The Production of Order and the Order of Production: Possibilities for Distributed Organisations, Work and Technology in the Print Industry

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Abstract.

Drawing on a fieldwork study, this paper considers different design options for the development of a system for facilitating distributed organisation and distributed working within a sector of the print industry. The relationship between the design of the system and the design of the organisation is also examined. It is concluded that if organisations are to practically benefit from the continued evolution of communication infrastructures, CSCW should attend to the *appropriate* development of information and work co-ordination systems. It is also concluded that CSCW should develop measures of the value of proposed systems for organisations and users.

Introduction

The advent of digital technology in the print industry has ushered in many changes in working practices and organisational configurations. Networking distributed production sites suggests the possibility of yet further changes. This is because networking offers various alternative technological and organisational possibilities to those that currently exist. Past research in CSCW on the introduction of networks into working environments (Bowers, 1994, Orlikowski, 1992, Rogers, 1992) suggests that it is necessary to develop better understandings of the work and the organisational context into which networks are introduce if they are

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to be optimally used to support the work of the organisation. In this spirit we have been engaged in a study of a UK commercial printer who is contemplating networking twenty Print Centres through ISDN links. This will provide the company with the opportunity to print-to-order a document that has been originated at, or submitted to one site, at another site. We are interested in understanding what order of organisational issues have to be addressed in the development of the network and the determination of what could be its optimal use by the company.

It has been suggested to the organisation that there are commercial advantages to be gained from such a move, for example, load-balancing, maximisation of resources, and enhanced services, (Bowers, Button and Sharrock, 1994). Currently, production is managed on a site-by-site basis. Thus, for instance, each site has its own job acquisition and scheduling procedures. Networking the sites, however, provides the opportunity to redesign the organisation. It has been suggested that in order to unlock the envisioned commercial advantages the twenty sites could be run as one large 'virtual' print factory within which the management of production across the network is centralised, with, for instance, centralised job acquisition and job scheduling.

At least two options thus exist for the way in which the management of production is controlled in the future. Should the company reconfigure itself as a large virtual print factory, the production activities of each site would be centrally determined and managed. This would require that production information about, for example, machine state and run progress is centrally gathered to determine not just which print machine a job will run on, but which geographic site will be used. The network could thus be used to distribute centrally acquired jobs according to a centrally determined schedule. Alternatively, if the sites are organised on a site-by-site basis then, although locally controlled, they can use the network to co-ordinate their production with one another. For example, passing jobs on to one another should they be overloaded; passing a job to another site if the intended destination for the job is actually nearer to that site than they are, or passing a job on to another site because a vital machine has gone down.

Not only does the possibility of networking sites open up different organisational options for the company with respect to the control and management of production, choosing between these options is also consequential for the design of systems used to facilitate the management of networked production. Thus, for example, should an organisational configuration of co-operating sites be established, production information about each site may need to be accessed by all sites in order to determine when a job may be passed from one site to another, or which site a job should be passed to. All sites may, then, need to be mutually aware of each other's real-time production status. This awareness may, however, only extend to the status of the scheduling of other sites so that the commissioning site can establish a priority listing of sites that could receive the job. Should, though, a centrally organised system be contemplated, awareness of production status between the sites would not be necessary, but the detail of production states may

need to be deeper and extend to production matters such as individual job status, stock status, and machine and personnel status.

There is a direct relationship between the design of the organisation and the design of the network and production management systems. Should the network be centrally designed, for example, it will pre-dispose the organisation to become more centrally dominated in order to be able to effectively and optimally use the network. However, should the organisation remain de-centralised then the network will be crossing different organisational procedures such as different pricing policies and will have to be designed accordingly. The designers of such networked systems and the organisational toolsmiths (Bittner, 1965) thus confront a dilemma concerning both the design of the network and the design of the organisation.

We maintain that contemplating the technical and organisational possibilities for networked factory production printing can be facilitated through an understanding of the methods and practices by which production is currently ordered. It is to the task of describing the production of order in Factory Production Printing (FPP) that the bulk of this paper is dedicated.[1] We go on to suggest that the design decision to produce a centrally or de-centrally managed network can be taken in a methodic fashion and how this in turn affects the design of networked information and co-ordination technologies for use in production management. The issues this study raises for the design of information and work co-ordination technologies are of general relevance for CSCW if the promised benefits for organisations from the growth of communication infrastructures are to be fully realised. This, however, begs the questions: 'how are organisations to measure and assess the benefits?', and 'how can a determination of what may be an optimal system for their purposes be made?' We conclude by suggesting that CSCW may find answers to these questions in understanding the nature of the entwined relationship between technology and organisations.

The Ordering of Factory Production Printing

FPP is large volume printing, for example, the production list for one day at one of the organisation's Print Centres recorded 141 jobs covering a total of 2,754,801 printed documents - let alone pages. Production is organised as a chain of processes through which a job passes, run according to a schedule and against a deadline. The print factories within the organisation we have examined were known as Print Centres (PC) and the persons allocated the responsibility of managing production were the Print Centre Manager (PCM); the Administration

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1 We are presenting a case study, for which we make no apologies. Establishment Printers is not, however, just a randomly selected firm, it is one of the largest and oldest European printers, and, at least in the UK, it is recognised to be a depository of 'industry wisdom'

Manager (AM); and the Production Manager (PM). It is their work of production management that is the focus of this present examination [2]

The work of production management displays an orientation to the order of production. Personnel make determinations such as: 'is this job on time?'; 'is this job going to be late?'; 'how late will the job be?'; 'what do we have to do to get the job out on time?'; 'do we have the necessary resources -the right paper in the right quantities, the necessary inks and toners, enough memory, money in the overtime budget?'; 'can we take this job on in the light of our other commitments?"; "how are we going to cope now this machine has broken down?'

These questions are formulated in the light of two imperatives for FPP: i) a maximum ten day turn around from the receipt of an order to delivery, and, ii) keeping the plant at full production, (Bowers, Button and Sharrock, 1995). The former is a contractual obligation entered into with their customers, and the latter maximises profitability. Personnel engage in a number of activities that are designed to achieve an order to PC production that is accountable to these imperatives.

The Production of a Schedule

The AM attends to the imperatives of production printing in working out a production order for the printing machines from out of the daily and contingently presented customer job requests using a 'forward-loading-board'. This organisational artefact is used to turn a circumstantially produced collage of job requests into an order of printing that is tractable to the imperatives of FPP. The PC is presented with a circumstantially produced collage of jobs because not all job requests can be anticipated. At best, the AM may know that a job can be expected because a customer has informed him that they are placing an order. However, on just what day the order will arrive is not always known in advance of its actual arrival. There is always the possibility that it will not arrive at all because even when a customer promises a job for a given day, past experience dictates that jobs do not always automatically follow such a commitment.

Consequently, the internal mail through which the postal and courier services are channelled presents the AM with a new array of jobs each working day. One way in which production on these may begin is by merely printing them in the order in which they arrive on the print room floor and at a time when a machine becomes available. Such a procedure, however, is unlikely to result in compliance with the imperatives of print production to turn the job around in ten days and to work to full capacity. For example, one large job may tie up one machine, but there may be insufficient demand for other machines that day which thus remain

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2 For the sake of brevity the details of our description are drawn from fieldwork at just one site, though the issues addressed are to be found throughout Establishment Printers We should also distinguish our ethnographic approach from the Operations Management literature which has extensively examined production management, especially production scheduling Cf Scott (1994) This work, however, emphasises mathematical modelling whereas we are interested in the embodied practices and oriented to features of production work and organisation

idle. Working up a production order in the face of *this* contingency by splitting the job between machines would then not only complete the job more quickly, it would also ensure all machines are working to full capacity.

Working up a production order in the face of a contingently presented array of jobs thus displays an orientation to the imperatives of print production. The AM must make decisions about which machine will print which job, about splitting a job across machines, about how long a job will take so that upon the completion of that job the next one is ready to go. In taking these decisions a new job must be interlaced into an existing history of production decisions. Past decisions thus constrain the decisions that can now be taken with regard to a new job. However, past decisions can be revised in the light of new jobs. In order to make these decisions the AM must be able to make *calculations* as to the effects that his decisions will have upon production. He must, therefore, be able to turn the daily array of jobs into objects upon which he can perform calculations. This will allow him to make decisions as to when a job will be printed and on what machine, what consequences this may have for past decisions and what degree of freedom it allows him with respect to future decisions.

The forward-loading-board is an organisational artefact that is used to work up the daily array of jobs into a rational production order and by means of which the AM is able to perform his necessary calculations. The board consists of a vertical axis made up of machines aligned against weeks, and a horizontal axis of the number of hours in a week, from 0 to a maximum of 100.

The AM knows from the job order form how many copies of a document are required. He knows from past experience the hourly production capacity for each machine and he is thus able to calculate how long a job will take if it is printed on any given machine. He can then give over a machine for a number of hours to a particular job. He blocks out that machine for the requisite number of hours and assigns the job name to the machine. In this way he is able to see, for example, if printing the job on that machine will extend the production beyond the point at which it should be delivered if it is to meet its ten-day turn-around target. It thus allows him to see if he needs to place the job on two machines.

Through the forward-loading-board the AM is able: i) to project ahead, ii) to see the consequences of past decisions; iii) play 'what if' games and examine the consequences of different production orders; iv) fine tune production, and v) establish the timings for a job with respect to its arrival on the print room floor from the prior origination process, and its progression to the next process such as finishing.

The AM is thus able to make rational decisions as to: i) can the print centre take on another job this week?; can it be accepted?; must it be turned down?; should the job be outsourced?, or should the customer be approached and asked if they would accept the job on a different time-cycle?; ii) is a job late, progressing to schedule, or early?; iii) the re-ordering of production should a production contingency such as a machine going down arise; iv) whether the PCM should be advised that over-time may be required, and v) in what order should the jobs be printed in? The forward-loading-board is thus an organisational artefact that is

used to make production a calculable phenomenon and to furnish data through which rational decisions as to the order of production can be made. Through the forward-loading-board a schedule of jobs for the print machines is constructed, and through the forward-loading-board a particular order to the production process is in part constituted.

Sequential Order

The AM and the PC editors are responsible for entering a job into the production system. In so doing they orient to a sequential order in the production process. First, they draw out the sequentially dependent relationship between processes in situatedly configuring for the job at hand a process profile from out of a range of possible profiles. Second, they provide a means through which the sequential imperative of 'first-things-first' can be met in the production life cycle. Third, they furnish a partial resource through which different parts of the production process can be co-ordinated one with another. It may seem to be a truism to suggest that in managing a production process one is managing a sequential order and that one of the primary rules is to ensure 'first-things-first'. However, arranging matters so those first things actually do come first in unproblematic ways is by no means an easy task.

Sequential Dependency

The activities required for the production of a particular job within the PC can be configured from out of a range of possible activities within each of the production processes: 1) *Origination*: authentication; composition; artwork; layout; bar codes; ISBN assignment; proofing; plate making; scanning. 2) *Printing*: signatures, highlights, grey tones, colour, over printing, embossing, inserts, covers. 3) *Finishing*: trimming, folding, cutting, stitching, binding, perfect binding, spiral binding. 4) *Dispatch*: tying, boxing, wrapping, customer distribution, client distribution. For each job a process/activity profile is configured from out of the above range of possible processes and activities a job can be subjected to. In discussions with the customer and using information retrieved from the order request form submitted by customers, the AM and the editors make up a specification for the job on a 'work-ticket'. The work-ticket is affixed to a 'work-bag' that contains the job request form, hard copy, electronic file, and artwork.

The work-ticket is a second organisational artefact that is used in ordering the production. In entering the process/activity profile in a section of the work-ticket entitled *Component Details,* the AM and the editors orient to the sequential order of the processes and make this a visible feature of working on the job. For example, they enter a numbered list of activities the job should go through, each number corresponding to a production activity. Thus any particular job will have a list of numbered production activities configured for it. The numerical hierarchy thus makes transparent the sequential order in which the activities are to be performed.

Accordingly, users of the work ticket are able to tell what has to be done next, and where that job should be sent once they have completed work on it. For example, following 'printing' the job may have to go to 'finishing' where it will be trimmed to size. However, trimming is only one of a possible number of activities that might relevantly be engaged in next as part of the finishing process. It could, for example, be folded or it could by-pass the finishing processes altogether and go straight to packing. Thus any one activity (with the exception of the activities associated with the last process) has a range of possible next activities that are relevant, and the work ticket constitutes a particular activity as the relevant next activity for *this* job. Accordingly, a resource is constituted for answering the question 'what next?' by making manifest the *defacto* sequential order to the production processes.

First-Things-First

The second orientation to the order of the work is displayed in the use of the work-ticket to attend to the issue of 'first-things-first' in the production process. The work-ticket furnishes a resource whereby users can determine what needs to be done before what. Thus, for example, the work ticket is examined by the Stock Controller to determine the type and quantity of paper required for the job. Should the necessary paper not be available from stock, or should there be an insufficient quantity, the stock controller is able to order the required paper. Unless the required stock is available then printing cannot begin, thus the work ticket is a means through which 'first-things-first' can be attended to: first ensure the stock required for printing is available before printing is to begin. The Stock Controller can thus order the required paper, should that be necessary, while the job is in origination.

Work Co-ordination

The third orientation to the order of the work that is displayed in the use of the work-tickets and work-bags is to the co-ordination of the work done on a job. An 'abbreviated work-bag' is made up at the same time as the main work-bag. It only provides information relevant for the actual printing of the job such as the type and colour of ink and the amount and type of paper required. The production work-bag is sent to the PM. From the information contained within the work-bag the PM can determine how to set up the machines for printing. For example, if a conventional printing machine is to be used, whether it needs to be 'washed', or if a job is to be printed on an electronic printer, which files need to be loaded? The PM also uses the production work-bag to determine what inks or toners are required and what paper is to be used. With this information he can drawn the required resources from the appropriate stocks and have them ready to hand behind the machines in anticipation of the arrival of the job. This means that when the job arrives from origination, the actual printing can proceed with the minimal delay. The production work-bag is thus a device the PM can use to co-ordinate the work of printing with the work of origination.

An orientation to the sequential order of production makes the work of production management accountable to one of the imperatives of production printing: a stringent deadline on turn-around. For example, having the necessary resources to hand so that printing may commence upon the arrival of a job from origination minimises the amount of time involved in moving the job on from one process to another. This contrast with a situation in which the job, having finished with one process has to wait before the next processes can be begun. Attending to 'first-things-first' guards against delays caused by the discovery that, at the time it is required, the necessary stock is not in store. Providing a resource for solving the problem of 'what next?' allows the job to be smoothly moved on to its next process so that the minimum of time is lost in the transfer. Attending to the sequential order of the work is thus a way in which time is saved and the possibility of meeting the deadline maximised.

Demand-Monitoring

The AM orients to the achievement of a smooth flow of work through the print room by working to make the consequences of his forward loading activities visible for the demand on printing machines and other machines involved in subsequent production stages. He is concerned with detecting the potential for log-jams in the production cycle that his prior decisions may cause but which, as he is making them, may not be detectable. To do so he uses another device he has designed to make production actives amenable to calculation.

A smooth flow of work through the PC is desirable within FPP because it attends to the imperatives of maximising production and meeting targets, (Bowers, Button and Sharrock, 1995). The mangers within the PCs are concerned with moving jobs on from one process to another with the minimum of delay. Thus, once a job has been printed it is stacked in front of the machine in an aisle way, awaiting collection by personnel involved in the next process. However, although a smooth flow of work from one process area to another is desirable it can be a problematic state to achieve for two reasons. First, one printing machine may become overloaded with the consequence that jobs stack up for that machine and their printing becomes delayed. Second, loading jobs onto printing machines in a certain order may result in similar jobs coming off numerous printing machines at the same time which are all destined for the same next process, for example, trimming. This may mean that a log-jam for this process develops and that jobs may have to wait rather than moving onto the next process.

In his forward loading operations the AM can exacerbate these problems and thus, while attending to one problem involved in the production of an order of production, scheduling, he may make decisions that adversely affect another, a smooth flow of work. The manger uses a device for calculating the load on a machine and processes in order to make the consequences of his forward loading decisions for the smooth flow of work from one process to another visible. This device consists of a board for each machine into which paper strips can be inserted. The details of a job are written on a strip, which is then inserted into the

board. It is thus possible to display a sequential list of jobs for each machine. As a job is finished the strip is taken out and moved to the next machine that will be used in the production process such as one of the folding machines, and the rest of the jobs on the ladder are moved up. The AM is, consequently, able to monitor the load that is building for each machine. The device does not so much allow him to project in advance what will be the consequences of his forward loading, but it does allow him to monitor the building up of pressure on certain machines and the potential for a log-jam of work. This, in turn, allows him to make remedial decisions such as re-ordering the work by swapping it to other machines or extending the production day through the use of over-time.

Recognising the Order

A pre-requisite for maintaining a smooth flow of work is that the jobs are identifiable to those who must move them on from one process to another, and by those who must ensure that they are moved on. It is also important that the job is moved in its entirety and not just some part of the job. Both matters can be more complex than might appear from outside of the work of the PC, for at any time the process areas can contain many pallets of printed paper in various stages of production. Pallets of printed paper are lined up in the aisles behind the printing machines, and one job may occupy numerous pallets. Pallets of printed paper are also placed in aisles in the finishing area and in the dispatch area. One job may be comprised of several pallets of printed paper and the pages may run on in order across a number of pallets. To move the jobs onto the next process it is necessary for those involved to be able to know which job it is and what parts make up that job. The problem they face is to bring into prominence the particular pallets on which the job resides from amongst the array of pallets on the floor, to identify just those pallets they require and all the pallets they require. To the inexperienced roving eye the jobs can all look alike, and the sheer quantity of the jobs can act to camouflage any one job.

Those involved have to, to paraphrase Melinda Baccus (1986), extract the animal from the foliage, and one method for so doing is to make jobs self-evident with respect to their identity. A device that is used to do this is the 'job-flag'. This is a large piece of paper that is inserted into the piles of printed paper sitting on the pallets and which displays the job title, number of copies and the number of pallets that make up the job and the sequential position of the particular pallet. The flags announce the identity of the job and are thus a device through which those involved are able to differentiate the contents of one pallet from that of another pallet. They are thus a resource that can be used in moving the entire job on to the next process.

Tracking the Job

The PM displays a pre-occupation with the order of work in attending to the interrelated questions: 'where in the production cycle is the job?', and 'is the job

progressing according to the production schedule?' He constantly reviews the jobs in the production areas with these questions 'in mind'. Thus any job as it, for example, lies on pallets or sits in the in-files of machine operators, may be examined under the auspices of these questions. To answer these questions the PM needs to satisfy himself as to: i) the identity of a job; ii) what has been done on the job and what remains to be done, particularly what is next to be done, and iii) the projected times by which work has to be done.

Jobs are made self-evident with respect to the first two questions through two devices. First, the work-bag remains with the job at all times, whatever form the job is currently in. The work-ticket on the front of the work-bag can thus be consulted in order to answer the question 'what has been done to the job?' for each of the manufacturing processes are laid out on the work-ticket and are signed off as completed. Thus, the PM can quickly ascertain what has been done, what has not been done, and what is to be done next, by consulting the work-ticket. Second, once printed, the job-flags inserted into the piles of printed paper allow the PM, as he makes regular passes through the production areas, to immediately ascertain the identity of the job. The PM can then match the jobs against the production-sheet and ascertain, for example, that the job is behind schedule because it has not yet gone into the folding process and thus may be in danger of missing its target completion date.

By making all jobs subject to the above questions and through using the three devices to answer them, the PM is able to monitor the flow of work from one production process to another. He is thus able to detect if a job is slipping behind its schedule, and look into the cause of the problem in order to take remedial action. Accordingly, the PM is able to explore the possibility that a job has been overlooked, or the possibility that there is a log-jam building for a particular process despite the best efforts of the AM. He may then be able to take remedial action by, for example, taking personnel from one production process to temporally help out in the execution of the process under pressure, or scheduling overtime and weekend working or, as a last resort, outsourcing the process.

Remedial action is often taken in collaboration between the PM, the PCM and the AM. A further organisational artefact that is used in this respect is the 'work-list-report'. This document is compiled at the beginning of the working day and lists all jobs currently being worked on. It contains information on their run length, run type, delivery times and dates, and status. Each job is examined in turn. For most jobs this is a simple matter of noting that it is progressing to schedule but for some jobs it is an opportunity to mark problems. For example, a job may be experiencing production problems because the printers are finding it difficult to match a particular colour. The PM may use the occasion to mark that a potential workflow problem may be in the offing should this problem not be effectively attended to. Contingency plans may then be drawn up. For example, the AM may take this into account when forward loading machines and possibly open up a space on another printing machine, which would allow the job to be spread over two machines if it is necessary to make up lost time. Those involved

use the work-list-report to reach agreement on particular production strategies to enable the smooth flow of work and to co-ordinate their work.

Production Management

In using the locally designed production management artefacts of the forward-loading-board, demand-monitor, work-ticket, work-bag, production-work-bag, production-sheet, job-flags, and work-list-report, those involved individually work, and collectively collaborate, to produce an order to production that is tractable to the imperatives of FFP.[3] These organisational artefacts are used as devices through which questions as to the various ways in which the sequential integrity of the process of production and the smooth flow of work can be answered. Thus, for example, questions such as 'what has been done to this job and what is to be done next?'; 'what is the next job to print?', and 'is this job going to be completed on time?' can be methodically answered. These and other questions are asked in the course of production so as to attend to both the progression that is being made with respect to a particular job and with respect to the load on the PC. They display that the work of production management is an ongoing accomplishment, the details of which are attended to during the course of production. This suggests that the uses of these artefacts orient to two features of the production of order: i) it is revisable in the light of the unfolding circumstances of production, and ii) it is visible in the products it provides for.

The Revisability of the Order of Production

A fieldwork anecdote is revealing in this respect. Half an hour into one working day the anxious AM conferred with the PM over a job, the proofs of which had been promised by the customer for delivery that morning. The production schedule relevant for that day had been constructed around this promise and one of the large presses which was due to come to the end of a million sheet run had been scheduled to pick up the job by mid-afternoon. Projecting backwards from that time, the AM had estimated that the proofs had to be in the PC by 10 o'clock in order to complete the necessary origination processes and to have the job ready for printing at the time the machine in question became vacant. Any later than this

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3 A reviewer was surprised that we made no mention of computer-assisted production systems that have been around for many years The organisation we studied is, to stress, a repository of industry wisdom and at the forefront of many technical innovations, yet it uses these simple paper based tools, not the CSCW technologies the reviewer champions Perhaps this, in itself, informs us of the practical utility of these systems If not a sufficient comment, see a previous study (Bowers, Button and Sharrock, 1995) that details the chaos that ensued when just such a computer assisted production technology was introduced by Establishment Printers A lesson we may draw from their experiences is that designers and developers should not become complacent about existing technology, and assume that just because there are systems that address production problems they have actually solved them One thing that can be learnt from studying technology-in-use is that there is often a shortfall between the technology and its reputation

and the scheduled machine would be idle for an indefinite time. The required proofs had not yet been delivered; the customer had been contacted and had assured the AM that the proofs would be hand delivered by 10 o'clock. Nevertheless, the AM was sceptical. The AM and PM developed a strategy to guard against this contingency which involved re-working the production order. Although this required some complicated calculations it was notable from reviewing the tape recordings made of their deliberations how quickly they arrived at their decision.

As this anecdote testifies, the order of production is a revisable order that is sensitive to the unfolding contingencies of FPP. The AM and the PM were able to revise the order of production in a very short time because, in the words of the PM, they had the production order 'in their heads'. By having the forward-loading-board in hand, and conducting their conversation around the production board they were able to readily consult these artefacts and confirm for themselves the order of production they were working to and view the opportunities for re-working that order. With a short walk to the plate room to consult work-tickets they were able to confirm where in the process two other relevant jobs were, and thus placed themselves in a position whereby they could make a decision to revise the order of production. The revisability of the order was done in the use of the artefacts that made production a rationally accountable activity. The forward-loading-board and production board are not only instruments through which an order to production can be initially constituted but are also instruments through which, and in conjunction with others, that order can be revised. Thus, the order that is achieved in scheduling and sequencing production is an order that is open to revision, and the tools through which that revision can be accomplished are the same tools with which the order is initially produced.

The At-A-Glance Visibility of Order

The revisability of order resides in the extent to which the order is visible to those who must revise it. As the above example suggests, the artefacts were a means by which the AM and PM could view the order of production 'at-a-glance'. They are publicly available and on public display. They sit at specified centres from which production is managed. Thus the forward-loading-board and load monitor sit on the AM's desk, the production boards on the PM's two desks (one on the print room floor the other in origination) and the work-tickets and job-flags sit on the jobs themselves. The only exception is the work-list-report. Although, involving particular peoples' desks, these centres of control are, however, public places. They are open and inspectable to all, not just to those whose desks they nominally are. As the PCM, AM and PM make their passes around the PC they can review the order of production by glancing at these devices, as they lie on each other's desks and on the jobs, and they can amend them as required. Not only are they used by the three managers they are also used by the process charge hands and process operators who consult them to remind themselves as to what jobs are upcoming, or where a job has to go next, and when it has to be there by.

The at-a-glance visibility of order afforded by the public nature of these artefacts is not only a resource in the revision of a production order but also in maintaining a production order, for the public availability of work-tickets and job-flags allows the relevant people to move the jobs on. Thus, at a glance, operators can see which jobs have to be shifted and, at-a-glance, a delay in production can be detected. The at-a-glance visibility of order is not, of course, a unique feature of the order of printing, it is a methodical feature of social order per se. The point we are making is how the at-a-glance visibility of order is achieved for the work of print production.

Conclusion: Deciding Between Options for the Network and the Organisation

The work of production management is thus oriented to providing for a revisable and visible order to the order of production. At the beginning of this paper we suggested that one possibility that is being seriously considered is a centralised system that will create a virtual PC with, for example, centralised job acquisition and scheduling.[4] We are suggesting that this consideration can be reviewed in the light of our explication of production management. This explication can be viewed as domain knowledge. It provides a rationale for making design decisions concerning the control of production management that are grounded in the expertise of those involved in the management of FPP. It thus allows the designer to use the organisations' expertise in FPP, an expertise not possessed by the designer, as a resource in their own designing work.

On the face of it there might be much to commend a centralised view, for it might seem that the use of resources could be maximised and the organisation rationalised. However, as we have described, although production management involves the organisation of a production schedule, the order of production that is embodied in that schedule is one that has to be ongoingly worked at to achieve and maintain, and one that is open to revision at a moments notice. The resources for so doing, however, are locally assembled and locally deployed. A virtual PC would then require the replication of these local resources within a generalised context. For example, as the local arrangements provide for the order of production to be 'in the heads' of the relevant local personnel, so too would ways be required to have the order of production within the virtual PC 'in the heads' of the relevant central personnel. Further, as there are ways of making the order visible to local personnel, at a glance, so too ways would be required to make the order visible, at a glance, centrally.

Alternatively, production management can be locally organised, and the transmission of a job from one PC to another could be folded into the order of production in the manner of any job submission. The network would then be used

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4 The issue of centralisation in technology has been extensively examined elsewhere. Cf Zuboff (1984)

to co-ordinate the work of one PC with another by providing access to the production status of each site on the network. AMs would thus be able to scan the network in order to off-load work to other, more lightly loaded sites. A job that might otherwise have to be turned down could thus be accepted. Currently, contacting other sites for this purpose is not systematic. The AM of one site might have to ring around all the other sites with the attendant problems associate with trying to contact the right people at just the time they are needed. Access to the forward-loading-boards would allow the AM to know which sites have a spare capacity. With an added service of being able to directly place the job into the job acquisition and work-ticket phase of production management, make a rational decision over the production of the job in the manner that can be currently made within individual PCs.

Although our examination has been concerned with just one organisation it does, nevertheless, suggest two general points of interest for CSCW: i) the need for CSCW to strenuously address the issue of appropriate information technologies and the co-ordination of work in the light of the evolution of communication infrastructures, and ii) the extent to which CSCW might develop measures of the value of proposed systems for organisations and users that trades on the entwined relationship between technology and organisations.

Communication Infrastructures and the Co-ordination of Work

The development of communication infrastructures and the concomitant proliferation of networking facilities for information technologies means that increasingly networks of organisations such as the one that has figured in this examination, may be developed into complex relationships of customers, suppliers, collaborators (even competitors) and outsourcers. Inevitably, again as this study suggests, this development will lead to increasing demands on the co-ordination of information systems. Current information technologies, however, are mainly concerned with insuring the interoperability of information systems predicated on the continued evolution of communication infrastructures. Thus, although the exchange of information will, seemingly, become increasingly easier, they will not, however, provide support for, nor make co-ordination easier. Consequently a situation that current information systems will engender, the increased need for co-ordination, is not addressed in the design of information systems.

Concomitantly, technologies that currently exist for the co-ordination of work and information do not provide for the easy communication of those involved, and have been strenuously criticised for their centralised and rigid approach to work order (Suchman, 1994). Consequently, it appears that there are no current co-ordination systems through which the co-ordination of work can be realised in a revisable and flexible manner. Thus organisations such as the one that figures in our examination are faced with a very real dilemma. There are clear business advantages to the organisation in capitalising upon the rapid growth in communication infrastructures. However, these infrastructures will result in a situation that will require the co-ordination of complex activities across different parts of the

organisation. Seemingly, neither the infrastructures, nor the current work co-ordination technologies, are capable of allowing the organisation to address this situation. However, the development of technologies intended to do this also confronts a dilemma, a centralised/decentralised information and co-ordination system. With respect to the latter, the entwined relationship between the design of the systems and the design of the organisation must be considered. It may just not be feasible for an organisation to maximise the benefits of enhanced communication infrastructures if the new information and work co-ordination systems necessities the re-design of the organisation in ways that compromise the very work that it carries out.

Technology and Organisational Design

The acknowledgement that there is an entwined relationship between technological infrastructure and organisational structure is widespread in sociology and organisational studies, and is now also quite commonplace within CSCW. Business Process Re-engineering obviously uses technology as a major force in the re-design of organisations and increasingly there are designers who recognise that new technologies impact upon the organisation and the work of those in organisations into which the technology is introduced. In addition, there are those 'toolsmiths' within the organisations themselves who use technology as a significant resource in their re-structuring activities, especially communication and information technologies. A question that members of these groups are held accountable to either by organisations employing their services, those they report to in the organisation, or the persons within the organisations who must now use new technology and orient to new processes is: 'how do we measure the success of the new organisational design?' For instance, should the organisation we have been involved with be 'sold on' a technology that would require it to re-design itself as a virtual PC within which existing local decision making with respect to job pricing; job acceptance; job acquisition; job scheduling; job pacing, and job distribution being transferred to a central controlling agency, the question that could be raised is: 'what measures can the organisation invoke to determine the value to be gained from such a re-design before going to the actual lengths of re-designing themselves?'

Put another way, those who are designing a new system will have to satisfy the organisation that any new organisational configuration it will necessitate is of exceptional value to the organisation. How can designers of the system do that? One type of answer that has been very common amongst designers is too ephemeral for many commercial organisations. It is one that theoretically postulates the value to be derived from technology developments, requiring organisations to make leaps of faith and share the designers' vision of the future. It is a measure of value that is derived more from the vaulting expectations of designers rather than the realities of trading, and as the studies to which we referred at the beginning suggest, designers expectations are often thwarted by the realities of organisational life. Designers of commercial systems thus need to be able to develop

measures of value that their systems can create for organisations that will satisfy the organisations' own methods of accounting. Although the difficult of measuring the business value of technology has been well document (cf. Brown and Remenyi, 1994), nevertheless designers need to be able to access and deploy benchmarks, standardised procedures, forms of solutions and the like, rather than unsubstantiated projected gains.

We are suggesting that one way in which the design of a distributed print factory can progress in this respect is through an understanding of the order of practices we have defined as the local management of print production. Making this the woof and warp of the design, we are arguing, will allow designers to measure the value of their intended system. We have here only been able to gesture at what this involves and do not underestimate the problem. However, even a gesture suggests that there may be less value to be derived by the organisation from following the original design path that envisioned a centralised system and organisation than there would be in designing a 'light-weight' system grounded in the current and highly successful organisational structure.

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References

Baccus, M.D (1986): Multipiece Truck Wheel Accidents and their Regulations. In H Garfinkel (ed), *Ethnomethodological Studies of Work*. London: Routledge and Kegan Paul.

Bittner, E (1995): The Concept of Organisation. *Social Research*, vol. 32, 239-55.

Brown, A and Remenyi, D. eds., (1994) *Proceedings of the First European Conference On IT Investment*. Birmingham: Operational Research Society

Bowers, J (1994): The Work to Make a Network Work: Studying CSCW in action. *Proceedings of CSCW'94, Chapel Hill, USA*. New York: ACM Press.

Bowers, J., Button, G , and Sharrock, W.W (1994). *Networking Reprographic and FM Sites at Establishment Printers*. Consultation Document presented to Establishment Printers

Bowers J., Button, G. and Sharrock, W W. (1995): Workflow From Within and Without: Technology and Co-operative Work on the Print Industry Shopfloor. In *Proceedings of ECCSW'95*, Dordrecht. Kluwer Academic Publishers.

Orlikowski, W J (1992): Learning From Notes: Organisational Issues in Groupware Implementation. *Proceedings of CSCW'92, Toronto* New York: ACM Press.

Rogers, Y. (1992): Ghosts in the Network: Distributed Troubleshooting in a Shared Working Environment *Proceedings of CSCW'92, Toronto*. New York: ACM Press.

Scott, B. (1994): *Manufacturing Planning Systems*. London: McGraw-Hill Book Company.

Suchman, L. (1994): Do Categories Have Politics? The Language/Action Perspective Reconsidered. *Computer Supported Work (CSCW)*, vol. 2 no. 3.

Zuboff, S. (1984): *In The Age Of The Smart Machine: The Future of Work And Power*. New York: Basic Books.