THE (COMMERCIAL) MEANING OF TIME

While the computer industry argues about operating system choices and e-mail APIs, it's interesting to sit back a little and look at the broader effect of information systems on industry as a whole. One big impact is on our perception of time...

In the old Soviet Union, if you bought a bathing suit it would have the same price summer or winter, in Odessa or Siberia, in a city-center store or a village kiosk (assuming you could find one at all).

At the other extreme, in the United States, consider this: If you want to fly from Dallas to Austin, about 200 miles, it may cost you $200 or $20, depending on when you're going, what day of the week, when you buy your ticket and how long you're staying. And on some occasions on trips from somewhere else to Austin, it may cost you less to fly the extra 200-mile hop to Austin than to get off at Dallas.

Well, one might say, these are extremes, but there's a reason. The bathing suit is a tangible thing, whereas an airline seat is a vanishing commodity.

This example illustrates our current tendency to think of time and matter as fundamentally separate. However, information technology is about to change our perception of time and matter; we will start to think of physical assets with an extra dimension -- time. That means both time to delivery and the timed use of manufacturing resources.

Two results are likely: One, goods will be priced according to delivery schedules, especially to time-sensitive resellers and industrial buyers, but also to consumers through the increasing proportion of direct sales.

Two, goods' prices will fluctuate more quickly in response to the actual costs of making them, including allocation of manufacturing resources.

So let's look at that argument again: The bathing suit is a tangible object; the seat is a vanishing value. Go back one step and consider how that bathing suit came into being: It took up a certain amount of time on a production line (along with, to be sure, some raw materials). Suppose you start to think of selling goods as selling time on your manufacturing line -- embodied as products? Suddenly you can think of scheduling your manu-

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facturing line as tightly as an airline. A product's cost is not just raw materials plus average costs, but a more complex figure reflecting the time-based value of the resources used to make it.

Currently, we have a somewhat post-Einstein notion of time: We understand that assets today are more valuable than assets tomorrow. That realization came with society's development of money (which provided for the measurement of value -- not just its storage -- in the first place); in an economy where you expect a return on investment, an asset held idle has a cost. Later the commercial world developed the notion of net present value: the present value of a future stream of income. The discount rate is a basic measure of expected return on investment: A return of more than the discount rate implies a valuable asset; less implies it's not earning its keep.

The notion of net present value usually assumes a linear rate of return over time. That's a reasonably good approximation, especially in the absence of more exact information. But now there can be more information available, from companies such as Intellection, page 6.

In short, net present value somewhat misses the point. There's not just time-until; there's time-during. Over the course of a day or a month or any other period, the immediate value (or potential return) of assets and the services they can deliver goes up and down, representing both levels of demand and availability of alternative supplies (whether of fungible competing resources or alternatives). There are peak times and slack times, unexpected shortages or oversupplies, and lumpiness associated with the turbulent flow of goods through sticky manufacturing and distribution pipelines.

In short, the curve of value is not straight; it moves in complex ways over time. The value reflects continually changing opportunity costs (returns from scenario A that you forgo by picking scenario B) and demand as well as more static elements such as financing and raw materials costs. (See Release 1.0, 11-91.)

Time in our hands

The business world has started to recognize the importance of time, but mostly in its linear incarnation; witness the recent attention to "time-based competition," concurrent engineering, just-in-time everything, time to market, mean time between failures. (Just-in-time is manufacturers' attempt to impose the scheduling challenge on their component suppliers, but it's not necessarily efficient as a whole.) DHL and Federal Express, among others, are helping companies to manage deliveries more efficiently, and are even managing warehouse and assembly operations for some customers. Companies such as pharmaceuticals makers are spending millions of dollars to speed up the process of developing and clearing products.

But all these are more focused on the length of time rather than the shape of the value curve over time. They do not focus on the management of assets as a function of time.

Airlines: a proving ground for yield management

Who understands this time dimension best? Probably the airline industry, which has practiced yield management with increasing skill and finesse ever
since American Airlines put the idea into practice in the Seventies. (Yes, they did do something besides Sabre and the AAdvantage program -- and all of them complement each other.) Indeed, Tom Cook, who pioneered the technique for American, is now running American Airlines Decision Technologies, a 475-person subsidiary. AADT now sells its yield-management skills to service companies, but it has done a feasibility study for an unnamed semiconductor manufacturer and plans to branch out into manufacturing consulting.

Hotels and car rental agencies are also dabbling in yield management, but less effectively than the airlines. Likewise, some transit systems and especially the phone company have always had peak and off-peak times. Now they're moving to "If you make more than 10 calls to Hungary in any one month..." pricing schemes. But most of these make only crude distinctions.

If an airline doesn't sell a seat, at any price, it vanishes forever. The science (and art) of allocating airline seats is called yield management -- the maximization of total revenue by a carefully managed trade-off between units sold over time and prices charged (see Release 1.0, 2-89). Overall, yield management involves not just predicting demand at each price at each time period before each flight, but segmenting the market so as to get maximum revenue from each segment. It includes complementary aspects such as management of overbooking and give-up-your-seat auctions (realtime yield management) and the differentiation of market segments by criteria other than timing such as meals, seats or early-boarding privileges. (What you do on Saturday night doesn't particularly interest the airlines, but it's their way of separating people who are price-conscious from those who aren't. If you're willing to inconvenience yourself to save money, then you weren't a candidate for the pricier seats anyway.)

For starters, yield management means maximizing the use of resources and minimizing costs; it also means pricing products (or services) so as to match costs and customer demand. That results in allocating scarce resources to the customers for whom they are most valuable.

Now what's the equivalent of a Saturday-night stay for a tangible product? Maybe it's being willing to pick the goods up at the warehouse yourself, or to get them on short notice. "Ma'am, your bathing suit is ready. Please come pick it up, but watch out for the snow in the driveway."

Tangible goods...

But that hasn't happened much in manufacturing yet. Just like the Soviet bathing suit mentioned earlier, goods in the US tend to have the same price everywhere, although there are many exceptions, especially at the retail level -- end-of-season sales, discount stores vs. fancy boutiques.

And these variations depend on the reseller. Manufacturers generally vary their prices according to volume but not time. (At Release 1.0, for example, our printer hates to get our work on Thursday or Friday; the shop is most busy those days. But the printer has never suggested that we pay a premium for those days -- or get a discount on others.) Although manufacturers may negotiate over delivery dates or premiums for rush orders, there's generally very little detailed information underneath.

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Usually, if goods are back-ordered, you just have to wait and take your turn (especially in direct sales to consumers); you can't pay a premium to have something delivered early (unless you're a very big customer, perhaps). Since most companies have no way of charging for expedited availability, such a premium would go to an individual salesperson and would be a bribe.

But isn't that a little silly? Why not create a clean and honest market for people willing to pay extra charges, instead of resorting to pleading or favors? One reason, of course, is that the requisite software and pricing systems would be extremely complex. Another is likely customer resistance. But how about routinely charging less for goods produced during a slack period? That would encounter vendor resistance.

...or embodied time

Nonetheless, some manufacturers are already starting to manage timing in a small way. They typically have a rush price and a regular price, and you can always negotiate if you have a large enough order. (Perhaps the government's recent discovery that capacity utilization is higher than it thought does not reflect a stretched economy, but rather indicates the start of more efficient utilization of resources.)

More significantly, Dell Computer plans to differentiate its products on a regular basis by delivery speed, with different prices according to the length of the order lead time. But again, the price differentials will be fixed, and won't reflect actual factory conditions -- just average costs. Still, this is a start, and in keeping with Dell's forward thinking overall. (Dell already builds custom-configured machines and treats each one uniquely; it is currently undergoing a substantial re-engineering of its logistics and information systems that may result in a more fine-tuned approach to time-based pricing.)

Like Dell, most manufacturers aren't yet acting from good information; they just know that they have, say, a four-week lead time and they quote that regularly. They don't know how to price a two-week order, or whether they could make money delivering next Friday but not next Wednesday. They don't manage for underutilized capacity or overbooking, the way airlines do to allow themselves the right margin of flexibility. The time-management function so far involves moving things around warehouses rather than allocating resource time. Price may vary at the retail level, but most wholesale prices are set without specific regard to timing or time-based costs.

Traditionally, prices help to allocate existing goods in the short term, and they affect long-term production and investment decisions. With good schedule management, they could also affect short-term allocations of assets and production decisions. Prices customers are willing to pay could then signal when as well as what to produce.

Time's time is coming

Again, think of selling manufactured goods as selling embodied time on a production line. What's perishable isn't the product, but the resource time used to make it.

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Until recently, that notion didn't have much practical implication. The cost of developing and managing the information for resource allocation was high compared to potential gains. But in our increasingly efficient (or competitive) economy, and with increasingly powerful and cheap information systems, the trade-offs are beginning to change.

Here's why: On the supply side, the cost of raw materials is dropping relative to the value added through manufacturing, assembly, configuration and all the time-consuming processes involved; the cost of these processes is essentially a function of the utilization of relatively fixed assets. That is, most of the cost of bread depends on the flour. But most of the cost of a highly engineered product is a function of the time allocated to its production by sophisticated machinery. Thus, even with automation, goods could be cheaper to make with more attention to scheduling.

Meanwhile, on the demand side, goods are expensive to inventory, even when they're cheap to make. That gives customers -- wholesalers and distributors, especially -- an incentive to schedule their purchases carefully.

Thus manufacturers could generate more revenue as well as lower costs with tighter attention to scheduling -- especially for high-margin goods built or configured to order. Alternatively, with lower costs they could lower prices to gain market share without sacrificing margins.

Until now, managing the production process has been a fairly seat-of-the-pants business. Factory managers can't properly cost or allocate resources. Software does exist to produce production plans, but it's not real-time. Moreover, it handles only one side of the equation -- the costs. Producing a workable schedule is considered victory.

Consequently, since cost estimation hasn't been good enough, there has been little attention to the corresponding issue of setting or negotiating prices to reflect actual costs. But if there were, the prices the market accepts would ultimately send a message back to manufacturing about what is most valuable to produce. (Of course, this happens, but only on a slow time scale, and without much specificity about individual product varieties except for mass-market brands.)

But now firms such as Intellection (below) are selling the tools and the philosophy of yield management to manufacturers -- and a few manufacturers are seeing the vision. Moreover, several airline consulting firms with expertise in yield management, such as Boston's SH&E, Atlanta's Aeronomics and American Airlines Decision Technology division are now considering selling their expertise to manufacturing clients. However, notes Aeronomics CEO Robert Cross: "We surveyed the Fortune 500 manufacturing companies [CEOs, CFOs and CIOs], and for the most part they hadn't thought yield management applicable to themselves. We have it in our business plan for 1995" -- but maybe sooner if a client shows some interest.

Time technology transfer

For example, the link to the airline business hasn't escaped the notice of Sal Miraglia, VP manufacturing for Timken Steel Company. He has spent substantial time benchmarking his operations against those of one of the leading US airlines, where he happens to have good contacts.
Could his operation manage schedules based on accurate, quantitative costs as well as physical constraints? That’s certainly his goal, within several years, he answers. He also hopes to charge customers prices that reflect those costs -- and the complementary value of certain delivery times to the buyers. All that can’t happen until he can acquire and manipulate realtime resource allocation information as flexibly and easily as a financial analyst can acquire and model securities prices.

INTELLECTION: RUN YOUR FACTORY LIKE AN AIRLINE?

In fact, Miraglia has found his time-management solution -- along with 14 other customers such as Black & Decker, Mary Kay Cosmetics, Motorola and Caterpillar. It’s a product called Rhythm, from Intellection of Dallas.1 Rhythm, which runs on UNIX workstations, is a realtime master production scheduler. It lets a user change schedules, as do many tools. But unlike most of its competition it’s also an interactive simulation tool; it works fast enough to process a huge volume of data and perform what-ifs, reallocate resources and display the impact right away. Users can interactively assess the impact of a change in a schedule, the relaxation of a constraint or a change in supply conditions.

Right now, a worker using Rhythm can take 10 minutes to rearrange a schedule to offset the impact of a sudden breakdown on line 33. In the future, a salesperson may use it (remotely) to decide whether to accept an order at a 10-percent premium for delivery next Tuesday.

For schedule building and optimization, Rhythm uses its own patent-pending constraint-anchored optimization algorithms.2 Developed by founder Sanjiv Sidhu and his team, they can optimize efficiently and quickly despite multiple and interdependent bottlenecks. In fact, the more complex the situation, the better Rhythm performs relative to traditional approaches.

Basically, Rhythm’s approach speeds up the optimization process by careful analysis and management of the constraints, which limits the search space of possible solutions regardless of the algorithm used to test the minima. The system first looks at an unconstrained schedule and assumes infinite resources, and then compares that to reality -- the actual inputs and processing facilities or machines available.

1 Other customers include Ford, General Dynamics, Logan Aluminum, PPG, Eli Lilly, Heinz, Northrop and Solectron. Revenues last year were $2 million.

2 How does it compare to the genetic-algorithm schedulers we described last year in Release 1.0, 5-92? You could replace some of Rhythm’s optimization algorithms with a genetic algorithm for scheduling, but a major part of Rhythm’s contribution is the efficiency of its constraint-anchored search approach.

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Then it lets the user ease the constraints (for example, ordering supplies early, subcontracting work, opening up extra lines or letting delivery dates slip) and develops a schedule working from the remaining constraints out -- backwards from due dates as well as forward from the present or the earliest possible availability of resources. This limits its search space of solutions to ones that are actually possible. By contrast, most systems work only forwards or backwards, and waste time considering impossible solutions.

Don't constrain me

What are the factors Rhythm must juggle? They include:

- set-up costs and time (How long does it take to put a machine or line into use and turn it off again? How long does it take to switch from producing one product to another? How much material, such as paint, is wasted in the process?)
- increases in cycle time as machines are used to capacity
- substitutes for resources available at any given time
- varying qualities and characteristics of raw materials and components
- labor availability and costs, including overtime and night premiums
- unscheduled (or scheduled) downtime or inventory shortages
- delivery requirements

All these factors define and constrain the range of possible schedules, and the trade-offs for each. Meanwhile, new orders come in, and old ones are modified or canceled. Rhythm has powerful facilities for representing those constraints and bottlenecks, and for calculating the priorities (as defined by users) of alternative scenarios.

Short-term and long-term

There are two basic user modules, Rhythm Master Production Planner & Scheduler (MPPS) and Rhythm Dynamic Scheduler (DS). MPPS is for planning long-term schedules; DS is for short-term rescheduling and modifications to a larger-scale plan. In long-term scheduling, the system determines the global constraints and generates the overall best schedule for a period of weeks or months -- interactively with a user who can decide which constraints to relax. The system looks at overall capacity and materials needs, predicted orders and other information.

For short-term scheduling, the user checks out and downloads the necessary subset of real-time data from the existing production systems to build a new schedule -- or do queries of work-in-process, maintenance scheduling, troubleshooting or other tasks. (From this point forward, a monitoring program captures all changes to the database so that integrity can be maintained.) Just as with a spreadsheet, the user can do queries, change values, reassign tasks and so forth, using the tool to see the potential impact.

When he commits any changes back to the production system, Rhythm takes the file of changes since the checkout time and runs them again against the new version of the database. Since the system operates in (real and virtual) memory, it uses the existing databases of the manufacturing operation; it's a modeling tool or application rather than a database itself, with normal locking facilities. Aside from simultaneous users, the only major changes are likely to come from new orders, which tend to come in batches from a

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separate department anyway; at this point at least, customers generally aren't online to manufacturing facilities!

Fast machines, slow humans

For both MPPS and DS, the calculations are relatively swift, not just in terms of the user's interaction, but in terms of elapsed time for producing a schedule. Long-term schedules that used to take Eli Lilly's Cardiac Pacemaker unit 10 days to produce now take 5 days with Rhythm. Even with swift calculations, the process requires user time to consider alternative schedules, decide which constraints to relax, talk to marketing, and so forth.

In theory Rhythm plus an expert system could do all of this, but we aren't there yet. Besides, users don't like leaving it all to a machine; they want to propose schedules and see the impact, open a line and see what happens.

Customer comments

Apart from all the theory, users do indeed like working with Rhythm. For example, the users at Caterpillar's gear pump division like Rhythm so much, says flow management coordinator Jim Lock, that they won't give up their old, tested, original version of the software to install Intellection's newest release: "They said, 'Leave us alone. We like it fine the way it is.' Instead, we're putting the newest version into several other plants."

Moreover, the system can be useful right from the start. Earl Mott, director of computer-integrated manufacturing technology for Black & Decker, recalls that during training, with real data in a test environment, planners would keep discovering problems and calling the factory to change things. The result was smoother operations before the system was even installed.

Mott's experience is probably typical, although Black & Decker is one of the leaders in US manufacturing and helped write the spec for the current factory management standard, MRP II -- which is now outdated. "Our current system is weekly-bucketed," Mott says. "Anything happening within a week is basically invisible. Suppose we get a call from Home Depot for a thousand drills. After a day or two, all the factory can say is 'maybe.' But we have no idea of the impact on other orders. But Intellection gives us an extremely good view. We can call back to marketing and say, 'We can give them to you on Friday.' Or we can do it on Wednesday if they insist, and then we tell them what orders we have to delay to do that. Our big goal now is service level -- and getting the business: A substantial proportion of our orders are ship-or-cancel. People want delivery in seven days, of which three to four could be transport."

Mott is one of four specialists overseeing the continuous re-engineering of Black & Decker's manufacturing processes. Among other approaches including object-oriented programming, they are working on group technology, or the notion of creating mini-factories within a factory where a small group of people and machines work together. But instead of building these physically, he says, with Rhythm B&D should be able to create efficient virtual groups that can be reorganized in response to changing conditions.

Currently, Black & Decker's systems (including Rhythm) classify labor by job skill but without wage rates, and handle orders by date but without estimates of profitability or price differentials for timing.

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Indeed, Intellection's Sidhu says, most customers aren't even close to knowing their costs, so the costs of most resources and trade-offs aren't denominated in dollars, but on scales of preference generated by whoever sets up the system. The real goal, of course, is to keep everything close to capacity with enough flexibility to handle high-profit last-minute orders; calculating the expected value of those orders is the real way to determine the "cost" of any line. It's an actuarial value which is itself determined by the intricacies and cross-dependencies of the schedule.

Likewise, many manufacturing operations pay little attention to the prices, let alone the profit margins, of the goods they produce. It's all they can do simply to fulfill the delivery promises of their sales operations.

Rhythm is written in C++, as one might expect, and represents all the elements as objects, with their constraints and other parameters defined as methods that interact with those of other objects. As shown above, users can interact with a wide set of customizable tools/views, including: 1. orders editor; 2. problem window, showing capacity, materials and other problems/constraints; 3. resource load, showing projected load vs. demand -- which needs to be resolved when load exceeds capacity as in the example shown here; 4. order plan, showing the resources to fill a particular order; 5. constraint-anchored optimization (CAO) parameters, which let the user control the optimization process, resulting in ... 6. post-CAO load, the plan for Assembly Line B; and 7. a Gantt chart.

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Quote me a time

In the short term, Rhythm’s value comes when something unexpected happens: a new rush order, a machine breakdown, a quality or supply problem that requires a new schedule. It can also flag danger points, likely shortages and other items in response to continually updated information from the factory floor. Overall, it allows a manufacturer to increase responsiveness to customers while reducing costs. (It’s easy to be responsive if you don’t care how much you spend.)

Long run, it helps not just in allocating resources but in making investment decisions (the airline equivalent of selecting hubs and route-planning). "Rhythm has taken the guesswork out of our capital-equipment decisions," says Caterpillar’s Jim Lock. "We can make simulations and figure out where we’ll get the most bang for the buck. Sometimes we found out we didn’t need a new machining center, for example; we needed additional tooling for an existing center."

The long-run benefit will be the ability to reflect costs back to purchasers, whether in-house departments or ultimate customers. In turn, the prices customers are willing to pay will indicate the profitability of producing any particular line of goods. (Perhaps some items should be made only if a factory has excess capacity.)

Intellection over time

The company was founded in 1988 by Sanjiv Sidhu, now 35 years old, formerly with the Texas Instruments Artificial Intelligence Laboratory, where he worked on complex scheduling problems -- not just in theory but for TI customers such as Ford and DuPont. The company’s staff of 30 is engineer-heavy and salesperson-light; most of the engineers have practical experience in scheduling problems. Sidhu grew up in Hyderabad, India, and came to the US in 1980. He earned a masters in chemical engineering at Oklahoma State and did PhD work at Case Western before being lured away by the opportunity to do work with real customers at TI.

So far, Intellection has won every account it has gone after -- which indicates to Sidhu that the company must not be stretching itself enough. On the other hand, it probably couldn’t handle much more business than the fifteen clients it has now. Although the system itself is easy to use, it takes three to six months of set-up time with consulting from Intellection, since most companies don’t yet explicitly represent all the constraints, costs and other data that Rhythm requires to do its work. The new version should shorten the installation process by half. "We don’t want to be the bottleneck," says Sidhu appropriately.

THE IMPLICATIONS: SUPPLY MEETS DEMAND

Intellection’s Rhythm is the equivalent of a spreadsheet for manufacturing. Just as spreadsheets started a generation of MBAs fooling around with costs and prices, market shares and projections, so will Rhythm and its eventual competitors foster more detailed analysis of manufacturing operations.
Rhythm and other yield-management tools that may sneak over from the airline business allow users to model the costs of different allocations of resources effectively. Each resource acquires another dimension: time. An item's shape in time is complex, since it's dependent on a variety of other factors. Using those changing values is the foundation of yield management.

Until recently, all these interacting factors were basically unrepresented in most models of resources, and so each resource had a "flat" profile; its cost was regarded as fixed over time. Traditional economies of scale reflected not only bulk purchases and the costs of switching resources, but the costs (or unavailability) of information about finer-grained approaches.

"Right now, manufacturing is starting to get more data," says Sam Fuchs of SH&E, an aviation consulting firm in Boston, who previously worked at Intel in manufacturing operations. "CIM is where airline reservation systems were in the late Seventies -- just before yield management took off. We have seen airline customers change their behavior in response to pricing, taking different routes and waiting for deals; maybe we'll see the same for manufactured goods eventually."

Supply and demand

As with airline yield management, there are two sides to making business use of the information. One is allocating resources according to constraints and imputed costs; this much allows a factory to supply the products ordered on time -- and at minimum cost. The second is to move that information forward into prices (profit margins) in order to maximize profits as well as minimize costs -- through either higher prices and margins, or lower prices and greater market share.

As well as costs, this requires demand-side data:

- what are the customers for various alternative production schedules willing to pay in the aggregate?
- what are customers willing to pay for in terms of delivery times?
- what are the predictions for last-minute high-profit orders?
- what are the predictions for last-minute cancellations (and how much could one charge to offset the costs they impose, equivalent to the airlines' $25 fee to change a flight)?

The real benefit will come when pricing reflects both costs of supply and details of demand -- which in turn feed back into opportunity costs. The laws of supply and demand, costs and prices, work only when there's feedback -- interaction between Intellection's analyses of costs and time, and the customers' price sensitivities and preferences for timing and products. Thus, yield management for goods will be reflected in delivery timing, but more careful scheduling and pricing may also affect production decisions; not just when to produce goods, but which goods to produce.

A fine-grained market

What we're talking about, of course, is a market -- where supply meets demand, and where prices reflect costs to the supplier and value to the buyer. Of course, markets already exist, but better information is likely to lead to better allocation of resources -- and more fine-grained pricing. For
manufactured goods, the impact will be partially on the timing of production of goods, but it will also be more accurate pricing. As CEO Robert Cross of Aeronomics says: "We had always focused on perishability, but it's the diminuition of the opportunity [to manufacture], not of the good itself, that matters in manufacturing. In other words, what's the highest-value use of your production facilities; what mix of products will maximize your return from these assets? And what return can you expect from holding them open for last-minute, high-value business?"

With electronic networks and information services, customers will be able to bid for the products they want, rather than merely selecting from what manufacturers have made and retailers are distributing. (See Release 1.0, 6-91 and 11-91.) Consumers will be better able to express their preferences both for particular goods and for particular timing. Although we don't address it here, note that we're assuming less room for physical middlemen -- traditional resellers -- and more use of direct channels (mail, phone, TV and e-mail shopping). There will also be a greater role for logistics/delivery services such as provided by Federal Express, DHL and UPS. Moreover, there will be a role for information services such as NetBuilder from Trilogy (see Release 1.0, 10-91 and 2-93), which allow dynamic configuration of products. Hooked up to factories, electronic middlemen could offer a two-way pricing service, with prices updated to reflect factory conditions.

The economies of scale that we considered a fundamental economic law turn out to be an artifact of insufficient information; it costs little more to build customized items than mass-produced ones -- if wanter and maker can find each other.

Services, services

While applying yield management to manufacturing may seem like a stretch, it's easy to see how it applies to services. Opportunities for yield management include everything from doctors' time and hospital beds to computer time at a computer center (capacity management is already widely practiced, but the next step, pricing, is not) or software development projects. The same techniques can be applied to office workflow, optimizing the production of electronic "paperwork" and, again, pricing services effectively. Staffing decisions could also be made more accurately.

As service becomes a greater part of our economy, delivery time becomes a more important competitive factor. Business used to be conducted from 9 to 5, Mondays to Fridays. Now it's not only start-ups and retailers that work on weekends, but also software support hotlines, banks, information services and direct-sales operations (manufacturing or at least delivering to order). White-collar workers can take their work home -- and even if they don't, their work may follow them home, via fax machines and e-mail, to say nothing of phone calls. While people are working longer, automated services allow many businesses to extend their hours with minimal additional employee time. As more and more services become automated, they can be designed and launched during "normal" working hours, but continue to operate at all times. Automated information services and automated production lines allow for the extension of work-delivery to the entire week.

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Customer acceptance

The biggest problem will be persuading customers to accept this new approach. Manufacturers want to save costs and be efficient, of course, but customers always look on pricing moves with suspicion. People don't yet represent their own price-sensitivity explicitly. Although they know they value a hotel room more on a busy Tuesday night than over a dead weekend, they still don’t feel they should pay more for it -- although they’ll happily accept a weekend discount rate. People are just learning to pay for convenience, for fast delivery, for on-demand service, but the mindset hasn’t been fully accepted yet. There’s still customer resistance, whether it’s a customer’s confusion and annoyance at flexible pricing (the old compare-with-the-guy-sitting-next-to-you-on-the-airplane story), or in-house inattention to careful costing.

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Always represent the variance as a discount from a high price rather than as a premium on a low price.
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Meanwhile, manufacturers may fear that yield management will lead to the kind of price erosion that the airlines are experiencing. We believe the airlines’ problem is a special circumstance due to the prevalence of bankrupt carriers who are dragging prices down for everyone. But it’s certainly a warning that an efficient economy may provide more benefits to consumers than to manufacturers; the potential profits of greater productivity may be competed away, as described in Release 1.0, 9-91. But in the meantime, the companies who become efficient first should gain market share and profits to invest in further growth.

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A rose on Mother’s Day is not a rose on July 4 is not a rose four days after Alice’s birthday. Nor is a rose here equivalent to a rose there...
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Benefits

Just as there is no true value for a share of stock -- other than what someone is willing to pay for it at a point in time, so is there no "true" value for any other item. Further, economic value can be added to any good or service if it is delivered to someone who especially wants it at a particular time. There are certain clearly visible costs -- for raw materials, say -- but resource costs and opportunity costs are always situation-dependent (see Release 1.0, 11-91) -- on alternatives, on interest rates, etc.

The benefits of this kind of insight go beyond higher production at lower cost. In the end, customers will have greater choice as to timing of what they buy and use, and will be able to express more accurately their (cost-adjusted) preferences for particular goods.

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SOFTWARE EMANcipATION TECHNOLOGY

Like Intellection's Sidhu, SET founder Vladimir Geisberg is an emigre. He left what was then Leningrad 20 years ago in April, and ended up in 1980 as a programmer at ComputerVision, where he was principal designer of ComputerVision's breakthrough SolidDesign tool. By 1983 he saw political problems at ComputerVision (shades of the Soviet Union!) and emigrated again... to Prime, where he helped build Medusa and CADDS-5. In 1988 Prime acquired ComputerVision, and Geisberg returned to ComputerVision as head of R&D for the combined company. As development manager, he looked for software design tools, but couldn't find what he really needed. "I was looking for where heat was generated but not much work was accomplished. Why was CAD a success while CASE was a flop?"

The model for the answer lay in a product developed by his brother Sam at Parametric Technology, a CAD tool that lets designers represent the dependencies among different parts of a design -- a task always considered too complex to solve in a general way for software. With that model, he started Software Emancipation Technology to build the product he wanted to use. (Yes, SET's own people are using ParaSET to debug itself -- and they will continue to use it for enhancement and maintenance of both code and documentation after the product is shipping.)

Software development is a major issue for the Nineties, since it's so fundamental to all of business -- call it the DNA of commercial organizations. Software will be the representation of most business services, of all our shared knowledge, of product designs and business procedures. In the Eighties, the industry tried to solve its software problems by treating software creation as an industrial process, in "software factories." CASE tools exemplified this notion; they imposed a methodology, looking at software development as a waterfall process, from spec to design to code, and they created tools to manage the process. "Integrated" CASE tools allow the output of one step to become the input of another, in the proverbial multi-tier waterfall. But changes made below are hard to send back up the waterfall.

-----------
When you go to Alaska, do you try to warm up the climate? Or do you just put on an overcoat?  
----------- -- Vladimir Geisberg

But in the demassified Nineties, some of us are wiser. Rather change the creative process into a sort of software factory, former programmer Geisberg is trying to retain the programming culture and style but make it work better, helping the individual developers do the job better (whether alone or in groups). In essence, they can do what-ifs with a large piece of software, just as Rhythm lets them do with a schedule, or 1-2-3 with a financial model. As Geisberg observes, software development is not sequential, but iterative. Insights obtained during one activity such as coding may reach back to affect a (theoretically) earlier stage, such as design. But while it's relatively easy to move from design to code, it's harder to move back.

What the waterfall approach sees as sequential stages, Software Emancipation sees as media: Ideally, changes to one element in one medium -- documentation, specs, code, comments -- should be reflected automatically in changes
to that same element in another medium, since all are merely different representations of the same underlying functionality. But of course in real life that never happens. A programmer changes the code to fix a bug but leaves the documentation as is (and neglects to notice the side-effects of his changes). Requested modifications are never completed. And of course, the product never matches the marketing literature!

Even if people were willing to do the work to keep requirements, documentation, specs, implementation and various versions in synch, just keeping track of all the elements is an enormous task.

Basically, that's what ParaSET's parametric design model does.³ It doesn't interfere with coding; it doesn't impose a methodology; it doesn't require a special language or sequence of development stages. It simply helps users individually and in groups to keep track of all they've created. It's a hypertext application especially designed to manage software projects.

The problem to be solved isn't the storage of the data, but creating and maintaining the proper linkages and dependencies and equivalencies among all the elements of code and related texts. The ParaSET model is a schema for managing a complex set of data, rather than the data store itself. (To continue with the spreadsheet analogy, it's like a spreadsheet model with formulas and macros that link the various cells.) Thus the fundamental idea is not a repository (although ParaSET could work with one), but a tool in front of a repository or a less structured set of code and text files; it supports the standard UNIX source code control systems. It sits around or in front of the data, just as a spreadsheet can sit in front of a database; it lets the user fool around with possible changes and watch their impact on other elements, and then commit the new data if he's satisfied. However, unlike in a spreadsheet, some of the dependencies cannot be represented in explicit formulas for automatic execution; at that point ParaSET flags them and says in effect, "You changed this element in the code; you should change the corresponding element in the documentation, as shown here" -- and leaves the actual change up to the user.

³ To get slightly technical, a different representation -- specs to design, design to code -- is actually a mapping from one form to another. The mapping can be quite creative, but there is some sort of correspondence from the components of A to those of B. The components can be considered the parameters of the mapping function F -- hence "parametric software development." Some of these mappings can easily be represented explicitly and created automatically; others must be generated by hand. And there are tools, of course, that can do some of the job, such as highlighting all numbers, identifying the titles and subheadings and screen texts in documentation, and the functions, subroutines and other elements of code.

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level view of the relationships among its entities (including associated
text files). In a way, it is a directory or catalogue for the .pset (for
ParaSET) files, which are associated with the individual modules of the ap-
plication or subsystem -- text files, diagrams, designs and source code.
The .pset files contain detailed information about the entities within each
file and their links and mappings to other entities. These files are gener-
ally shared; developers check them out and lock them along with the content
they relate to.

How it works

How are these generated? The way it works is in fact not magical. In es-
sence, ParaSET (in its four modules) can do some of the linking and mapping
automatically, and some it leaves to the user. For machine-readable source
code, ParaSET can derive and instantiate the links itself. Relationships
defined in the code -- variables, where items are used, classes and data
structures and their components, functions and their invocations -- are un-
derstood by the Para/Designer and Para/Programmer modules as they parse the
code to create the ParaSET model (either new code or some old code being
prepared for reverse engineering or maintenance). The tools examine the
code exhaustively, using the same techniques as a compiler, but the result
is the parametric model rather than executable code. Moreover, notes Geis-
berg, it does its job across files, not just within each file.

Traditional CASE helps you build software; ParaSET also helps
you change it -- a much more frequent activity.

Programmer hygiene

For the rest, it allows/requires the designer to define the elements of the
program, design, spec or documentation and link them to the appropriate
other elements. (In theory, ParaSET could incorporate a parser for a design
language, but for now it works only with programming languages C and C++.)

Although there's no methodology, the system does require this small amount
of adherence to programming hygiene. This happens as painlessly as pos-
sible: While the user is looking at part of the documentation and writing a
design to implement it, he can link the appropriate elements with a few
strokes of the mouse. Both parts are on the screen; he doesn't need to type
stuff in or search for things. This approach reminds us of a wonderful UPS
ad (from the days before it got its logistics in order and was selling more
on price): "You want it there tomorrow? Send it yesterday [-- and use
UPS's cheap two-day service]!" As the developer develops, he can put in
some of the relationships by hand. Self-styled true artists may consider
this extra work, but it serves to make their meaning clear and may actually
help impose a little discipline, since the user must explicitly answer the
implicit question: "See this item in the spec? Please indicate where it is
handled in the design." This saves the trouble of making sure that all of
the spec has been addressed.

Basically, if the user takes a small amount of trouble at the start, when
he's generating the content, all its fine-grained modules will be properly
linked and easy to find thereafter. As a simple example, a spec might say:

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"Allow 30 seconds before flashing the user to ask if he needs more time." If you change that to 40 seconds in any one place, that same figure will change wherever else it appears: in the design, in the implementing code, in the documentation.

Across is a typical ParaSET display: documentation (top left), entity-relationship diagram (top right), code (lower left), and call tree (lower right). Linked items are highlighted in the same color; in this monochrome illustration, we show the links as lines. Those between the code and the two design diagrams were created automatically. A user can create links between an element in the documentation and any other item by selecting both items and then selecting "Hard [or soft] associate" from a pull-down menu (not shown because Motif can't print out in that mode!).

But that's a simple change with no (few?) side-effects, and a simple integer-to-integer mapping with no transformations. Imagine a more complex change: A developer adds a new field to a database to record the color of an item, so the related query function (a soft association) needs an argument specifying the color to search for. When the developer adds the extra argument, ParaSET produces a list of all the calls to the query function that need to be updated (a hard association). At the user's option, it can also automatically add a default (such as "select all") or allow each query to be specified individually.

Two other modules, Para/Interpreter and Para/Analyzer, are debugging tools and browsers and analyzers, showing the user the links and identifying the groupings of software for structuring it into appropriate subsystems.

A para reasons to use it

The real value, of course, is not in the small proportion of effort that is involved in building the system (although it may foster more attention to related documentation in the first place), but in the long time thereafter that is involved in maintaining and improving it. Moreover, as Geisberg points out, "Normally people hate to spend time on the documentation because they know it will just get obsolete in a few months. Either it won't matter or it will have to be redone, so they don't care."

But ParaSET makes it easier for them to do the right thing, says beta user Chuck Kolbenson of Summa Four, which sells a complex 115,000-line-of-source program to manage telecommunications switches -- and upgrades and customizes
it continually, of course. "We liked ParaSET," he says, "because we could pick it up in midstream; it didn't impose a methodology and make us start over. There were no training or adoption costs. We saw a benefit rather quickly." A lot of errors are side-effect related, and ParaSET makes the developers aware of the cross-references, even when they have to make the changes manually.

Moreover, by presenting cross-referenced items on the screen automatically, ParaSET overcomes programmers' disinclination to do anything but code. Says Kolbenson: "We want engineers to understand that documentation is part of the product. We do design and specs and documentation, but the engineers don't specifically have time allocated to update them. If it's up there on the screen and actively linked, it makes it easier and part of the job."

Another magic ingredient: SGML

Interestingly, ParaSET may be the forerunner of a much broader field of such systems. In essence, it is a smart hypertext system, with the intelligence to derive some links and the discrimination to manage typed links in specified ways (i.e., it can understand how to represent the specific linkages of an entity-relationship diagram).

It is the first glimmer of an answer to the promise of a global representation of information within a corporation (or across corporations, for that matter). As noted in many previous issues of Release 1.0, we'd like to see a system that linked requirements, specs, design, implementations for various platforms, documentation, performance support, marketing literature, bug reports, Juan's version and Alice's version, and perhaps discussions about relevant policies, pricing, etc. The best approach to identifying all this information so that it can be described and uniquely identified is probably SGML DTDs (or document type definitions; see Release 1.0, 4-91). The actual items would be stored in a database, to be assembled into documents according to the rules of a DTD. A DTD could be a template (but a complex one) for documentation, or, in extremis, you could say that a compiler was a sort of DTD (although only an academic would go so far). Call ParaSET a special, rich case of a DTD with software engineering tools attached.

Separately, but integrated, one could also move beyond ParaSET's ability to parse code with tools to parse the documentation and other texts. The tool might be a specialized version of, say, Oracle's Context Engine (see Release 1.0, 2-93). It could derive much of the necessary information from the text in order to support automatic linking of related text and image files.

Documentation (market facts)

The basic version of ParaSET costs $7500; with options, the typical price comes to about $10,000 per user -- well under the $25,000 Geisberg says he would have paid to have such a tool at ComputerVision. It works on Sun now (in beta), with versions for HP/Apollo and DEC workstations in the works. The company also promises other languages beyond C and C++. Production copies should be available in June.
RESOURCES & PHONE NUMBERS

Robert Cross, Aeronomics, (404) 763-5454; fax, 763-5440
Tom Cook, American Airlines Decision Technologies, (817) 967-1468; fax, 963-2719
Peggy Hunt, Cardiac Pacemaker (Eli Lilly), (612) 638-4560
Jim Lock, Caterpillar, (815) 729-5607; fax, (815) 729-6352
Earl Mott, Black & Decker, (410) 716-3184; fax, (410) 716-3053
Mike Brook, ComputerVision, (617) 275-1800 x2530
Chris Gopal, Dean Kline, Dell Computer, (512) 728-8830; fax, 339-5365
Sanjiv Sidhu, Intellection, (214) 620-2100; fax, 484-8110
Dave Fischer, Logan Aluminum, (502) 755-6144
Sam Fuchs, SH&E, (617) 894-6214; fax, (617) 894-4135
Chuck Kolbenson, Summa Four, (603) 625-4050; fax, (603) 668-4491
Vladimir Geisberg, Michael Miller, Software Emancipation Technology, (617) 466-8600; fax, (617) 466-9845
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**May 28**  
The Copyright Office comes to Silicon Valley - Stanford.  
Sponsored by Apple Computer, Sun Microsystems and several law firms. Speakers include Paul Goldstein, Stanford Law School and leading officials from the Copyright Office. Call Elizabeth Moody, (415) 723-5905.

**June 6-9**  

**June 6-9**  
Perspective '93 - San Francisco. Sponsored by InfoWorld. With Stewart Alsop, for corporate users and purchasers. Call Jackie Rawlings, (508) 443-3330; fax, (508) 443-4715.

**June 6-9**  

**June 7-10**  

**June 14-16**  

**June 14-17**  
@Electronic Messaging '93 - Atlanta. Sponsored by The Electronic Mail Association. Call William Moroney, (703) 875-8620; fax, (703) 522-0241.

**June 14-17**  

**June 15-17**  

**June 16-18**  

**June 17-18**  

**June 18-21**  
InterAct 93: Solving the interactive services mystery - Toronto. Sponsored by the Interactive Services Association. Keynotes by Dr. Richard Green, Cablelabs; Richard Tompane, 3DO. Speakers from America Online, Checkfree, Ogilvy & Mather Direct, Reality Technologies, ZiffNet and others. Call Robert Smith, (301) 495-4955; fax, (301) 495-4959.
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<td>August 9-13</td>
<td>*Groupware '93 - San Jose. Sponsored by The Conference Group.</td>
<td>See groupware in action -- or at least in demo. Contact: David Coleman, (415) 282-9151; fax, (415) 550-8556 or Jim Burks, (602) 661-1260; fax, (602) 661-0449. Followed by...</td>
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<td>August 12-13</td>
<td>*Workflow conference on business process technology - San Jose. Study the tools... Sponsored by The Conference Group.</td>
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<td>August 14-19</td>
<td>International open systems symposium - Santa Cruz. Sponsor: Santa Cruz Operation.</td>
<td>Call Tony Bhanot, (415) 966-8440; fax, (415) 966-8934; Alicea Kernaghan, 44 (923) 816-344; fax, 44 (923) 223-155.</td>
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<td>Aug 29-Sept 3</td>
<td>International joint conference on artificial intelligence - Chambery, France. Sponsor: French Association for Artificial Intelligence and a host of others. Contact: Catherine Vidonne, 33 (79) 356-622; fax, 33 (79) 613-792; e-mail, <a href="mailto:vidonne@imag.fr">vidonne@imag.fr</a>.</td>
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<th>Date</th>
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<td>September 15-17</td>
<td>Windows Solutions - Santa Clara. Sponsor: Seybold Seminars. Call Beth Sadler or Kevin Howard, (800) 777-6650 or (310) 457-5850; fax, (310) 457-8599.</td>
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<td>September 21-23</td>
<td>*UNIX EXPO - New York City. Sponsored by Bruno Blenheim. Call Annie Scully, (201) 346-1400 or (800) 829-3976; fax, (201) 346-1532.</td>
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<td>September 25-29</td>
<td>Visualization '93 - San Jose. Sponsored by IEEE. Call Bernadette Minton, (510) 422-1657.</td>
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<td>October 5-7</td>
<td>NetWorld 93 Dallas - Dallas. Sponsored by Bruno Blenheim. Call Annie Scully, (201) 346-1400 or (800) 829-3976; fax, (201) 346-1532.</td>
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<td>October 21-23</td>
<td>Seybold San Francisco - San Francisco. Sponsored by Seybold Seminars. Call Beth Sadler or Kevin Howard, (310) 457-5850; fax, (310) 457-4704.</td>
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<td>October 24-27</td>
<td>ITAA management conference - Seattle. Sponsored by Information Technology Association of America. Call Valerie Czuszak, (703) 284-5350; fax, (703) 525-2279.</td>
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November 2-4  EuroComNet 93 - Amsterdam, The Netherlands. Co-sponsored by IDG World Expo and RAI Amsterdam. Call Lisa Judd, (508) 879-6700; fax, (508) 872-8237; Rob den Hertog, 31 (20) 549-1212; fax, 31 (20) 646-4469.

November 7-10  *GeoCon/93 - Cambridge. Sponsored by Soft-Letter. For foreign software vendors hoping to find a US market. Call Tom Stitt, (617) 924-3944; fax, (617) 924-7288.


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Please let us know about events we should include. -- Denise DuBois

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