

INFORMATION—COMMUNICATION TECHNOLOGIES OPEN UP INNOVATION

ICTs are transforming open innovation and providing a competitive edge to the organizations that select and deploy them carefully.

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OVERVIEW: *Information—Communication Technologies (ICTs) are no longer just for internal use. Rather, in the era of open and distributed innovation, they must be leveraged by businesses and organizations to reach, record and review ideas from internal and external sources ranging from vendors, suppliers and customers to employees. ICTs enable the entire innovation process, from idea generation and development to experimenting and testing, and, finally, to commercialization of ideas.*

KEY CONCEPTS: *innovation, information technology, communications.*

The aim of this paper is to describe how sophisticated information and communications technologies (ICTs) are being used to support distributed and open innovation. ICTs have helped organizations automate their work processes, bridge issues of space and time, and re-define collaborative efforts. ICTs have had a significant impact on innovation processes, providing organizations with new opportunities to undertake innovative projects, collaborate with other entities, test new ideas, share concepts and knowledge, and even bring innovations into the marketplace.

We begin by exploring the contribution of ICTs to the stage of idea generation and development, followed by the design, testing, and refinement of ideas into products and services, and finally to the commercialization stage (see Table 1).

Understanding Idea Sources

The first role of ICTs is to help organizations *understand the sources* of ideas. For example, organizations can use ICT tools to learn how their customers use their products and services by collecting demographic, usage and similar data. Customer databases can be “mined” to identify customers to target.

Knowledge about the customer is obtained primarily through information processing activities. Abundant

information can be collected from multiple sources like financial institutions, credit reporting agencies, and local stores. Online companies like Yahoo record every click made by visitors to their websites, collecting billions of bytes of data daily. Information collection and identification devices like store cards and radio-frequency identification (RFID) devices enable organizations to collect accurate information on the purchasing behavior of customers.

On the B-to-C (business-to-customer) side, customers can find their queries answered and problems resolved online through chat-rooms, e-mails, and structured reasoning systems. For instance, most computer manufacturers have interactive web-based programs that allow their customers to find answers and debug problems with their products. By using ICTs to support customers, organizations can understand their issues and develop ideas into future innovations.

This web-based approach is a natural outcome of many firms’ strategic understanding that accurate capturing of customer opinions gives them a valuable competitive edge. Dell’s “virtuous” cycle approach is a good example. Through its web-based information systems service, Dell allows customers to have control over their computer orders, while it captures high-quality knowledge of customers’ behavior. This knowledge made Dell’s market forecasting ability superior to its competitors (1).

Application of sophisticated ICTs for customer relationship management (CRM) is equally visible in service industries. KLM, for example, successfully fine-tuned its CRM system to identify and recognize its airline customers at any point of their interaction with KLM (2). Customer data-gathering capability was greatly enhanced so that customer data was much better understood and segmented. In addition, the CRM became tightly coupled with KLM’s sales and marketing strategy.

This trend will continue. Although few volume retailers besides Amazon.com have actively mined customer feedback, the success of volunteer-based user network sites such as Wikipedia and MySpace indicates trends. New tech startups are emerging to invest in data mining technology for understanding customer opinion (3).

Documenting Ideas and Sources

The second role of ICTs is to help capture ideas from the sources—the *documentation* role. Thus, Whirlpool created an electronic space on its intranet where employees can share their insights with other employees (4). “Innovation E-Space” enables individuals to access both electronic and human resources. The website links to electronic libraries and connects employees with in-house innovation consultants, named “I-Mentors.” Individuals can access human innovation experts via networks that are unrestricted by formal hierarchical

structures. An “I-Pipe” tool tracks how ideas evolve from inception to implementation.

The success of I-Mentors and I-Pipe demonstrates that knowledge-capturing systems can be most effective when they take a human-centered view of knowledge. Social enabling tools allow people to form mentoring relationships and create special interest groups. ICTs not only facilitate communication between individuals, but also strengthen organizational structure (e.g., reward systems) (5).

This human-centered approach also highlights the need to understand the complex nature of innovation work, as well as its organization. The U.S. Army, for instance, has a long-standing practice of recording mission-based experience and accumulating its lessons in after-action reports. Since 9/11, the U.S. Army has recognized an additional need to share the tacit knowledge possessed by its personnel and facilitate knowledge sharing with

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Table 1.—Role of ICTs in Distributed Open Innovation

Innovation Stages	Idea Generation and Development	Design, Testing and Refinement	Commercialization
Nature of innovation	Organic, flexible, inclusive.	Innovations closely related to business practice.	Distributed, open to the customers, more inclusive.
ICT used (company)	Data collection—website (Yahoo) Data collection—RFID Customer feedback data-mining (Amazon) Data mining (MySpace) Use-driven content/management (MySpace + Wikipedia) Interactive Website data collection—CRM (Dell) CRM (KLM) I-Mentors I-Pipe Knowledge Capturing System—After-action reports (U.S.Army) Innovation E-Space (Whirlpool) Internet-based tools (Bush Boake Allen from Nestle) Insight (FedEx) IdeaCentral (Cargill) Democratic evaluation of ideas (MicroArts) Knowledge Portal (Netherlands) Network-based collaboration practice (Lego, BMW)	Product Life Cycle Management System: supplier-customer cooperation (ZF Friedrichshafen) Flex—Modularization of business activities (Cisco) DSS—Dynamic synchronization system (Cemex) Simulation (BMW) Simulation—VirTra (U.S. Army) Virtual Studio Collaboration (Dreamworks, Hewlett-Packard, PepsiCo, AMD, Procter and Gamble, Novartis)	Wiki (Nokia, MicroStrategy, Angle.com) OnStar (GM) Web-based system (Toyota)
Nature of new changes with ICTs	More flexible and effective application of ICTs is possible. Certain human functions can be enhanced (e.g., problem-identification, solution-seeking).	More powerful, faster ICTs with better user interfaces make the computerization of complex business processes possible.	Collaborative tools
Contributing roles of new ICTs	ICT as enabling agent for flexible generation of ideas Example: (automatic) data collection tools, distribution of ideas.	Innovation (ideas channeled and worked on) is now done more effectively and efficiently.	ICT applications influence changes in innovation in both organizational and technical dimensions. In other words, organizational change makes technology adoption possible; technology adoption brings further organizational changes (e.g., Toyota).

various knowledge-capturing systems. The Army’s experience has been that while the technology is now ready for capturing knowledge, most challenges arise from involving multiple parties in knowledge capturing and sharing (6). This is a typical challenge found in many innovation projects.

The challenge of understanding and capturing ideas in distributed and open innovation processes revolves around the many stakeholders and their needs. To address these issues, an increasing number of organizations deploy *user tool kits* that let customers join in innovating products and services (7,8). In general, companies

must understand user needs as accurately as possible to develop innovative and successful products. However this task is becoming more difficult as user needs change more rapidly, technology life cycle times decrease, and firms have to expand into niches—in some cases serving so-called “markets of one.”

With user tool kits for innovation, manufacturers, under certain circumstances, no longer have to try to understand their customers’ wishes in detail. Needs-related aspects of product and service development may be shifted to users, along with an appropriate tool kit possessing the following four characteristics:

The first role of ICTs is to help organizations understand the sources of ideas.

1. The kit enables users to learn during the process of designing their custom product. This is important because problem solving in product design is fundamentally based upon trial-and-error learning.
2. Tool kits have to be user-friendly, meaning that users must be able to use their existing skills with minimal additional training. Often, internal training can be more cost-effective when a corporate IT group understands and routinely interacts with its users (9).
3. Based on existing experience, a tool kit has to include libraries of useful, tested elements and modules.
4. Tool kits must contain information about the solution space within which the customer can act creatively. These limits may, for example, be determined by the production process used to manufacture the future product, thereby ensuring that a user's design will in fact be producible. In the food industry, for instance, Bush Boake

Allen, acquired in 2000 by IFF Inc., has allowed clients like Nestle to develop their own specialty flavors using an Internet-based tool. The customer can create a customized flavor by using a database of flavors, and then send the new flavor design to a machine that manufactures a sample within minutes. After tasting the flavor, the customer can make modifications and request a new sample.

FedEx also found a new way to help its customers improve their business practices, and thus to serve them better (10). Based upon its study of customers' business practices, FedEx realized customers weren't satisfied with the package tracking information on the typical web-based delivery system. A new ICT product "Insight" was designed to let customers see what would be delivered on any given day. This enabled FedEx customers to plan their daily operations with a higher degree of precision and satisfaction.

Distribution and Sharing of Ideas for Cross-Application

The third role of ICTs is to enable the *distribution* of ideas. Ideas generated at one source may be applicable elsewhere, and ideas may be complemented by feedback or input from other sources; hence, the need to gain synergies from idea combination is critical. Cargill, one of the largest companies in the food industry, has a managed box-of-ideas process supported by a web-based application. Using Imaginatik's "Idea Central," Cargill is able to easily capture ideas from employees, distribute them throughout the organization and have them evaluated by peers or formal review teams who add their view and knowledge. The company significantly increased the rate of existing product- and process-improvement after institutionalizing the process.

At MicroArts, a brand-design and marketing communications company, the innovation process is democratized and distributed with the help of ICTs. Design team ideas are posted three times daily on computer monitors around the office to receive feedback from all employees

How the Study Was Conducted

We first collected data from secondary sources that described the role played by ICTs and innovation. Next, as part of an ongoing research project, we interviewed over 30 executives, representing over 20 organizations, on the usage of ICTs in their innovation processes (see Tables 2 and 3).

Table 2.—Firms by Industry

Industry	No. of Firms
Banking and financial	3
Technology and engineering	4
Consumer products	3
Advertising and media	2
Defense	2
R&D labs (government and private)	4
Management consulting	3

Table 3.—Title of Respondents

Title	No. of Interviewees
CEO	4
CIO (or vice president-level executive responsible for information systems)	6
Innovation managers	8
Director of R&D	5
Marketing (senior-most executive responsible for marketing and customer relationship management)	6
Product development (senior-most executive responsible for new product development)	3
Business unit or product line directors	3

(11). A sharing culture is promoted and creativity is encouraged—ideas are discussed and developed from the earliest stages.

Open and collaborative innovation is replacing the traditional model of vertical R&D in many companies. Lego illustrates how Web-based collaboration allows each participant to focus on core competences and implement only the best innovations in products and services. Enthusiastic users reverse-engineered Lego's Mindstorm robotic system and fed suggestions back to the company. Instead of blocking such efforts, Lego created a website incorporating users' suggestions and encouraged them to co-construct Lego products.

BMW released an online tool kit to encourage customers in peer-production community activities. As a result, 15 participants were invited to work with BMW engineers (12).

Idea Design, Testing and Refinement

More powerful and faster ICTs help organizations leverage *design, testing and refinement* capabilities across a wide assortment of sources so that ideas can be channeled and worked on effectively and efficiently. A good example is the automotive industry, where tier one suppliers cooperate closely with their customers—original equipment manufacturers (OEM).

The ZF Friedrichshafen AG (ZF), a worldwide supplier of auto driveline and chassis technology, has more than 100 locations around the world and hence depends on a smooth exchange of information throughout development and manufacturing. A product life cycle management (PLM) system permits planning, sourcing, producing, and selling on the basis of access to information on about 4 million individual objects at any time. This system, originating in a product data management system, also established interfaces to customers' systems so that ZF can provide both products and data.

In close cooperation with customers, even hosting resident engineers, ZF provides its customers with all the necessary information. Where applicable, ZF also uses some of the customers' systems mostly as front ends, with close connection to the in-house process chains and systems. The PLM system is updated regularly to ensure that the processes and systems cope with the yearly doubling of the quantity of data exchanged with customers and suppliers.

Efficient data exchange and effective idea channeling from customers can be greatly enhanced when business processes are coupled with ICT implementation. However, customer involvement takes more than a conventional hardwired coupling of the two. Cisco identified this challenge early when it established a global process network of thousands of channel partners. In order to manage this diverse and unique collection of innovation

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partners, Cisco grouped business activities into separate, independent modules with clearly defined outputs. It also standardized the description of procedures and information. Combining modularization with standardization brought a tremendous amount of flexibility and clarity to the company's innovation partners (13).

Well-adapted ICT applications enable better business practices, even in a traditional industry like cement. Cemex is a cement company that recognized challenges from its old business processes as well as the physical nature of the product it handled. Cement mixtures were hard to handle and thus unpredictable in delivery. This had always been a huge cost factor, so Cemex coupled an investment in a satellite communications system and a delivery system (Dynamic Synchronization System) with a new on-time delivery service. Cemex's customers were pleased and profit jumped dramatically (14).

ICTs can also enable experimentation, which is crucial but also costly (15). New technologies such as computer modeling and simulation can minimize that constraint. The economics of experimentation change when the impact of learning is amplified, and ICTs create the potential for better R&D performance and new ways of creating value for customers. Thomke argues that to unlock such potential, companies must not only understand the power of new technologies for experimentation, but also fundamentally change their processes, organization, and management of innovation (15).

Crash simulation and modeling at BMW (München) illustrates the benefits of using modern simulation tools. In the early 1980s, one of BMW's early simulation models, using about 3,000 finite elements, ran for nearly three months and delivered no significant improvement in design decisions. In 2002, the simulation model of the new car model X5 used roughly 700,000 finite elements, ran less than 30 hours and drove important design decisions (15).

Simulation tools also come with hearing and sensory aids. VirTra Systems, a simulation training company, introduced a simulation tool that lets trainees experience

not only the learning but also the consequences of their decisions in real field operations (16). With this added feature, experimentation through simulation can enhance individual as well as collaborative learning.

DreamWorks Animation SKG (DWA), which produces highly praised computer graphics animations, extended its innovation capabilities with virtual collaboration technologies, utility computing, and open-standards technologies (17). Computer graphics animation requires creative collaborations and tremendous computer resources. In 2001, DWA made the decision to produce two films per year. To achieve this goal, DWA needed to overcome several difficulties. Geographically distributed talents needed to collaborate intensively and couldn't do the usual person-to-person interactions. Traditional electronic communication such as email, instant messaging, conference calls, and videoconferencing were not enough to convey the non-verbal expressions that are essential in creative collaboration. DWA developed a system called Virtual Studio Collaboration (VSC), which allows people in two different studios (Redwood City and Glendale, California) to collaborate using many visual cues. Life-size screens that could display images and data in different studios simultaneously were able to capture such behavioral details as smiles, shrugs, smirks, and laughs. The success of VSC, which lets people feel as if they are working together in the same place and in real-time, spurred Hewlett-Packard to develop Halo, a commercialized version of VSC. PepsiCo, AMD, Procter and Gamble, Novartis, and HP were early Halo users (17).

Idea Commercialization

In the final stage of the innovation process, ICTs can support the transfer of products and services from within the organization to external stakeholders and customers. ICTs are also well-placed to facilitate collaboration and the exchange of ideas at the commercialization stage. For example, employees may have experiences in how successful they were in introducing ideas into their markets. These experiences need to be shared so that the same pitfalls do not take place and good practices are shared throughout the organization.

The use of collaborative technology such as Wikis is on the rise because they enable organizations to maintain a level of history and conversation around the issues that emerge throughout the innovation process. The web-based nature of Wikis is highly effective for distributed innovation. Wikis promote many-to-many knowledge creation and sharing while organizing knowledge by topic (18). All the participants can actively join the commercialization process with a stronger focus on the end product.

Thus, the openness of Wikis allows a strong, organic collaboration that rapidly moves the ideas from their

Wikis allow organizations to maintain a history and conversation around issues that emerge.

infancy to adoption and commercialization. For example, the corporate strategy department of mobile communications giant Nokia has active Wikis on both open-source and proprietary platforms. At Nokia, which has more than 100,000 employees, Wikis have proved to be an effective means of saving time and effort previously dedicated to the task of distributing and storing corporate intelligence. After successful implementation on a small scale, Nokia is funding a company-wide Wiki as well as other collaborative tools.

Angel.com is a start-up subsidiary of business intelligence firm MicroStrategy, Inc., specializing in Interactive Voice Response (IVR) software. Angel.com uses its Wiki in the expected ways—tracking internal documents and conversations, channeling information to the appropriate people, and so on. But the sales team also uses it in novel and innovative ways: lead accounts and partnerships, best-practice use of the company's software, competitive intelligence, and internal business processes are all cataloged by the Wiki, cradle to grave.

One of the primary benefits of Wikis is that turnover in user population does not affect the knowledge base—no more lost documents and files when somebody leaves. Wikis thus serve as organizational memories, fueled by employees who continuously amend existing organizational knowledge with new insights, documents, and competence mapping (who knows what type of knowledge) (19).

There is also a growing interest in the concept of “edge technologies” that help the organization connect with customers and drive innovation. For example, General Motors sends a monthly report to its customers via OnStar, which allows GM to monitor vehicle performance, status and location via sensors on the vehicles and cellular connections (20). These reports are based on the analysis of more than 1,000 trouble records.

The application of IT to customer relationship management significantly changed the way GM interacts with

customers. Traditionally, GM only interacted with customers before purchase via mass advertisement and at purchase. Now GM retains the relationship after purchase by providing information that helps customers.

OnStar has brought GM significant benefits. First, it improved GM's customer relationships, receiving 15,000 emergency service calls, 23,000 roadside-assistance, 29,000 diagnostic calls, and 380,000 requests for directions. Second, the real-time observations of vehicles in various condition provides information GM can use to improve vehicle designs. Third, it provides GM with new income sources. For example, GMAC offers different insurance services for customers based on a car's mileage. Customers driving lower-mileage vehicles can get lower premiums.

Although edge technologies promise the above benefits, there are drawbacks too. First, they may increase information overload. Organizations have more data than they can analyze; analyzing it appropriately and applying it to the right situations is important for successful implementations of edge technologies.

Amazon.com has a platform that records all transactions and product-evaluation history of active customers (20). It analyzes the data and improves customers' shopping experiences through sophisticated data mining technologies.

The Hartford Financial Service also has a platform that records all telephone calls between customers and service representatives (20). Talk time, hold time, outcomes, etc., are recorded and made available for study by service representatives and supervisors.

Toyota skillfully applied edge technology to promote its first commercially mass-produced hybrid car, the Prius (21). The hybrid car market was new to Toyota and its designers were not sure how the consumers would react. To avoid missteps, Toyota was committed to be as flexible with consumers' needs as possible. It decided to meet the market demands whenever and wherever they appeared and consequently deployed an Internet-based ordering system that enabled the company to build a more accurate market demand prediction model. The new ordering system helped Toyota to identify customer hot spots and to allocate the proper number of Prius cars to dealers.

In the implementation of edge technologies, organizational context matters. Shared understanding of the innovation's benefit is critical because the same technology can be seen differently and draws different organizational responses. Moreover, idea commercialization takes more than one good technology. The integration of "disruptive" technologies is becoming widely common in this era of IT convergence. Having two or more disruptive technologies can result in a new discontinuous innovation. For example, service offerings and revenue

Technology implementation is also about creating listening and responding mechanisms.

models will change as well as technical characteristics of the product. This will require different technological learning and potentially multiple approaches for successful integration (22).

Edmonson concludes that innovation is another learning process for organizations and their employees (23). Therefore, innovation project leader roles, team roles, and project intentions exert significant influence on project outcomes. Effective communication and shared framing of the project are vital to successful technology implementation of innovation. A study of enterprise systems implementation in retail financial services also shows that shared framing of innovation project is critical (24). Technology implementation is not only about building a customer knowledge base, but also about creating listening and responding mechanisms.

The Competitive Edge

ICTs bring substantial positive changes across all three stages of innovation. For instance, ICTs allow customers to bring new innovation ideas to organizations and to refine existing products and services. Also, increasingly more powerful and versatile ICT functions transform innovation processes into more interactive collaborations, which, in turn, accelerate the adoption of distributed and open innovation practices. This is becoming particularly visible during the commercialization phase of innovation. However, in order to ensure successful ICT adoption, CEOs and CIOs will have to carefully consider which ICTs will best fit their organizational goals, management structures and customers. Rapid changes in ICTs make this inevitable.

ICTs have already brought about many important changes to innovation management. The emerging trend of distributed and open innovation illustrates one such transformation: customers and users are no longer passively waiting for products. Widely connected, interactive and collaborative practice of innovation will

provide a competitive edge to the corporations that carefully select sensible ICT adoption strategies and skillfully execute with clear determination. ☺

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