Completing the Loops

PETER J. DENNING
Computer Science Department
George Mason University
Fairfax, Virginia 22030

RAÚL MEDINA-MORA
Action Technologies, Inc.
1301 Marina Village Parkway
Alameda, California 94501

Total quality management (TQM) and business process reengineering (BPR) have emerged as important practices but not yet as a discipline. A methodology for mapping, measuring, tracking, and managing commitments in business processes is necessary to make a discipline from TQM and BPR. An organization's network of commitments can be depicted as a map of interconnected work-flow loops. That map can be used as a guide to design work processes and their supporting information technologies, manage commitments to completion with customer satisfaction, and measure productivity. A study of a complex process, course scheduling, at George Mason University shows how the mapping notation and the method work.

In the past decade, many service-sector businesses that were not organized to provide consistent customer satisfaction have disappeared or have met with wrenching hard times. The survivors want to reconstitute themselves so that they can deliver products on time, offer services that consistently satisfy customers, maintain market credibility and reputation, and introduce new products and services faster than competitors.

Redenbaugh calls this the service-sector crisis [1994]. Its dimensions are enormous: 80 percent of jobs and output are in this sector, yet productivity has been flat for over a decade. In contrast, process automation has helped sustain an productivity increase of four percent per year in the man-

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factoring sector over the same period [Dertouzos, Lester, and Solow 1989].

Most office automation has focused on processes that deal with documents, data, forms, and files. The mechanisms of automation are word processors, spreadsheets, databases, scanners, laser printers, copiers, faxes, file-servers, local-area networks, and E-mail. These devices have greatly extended the reach of transactions and businesses. Paradoxically, in spite of 20 years of improvement in these technologies, the productivity of office work has not improved.

The real problem is that we have not defined or automated the business processes that produce customer satisfaction. By automating processes not explicitly oriented toward customer satisfaction, organizations have accelerated the production of dissatisfied customers. The crisis in the service sector is one of understanding, not of technology. The solution lies in discovering the fundamentals of coordination and then building tools and systems that will give organizations the capacity to coordinate effectively and satisfy customers.

In the early 1980s, firms in the United States started to practice Deming's philosophy of Total Quality Management (TQM), which had spread through Japan under his tutelage [Deming 1986]. TQM focuses on satisfying the needs of customers through continuous improvement of processes supported by extensive statistical measurements of flows, outputs, defects, cycle times, complaints, jobs done on time, and the like. The worker is considered an internal customer whose needs for contribution and recognition must be satisfied. Deming's philosophy has been summarized in his famous 14 imperatives [Walton 1986].

By the end of the 1980s, many ailing organizations realized TQM could not save them. Michael Hammer and James Champy introduced a different movement called business process reengineering (BPR) [1993]. They advocate radical change: Do away with most of the command-and-control structure and instead operate with fluid, mission-oriented teams made up of all the people needed to accomplish a goal. Once the change takes hold, continuous-improvement approaches, such as TQM, might maintain the organization in a successful position.

Their basic principles are stated as aphorisms.

Both TQM and BPR rely on information technology to measure process times and outputs and to make process records available to all participants. To support this, a new, work-flow-technology industry is emerging; it is forecast to grow to $2.5 billions in the United States by 1996 [Koulopoulos 1994; White and Fischer 1994]. Business concerns are also driving organizations toward new computing architectures, in which client-server systems are interposed between mainframes and desktop computers to support self-managing work groups [Vaskevitch 1994].

The proponents of work-flow technology intend to make their tools so widely available that cost will be reasonable and organizations can adopt the tools on their own without having to hire expensive TQM or BPR consultants. We doubt, however, whether most work-flow technologies as currently conceived will stimulate the kinds of changes envisaged by those consultants. Our concern is that most existing document-based and form-based work-flow technologies are not based on rigorous interpretations of human work. Consequently, they are not systematic in their effectiveness and are likely to fail in many organizations. Their basic principles are stated as aphorisms that do not constitute a basis for a theory of communication and work, consistent practices for excellence, or a discipline of reengineering.

A new conception of work was proposed by Fernando Flores in 1979. Flores's interpretation led about a decade later to a new method of business process mapping that allows its practitioners to see the sources of the breakdowns in work, to see the connection of these breakdowns to moods and trust, to design information technology to support work, and to guide the redesign of work processes toward greater productivity and satisfaction. Action Technologies has developed Flores's methodology and tools for using it. George Mason University employed the methodology to revise course scheduling, a complex process that affects everyone in the university.

Shifting Interpretations of Work

A hundred years ago Frederick Taylor articulated the principle of "scientific management." [1911] He described the organization's work as a series of tasks, each of which is a precise procedure whose steps are motions and activities of a worker; management plans and optimizes the tasks and then supervises the workers in carrying them out "the one best way." With the introduction of the electronic computer 50 years ago, it became possible to draw parallels between the motions and activities of workers and the steps of algorithms; accordingly, the individual worker could be modeled as a function that processes input information into output information. These views were reinforced in the 1950s when Herbert Simon [1977] described management as decision-making by evaluating alternatives and in the 1960s when Jay Forrester analyzed organizations as nonlinear feedback signal-processing systems [1961]. Today, these information interpretations of work have been embodied in such work-flow analysis systems as Stella (a program implementing Forrester's systems dynamics) and IDEF1 (a data-flow analysis method originally designed for observing commodity flows in manufacturing plants). In all these systems, work is seen as the process of transforming the given inputs into the desired outputs.

Although these views have made it attractive to think that Taylor's principles can be extended to knowledge work, they have not helped much with knowledge work in practice. Drucker says that the old ways of improving productivity are not effective for knowledge work; he emphasizes the need for effective communication of information among workers [Drucker 1993].

As early as 1979, Flores argued that the breakdowns experienced by organizations are a direct consequence of the input-output interpretation of work [Flores 1979, Winograd and Flores 1987]. He says that the effective management of organizations operating in a worldwide telecommunications network requires a shift in the conception of work [Flores 1991]. He claims that effective coordination of action is the same as effective management of commitments and that the progress of work can be traced by watching "speech acts" in the communications of those coordinating.

Input-process-output models of organizations are good for watching the movements of information and material items but not for observing human commitments. These models are blind to the human processes in which people request work and agree on what will be done, who will do it, and when it will be done; they provide no mechanism for ensuring that any customer is satisfied. As organizations and markets have burgeoned -- fertilized by information and communications technology -- failures to see and manage human processes have changed from an annoyance into a crisis.

Work Flows and Coordination Processes

Every organization depends on three kinds of processes: material, information, and human coordination. The first two are of the traditional input-output kind: They both deal with the movement of objects (materials, data) to particular sites where they are transformed, manipulated, consumed, or combined into new objects. Human coordination processes deal with requests for work to be done, agreements about what will be done, who will do it, when they will do it, and whether the requester is satisfied with what has been done. Work is initiated and completed in the coordination processes. The movement of information and material is the consequence of work and supports work but is not the work itself.

Technologies for modeling material and information processes are mature. But technologies for drawing maps of human coordination processes and tracking the events that constitute them have not been widely available or appreciated. As these technologies become more common, they will affect the design of computer operating systems and networks [Denning 1992; Denning 1994; Vaskevitch 1994].

The basic element of a coordination process is a closed loop, called a work flow, that connects two parties. One of them promises to satisfy a request of the other. In business parlance, used here, the two parties are called performer and customer. In marketing they are called seller and buyer. In everyday life, they might be called doer and asker. As shown in Figure 1, the loop consists of four stages separated by four speech acts [Denning 1992; Medina-Mora et al. 1992]. First, the customer makes a request of the performer (or accepts an offer made by the performer). Second, they negotiate on the conditions that will satisfy the customer, culminating in the performer's promise (implied contract) to fulfill those conditions. Third, the performer does the work and ends by declaring that it is done. Fourth, the customer accepts the work and declares satisfaction. Satisfaction means that the implied contract has been fulfilled; it means neither gratification nor a psychological report about the customer. The common workplace expression "closing the loop" signifies completion of a work flow.

In carrying out the work, a performer makes secondary requests. In so doing, the performer becomes the customer of others, who may in turn make further requests. In this way, a network of performers and customers comes into play in fulfilling the

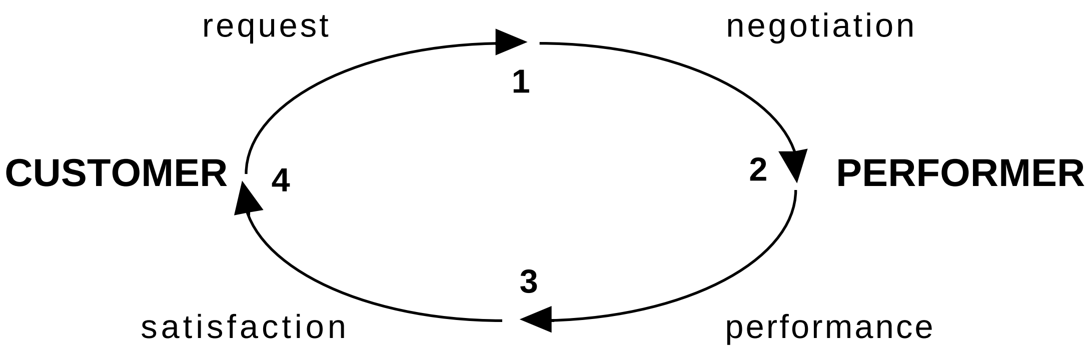

Figure 1: The basic work-flow loop connects a customer (a person making a request or accepting an offer) and a performer (a person making a promise) in a four-phase cycle. The loop moves toward completion as participants make key declarations: (1) the customer says, "I request"; (2) the performer says, "I promise"; (3) the performer says, "I am done"; and (4) the customer says, "I am satisfied."

original request. The resulting interconnection of loops is a social network in which a group of people filling various roles carries out a business (coordination) process that serves the organization's customers. Put another way, the loop connecting an external customer to the organization itself decomposes, fractal-like, into webs of constituent loops, until the roles of everyone in the organization are accounted for. Secondary loops can arise in any of the four segments of a given loop: either party can make further requests during any segment. The network of loops thus depicts the network of commitments that constitute the organization.

The work of an organization is likewise carried out in the network of business processes in which the organization is involved. Those processes may span several organizations, as in the cases of alliances, joint ventures, and partnerships with suppliers.

Figure 2 shows a map of a simple business process for procuring material. It consists of a main loop (procure equipment) that connects to three secondary loops (verify status, get bids, place order). In the main loop, the procurement officer is the performer, while in each secondary loop, the procurement officer is the customer. All three secondary loops rely on the same accounting data system for information.

In many procurement offices, the fourth segment of the main loop (satisfaction) is partially or fully missing. This can happen when the procurement office does not follow up with the customer to see if the material has been delivered and is satisfactory; the unhappy customer is sure to complain. The procurement office ends up with a new loop (resolve complaints); the time, effort, and emotional stress expended on this loop is mostly wasted because it could be eliminated by organizing the main loop for completion.

Figure 2 illustrates one of the big problems that business process maps can reveal. Incomplete work flows invariably cause breakdowns, and if they persist, they give rise to complaints and bad feelings that interfere with the ultimate purpose of

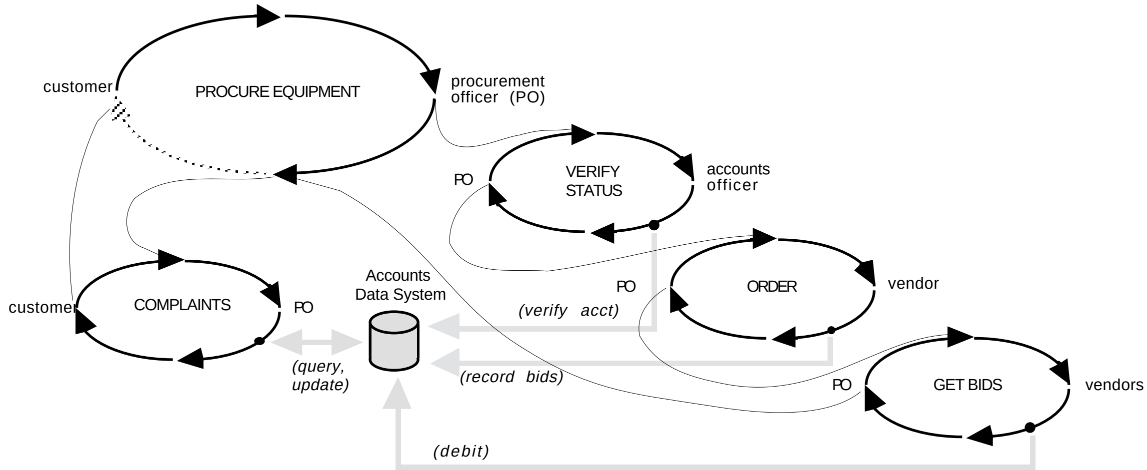

Figure 2: In the map of a procurement process, three secondary work-flows make up the performance phase of the primary work flow. When the satisfaction phase of the primary loop is persistently incomplete (from lack of follow-up), the procurement office will be forced to set up a new loop for resolving complaints. The frequency with which customers invoke the complaint loop is closely correlated to the frequency of incompletions in the main loop. The new loop lengthens the time to customer satisfaction and increases the effort and cost of procurement. Performers in all the loops access a shared database (gray arrows); their ability to meet cycle time requirements may depend on the response time of the data system.

work -- to satisfy the customer. Human beings are remarkably inventive in finding ways to break loops. If no one is responsible for seeing that a particular work flow is completed (a "missing customer"), or if no one is responsible for fulfilling a promise (a "missing performer"), satisfactory completion is unlikely. Many purely information-flow offices are like this: An in-basket obscures the customers who submitted request-forms, and the anonymity of an office hides the performers. Here are examples of failures that can occur in each of the four segments:

—*Request:* The requester can fail to make the request clear, thinking that the performer interpreted a hint or suggestion as a request. The requester may make a request in a form not expected by the performer.

—*Negotiation:* The intended performer may not decline a request clearly, leaving the customer expecting something that will not happen. The performer may ignore the request, giving the customer no response. The two parties can emerge from a negotiation without suspecting that they have different understandings of the conditions of satisfaction. The performer can fail to take responsibility for the agreement.

—*Performance:* The performer can stop work without telling the customer. The performer can deliver shabby results. The performer can work gratuitously, without a customer.

—*Satisfaction:* The customer can fail to acknowledge receipt of the results. The performer can fail to find out if the customer is satisfied.

Any of these breakdowns can leave the customer expecting work that the performer will not do or the performer doing work that the customer does not want.

None of these breakdowns can ever be completely avoided because people are never completely explicit and because they usually assume wrongly that they both have the same understanding of the language they use to describe actions.

In their consulting work with organizations, Business Design Associates (BDA) have shown that organizational mood, market position, and customer satisfaction are directly and positively correlated with the degree to which everyone in the organization contributes to completing the loops in which they participate. BDA have shown that persistent failures to complete loops leave trails of dissatisfied customers. The people working on those loops will lose the trust of their colleagues, and eventually the managers will lose their employees' trust for allowing the situation to persist. Distrust can seed other negative feelings such as frustration, misunderstanding, resentment, resignation, and dissatisfaction. Outside the organization, the same, persistent failure to complete loops can erode trust, reputation, credibility, market position, and quality. The resulting low morale interferes with productive work and increases dissatisfaction among performers and customers alike. This fosters waste as new work flows are added to deal with complaints.

Evidently, many of the problems that plague organizations are connected with persistently incomplete work flows. These problems will not be resolved until organizational practices (people's habits) change and the work flows are consistently completed. Redesigning work flows to make them complete or business processes to make them more productive is not simply a problem of deploying information technology in the right places. A business process, however dysfunctional, is held in place by a set of shared, often unspoken agreements among the participants -- sometimes called the "company culture" or "common sense." Technology can help facilitate changes, but only if the participants understand the nature of the work, understand that incomplete loops can cause problems, and agree to the changes.

Organizational problems are also caused by processes that are missing entirely -- for example, processes for planning or determining market position. This topic is beyond the scope of this article.

Constructing a Coordination Process Map

In the spring of 1991, a group of faculty members and administrators of George Mason University formed a working group to investigate the university processes that were producing the most complaints and to recommend changes in the design of those processes. The most troublesome process was course scheduling.

Course scheduling is the single largest process in any university. At George Mason University, it affects 21,000 students, 650 faculty, and many administrators daily. In addition to determining the times and locations of classes, this process includes advising, career counseling, plans of study, and curriculum planning. Breakdowns anywhere in this process produce unmet expectations, leading to dissatisfied customers (students) and performers (faculty). Because course scheduling is a long-term process, breakdowns can delay students' graduations. As is true in many universities, this process is the subject of endless complaints from all participants. The complaints about Mason's process were:

(1) Approximately 10 percent of the students applying for graduation had not met requirements because courses were unavailable, sections were closed, or the students had inaccurate information.

(2) Approximately 20 percent of the classes in the published schedule were changed after students registered, necessitating cancellation and reregistration.

(3) Many students could not graduate in four years because courses they needed were offered infrequently or were full.

(4) Many students requested and received special exceptions and waivers so that they could substitute courses for those that were not available. Processing these requests occupied much faculty and staff time.

(5) Students' graduation records often did not reflect the coherence advertised in the catalog; students often took more courses than required for their majors.

(6) On the first day of classes, many faculty would be confronted with students who could not register because the class was full and who sought special permission to register.

(7) Many departments did not provide adequately for advising. Faculty said they received little reward or recognition for time spent advising.

(8) The paperwork was immense. Departmental data were copied manually from online spreadsheets to special forms, and then were copied manually into the Student Records data system.

Investigative Method

Members of our working group met with the persons responsible for course scheduling in the schools of education (SED), business administration (SBA), information technology and engineering (SITE), and nursing (SN). They also met with people in the Student Records (SR) office. We constructed maps of the portions of the process they were involved in. We also learned which breakdowns were the most irritating and which changes the participants would value most.

Constructing a map of the work flows *as they are actually performed* is a process of listening for the speech acts that trigger state-changes in the process. Table 1 is a guide. We identified who makes what kinds of requests (customers) of whom (performers), how those requests are conveyed, how the participants reach agreements, what steps are taken to carry out typical agreements, who the performer asks for help in completing tasks (secondary requests), how the performer communicates the final results, and how the loop is closed or not closed. During each interview, we sketched the work-flow process described and the participants validated it.

Phase	Customer Act	Performer Act
request	initiate request accept offer	make offer
negotiation	counteroffer decline counteroffer accept counteroffer	counteroffer decline agree
performance		report completion renege on agreement
satisfaction	decline to accept declare satisfaction	
any phase	cancel comment	comment

Table 1: Speech acts that change a work-flow's state.

(The ActionWorkflow Analyst tool, which was not available then, would have accelerated the map-making process [Action Technologies 1993].)

The process as seen by the SR office is shown in Figure 3. Beginning 11 months prior to the start of the semester being scheduled, the SR office sends a request to all

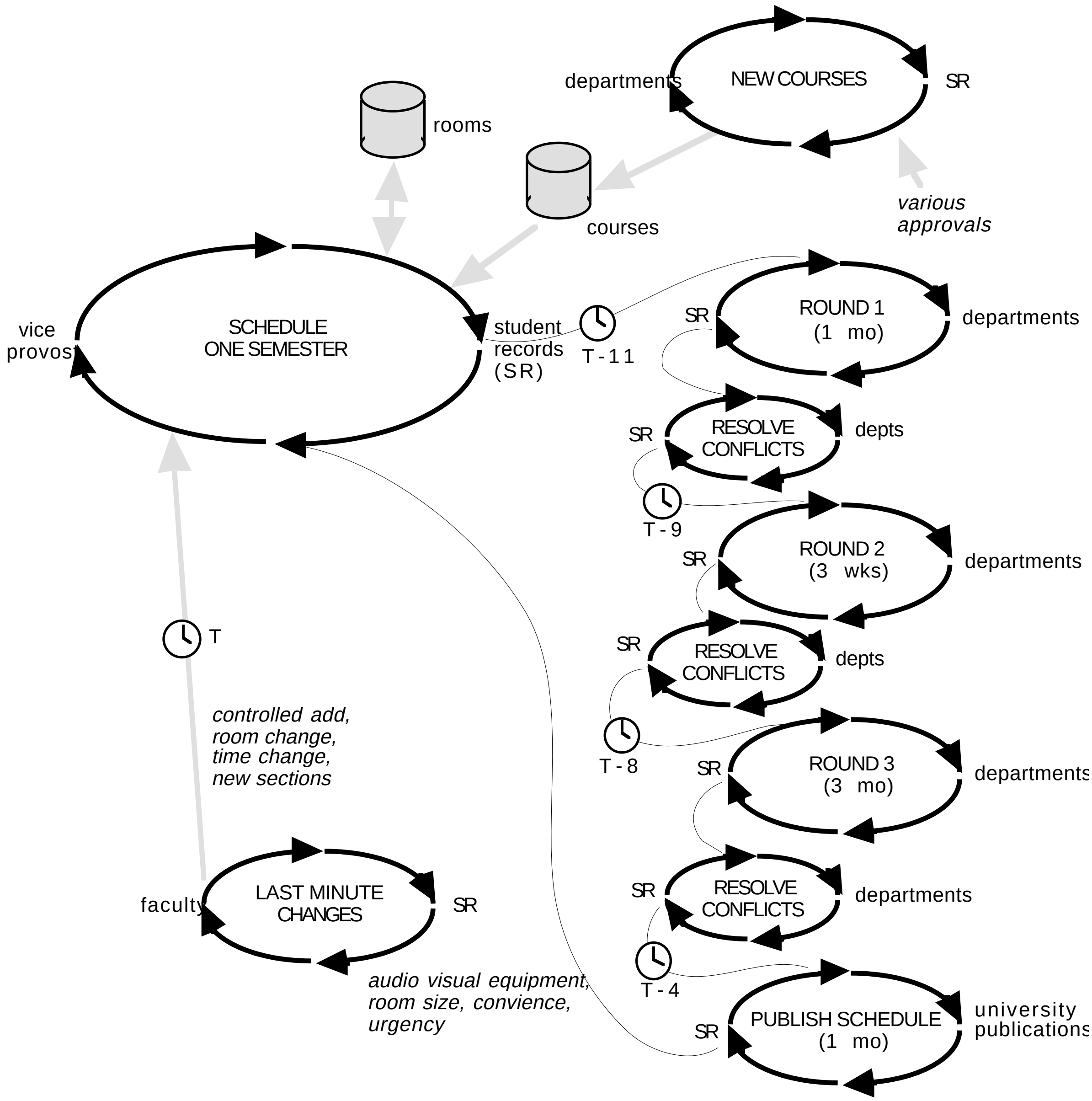

Figure 3: The portion of the course-scheduling process administered by the student records (SR) office begins 11 months before the semester covered by the schedule. Three rounds of drafting, conflict resolution, and revision precede the publication of the schedule. Starting times for each round are shown as small clocks, where T is the start time of the semester being scheduled. About 20 percent of the schedule is changed at the last minute.

departments to draft an initial schedule. The SR office compiles the requests, resolves conflicts, and sends a revision to all departments. After two rounds of revision, the SR office publishes the "final" schedule halfway through the preceding semester. Then students start to register.

Figures 4 shows what happens in the School of Business Administration when SR's request arrives. That school's process is similar to the processes within the Schools of Engineering and Education. These three schools encompass over 90 percent of the faculty and students. The problems begin in the early, incomplete loop in which department chairs ask their faculty members to state their preferences for courses to teach and times to hold classes -- it is not clear that all faculty members have agreed to be flexible with their preferences or that the department chairs are satisfied with their responses. The problems come to the surface when the university publishes the final schedule. Some faculty members react with annoyance or even outrage; they immediately enter into negotiations with the nearest person of authority (department chair, dean, provost) to have the schedule corrected to reflect their preferences and needs, and they often do this without consulting with the person officially responsible for the schedule.

The complexity of the map of the total process is striking. There are many incompletions at the department level that lead to many complaint loops. The second and third rounds from the SR office seem to provide only incremental improvements over the first round. Given the long cycle time of the process (11 months), it is little surprise that 20 percent of the work is undone by last-minute changes.

Reengineering

In discussing with participants why this process has evolved into its present form, we discovered several assumptions that constitute an unspoken social contract that keeps the current course-scheduling process in place. Two assumptions are especially important because they arise from the traditional view that the faculty is responsible for determining the curriculum and knows best what a good education for the student is.

(1) *The scheduling process is faculty driven*. The first three rounds of course scheduling are rooted in negotiations with faculty. Student demands are incorporated late or not at all and are often not known accurately. While the faculty gets several months to react to the draft schedules, the students get only a few days. Faculty members call upon department chairs, deans, the provost, and sometimes even the president for changes if the published schedule does not meet their preferences. Work flows for resolving complaints are disconnected from the SR office. In effect, the real customer -- the student -- is lost.

(2) *Students have little responsibility in the process.* Their only job is to check with advisors to make sure they are fulfilling requirements and to register for the coming semester during the prescribed registration periods.

There were four secondary assumptions: (1) the SR office assigns all rooms, (2) classes must be scheduled in one of three kinds of

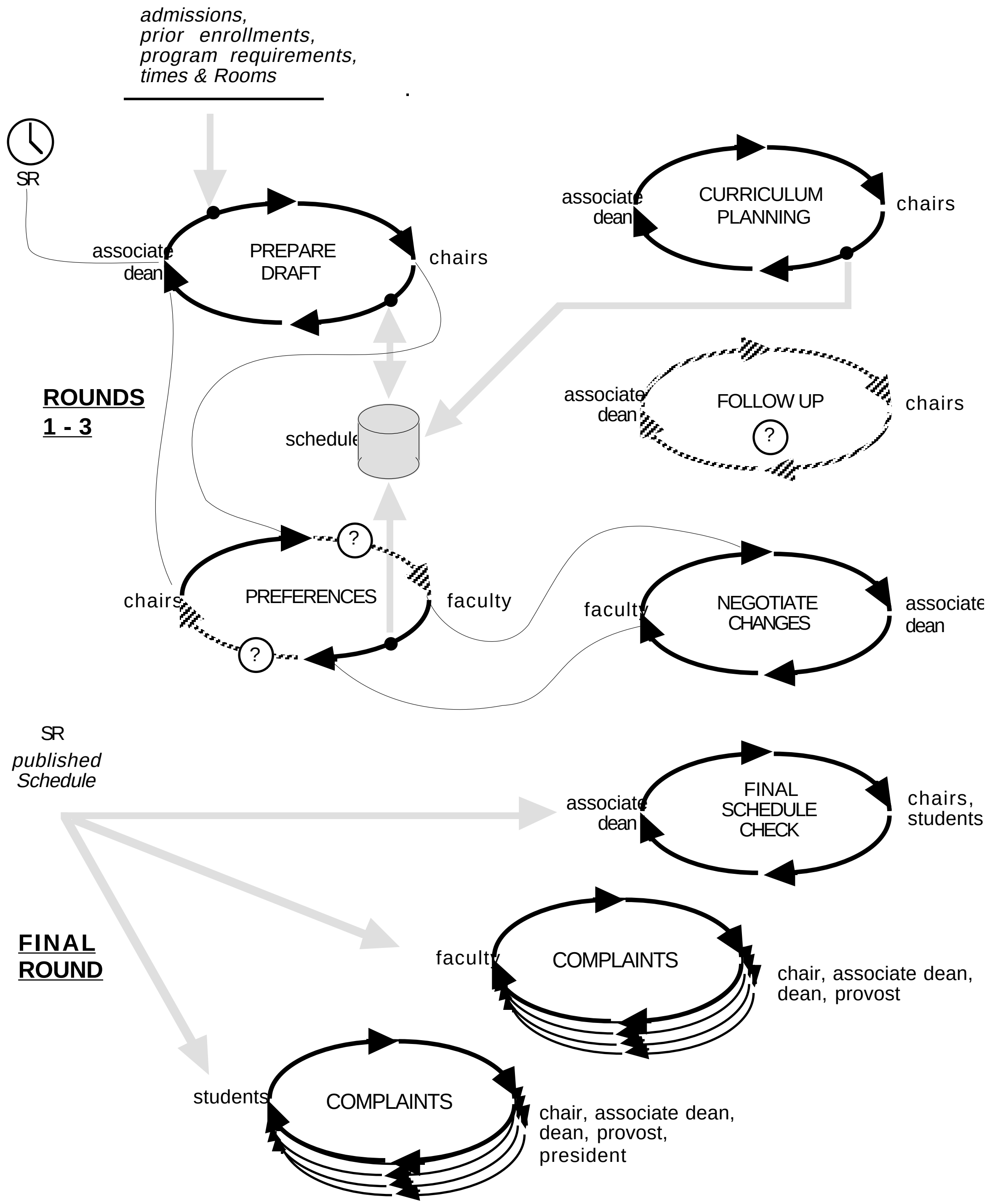

Figure 4: The portion of the course-scheduling process in the School of Business Administration (which is similar to the portions in engineering and education) shows many breakdowns that lead ultimately to a large effort in complaint resolution after the schedule is published.

slots, (3) summer classes are scheduled independently from fall and spring classes, (4) the published schedule contains much information copied from the University catalog. These assumptions are much less important to the faculty than the first two.

To arrive at a simpler process, we started by stating the results we wanted from the scheduling process: to accommodate most student demands, to design the schedule in one round, and to minimize last-minute changes. The process shown in Figure 5 meets these requirements. Its simplicity comes from transforming the basic assumptions to these:

(1) *Students file plans of study that can also serve as course reservations.* A plan of study is an agreement between student and advisor about the courses the student will take each semester to fulfill the degree requirements. The filed plans are interpreted as requests by the students, who in turn are guaranteed classes corresponding to their plans. We estimate that about 75 percent of the demand can be learned from filed plans.

(2) *The schedule is generated in one round after departments are given their demand data.* Early in the semester before the one being scheduled, each department confers with its faculty in light of the demand data and commits to a schedule for the following semester.

The lead time for publishing a schedule based on these assumptions would be much shorter than the current 11 months. The university could publish the schedule in the middle of the semester prior to the one it covers. A key enabling technology here is one that supports the formulation and storage of student plans of study and

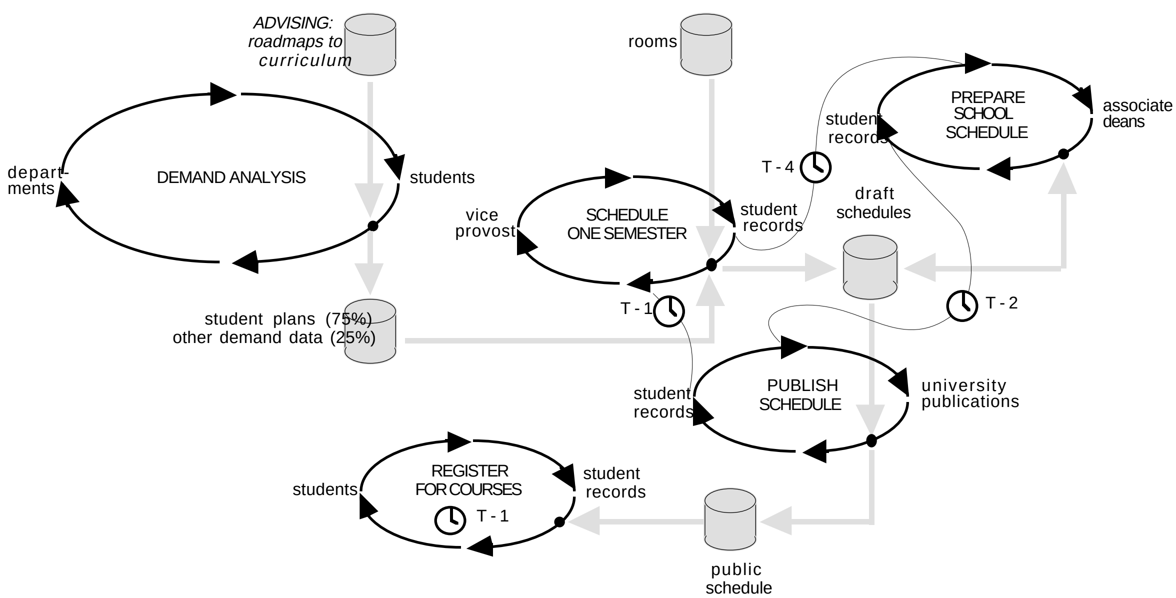

Figure 5: The university's course-scheduling process could be simplified by starting it with an analysis of student demand for courses rather than with statements of faculty preferences. If students' plans of study can also serve as course reservations, this map outlines an ongoing process that converts student demands for courses into a final schedule that is issued toward the end of the semester preceding the one covered by the schedule.

their conversion into statements of demands for courses.

After we specified a simpler process, we discovered that the School of Nursing already had a process close to the ideal; its map was similar to Figure 5 and was free of persistent breakdowns. Its process is a blueprint for the university's reengineered process. Its approach is based on a distinction between two responsibilities of the faculty: (1) to determine the curriculum, and (2) to cooperate with the students in delivering the curriculum effectively. Its success derives from its approach to the second responsibility: the process of delivery is driven by student demand.

The outcome of our study was mixed. On the positive side, the Student Records office eliminated one round of drafts and simplified paperwork, shortening the cycle time by 2 months. It plans further reductions by moving to direct electronic input from departments. On the negative side, there is still no database system for storing student plans and other course-demand data. Faculty members appear unwilling to accept the notion of student as customer, even in the restricted case of course delivery. Despite the mixed outcomes, the campus administration continues to move toward a new process as fast as the database and networking infrastructure on campus will permit.

Other Experiences with Work-Flow Technology

A number of organizations have used the Action work-flow methodology and technology.

---*Young & Rubicam, San Francisco.* Young and Rubicam is a well-known and respected advertising agency headquartered in New York. They automated the paper- and time-intensive process of project traffic control in their San Francisco offices, using the ActionWorkflow Manager system from Action Technologies implemented for Lotus Notes. The resulting automated work flow not only made its team more productive, it has improved job satisfaction considerably [Marshak 1993; Riley and Rudd 1993; Rooney 1993].

The main results were that, within three months, Y&R reduced total overtime by 50 percent and re-do's arising from miscoordination by 64 percent. It also increased jobs completed on time by 63 percent and jobs completed within budget by 19 percent. Participants reported decreased duplication of work, higher percentage of effective time, and less waste in accessing relevant information.

Y&R surveyed participants prior to the implementation, after one month, and after three months [Marshak 1993]. After three months there was a significant, measurable increase in employee satisfaction. After one month, however, employees had reported a decrease of satisfaction, due no doubt to the temporary loss of productivity associated with learning new practices and tools.

—*IBM Personal Computer Company*. The IBM personal computer manufacturing plant in Austin, Texas, used the Action-Workflow methodology in its engineering change process with good results [Center 1993; Center and Henry 1993; Center and Scoggins 1993]. They reduced the cycle time for engineering changes; for one category of changes, cycle time was reduced from 25 days to seven days. IBM reported that it had reduced the resources to perform the process, improved cost recovery, and increased worker productivity. Some users were served from Lotus Notes and others from PROFS on a VM host; managing two systems caused some performance and maintenance problems.

—*Bankers Trust.* Bankers Trust manages assets for big financial institutions. With large sums in assorted investments, clients occasionally detect (or suspect) errors. To deal with their inquiries, clerks in New York resorted to primitive manual methods of locating records: they hauled out big boxes of papers, searched through them, and consulted various departments and a record center in Nashville. The entire history of each case was kept in a manila folder (not a computer file). It took 3 to 5 days to answer one of these inquiries.

Bankers Trust turned to ActionWorkflow in Lotus Notes to automate the record system [Kirkpatrick 1993]. A five-person team analyzed the steps involved in resolving customer queries. It created a work-flow map of the process. Within seven months, the team had the system operational for 125 users in two New York locations and in Nashville. Now the bank guarantees clients a maximum of three days turnaround on queries and completes most within a day. One office of account administrators was able to reduce its staff from 13 to nine because it no longer needed the clerks who searched boxes and kept manila folders. With the new system, anyone can quickly find out who is handling a particular query and what its status is.

—*Tandy Electronics.* The director of planning and administration of Tandy Electronics Design in Fort Worth, Texas, tracks and reviews the company's various research and development projects. The division handles 60 to 70 new product designs a year, each involving 200 to 300 action items.

This division turned to Workflow Designs in Dallas, Texas, to implement a system for tracking and managing these projects [Radding 1994]. It used ActionWorkflow in Lotus Notes to implement the system, which now coordinates about 120 active product development personnel in the United States and Asia. In contrast to expensive process reengineering projects that employ many management consultants and take years to implement, Tandy's work-flow project was completed in two months -- including process analysis, redesign, and programming the Notes databases. Tandy expected the investment to pay for itself within three months and to produce a 10 percent gain in productivity.

Conclusions

A coordination process can be interpreted as a network of loops (work flows), each representing a recurring sequence of promises completed by a performer in response to requests by customers. This network represents a new conception of work as the fulfillment of commitments to someone's satisfaction. It displays how a small set of verbal statements (speech acts) drive the information and material processes of an organization.

Formulating the coordination process in this way connects the completion of loops to the satisfaction of customers, both internal and external. Persistent failure to complete loops leads to negative outcomes, such as distrust and damaged reputation, both of which can render an organization ineffective. Technology tools, such as

ActionWorkflow, for mapping coordination processes and representing them in databases, allow managers to track and measure process output, throughput, and cycle time; they also permit work groups to redesign and reconfigure a process with little more effort than updating a database.

Reengineering those processes is not simply a matter of drawing new maps and introducing new technology. It is also a matter of reorganizing people's practices, habits, and self-interest -- shifting their conditions of satisfaction. Extraordinarily complex processes involving many departments will be difficult to modify without providing technology that allows the many participants to see significant personal gains in productivity within the new process.

The work-flow methodology fills important gaps in TQM. It is explicitly concerned with the fulfillment of commitments, something not mentioned in TQM even though it is essential to customer satisfaction. It ties satisfaction to fulfillment of commitments, whereas TQM equates satisfaction with shifting notions of customer needs or happiness. Work-flow technology can support TQM with a rigorous method of observing customer satisfaction, cycle times, and breakdowns resulting from incomplete loops.

This methodology also fills in an important gap in BPR. It provides a rigorous approach to mapping the processes that are to be reengineered and to specifying the information technologies needed to support the new process.

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Biographical Information

Peter J. Denning is Professor, Chair of the Department of Computer Science, Director of the Center for the New Engineer, and Associate Dean for Computing in the School of Information Technology and Engineering at George Mason University. He has authored 240 technical articles and three books. He is a former president of the Association for Computing Machinery and is currently Chair of the ACM Publications Board where he is working on electronic publication. He is a fellow of ACM, IEEE, and AAAS. He holds two honorary doctorate degrees in addition to his real PhD (from MIT). He received distinguished service awards from ACM and from the Computing Research Association.

Raúl Medina-Mora is Vice President for research and Chief Scientist at Action Technologies in Alameda, California, where he was responsible for the development of the Action Workflow Manager system and its field testing. He was the chief implementor of The Coordinator, an electronic mail system for managing simple two-person processes, and of the message-handler system MHS that has since been incorporated into Novell Netware. He received a PhD in computer science and software engineering at Carnegie-Mellon University.