5. Services

Group Leader: Colin Crook

Rapporteur: C. Richard Neu

Information Technology and the Character of Business

The group began its discussions by noting that the character of business activity is changing in important ways. These changes are facilitated and, arguably, in some cases caused by, developments in information technology (IT). To date, these changes are most visible in the United States, but they are occurring throughout the industrialized world.

Perhaps the most striking of these changes is the shift in business emphasis away from products to services. Increasingly, businesses see specific products as elements or components of a broader service that the firm provides to customers. Firms work with customers to identify a need, design strategies to meet the need, deliver necessary products, instruct customers in the proper use of products, provide maintenance and oversight of the products, help customers to recognize the need for follow-on products, and so on. In some cases, the product is in fact never delivered to the customer; the firm simply operates the product on behalf of the customer. One member described the recent history of a major producer of scientific test equipment: Once, this firm simply manufactured test equipment that it sold to customers. Customers began to ask for advice on the most appropriate equipment. After a while, customers stopped purchasing equipment, preferring to lease it instead and relying on the provider to notify them when new and improved models became available. Eventually, customers stopped even leasing equipment. Now, they prefer simply to buy test services from the manufacturer. This pattern, several members of the group noted, is being repeated in many industries.

IT is central to this new business model for a number of reasons. This new model for doing business requires much more interaction between producers and customers than did traditional business models. IT facilitates this interaction. IT also allows services to be highly tailored to the needs of specific customers.

Finally, as services rather than products come to dominate economic activities, delivery mechanisms change, and IT becomes the dominant distribution modality. A firm that once relied on a fleet of trucks to deliver test equipment now uses high-speed data links to deliver test results.

Economies of scale and the advantages that accrue to first-movers are likely to become more pronounced in the emerging economy of IT-intermediated services. Standardized procedures and protocols for moving and using information facilitate interactions with customers, suppliers, and partners. Firms that set standards later adopted by others and firms that are able to exploit large volumes of information about potential customers and partners will thrive and become even more dominant. Consequently, firms that once hid technical details are now making these details publicly available in order to encourage others to adopt their standards. Although dominance by a single firm may be characteristic of the new service economy, this dominance may be less enduring than in the old product-oriented economy. IT technology and its applications are changing rapidly. A single firm may be dominant for the entire life of an industry, but whole industries may be ephemeral. Some members of the group opined, for example, that the U.S. Department of Justice is too late in seeking to break up Microsoft. The industry that Microsoft dominates is likely to be gone or drastically altered in the next few years.

IT is also changing the structure of firms. In an era when information was scarce and moving information was difficult and costly, large, hierarchically organized, multi-functional firms allowed efficient information utilization and management. Information was collected in and passed upward through a single centralized reporting chain. At each level, managers scrutinized and combined the sparse information available and sent necessary instructions back down to subordinates, who typically knew and needed to know little of what was happening in other parts of the organization. Mid-level managers would suppress some information and pass what remained on to higher levels. Effective information management structures were rare. Whenever such a structure was created, there were strong incentives to use it for multiple purposes. The result were large corporations that attempted (and often succeeded) in managing very different lines of business.

As information becomes plentiful and moving it becomes easy, the rationale for these organizational structures is eroded. Now, the flow of information is too large for managers to digest. The task of coordinating activities among different units of a large organization is delegated to the units themselves, and units are expected to communicate with each other to understand what each needs and what each can offer. In some cases, it becomes apparent that there is

no longer any reason for units performing very different functions to be part of the same organization. If they are successfully exchanging information and coordinating their activities without the intervention of some common manager, they have become effectively independent. When the availability and management of information is no longer a binding constraint, the incentive to use a single information management chain to accomplish many different functions is reduced. Thus, the rationale for placing a single effective information management system at the center of a large, multifaceted enterprise goes away. Increasingly, the key to business success seems to creating valuable partnerships rather than integrating diverse activities into a single company. By facilitating the flow of information, IT clears the way for a richer variety of management structures.

What we see in the emerging service-oriented and IT-intermediated economy, then, are simultaneous incentives for both consolidation and divestiture. To capture economies of scale, firms in roughly the same lines of business will benefit if they can combine and increase the scale of their operations. But because it is now easier to partner with or otherwise to obtain non-core functions from other enterprises, firms are spinning off functions peripheral to their core competencies.

Some members of the group saw parallels between the IT industry today and the early years of the auto industry. In their early stages, both industries were marked by many firms trying to produce final products from start to finish. In time, though, a small number of large integrators or final assemblers emerge, which buy component parts and support services from a huge number of much smaller specialty firms. In the auto industry, the specialty firms provide windshields, design services, safety engineering, and marketing, among many other things. In the IT sector, specialty firms will provide customer service, billing, payments processing, information about customers, subsidiary software, Internet access, Web hosting and so on.

The new business plans facilitated by IT developments will pose some difficult choices for those who adopt them. Close interactions between customers and suppliers will allow the production of highly tailored products and services. Sharing of information about requirements, capabilities, and processes will make it easier to establish successful business relationships. But none of this can be accomplished without a loss of privacy: characteristics of buyers, sellers, and business partners that were once closely held will have to be shared. It may turn out that choice, efficiency, and convenience will be available only to those who are willing to forego privacy and vice versa. How the information revolution affects business practices and societies more generally will depend

importantly on how different individuals and different cultures balance choice, convenience, and efficiency against privacy. Some members of the group saw this conflict of values as giving rise to an entire new industry of trusted intermediaries that would allow parties to share information anonymously.

A Structure for Thinking about Information Technology and Services

Early in its discussions, the group recognized that effective use of IT in delivering final services will require a host of intermediate and enabling IT services. A few key enabling services will be essential for effective delivery of many final services. Robust security for records and communications, for example, will be essential for medical, financial, governmental, and many other kinds of services. To capture this interaction between final and enabling services, the group decided to structure its discussions in the form of a matrix in which the columns represent examples of potentially important final services and the rows some of the more important key enabling services.

Time limitations forced the group to concentrate on a small number of each type of service. The final services that the group discussed were health care, education, entertainment, and supply-chain management. The enabling services discussed were security, payment, validation, and "dynamic brokering." The group sought to understand how each of the final services would make use of the enabling services. Thus, matrix in Fig. 5.1 represents the space for group discussions.

	Health Care	Education	Entertainment	Supply-Chain Management
Security				
Validation				
Payment				
"Dynamic Brokerage"				

Figure 5.1 – A Framework for Information Technology and Services

The remainder of this section summarizes group discussions first regarding the enabling and then the final services.

Enabling Services

Security

There was strong consensus within the group that security would be a paramount concern for almost all IT-intermediated services. As more and more parties share increasing volumes of information, the responsibility of each party to protect information grows. (One member of the group noted that his firm has and protects proprietary information from more than 7,000 partners.) IT enormously expands choices of suppliers and partners. Any firm that fails to provide adequate security will find its customers and partners going elsewhere.

As services become more seamless, so must security. Security cannot, the group agreed, be added as an afterthought. True security for IT-intermediated business must be end-to-end and built into business process from the beginning. As security becomes more complex and demanding, many firms will prefer to buy security solutions from specialist firms rather than to develop and to maintain their own security procedures.

As the demands for security grow, so will challenges to security. Because the emerging service economy will have a strongly winner-take-all character, disruption of the operations of the current front runner may appear to be an increasingly attractive strategy for displacing or punishing a dominant player. Further, since the benefits of the new service economy are likely to be unevenly distributed, some nations or groups may perceive that they have little to lose if the information economy is disrupted. Finally, as firms become repositories of increasing amounts of private or proprietary data, vulnerability to corrupt or disgruntled employees will rise.

There was general agreement within the group that working at the frontiers of IT and IT applications requires simultaneously working at the frontiers of IT security. Some in the group severely criticized current U.S. government policies restricting export of encryption technology as hindering overall progress toward a truly secure IT environment. If strong encryption and authentication procedures had been widely in place, one member archly observed, the “Love Bug” virus that caused so much trouble in the weeks just before this conference

would never have spread. Certainly, strong encryption will pose challenges for intelligence services and law enforcement. But we simply have to learn to deal with strong encryption. To live without secure IT will be much worse. Without very good cybersecurity, some members predicted, the next few years will almost certainly see some sort of serious "train-wreck"--a large-scale compromise of sensitive personal or business information--that could sour an entire generation on IT-intermediated services.

Payment

One of the key advantages of new information technologies is that they can make information and services widely available at very low costs. Unfortunately, there is today no fully satisfactory way to manage the large volume of small payments (so-called micropayments) that will potentially be generated by on-line services. Subscription services are impractical for occasional users. The costs of processing a credit card payment are prohibitive for small transactions. The group noted its expectation that firms offering cost-effective micropayment services are likely to appear in the next few years.

Validation

IT developments are bringing an enormous expansion in the number of channels through which information can flow. In general, the group viewed this as salutary. Advantages that accrued to narrow groups by virtue of their control over information are being eroded, and the benefits of access to information are becoming more widespread.

The group recognized, though, a danger in the proliferation of information channels: Some (much?) of the information that moves through these new channels may be wrong, misleading, dangerous, or otherwise "invalid." As control over information diminishes, traditional mechanisms for screening, checking, or editing information are weakened. Users of information will encounter increasing difficulty knowing what purported information is to be trusted.

For some applications--health care and education come immediately to mind--the quality, authenticity, and integrity of alleged information will be of enormous importance. The group noted that new approaches to certifying the quality of information will have to be found. In some cases, information might be effectively "branded;" if you find information on a trusted web-site, you will have confidence that it is reliable. But more elaborate mechanisms may be

required: watchdog groups; voluntary associations of information providers in certain fields; certifying bodies; etc. Few such mechanisms have evolved so far, but the group saw them as necessary and inevitable.

"Dynamic Brokerage" Services

Several members of the group offered the view that the huge variety of IT-intermediated services that will soon be available and the need to customize these services and combine them with other services will give rise to an entirely new kind of enabling service, which they termed "dynamic brokering." Group members envisioned a decentralized capability for matching highly specific requests from customers for packages of services with suitable offers of these services from a wide range of suppliers. No single supplier would necessarily be able to provide all of the services requested by a customer. The power of the dynamic brokering capability would lie in the ease with which a customer could identify and then combine services from many providers to create the specific package he or she requires. Sufficient standardization of interfaces would eliminate the need for the providers of the various component services that make up an entire package to collaborate directly or even to be aware of each other's identities. This brokerage capability would be dynamic in the sense that customers would use it to find necessary services when and as they need them and to find different suppliers to meet different requirements from one day to the next. The system would be decentralized in that there would not have to be any central repository of information. Requests would be routed to possible suppliers in a way analogous to the way that e-mail messages move today.

The key to creating this sort of a brokering system lies in the creation of a standard vocabulary for articulating requests for services. Members of the group noted that several attempts to create such vocabularies are already underway, and that the coding necessary to implement a good brokering system is probably not particularly challenging. One member estimated that a good dynamic broker would require on the order of 100,000 lines of code. Predictions were that this kind of a capability will be feasible in about five years and that the changing character of the services market will make demand for such a service very strong.

Some members argued that the arrival of this kind of service will dramatically change the character of IT industries. By working through this new "distribution layer," users will be able to access the IT services without actually having to perform IT functions locally. The market for "shrink-

wrapped" software distributed on disks will largely disappear. Indeed, the market for "owned" software--however distributed--will probably shrink. Because users will buy IT services rather than IT itself, we will see a proliferation of specialized terminals and access devices that incorporate simple, generic approaches to accessing available services. Demand for powerful multi-purpose computers and for the complex operating systems that control such devices will decrease markedly. (Some members noted that the large installed base of such hardware and software may stand in the way of the new distributed information and services structure--but only temporarily.) One member predicted that the arrival of this kind of brokering capability would lead to broad reinvention of the whole field of computer science, in the course of which we would re-discover the virtues of simple, elegant, older systems.

In a particularly apt metaphor, this new distributed information structure was characterized as an "information plug" similar to the ubiquitous electric outlet. You can plug any kind of an appliance into an electric outlet, because you understand what will come out of it. A standard vocabulary for requesting and receiving information will allow equally flexible use of this new information outlet. Perhaps most important, this new distribution apparatus will NOT divide the world into haves and have-nots. Because this new information structure will enable many new kinds of devices and access modes, all people will stand to benefit.

Final Services

Health Care

The group noted strong pressure within the health services sector to provide more and better care without spending additional resources. This pressure, they felt, would provide a strong motivation to find ways to provide health care and related services remotely. Developments in information and communications technology, they argued, would make remote care a reality within a few years. In industrialized countries, the necessary communications infrastructure will be available. So will a wide array of sensors that will allow remote monitoring of vital signs and health status. Electronic medical records, easily transferable and containing detailed images, will soon be commonplace. The group expected that within the next fifteen years, a significant fraction of all diagnoses will be made remotely. The physician and the patient need not be in the same location.

The arrival of true telemedicine (as IT-mediated health care has come to be called) will likely bring profound changes in the organization of health care. Both patients and health-care professionals will have access to experts, wherever these experts happen to be located. This will probably reinforce the economies of scale that are already emerging in medical care, which give a decided advantage to specialists who treat large numbers of particular kinds of patients and develop special expertise. Nonetheless, telemedicine will probably also give rise to a variety of subcontractors who will provide necessary in-person care and who will help direct patients to specialists. Information about health and health care will be more accessible, and patients will be much better informed than in the past. Access to second opinions and alternative views on proper treatments will become routine. Patients will also have access to information about the effectiveness of various treatments and the success rates of various practitioners. Because access to multiple health-care providers will be made easier, local monopolies will be eroded, and the health-care sector will see increasing competition.

Telemedicine will, of course, require a very high level of information and communications security. Indeed, the health-care sector is already one of the main drivers of advances in information and communications security.

Telemedicine will also require a very high level of validation services. There will be very strong demand for mechanisms that will ensure that information and diagnoses provided on-line are in fact correct. This demand will be so strong, the group believed, that mechanisms will undoubtedly be developed to meet it. Little progress has been made in this direction to date, though, and precisely what these mechanisms will be, is hard to predict. Almost certainly, geographically based licensing of health-care providers (e.g. state medical licenses) will be inadequate, since the whole point of telemedicine will be to erase geographical boundaries. Local regulators, the group predicted, will try to slow the advance of telemedicine, but these regulators are bound to fail. The attractions of remote health care will simply be too great. A more likely solution will be some form of "branding." Remote providers will organize themselves under the supervision of a few prominent institutions, which will vouch for the quality of care provided under their "marque." Prestigious clinic and medical centers already provide assurances regarding the quality of care provided by their associated physicians. Extending such assurances to cover care providers reached through communications channels established by the clinic or medical center does not appear to be a dramatic departure from current practice.

The opportunity to access information and actual care from a vastly expanded set of providers will confront both patients and health-care professionals with a bewildering array of choices. In these circumstances, an efficient means of finding the appropriate provider will be essential. For this reason, telemedicine is likely to provide a strong impetus to the development of dynamic brokering services.

Professional health-care services delivered electronically will probably not generate heavy demands for payment services. Unfortunately perhaps, health-care services are typically sufficiently expensive that traditional payments methods (such as credit cards) will probably suffice. Occasional access to medical information, however, may require micropayments. Given the apparent appetite of consumers in industrialized countries for health-related information, health information could become one of the earlier applications of micropayment technologies.

The development of telemedicine will probably widen the gap between rich societies and poor societies. Effective telemedicine will require enormous bandwidth, and only countries that can create the necessary infrastructure will be able to exploit the full benefits of telemedicine. Even so, some benefits may accrue to poorer countries. Medical students and practitioners in these countries may gain improved access to information and training, for example. One member of the group also noted efforts now underway within the U.S. military to develop a "smart stretcher" that will transmit detailed information about a wounded soldier to physicians at a central location who can then instruct a medical corpsman to take particular actions. Technology of this sort might eventually prove highly valuable in countries that are short of trained medical personnel.

The group believed that advances such as those outlined here are close to inevitable. They may be delayed, however, by regulatory rigidities and by the generally conservative attitudes of health-care professionals. One member suggested, however, that these attitudes might be changing. With telemedicine a realistic possibility, he noted, entrepreneurs and innovators may once again find the medical field appealing.

Education

The group expected that new information and communications technologies will bring important changes in education and training in the next fifteen years. In particular, these technologies will give a strong impetus to “distance learning,” allowing students remote access to teachers and educational materials.

The group noted that educational applications of IT will probably require less security than health-care applications and less sophisticated payment arrangements than entertainment. Consequently, educational applications should be able to "piggy-back" on enabling services in these two areas that are developed for other purposes. In contrast, validation--guaranteeing the quality, correctness, and effectiveness of education services--will in some applications be very challenging. Similarly, the brokering function that matches students with educational resources will have to be quite sophisticated.

The group also noted that, like medical applications of IT, political structures, regulators, and the conservative attitudes of many educators will resist educational applications.

The group recognized that IT will be differentially effective at different levels of education and will be adopted more easily at some levels than at others.[9]

- Perhaps the earliest and most dramatic educational applications of IT will be in the areas of **lifetime learning and specialized training.** These areas are burdened with few regulatory constraints, and there is already keen competition among providers of such educational services. An ability to provide instruction tailored to individual students' needs, remotely, and at a time that is convenient for the students will be a strong competitive advantage. Consequently, the group expected considerable effort and resources to be devoted to developing innovative distance learning techniques and the facilities necessary to exploit them. Validation is relatively simple in these settings. Students will generally be well placed to assess whether the training they are receiving meets their needs.

- IT will also bring important changes to **post-graduate education**, where it will allow students to "customize" their degree programs, enjoying lectures from and consultations with professors at multiple universities. The reputation of professors will be the principal guarantee of quality, and so complex validating systems will probably not be required.

- Opportunities will be more constrained at the **university undergraduate level**, where social aspects of education are more important and where faculty committees and conservative establishments may hold greater sway. Nonetheless, there is already strong competition among universities for the best students, and universities will be under considerable pressure to

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[9] These views are based on a U.S. perspective. The situation may well differ in other nations.

develop innovative teaching techniques and highly tailored instructional programs that will make extensive use of emerging IT capabilities.

- It is at the **K-12** level, where IT applications will prove most problematic. Inertia, entrenched unions, unfamiliarity with and inability to use new technologies, the costs of acquiring equipment and building infrastructure, and (for public schools) political interference will all constitute serious barriers to adoption of new IT-based teaching techniques. Validation of techniques and information provided on-line will also be problematic. In many cases, parents and administrators will be unable to judge the quality of IT-intermediated services, and they will consequently be reluctant to adopt new approaches. Some members of the group predicted increased use of IT to facilitate standardized testing, a prospect that most in the group found unattractive.

Full exploitation of IT-intermediated educational services will require considerable investment in equipment, facilities, and infrastructure. It will also require the services of highly skilled, dedicated, and much-in-demand educators who can develop effective new teaching methods to be used in conjunction with new media. Consequently, the group predicted advances in educational use of IT are likely to prove divisive along lines of income and wealth: Individuals, communities, and societies with the resources to take advantage of new opportunities will flourish and further increase their advantages over those who are not so fortunate. The group also noted that expanded use of IT for education will tend to make education less specific to particular societies or cultures. It will become harder to use education to shape a particular national or group identity.

Finally, the group noted that many techniques for educational uses of IT will likely be derived from the entertainment industry. Because the entertainment industry is largely unregulated, faces few resource constraints, and enjoys an innovative culture, we might expect many more new ideas and techniques to spring up in the entertainment context than in the educational context. For better or for worse, many of these techniques will be transferred to educational applications.

Entertainment

There was general agreement within the group that entertainment applications would the most powerful drivers of IT developments in the next fifteen years. Entertainment will create the demand for high-band-width infrastructures, for new terminals and access devices, and for new software. New information

"pipes" will be filled primarily with entertainment, and, as one group member put it, "all the other good stuff will come through the cracks in entertainment."

Members of the group predicted a variety of entertainment-related applications that may have the capacity to change the way people interact and perceive the world around them:

- Multi-person, computer-based games are just beginning to emerge. These games will create new spaces and new modalities for human interaction, with consequences that are difficult to forecast.

- Within the next fifteen years, group members predicted, web-mediated physical activity would be commonplace. With the aid of new sensors and physical feedback devices, interactive games that now involve only the movement of a joystick may evolve into games that require strenuous physical responses. In the future, the notion that IT produces "couch potatoes" may seem quaint.

- Web-cams will become much more common, allowing good things (e.g., improved interpersonal interaction at a distance) and bad things (intrusive surveillance).

- Interactions with people from very different cultures will become easy and commonplace, particularly if effective translation programs are developed.

- A multitude of hobby and special interest groups will proliferate, not all of which will prove socially constructive.

- With enough computing power (surely coming) and enough digital imaging devices to record events from many angles (also coming), it will become possible for viewers to experience events (athletic or cultural events, say) from almost any imaginable vantage point. The result may be a very different way of perceiving reality (or at least reality that occurs in a suitably prepared venue).

- Video glasses that place images directly before a viewers eyes will likely be developed first for entertainment applications but will quickly spread to many other applications.

- E-books will become commonplace.

Rapid development of e-entertainment has already challenged traditional methods for maintaining control of intellectual property. Indeed, one member of the group predicted that the rise of new media will have the effect of revivifying the concept of live performances, since it will become increasingly

difficult to protect and therefore to make money on any kind of recorded performance.

Entertainment will also drive development of some key enabling services. (Some members of the group noted that modern streaming media were first developed to support on-line pornography.) The need to sell entertainment in very small packages is likely to generate the first efficient micropayment systems. Systems that allow customers to search huge numbers of entertainment sources for a particular service or experience may be the precursors of more general dynamic brokerage services. The need to protect intellectual property and expose counterfeit or bootleg entertainment may lead to the development of sophisticated validation systems that will establish the authenticity of specific entertainment products and services. A desire to enjoy entertainment services in private may prompt further development of security protections and "anonymizers."

Within the group, there was also recognition of a dark side to emerging entertainment technologies. New technologies will make it easier for those who are so inclined to consume what many would consider undesirable kinds of entertainment--child pornography, for example. The social dangers inherent in such entertainment may extend beyond its content. Because customers will be reluctant to acknowledge their access to such entertainment, users may fall victim to blackmail. Because dubious entertainment may have to hidden from information systems managers, viruses may be more easily transmitted. And dangerous, incorrect, or subversive information that is packaged with dubious entertainment will be hard to combat or to refute because it will seldom be out in the public eye.

Supply-Chain Management

The last of the final services discussed by the group was supply-chain management, and control of production processes more generally. The aim of supply-chain management systems is to extend just-in-time concepts of management as far down into the production process as possible and to reduce inventories wherever possible. In today's business climate, one member noted, "a company's assets are really liabilities."

Beyond supply-chain management are more complex information and manufacturing systems that allow highly tailored--almost personalized--production. Indeed, as production management systems evolve, the whole design process will change. Rather than designing products in the hope that

customers will like them, the emphasis will be on creating a system within which the customer can truly design his or her own product.

The group noted that some sophisticated supply-chain and production management systems are already in place. The best-known example, perhaps, is Dell Computer. Less well known but equally impressive, according to one member, are the inventory control and stocking processes employed by Walmart. Precise records are kept not only of what inventory remains and how much of what will need to be ordered, but also of what items are purchased with what other items, the better to arrange the distribution of goods around the store. This member noted that "Every Walmart store manager is a mini-CIO."

The next step, some members hypothesized, will be the creation of information systems that measure performance of an entire production, distribution, and sales process identifying opportunities to increase efficiency. Perhaps the key to such systems will be to devise ways to allow humans to visualize and to understand intuitively the workings of very complex systems.

Good supply-chain and production management systems will drastically reduce the advantages that accrue to cheap labor, possibly ending the flight of manufacturing process to the developing world. This could, of course, have profound consequences for the global distribution of income.

At the request of conference organizers, the group spent some time thinking about the consequences of such systems for agriculture (noting, however, that no one in the group was an expert on agriculture). The group saw great promise in sensing systems linked to GPS receivers that would assess the requirements of very small portions of fields for different amounts of water, fertilizer, pesticides, etc. This information could be transferred to dispensers in tractors moving across the fields and applying precisely measured inputs to exactly the spots in fields where they are needed. The result could be very substantial increases in yields, marked decreases in cost, and reduced pollution due to over-fertilization or runoff. Interestingly, the group believed that the development of such agricultural techniques would probably not widen gaps between rich and poor. They believed that the minimum efficient scale for exploiting these new production technologies could be quite small. Small farmers might therefore benefit. "All you need," one member suggested, "is a sort of expensive tractor."

Of the four final services considered, supply-chain management probably makes the least demands on the enabling services of security, payments, validation, and dynamic brokering. Perhaps this is not surprising since supply-

chain management systems are already well advanced, in the absence of most key enabling systems.

Additional Observations

Throughout its discussions, the group repeatedly returned to the notion that distinctions between different final services are eroding and will continue to erode in the future. A fundamentally new distributed information structure containing all key enabling service is evolving, the group believed, and this new information structure will be common to all final services mediated by IT. The techniques and the characteristics of different final services will become increasing intertwined, with developments in one area quickly being adopted in other areas. The global information structure will be as different twenty years from now as today's information structure is different from what prevailed twenty years ago. Forecasting trends in technology, applications, or their consequences in such a dynamic environment is probably hopeless. Taking issue with the entire premise of the conference, one member suggested that agencies and institutions charged with understanding the consequences of the information revolution should worry less about extrapolating current trends and more about building capability to monitor and to understand developments in real time.

In the course of group discussions, concerns were raised several times about the quality of training many information science professionals are receiving today. Too many students today, members of the panel complained, mistake programming for computer science. "People," they said, "are building information systems today that they don't understand."

Stepping outside its explicit charter, this group speculated about some potentially interesting new information-related artifacts:

- Household implements--dishes, clothes, etc.--may soon be available with built in identifiers that will tell household appliances--the microwave oven, the dishwasher, or the washing machine--how each item is to be treated or processed.

- The group also noted that the price of information storage is falling very rapidly. It will soon be possible, one member suggested, to equip new automobiles with "black-box" recorders that will maintain a record of every aspect of the car's life: every jolt or impact that it has received, the number of hours the engine has run at various speeds, the nature of the roads it has traveled over, servicing that was performed, all manner of

> diagnostic information, and even input from GPS receivers to record where the car has been. This information could be downloaded remotely to a mechanic who could order necessary replacement parts in advance of the car's arrival for servicing. Noting the downside of vast volumes of detailed information, other group members asked what the consequences might be if such a black box could be subpoenaed in a legal proceeding and then used to reconstruct the activities and the whereabouts of the car and its driver. How many people would want to create a record of so many of their actions?

In commenting on the report of another group, this group was dismissive of backward-looking attempts to characterize the potential market for new technologies and applications. They noted laughable underestimates of the demand for current technologies--Thomas Watson's famous projection that there might be four or five companies in the world that would find they needed a large computer or Alexander Graham Bell's suggestion that telephones might one day become so popular that there would be one in nearly every city in the United States. They noted that demand for new technologies is sometimes more discontinuous and harder to predict than the technologies themselves.