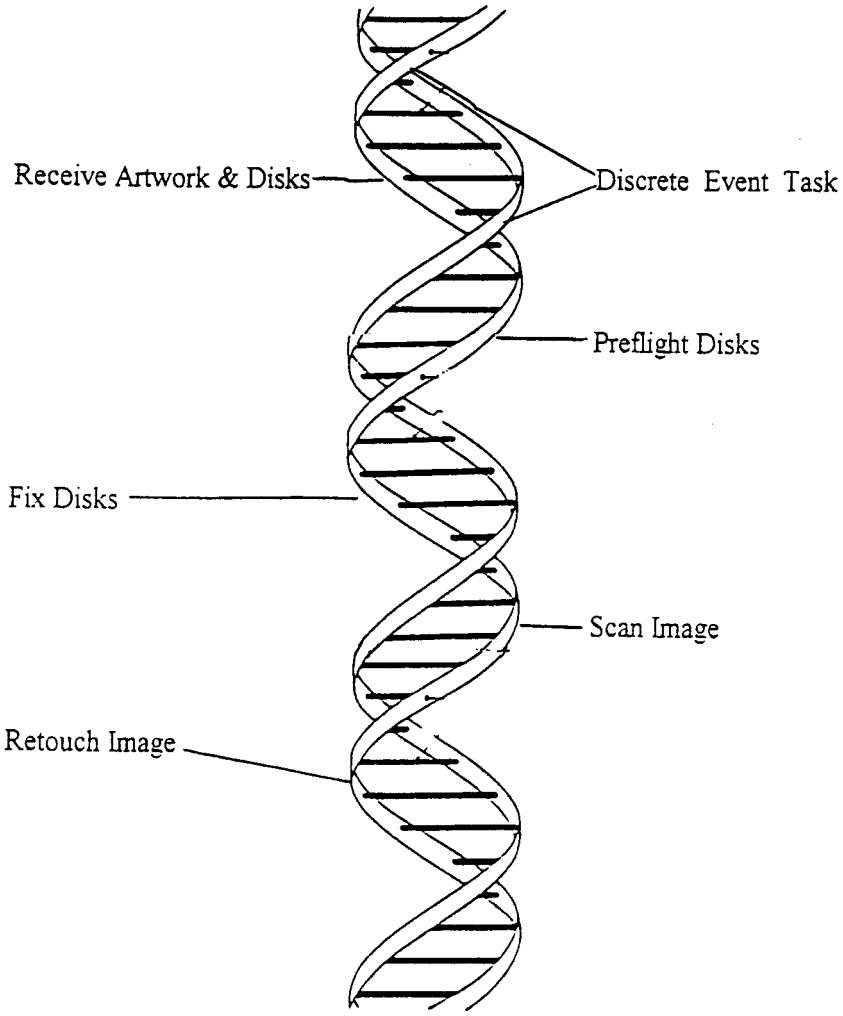
The DNA helix looks like a spiral ladder with sides A and rungs B modified here to equal eight.

The above Economic DNA Helix drawing offers a visual perspective for understanding and communicating the microeconomic elements or "microeconomic genes" of an event.

Having a picture of several events pertaining to a given printed work depicted in an "Economic DNA Helix Run" (see next page for illustration) shows the fundamental costuant make-up of printed job species. The relationship of each individual helix in the run represents a single task, with economic ratios and interrelationships unique to the specific product being produced. The following illustration represents a portion of an Economic DNA Helix Run for the prepress portion of a work-in-process.

Economic DNA Helix Run

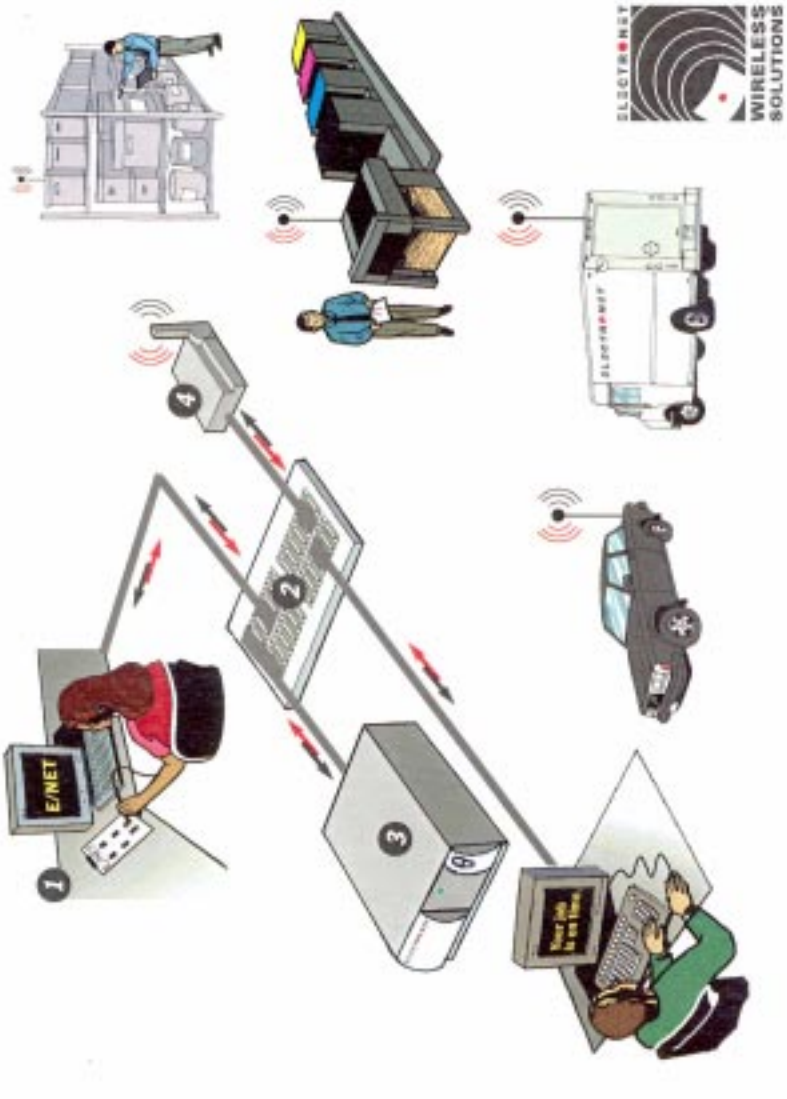
Events in a Prepress Job



Collection, Assessment and Feedback of Event Variety in Automated Printing Control Systems

The following illustration demonstrates how Economic DNA has been collected by Electronet Information Systems, Inc. for tens of thousands of live printing jobs over the past decade or so.

How Electonet E/Net Events Radar™ Works



(See next page for picture caption.)

Steps in Electronet E/Net Events Radar™
(Caption for illustration on previous page)

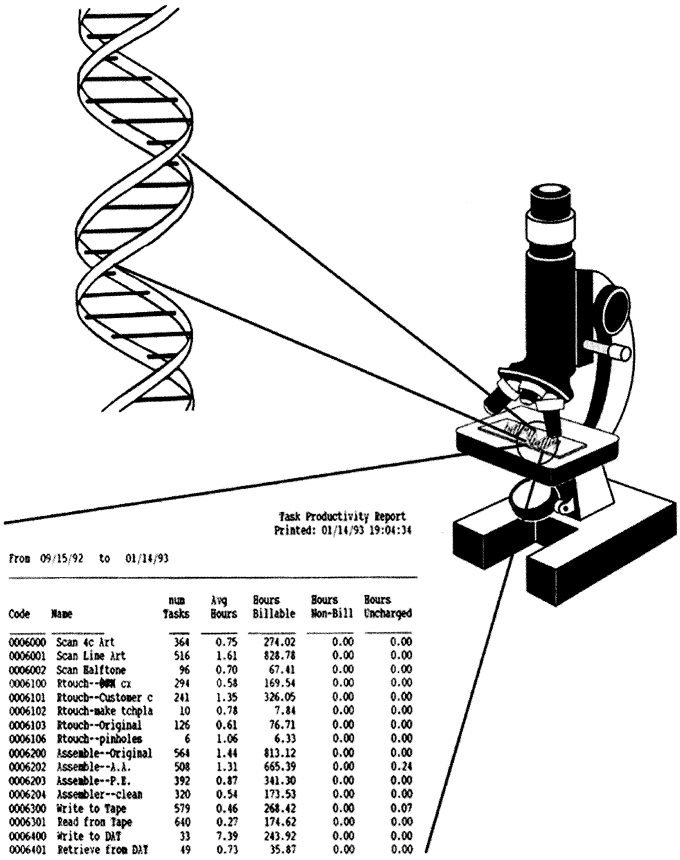
1. Person scans barcode reporting job, task, and other information in process.

2. Multi-serial port interface allows many types of devices to connect to the E/Net PBX.

3. The Electronet E/Net Performer PBX monitors and reports events in three time zones – past, present, and future.

4. Electronet's wireless connection capability results in a highly accurate, adaptive, and mobile solution that improves work for people.

Assessment of Economic DNA



Task Productivity Report
Printed: 01/14/93 19:04:34

From 09/15/92 to 01/14/93

Code	Name	num Tasks	Avg Hours	Hours Billable	Hours Non-Bill	Hours Uncharged
0006000	Scan 4c Art	364	0.75	274.02	0.00	0.00
0006001	Scan Line Art	516	1.61	828.78	0.00	0.00
0006002	Scan Halftone	96	0.70	67.41	0.00	0.00
0006100	Rtouch--[illegible] cx	294	0.58	169.54	0.00	0.00
0006101	Rtouch--Customer c	241	1.35	326.05	0.00	0.00
0006102	Rtouch-make tchpla	10	0.78	7.84	0.00	0.00
0006103	Rtouch--Original	126	0.61	76.71	0.00	0.00
0006106	Rtouch--pinholes	6	1.06	6.33	0.00	0.00
0006200	Assemble--Original	564	1.44	813.12	0.00	0.00
0006202	Assemble--A.A.	508	1.31	665.39	0.00	0.24
0006203	Assemble--P.E.	392	0.87	341.30	0.00	0.00
0006204	Assembler--clean	320	0.54	173.53	0.00	0.00
0006300	Write to Tape	579	0.46	268.42	0.00	0.07
0006301	Read from Tape	640	0.27	174.62	0.00	0.00
0006400	Write to DAT	33	7.39	243.92	0.00	0.00
0006401	Retrieve from DAT	49	0.73	35.87	0.00	0.00

Emerging Commercial Technology Examples of Expert Systems

At the time of the writing of this paper, we are on the doorstep of seeing commercially available off-the-shelf expert systems approaching some of the capabilities discussed in this paper. For illustration and discussion purposes only, the following are some examples and their capabilities. The descriptions herein have been provided by the vendors and are for example discussion only.

PrintCafe - E-commerce Platform Printellect tool

PrintCafe products provide for extensive decision tree structures through their Printellect tool. With this tool a printer or buyer may define a question or questions that only have a valid series of response(s), or that may lead to another branch that would ask an additional question(s) and limit the user to only the valid response(s) to insure that rules are followed. This approach works well as it eliminates an error or potential production definition error from occurring in the first place. This insures that the user does not have to be an expert in order to resolve the error as would normally be required in an error trap process. Consider this error avoidance as opposed to error trapping. If there is a negative to this approach, it is the need to have an expert develop the Printellect (decision tree) series that will be made available to the end user.

E-commerce to MIS Integration in PrintCafe's Systems

Not all of PrintCafe's clients decide to create extensive decision trees for the end users. Some rely on the expertise of the estimator to review the information before generating a quote or order confirmation. In this case, the integration engines looks for past occurrences and if it sees a new entry (a stock or ink that is new to the integration flow) a dialogue box requests the mapping instructions from the estimator or production planner. What is made available are only those items associated with the generic type of the actual end user entry. (i.e. A stock entry made under Web Stocks would only be mappable under Web Inventory. Sheetfed Inventory would not be shown as usable.) The advantage of this approach is that an end user could describe any type of product in whatever terms they desired, the print staff would then translate that term as needed. The key is an expert creates the mapping, and then that mapping is retained and will be utilized automatically if that end user provides the same description in future jobs.

PrintCafe MIS Platforms

While PrintCafe has five unique MIS platforms that they provide to the industry, each platform has error trapping as part of its structure. All platforms provide for a level of decision tree structure in the initial entry and maintenance of the production standards that a printer would enter into the system. As an example,

only Web Stocks would be made available to Web Presses and Sheetfed Inks would only be selectable when a Sheetfed Stock was selected. Another example would be In-line operations only being selectable on those presses, which are capable of running that operation. Another example might be minimum hours before a second pass for drying time. These associations all insure that only allowable selections can be made.

The last level of error trapping becomes more complex. These are the actual logic and sanity checks that occur when an estimate calculation occurs. This includes such things as caliper, width, and length checks to insure that the production equipment can actually handle what is being requested. There are things that cannot be obtained based on requested equipment, etc. such as allowable printing area checks on the press, minimum run or production times based on length of run, adjustments to production standards outside of allowable ranges, and folding or binding definitions. In these cases, the common approach is to provide the estimator with a message or error dialogue that highlights the problem and asks how the user wants to resolve the situation. The printing industry is a custom manufacturing industry, except where the estimator simply asks the system to do a process or step that cannot be logically calculated. This allows the estimator to force layout and estimates as required due to unique situations.

The end result of having these various levels of error trapping and decision tree association is that our clients can determine the most efficient process for end user structure and utilize staff expertise where and as needed to insure job and quote submission processes are timely and effective.

PrintCafe PrintFlow as a rule-based Expert System

In somewhat dry mathematical language, PrintFlow is a tool to find and optimize solutions of resource allocation problems. A resource allocation problem can be, generically speaking, defined by:

1. Available resources - Machinery, personnel, tools, materials, etc.;
2. Constraints on these resources that limit their abilities, availability, and capacity;
3. Consumers of the resources - Jobs (Orders) or more precisely, the production steps to produce the components of the jobs;
4. Constraints on these steps that limit the possible solutions.

The solution to the resource allocation problem is a schedule. That is, a plan for which resources to use at which time.

The problem definition, as outlined above, can be read as rules, like:

1. Available resources

Most resources have as a primary rule mutual exclusivity, meaning that one machine can do only one activity at a time. Some machines have the ability to do a limited number of concurrent activities and some have unlimited capacity. Each resource has a collection of rules that determine its behavior when loaded with tasks and the way that tasks are chosen from the waiting queue.

2. Constraints on resources

Users can add an arbitrary number of constraints that determine how a resource can be used, for example, limits on physical dimensions, number of color, etc.

3. Rules of Production

Jobs are described with rules that describe the production steps to manufacture them and the relationship between these steps. This is usually an ordered graph of resource requirements (production steps on machines defined in 1.) and links between these steps that ensure synchronization. Other rules describe due dates of the job and its constituent components, and earliest allowed start dates for each of them.

4. Other Constraints

Each individual step can have further constraints attached to it that describe, for example, proof dates, or customer material or raw material in dates, etc.

The problem solution is calculated by PrintCafe using a variety of engines, which use the rules above to find a solution that satisfies most of the above rules. Some rules are very strong and cannot be broken in a solution, for example, the earliest start date for a job cannot be violated. Others are just recommendations, like the preferences for certain machines in the parallel distribution. Some are contradicting each other, and a solution tries to find a good compromise between them, for example, the aim to minimize setups by grouping like jobs is often contradicting the rule to do most urgent tasks first.

The fact that the customer can change and add any rules and even change the weight of rules makes PrintFlow extremely flexible to cope with a wide spread of different expectations and business practices.

Open standards such as the Print Production Format (PPF) and the Job Definition Format (JDF), both controlled by the CIP4 organization, of which ScenicSoft is a member, have played a key role in establishing connectivity with existing solutions outside the prepress arena. UpFront leverages these standards to establish the missing link between the departments of any printing organization. The product has proven to be situated at a critical crossroads in the production flow and is enabling upstream as well as downstream digital connectivity.

MIS Integration

UpFront provides the much-needed bridge between the business and execution sides of a printing organization by integrating with the estimating packages offered by leading MIS vendors such as Prism (Prism WIN and Prism Enterprise) and Optichrome (Optimus™ 2020). Integration between UpFront and MIS solutions is based on the Job Definition Format (JDF). The benefits of integrating MIS systems with planning, prepress, and finishing systems are obvious: more accurate estimates, better scheduling, higher consistency and repeatability, error and waste reduction, and increased overall throughput.

ScenicSoft Prepress Integration

Jobs planned in UpFront can be passed on digitally to ScenicSoft Preps®, the world's leading digital imposition solution, and ScenicSoft's entire suite of prepress production tools. Preps is also a core component in the most popular high-end prepress workflows: Creo® Brisque™, Creo Prinergy®, and Agfa® Apogee™. Other popular workflows that officially support Preps imposition output include: Rampage™ RIPing System, Heidelberg® Delta™, Heidelberg MetaDimension®, Screen TrueFlow, Fuji® CelebraNT, and Valiano™, among others.

Finishing Integration

The setup of finishing equipment can also be automated when a printing organization is connected to an optional digital CIP3 link that can accept and interpret PPF files. UpFront generates the detailed finishing data for these devices in the production planning stage. ScenicSoft recently announced formal cooperation efforts with POLAR-MOHR®, Wohlenberg, and Müller Martini®. These are three major vendors that cover a large percentage of the cutting and binding equipment sold worldwide.

Users are already starting to take advantage of the significant steps ScenicSoft has taken toward providing an automated solution. With added JDF and PPF support and existing connectivity between UpFront, Preps, and other ScenicSoft applications, users are installing and building solutions today that connect the

entire range of activities from the CSR all the way into the bindery. ScenicSoft and its partners are providing their users better options to achieve goals that were deemed unrealistic just a few years ago.

Evolutionary Industry Cultural Impacts

The long history of printing production trade and craft knowledge started with the elimination of the scribes, who copied manuscripts, due to technological innovation. Today, as discussed, the print requesting location has become a part of the production system. Ever since office based word-processing systems sent text data to remote trade based production facilities for typesetting, customers have been delivering part of the production process. We have witnessed the exit of people in the trade known as typesetters. As a result of technology, we will see many more people exit.

With the advent of the PC followed by desktop publishing and today's office systems, the manual imposition stripping process, and CTP platemaking, trade staff is being automated out of the process. Today in some printing operations on-line e-commerce based systems have replaced salespeople as well as estimators that have been replaced by computer systems and customer service representatives. Some printers do not have sales people or estimators, just customer service representatives that are augmented by the on-line e-commerce technology. With printing reported to be the second largest employing industry next to the automobile industry, societal impact is extensive. Highly automated systems are catastrophic to trade and craft skilled people.

Managers of printing operations not applying the appropriate technology will see their jobs gone as well. It is becoming increasingly complex to adapt a digital culture to existing traditional operations.

Conclusion

It is possible to optimize the printing reproduction process with highly automated knowledge based expert systems. The underlying fundamentals of the 1950's cybernetic systems formations are taking root in today's advanced e-commerce and production management information networks.

The ability to receive customer information, simulate a printed work to be produced, price sell, measure and report manufacturing information in real-time has occurred. The ability to automatically configure printing and finishing equipment from this information is speeding production and changing the industry.

An automated networked management control logic to operate a printing production facility results. Such technology is now commercially available, will continue to evolve and has a greater impact on the industry than new printing materials and processes.