Architectural Changes in the Information and Communication Industries[1]

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Recently economists are beginning to discover the Internet, but they are slow to understand it. For example, some economists argue that because only market mechanisms can create an efficient *de facto* standard the government should not interfere in the "freedom to innovate", and that the protection of "intellectual property rights" is necessary for the incentive to innovate. But the Internet, the greatest engine of innovation, is neither the product of markets nor protected by copyrights. It is made by discussion in non-profit organizations of engineers and its protocols and languages are distributed for free.

The mechanism of the Internet is quite different from those familiar to economists. To understand it, we may have to abandon the common assumption such as that the market is the most efficient mechanism to allocate resources and protection of property rights is indispensable for its efficiency. In this essay I characterize some stylized facts observed in the structural changes in the organization of information and communication industries triggered by the Internet and try to explain them in economic perspectives. Of course, as these industries are in the midst of revolutionary change, this is inevitably a tentative and incomplete sketch.

1. The Architecture of the Internet

It is odd that the Internet, which has been developed by counter-cultural hackers across national borders, is a byproduct of the Cold War. It was born as ARPANET, an experimental wide area network to interconnect many kinds of computers in universities and research institutes participating in ARPA (Advanced Research Projects Agency) funded by the US Department of Defense. ARPANET was designed as a distributed

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network without headquarters in order to survive when any part is destroyed by nuclear war. So it is a *packet switching* network that switches data packets of TCP/IP (Transmission Protocol/Internet Protocol) by routers locally without any central supervision.

This decentralized architecture is contrary to the *circuit switching* of telephone systems, where telephone exchanges control traffic and secure reliability centrally by connecting the circuit end to end. Here telephones are “dumb” terminals that can only send and receive voices. This architecture makes telephone systems so expensive and gigantic that they used to be operated by state-owned companies. In contrast, the Internet is sometimes called “stupid network”, because it doesn't control traffic and guarantee quality of services, but only makes “best efforts” locally.

IP *unbundles* the service layer such as ftp, telnet and WWW (World Wide Web) from the physical layer such as switches and routers. This layered structure allowed rapid innovation in technologies and services in the upper layer without permission of telephone companies. In order to connect various kinds of computers, data on the Internet are not communicated directly but *encapsulated* into standard IP packets by senders and *decapsulated* by receivers.

Telephone companies and mainframe computer manufacturers used to despise the Internet as redundant and unreliable. However, when NCSA Mosaic made WWW the superstar of multimedia in 1993, the vice turned to virtue: encapsulation allows anybody to connect to anybody, and everybody can innovate freely as long as it is encapsulated into the IP. This strong incentive for innovation overwhelmed its inefficiency in transmission.

If we define *architecture* as the structure of a network and its factor technologies, the Internet and PC are complimentary factors of new architecture, because decentralization needs independent individuals who make decision without order or permission. By virtue of Moore's Law, which predicts that semiconductor density doubles every eighteen months, PC's performance has grown more than ten thousand times since its birth. It made users so intelligent that they have as much computing power on the desktop as the mainframe computer of the 1960s.

Moreover, IBM-PC itself has been *modularized* into standardized parts such as CPU, DRAM, video cards, etc., which are encapsulated from other parts so that they can be upgraded without affecting others. And MS-DOS, by unbundling software from hardware, enabled “clones” that emulate IBM-PC by assembling same parts, because they are indifferent from IBM-PC as long as DOS runs on them.

2. Organizational Changes in the Information Industry

From Vertical Integration to Horizontal Stratification

This architectural change in technology has remarkable impacts on organizations in the information and communication industries. As the Internet unbundles applications from facilities, most software developers in Silicon Valley, outsourcing back office staff and physical facilities, have only some hundreds of employees. Since their organizations are modularized, they can be reorganized by mergers and acquisitions without great friction. For example, Cisco Systems has acquired forty companies since 1993.

This *deintegration* of organization was vital for Silicon Valley to be the center of the Internet. As a result, the American model of vertical integration since the late nineteenth century gave way to the three-layer architecture of *application* layer and *physical* layer divided by the standardized *platform* layer, as is seen in personal computers, software, and the Internet. It is more similar to the structure of publishing and media industries than manufacturing (See Table).

	PC	Communication	Media
Application	software developer	Web service	author
Platform	Microsoft	ISP	publisher
Physical	Intel	common carrier	printer

Table: Three-layer Industrial Architecture

In contrast to the application layer, the physical layer has been “superintegrated” recently. For example, AT&T has acquired cable TV operators for more than 130 billion dollars since 1998, and MCI WorldCom acquired Sprint for 115 billion dollars, the largest acquisition in history. Similarly, manufacturers of semiconductors are becoming more capital intensive and oligopolized by several companies such as Intel and Motorola, because few companies can afford to invest the money required to develop and manufacture them.

There are many reasons to suspect that these “megamergers” are new examples of Empire Building that failed by pursuing so-called synergy, but they are different from conglomerates. For example, when WorldCom acquired CompuServe in 1997, it bought only facilities and swapped out the content divisions to America Online in exchange for its facility subsidiary. As a result, WorldCom is specialized in facilities and AOL in

contents. It can be argued that these mergers and acquisitions were made possible by the modularization of organizations facilitated by information technologies.

Disintermediation and Reintermediation

It is often argued that the Internet *disintermediates* networks and makes central coordination useless. Indeed the Internet is a completely distributed network nobody can control. In fact, there is no network as the Internet; it is an informal name of the concept “internetworking” of tens of millions of independent networks worldwide that adopt TCP/IP.

But that does not mean that there is no need for intermediation and coordination. Standards of the Internet are not coordinated by international standardizing organization such as ISO and ITU, but by non-profit organizations of volunteer engineers, IETF (Internet Engineering Task Force) and W3C (World Wide Web Consortium). They have no legislation to enforce their standards, but they are much more speedy and powerful than the *de jure* organizations. IETF is not run by formal conference of national delegations but mailing lists on the Internet that anybody can join, but few can get their proposals through heavy discussion by tens of thousands of e-mails.

WWW is a distributed database that hyperlinks data scattered on many sites in the world. It enabled the free description of data on home pages and surfing the Net by clicking the links without central administration, but it became difficult to search for data by describing their contents. So search engines such as Yahoo and AltaVista were developed to coordinate the information by intermediating them virtually.

Vertically integrated intermediaries such as telephone companies were replaced by ISPs (Internet service providers) specialized in supporting the services such as e-mail and websites. Popular e-commerce sites such as eBay and E*trade are disintermediating retailers and brokers, but they are intermediaries themselves. They are different from traditional intermediaries in that they don't have inventories and delegate risks to users.

This is comparable to the disintermediation in financial institutions in the 1970s, where monolithic commercial banks were replaced by investment banks and mutual funds specialized in risk management. Since the risks became *alienable* as financial derivatives such as options and futures, they were unbundled from assets and traded worldwide. In other words, these transparent intermediaries (sometimes called *infomediaries*) are complementary to the modularized form of information in the new architecture.

As a result of such disintermediation and *reintermediation*, the market would be

controlled by “sovereign” consumers as is supposed in neoclassical economics, where all goods are alienable and all information is available at no cost. In this frictionless world there would be no place for a firm that has organization and capital, because every human and non-human asset can be bought in the perfectly competitive market. So the capitalist firm might be redundant if the market becomes complete, as Coase predicted.

However, even neoclassical economics needs an intermediary, i.e., the *auctioneer* necessary for the existence of general equilibrium but notorious for lacking rational grounds. How can she compute the equilibrium price and communicate it? What is her incentive to be engaged in such tasks without payment? These questions can be answered partly by the auction and brokerage sites on the Internet, though the process is different from *tatonnement*. For example, eBay doesn't compute prices but only sets the auctions on its website. It is up to buyers to inspect sellers, insure risks, and settle payments. Thus eBay, the largest e-commerce site, is profiting from the commission of two million auctions executed every day.

3. Architectural Competition

Competition among Platforms

On the Internet, data are completely alienable and interoperable with each other as long as they are carried on IP, and applications are alienable on the desktop if written on MS-Windows. When knowledge becomes alienable without loss of performance, the transaction costs will be reduced. So deintegration and stratification of organizations in the information industry is explained by the distribution of knowledge in alienable form such as software (Jensen-Meckling 1992).

But it is not always efficient or preferred to make all assets alienable, because it becomes harder to optimize for specialized use and profit from such “commoditized” products. So it is very exceptional that all companies in an industry comply with the same standard without any enforcement. The width of railroads and voice transmission of telephones were different for each company in the nineteenth century, until the government set the standard or Bell company bought all others. It is even more difficult in the high-tech industries, where standards are inseparable from technical information.

Standardization by DOS happened accidentally by IBM's fatal mistakes and Microsoft's clever strategy to exploit the chance. The rise of the Internet was also a

historical accident, because its architecture was designed for special purpose of military research. But once it became the international standard nobody had an incentive to deviate from it, because it is Pareto superior to fragmented markets.

When everybody is trapped in an inefficient equilibrium, there is profit opportunity by bringing new efficient technology. The new one doesn't have to be superior in technical sense. For example, admittedly MacOS was superior to Windows technically, but because it was bundled to its hardware, it was inferior in economic sense.[2] If a monopolist exploits his market too much, others will go to another platform instead of fighting the monopolist within his regime.

This *architectural competition* is effective in the computer industry, where new platforms are rising frequently. It is different from the neoclassical concept of competition, where firms are competing by their individual products on given rules of the game such as law, standards, etc. In this industry, the rule itself is subject to competition. Theoretically, inferior Nash equilibrium in a coordination game can be upset by the member's *exit* as long as there is enough mobility to play more efficient games in other regions (Matsushima 1999).

From PC to Web

Although it is often argued that the Internet leads to "winner-take-all" results due to "increasing returns," there is little evidence to support this claim. Recall that Pointcast and DigiCash were once the stars of the Internet. Market pioneers such as E*trade and CDNOW were surpassed by e-Schwab and Amazon.com respectively. On the Internet, where competitors are only one click away and based on open standards, competition is fiercest and winners may become losers instantly.

However, this doesn't mean that all monopolists are allowed to do anything they like. In the Microsoft trial, Richard Schmalensee testified that Microsoft was not a monopolist because there was "platform competition," but when he was asked to name the competitor in the cross-examination, he admitted that there had never been an effective one. In fact it was this challenge from other platforms, in particular the Internet, that Microsoft tried to kill in advance.

Marc Andreessen, the co-founder of Netscape Communications, once joked that Netscape would reduce Windows to "a collection of poorly debugged device drivers," which infuriated Bill Gates. It was an expensive mistake to make Microsoft aware of the

[2] Liebowitz-Margolis (1999) refute the myths of QWERTY keyboard, Beta-VHS, and other examples of "market failure". However, ignorant of the Internet, they recommend simplistic *laissez-faire* policy.

threat from the Internet too early, but this joke pointed to the heart of the problem. If Netscape becomes the platform across various operating systems, Windows would be hidden below and dispensable with other parts. So the competition is not going on between one product and another but *between different layers*: PC-centric and Web-centric architectures. It was necessary for Microsoft to put the Web under the control of desktop by bundling Internet Explorer with Windows.

Microsoft has been the main driving force to change the industrial architecture from vertical to horizontal one. If it were not for Bill Gates we might be still living in the monolithic world of Big Blue. But Gates could not understand the logical result of the revolution he triggered and he tried to stop it halfway to retain his monopoly, as IBM tried to stop the PC revolution. This move is destined to fail because there has never been a precedent that reversed an open standard to a proprietary one.

In the next decade applications and data will be shared and managed on Web severs, as is done in local area networks. Users will not have to “own” programs and data on clients but only access the Web by various tools such as mobile terminals and information appliances, which will outnumber PCs in a few years. Their platform will not be the desktop operating system but the open standard on the Internet such as TCP/IP and XML (extensible markup language), which can’t be owned by anybody. Even Windows is challenged by Linux, a free OS created on the Internet. Gates might have paved the way to go beyond the capitalist economy based on private ownership.

4. Conclusion

As technology affects organization, organization affects technology, so they form together an institutional architecture in which elements are complementary. Since the institution is constrained by local history and culture, it is difficult to adapt them to the rapid and fundamental changes. It can be done only by Creative Destruction, as Schumpeter pointed out, in which new entrants replace incumbents.

This often happens without entrant’s intention. For example, Toyota production system was not designed deliberately for post-mass production systems, but evolved from the struggle to survive in limited supply and narrow factories in postwar Japan. It is not their evil intention to dominate the world but the abrupt change of environment after the Oil Crisis that made Toyota the superpower in the automobile industry.

Similarly, Silicon Valley was not born to be the center of high technology. In fact, it kept declining in the 1980s, defeated by Japan in the semiconductor industry.

Economists used to blame Valley's "too independent" corporate culture and urged the companies to consolidate like Japanese companies. But when the Internet prevailed, the open culture, independence, and frequent human exchange across firms were suddenly found to be an invaluable asset in cyberspace. Such *unintended fit* (Aoki 1997) works as the selection mechanism in the architectural competition between economic systems.

If Japanese firms understand this logic of unintended fit, they could find some way for "intended fit." If technology changes drastically it is best to change organization, but when it is hard to change it would be advisable to promote the technology that fits the organization. The US government promoted the Internet because Americans had the comparative advantage in it more than semiconductors and electronic appliances.

Since bandwidth is growing so explosively that one optic fiber can carry all the communication traffic in the world, the Internet will turn to video and audio media and PC will be integrated into TV in the next century. So there would be a chance for the Japanese entertainment industry and manufacturers of information appliances connecting to the Internet. But it should not be confused with the closed world of microelectronics; the software inside them should be based on the open standard. The imperative on the Internet is that you must be open or you will be a loser.

References

Aoki, M.(1997) "Unintended Fit: Organizational Evolution and Government Design of Institutions in Japan", in Aoki, M., Kim, H. and Okuno-Fujiwara, M. (eds.) *The Role of Government in East Asian Economic Development: Comparative Institutional Analysis*, Claredon Press.

Jensen, M.C. and Meckling, W.H. (1992) "Specific and General Knowledge and Organizational Structure" in Werin, L. and Wijkander, H. (eds.), *Contract Economics*, Blackwell. http://papers.ssrn.com/paper.taf?ABSTRACT_ID=6658

Liebowitz, S.J. and Margolis, S.E. (1999) *Winners, Losers & Microsoft*, Independent Institute.

Matsushima, H. (1999) "The Role of Mobility among Regions in Coordination", manuscript, University of Tokyo.