

Knowledge Chain in the Clockspeed-Based Organization

by

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Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Engineering and Management
at the

Massachusetts Institute of Technology

May 2000

[June 2000]

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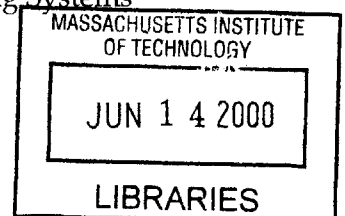
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Abstract

Adding to the increasing complexity and ambiguity in products and customer values, the sudden rise in the clockspeed of business operations is forcing existing companies towards a new organizational model, which autonomously integrates knowledge across technologies, functions, and clockspeeds to find optimal solutions.

This thesis first analyzes clockspeed characteristics in terms of four dimensions (customer value, product, process, and organization) and clarifies them by means of presentations. Based on this analysis, it develops a conceptual framework and an organizational model for the mixed clockspeed organization: that is, a company whose products individually involve components or elements with different clockspeeds, and where the four dimensions of clockspeed are not necessarily highly correlated.

Finally, the thesis proposes an original model for organizing such a mixed clockspeed organization, focused on building an intermediate layer of organization to mediate between the formal business unit structures and the informal human networks that have long been recognized as crucially important for technical organizations.

Thesis Supervisor: D. Eleanor Westney
Sloan Fellows Professor of Management

Acknowledgement

While writing this thesis, I have sometime felt the road after leaving Japan to enter System Design and Management Program at MIT to be a very long one. I might not have finished this hard road without the following people. I wish to thank them.

D. Eleanor Westney, my thesis supervisor, who helped me organize my thinking, read drafts, and provide comments. She has been a great mentor of mine and I have enjoyed the working with her. I thank her from the bottom of my heart for her help.

I also wish to thank Chu Yamamoto, Masami Kinoshita, and Kazushige Oikawa, my former managers, for allowing me to be in MIT for the entire full-time SDM program. I thank them and Osamu Takeuchi and John D. Kavazanjian for their helpful recommendations to apply to the SDM program.

And my family who came with me in this foreign country. Your sturdy behaviors have encouraged me. Thank you Keeko, Yuki, Toshiki, and Airi.

Finally, Atsuko Tanabe, my mother, who passed away before my graduation from MIT. I hope you sleep in peace.

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Windows 98	Windows NT	Unix	Swatch
Disney	Tarzan	Sony Computer Entertainment	
SCE	Playstation-2	PS2	Sony
Sega	Dreamcast	Microsoft	X-Box
EPSON	Canon	Minolta	Fuji Xerox
Hewlett Packard	HP	Boeing	Compaq
Intel	Walkman	FedEx	DHL
JIT	TQM	CMM	ISO

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Introduction

With the rapid evolution of information and communication technologies, which involve fundamental shifts in engineering and in society, existing companies have to cope with the sudden rise in the clockspeed of their business operations. In addition, increasing complexity and ambiguity in products and customer value are forcing them towards a new organizational model, which autonomously integrates knowledge across technologies, functions, and clockspeeds to find optimal solutions. Some aspects of this advanced organization can be seen in new venture companies. However, for large companies such as automobile manufacturers or those in office automation industries, it is quite difficult to integrate the venture model into their organizations, since they produce such a variety of products, including complex technologies with a range of different clockspeeds. Different clockspeeds are often mixed even in a single product line. Although their business cycle is longer than those of most new ventures, they face many of the same strategic and organizational challenges.

In this thesis, first, the characteristics of clockspeed in customer value, in product, in process, and in organization are analyzed with graphic representations. The thesis then presents a model of Clockspeed-based Organization, which separates empowered business units into three clusters based on clockspeed (slow, middle, and fast) so that the organization can be effectively tailored to clockspeed needs. Then, the role of the Chain Architect is introduced to add strong top-down integration into the mixed clockspeed organization.

Second, the concept of "Knowledge Chaining" is introduced, defined in terms of two kinds of knowledge linking. One is Vector Knowledge Chaining, and the another is Scalar Knowledge Chaining. The former is the vertical linking of the knowledge involved in developing and producing a product, while the latter is the horizontal linking of knowledge elements, whose integration has potential utility rather than immediate product use. In the past, Scalar Knowledge Chaining has often been informal since it depends on serendipitous linking of Vector and Scalar knowledge, but the informal patterns have been less effective than the pace of

change demands today. The Chain Integrator role is proposed to manage knowledge chaining.

Finally, the concept of the Shadow Organization is introduced, in which the more bottom-up activities coordinated by the Chain Integrator and the top-down strategic integration provided by the Chain Architect are linked for productive knowledge creation in the mixed clockspeed organization. This produces a three-layer model of organization. The front-end layer consists of empowered business units separated according to clockspeed. The back-end layer consists of the human networks in which knowledge chaining occurs. The middle layer is a management layer which manages the back-end knowledge chaining and integrates it into the business operations through top-down and bottom-up processes.

Clockspeed

Clockspeed is just like a river running through industries. It can be deep and slow at some points, but shallow and fast at others, even though all these points are part of the same river. Managers and management experts have analyzed the geographical characteristics of river, namely markets, products or technologies, in order to manage business and operations more effectively. However, now we are facing the challenge that those geographical factors have changed virtually overnight because of the shift of clockspeed. Clockspeed has become a fundamental factor in business management.

Characterizing clockspeed based only on existing businesses might be dangerous, since the real market is expanding in diverse and often unpredictable ways. However, putting it the other way around, clockspeed can be an effective parameter for business operations and it may help to think about future businesses. Indeed, I believe clockspeed is now a function whose importance may well be the single most important factor shaping the organization of business operations.

Industrial Dilemma

Information technologies and communication technologies, evolving at the fastest clockspeed, are fundamental factors shaping society and organizations. As a result, the evolution of these technologies affects all industries by accelerating the clockspeeds in products and in systems for business operations. Even if a company's products don't directly build on such technologies, its offices, its environment, and even its working styles are strongly affected by these technological changes.

For many companies, on the other hand, integrating the latest technologies into their products is essential to win the competition for markets; however, it shortens the product lifecycle, which has in the past required a reasonably long time frame to balance returns with costs. And, of course, products and technologies have their own clockspeeds, and the clockspeed of a product may well be different from the

clockspeeds of technologies embedded in the product. For example, a higher speed of CPU is released almost every six month, but an automobile usually changes its model over two years at the shortest, and over three to four in slower companies. Yet the automobile increasingly incorporates electronic technologies linked to the more rapidly evolving CPU. This means that the wider the technologies needed for products, the more difficult it is to manage the business.

Here is a problem faced by many traditional companies, which have been leading players in most economies: they are producing complex systems, which integrate not only information and communication technologies but also growing number of technologies with different clockspeeds. The clockspeed of the final products sold by those companies is slower than that of information technologies and communication technologies, as shown in Figure 1. This means, for example, the lifecycle of key technologies or equipment for engineering might be shorter than the products produced with them. Obtaining faster clockspeeds is a matter of life or death for large established companies.

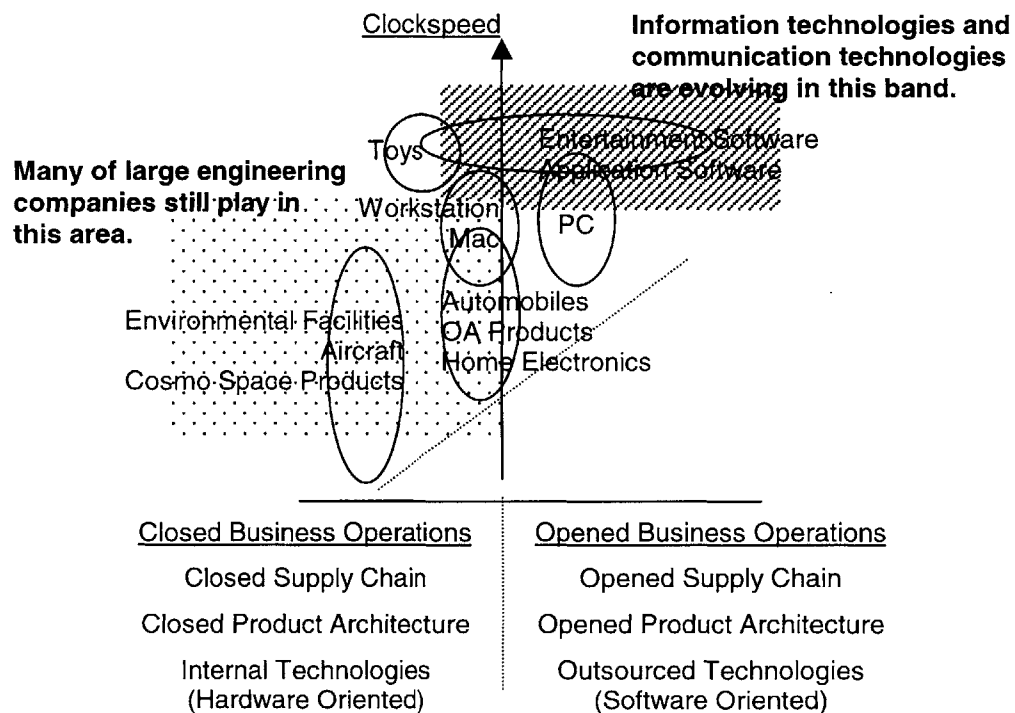


Figure 1: Industrial Map on Clockspeed

Measuring Clockspeed

One major difficulty in measuring clockspeed is defining the categories to which the clockspeed is applied. For example, the product lifecycle is usually longer than the development cycle, which is much longer than the decision cycle, but shorter than the lifecycle of manufacturing equipment. Professor Charles Fine has developed three kinds of clockspeed: one in product, one in process, and one in organization, which are quite useful from the provider's point of view. In addition to these, I also suggest that it is useful to think of a category covering clockspeed in customer value, to clarify the customer's point of view.

The second difficulty is the definition of scale. Clockspeed, as the word itself indicates, is a fundamental cause of systems and behaviors but itself is invisible, and has no absolute scale. For example, the scale used for the nuclear industry should be much longer than that for information technologies (IT), even though the former includes the latter technologies. I have simply used three velocities: fast, middle, and slow, to analyze clockspeed. Fast is a clockspeed of less than one year, middle is from one to three years, and slow is more than three years. Clockspeed itself is in reality quite qualitative and relative, however – like another widely-used concept, customer need, which is also qualitative and for which qualitative analysis has been widely used. Indeed, I believe qualitative analysis is sometimes more useful than quantitative analysis for grasping both the fundamentals and the details of an actual phenomenon.

Clockspeed in Customer Value

Accelerating clockspeed in customer value entails technology change; reducing it involves developing value that compensates for the price. However, these are factors that concern products; actual customer value differs from clockspeed in the product. For example, customers require a cheap product if its lifecycle is short, but they are willing to pay more if the lifecycle doubles, for example. Customer needs and product specifications are two sides of same coin; therefore, characterizing

clockspeed in customer value without defining the specific product is quite difficult. Therefore I have distinguished between Quality (including features and functions), Cost (meaning the price to customers), and Delivery-date. These factors are commonly called "QCD" to estimate products. In this analysis, Delivery-date is exactly specified to product release time factors, since the lifecycle of customer value is a given condition of clockspeed.

On the other hand, customer value has both necessary and sufficient conditions. Necessary conditions are identified with QCD, while sufficient conditions are the balance across the three. I call the latter "the customers' value driver": timing is the critical value driver in the fast clockspeed, assuming that quality and cost are reasonable; quality is the key in the slow clockspeed; and cost-performance, namely the balance of quality and cost is the key in the middle clockspeed. The overall characteristics are summarized in Figure 2, including the analysis of necessary conditions.

Quality:

The slower the clockspeed, the higher the level of basic functions that are required. On the other hand, as clockspeed increases, customers require more updated functions. For example, many individual PC users bought Windows 98 because of its new functionality, even though they knew its reliability was less than perfect. On the other hand, almost all office users selected Windows NT or stayed with Unix workstations, since the reliability was higher and basic functions, such as security, were superior to those of Windows 98.

Customers' motivation to upgrade to new product generations in the middle clockspeed is often not so great, since many products in this area have already been adopted and are often woven into daily operations. Therefore, the comparison with prior products is an important criterion for customers, and if they are to switch to a new model or product, the quality should always be better than the previous generation of product.

Cost:

The higher the clockspeed, the lower the acceptable price. However, the slower the clockspeed the more sensitive the customer is to the price, because the prices in the slow clockspeed are usually much higher than those in the fast clockspeed. For example, we are very price sensitive in purchasing an automobile, which costs more than \$10,000, and spend several days to select the best one. In contrast, we don't care so much about the price when we buy a Swatch whose price is around \$30, and select best one within an hour, or decide by catalog even before visiting the shop. To summarize, the cost can be characterized as agreeable in the fast clockspeed, reasonable in the middle clockspeed, and profitable in the slow clockspeed respectively.

Delivery-date:

The longer the product lifecycle, the longer the releasing cycle for new versions, because customers want the product to be superior as long as possible during the time they are using it. Airplanes provide a good example of this.

On the other hand, the shorter the lifecycle, the earlier the timing in which customers want to obtain the product. This might seem paradoxical with the previous factor, but the paradox is more apparent than real. A short lifecycle often doesn't originally meet the customers' needs; they are rather forced to buy those short-cycle products because of some over-riding reasons. For example, children buy new video games as early as possible, because they want to be good at the game more quickly than their friends are. Customer motivation differs around the customers' value regarding the products. If they know the product value doesn't live long, they want to obtain it earlier than other people do, and so they rush to acquire the products in the fast clockspeed.

Customer value in the middle clockspeed differs somewhat from the other two. As I said, customers' buying motivation is not so high in the middle clockspeed, since many products in this area are already established. Therefore, a standardized

releasing cycle is useful for customers to think about changing the product to the next generation.

Exceptions:

An interesting exception where customer value is not always a part of the product can be found in the entertainment industry. Hollywood has been performing at the fastest clockspeed to develop products, while the product itself has a long lifecycle. “Tarzan”, for example, has a life of more than fifty years. The first Tarzan movie was made many decades ago; Disney just made an animated Tarzan movie in 1999. The customer value is defined by the character or profile of Tarzan himself, which has a long history; however, the most recent movie itself was made using animation technologies with the latest Computer Graphic (CG) technology, which is different from older movies made by human actors. The value of Tarzan has a long lifecycle but the Tarzan products have a short one.

Another example already described is the video game. Game software itself is reusable almost forever, but its value does not live long. Its lifecycle is defined by customer value, not the product itself.

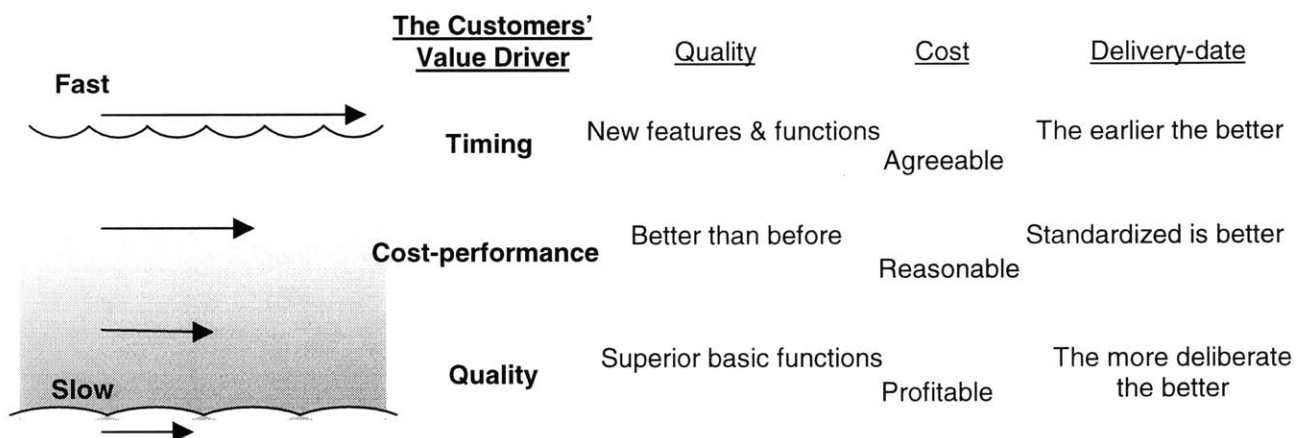


Figure 2: River Model of Clockspeed in Customer Value

Feedback to the Business Operations:

Accelerating clockspeed doesn't always have negative implications for customers; adding qualitative value is important in the fastest clockspeed. However, capturing what value means to customers can be difficult, and therefore, the faster the clockspeed, the closer the business operation should be performed in relation to the customers. Related to this factor, an innovative process that merges engineering and marketing is necessary in the fast clockspeed to generate qualitative value for customers. This process can be negatively affected by the use of analytical methodologies, such as TQM (Total Quality Management), since experimental knowledge doesn't always work well in the fast clockspeed, and it takes time to generate. Experimental knowledge might not live longer than the process cycle.

In general, clockspeed should strongly influence product reviews so that such reviews focus on meeting the key customer value drivers: timing for the fast clockspeed, cost-performance for the middle clockspeed and quality for the slow clockspeed. So far, many companies have applied same QCD criteria for all product releases; however, customer needs have a very different balance across the dimensions of QCD, according to clockspeed. Quantitative specification and data are of paramount importance only in the slower clockspeed, to inform customers of the exact performances of products.

An Advanced Example of Managing Clockspeed in Customer Value:

The most advanced cutting-edge techniques leading to customer value can be seen in the fast clockspeed. This is an information control called "Commitment Business." For example, Sony Computer Entertainment (SCE) announced the major specifications of its Playstation-2 (PS2) and committed to its release date as soon as Sega launched its product, Dreamcast, into the game market. Similarly, Microsoft announced its intention of producing the X-Box, a code name for its game-box to be launched one and half years later than PS2, when Playstation-2 was released into the market. These operations are quite effective at enlarging future markets by keeping customers' attention focused on the future, which is what they really do, more than

preventing customers from buying current products produced by competitors. In fact, in the case of PS2, SCE sold 750,000 units, which was upper limit of its manufacturing capacity, in Japan during the first three days and there were still 550,000 units on back order. The commercial media reported on a range of phenomena such as many people forming lines in front of shops, a boy coming all the way to Japan from Germany to buy a PS2 (whose initial launch was limited to Japan), or a PS2 being auctioned at the price of \$1,000 in the USA. Some analysts suggested that these media stories were worth more than \$50million of advertising for Sony. The same kinds of operations have been seen in the PC industry and in e-commerce.

However, these strategic operations force players to reconsider not only their marketing strategy but also engineering and manufacturing strategies. In the case of X-Box, for example, planning, engineering, manufacturing, supply chain designing, and marketing – all the functional groups in Microsoft had to commit to the release of X-Box when it was announced, probably before any prototypes had actually been made.

On the other hand, there is some downside to this approach, which is that it might escalate into conflicts and agitation, and have negative impacts on the company's image. There are some companies that seem deliberately to restrict the supply of their products supply in order to increase customers through making a shortage of products and stimulating customers' interest. There have actually been some cases where such premium goods were stolen or caused fights in schools. "Commitment marketing" requires very careful strategies if it is have only the positive effects that the company intends.

Clockspeed in Product

The main triggers accelerating the clockspeed in product are market competition and technological evolution. In contrast, the cycle of investment and profitability can work as brakes for both customers and suppliers against clockspeed acceleration. Therefore obtaining competitive power through integrating new technologies into

the products is most important in the fast clockspeed; targeting profitability is more important in the slower clockspeed. Also, the faster the clockspeed the shorter the lifecycle and competitive power of products, since those factors follow the clockspeed of technologies embedded in the products. As a result, the faster the clockspeed the stronger the tendency to take a business strategy of “small profits and quick returns” and this reflects product profiles.

Products in “small profits and quick returns” businesses generally target personal consumer markets to take advantage of mass-production scale economies. And this mass-production leads to the open-architecture for complex products and integrated-architecture for simple products. An example of the former is the PC; an example of the latter is the cellular telephone. In contrast, products in the slow clockspeed target industrial markets and take an integrated-architecture approach to keep the profit per product at a high level, since the size of each production run is not so large. Products in the middle clockspeed must cope with both the characteristics of the fast clockspeed and the slow clockspeed, and take a modular-architecture approach. This architecture extends the lifecycle of developed assets by module and maximizes outsourcing by keeping core-technology internal to the company and by prescribing module-interfaces for suppliers. Today, companies should define product architecture to meet clockspeed rather than on the basis of the capabilities existing inside the company.

On the other hand, to follow the clockspeed in customer value, which I already mentioned, new features with creative concept are key in the fast clockspeed, while high quality basic functions based on the superior technology are key in the slow clockspeed. And similarly, balanced QCD is important in the middle clockspeed. These factors make technologies more software-oriented along the clockspeed goes faster since software is more useful to produce value-added functions. In contrast, hardware technologies are important in the slow clockspeed and both are needed in the middle clockspeed.

Adding on the above-mentioned relation between customer value and product, an interesting phenomenon is seen in both fast clockspeed and slow clockspeed. That is the customized product. Demand in the slow clockspeed is generally small

and unique while the product price is high, and customization, so to say “production for order,” is popular. However, customization in the fast clockspeed is generated by the need to meet various and ambiguous customers’ needs. Therefore, it is usual that this customization is performed as an arrangement based on the standardized products designed with modular-architecture.

Finally, producing the products which include a wide range of technologies is becoming harder and harder because this requires gathering different clockspeeds into a product. And the companies, which produce products whose clockspeeds are mutually different, are similarly facing difficulties not only in managing engineering but also in characterizing products.

Clockspeed in Product Chain:

One approach to dealing with the difficulties of clockspeed in products is “strategic product chaining”, which gives different business missions to the product-lines depending on their clockspeeds. This Product Chain Designing is especially important from corporate strategy point of view. We can see an example in EPSON, a famous ink-jet printer maker in Japan.

EPSON spent almost three years to reach profitability in its ink-jet printer business, even though it had obtained the position of the leader in the Japanese printer market in earlier days. Instead, EPSON’s printer group produced profits from its wire-dot-matrix printer, which was already outdated, by exporting it into China. In those days, EPSON faced serious problems because its laser printer, which had virtually created the low price market in laser printers, was losing market share, and the wire-dot-matrix printers, which had dominated the market (helped by the withdrawal of most competitors), would inevitably lose the market to other technologies sooner or later. It also had to find new products to maintain its manufacturing equipment and human resources, which had been expanded for laser printers. On the other hand, at that time, the ink-jet printer market was dominated by Canon. Under those conditions, EPSON organized strategic Product Chain Designing to increase revenues and keep profitability while keeping its equipment at

the same rate of operation. The key elements of this Product Chain Designing are summarized as follows:

- Introduce low price ink-jet printers:

It was estimated that ink-jet printer market would grow since customer needs for personal printers were increasing and ink-jet is a superior technology to achieve color printing at a low cost. It also fit the distribution channels that EPSON had developed for other products and the estimated production scale was enough to utilize the capacity of available manufacturing operations. Therefore, winning market share from competitors, especially Canon, who had dominated the market, was important to obtain long-term market share and to lead this new market. Keeping revenue and rate of operation was the first priority even if it might not produce any profit.

- Keep wire-dot-matrix printer business until ink-jet printer produces enough profit:

On the other hand, it was estimated that exporting wire-dot-matrix printer into China would be profitable enough to keep the corporate-wide profits until the engineering of ink-jet printer is improved to produce profit.

- Establish business in printing consumables market:

Ink-jet printers had a technological disadvantage: producing a long-life printing head is quite difficult, and its product lifecycle is short, because of technology evolution in other components such as image processing or PC connecting interfaces. To break through these problem, making the printing head be a customer replaceable unit was a very useful way to maintain the printer's reliability and to increase the profits in printing consumables. EPSON targeted the establishment of a new business in printing consumables, whose profitability is high and whose clockspeed is longer, even if the printer itself has a short lifecycle.

Now in EPSON, the largest revenue is produced by the sale of ink-jet printers, but its largest profit is obtained with printer consumables.

I think EPSON learned from the case of Minolta, one of Japan's famous camera makers. Many years ago, Minolta created a camera boom in Japan when it produced a low price but high quality camera. The technology of auto-focus was key to the popularity of this low price camera, and Minolta dramatically increased its market share. Minolta expanded its manufacturing capacity with huge investments, since it believed that no one could develop an auto-focus system for five years, given the company's patent protection. However, Canon developed an auto-focus system for a high quality camera two years after Minolta's development, and regained market share from Minolta. As a result, the profit obtained as a first-mover advantage was gone, because of the debts incurred for capital investment in production equipment. Canon was also exhausted by its efforts to beat Minolta. Even though it won, it spent huge amounts of money for the development and marketing of its new auto-focus system, and the profits from the camera business had already been decreased by Minolta's strategy, which can be described as "small profits and quick returns." There is, however, one company that made enormous profits from this fight: Fuji Photo Film, the dominant Japanese player in the photographic film industry. The competition created a big camera boom in the market, and the amount of film consumption jumped up, regardless who was the biggest camera supplier.

Product Chain Designing is increasing in importance along with the increase in clockspeed. This is different from simply defining the Product Mix, which managers have long recognized as important, and I believe it is the essence of a corporate strategy based on clockspeed management.

Figure 3 summarize the clockspeed in products applied to the Office Automation (OA) industry to which Fuji Xerox belongs. Its product chain consists of several product-lines, such as client PC applications, network server applications, printers, copiers, overhead projectors, paper, and toners. This is a typical industry which should manage different Clockspeeds in its Product Chains.

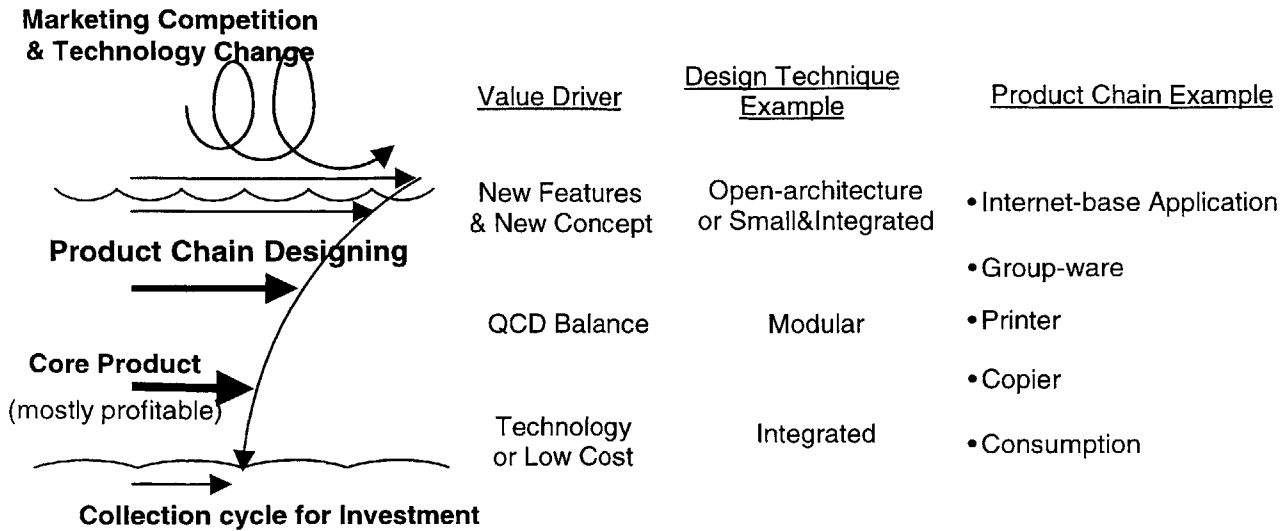


Figure 3: River Model of Clockspeed in Product Chain

Clockspeed in A Product:

Another example from the OA industry might be useful at this point. A shared-use printer, which is priced at more than \$5,000, consists of several modules whose clockspeeds are different. In this price band, the model change cycle of the printer is usually 1.5 or 2 years, and the product lifecycle is 3 to 5 years. However, those printers have optional boards, such as network connection cards, which are generally up-graded every year, and have such consumable units as the toner cartridge, of which lifecycle is less than one year in use while the model change cycle is more than 5 years. Besides those replaceable units, this class of printer integrates some modules whose lifecycle is different, for example, the marking engine, which has a longer lifecycle than printer's lifecycle since it is shared with later generations of the model or with other series of printers. Generally, the Behavioral Clockspeed, which is recognized by customers, is different from Contextual Clockspeeds, which are defined by the unit, module or the technologies integrated into the product.

Just like Product Chain Designing, Technology Chain Designing is important to develop products. Technology Chain Designing means both visualizing the technology lifecycle and defining the Contextual Clockspeeds by module or unit. An

example for this in OA industry is Original Equipment Manufacturing (OEM) of printer engines. Canon has been supplying the units for black & white laser printers to Hewlett Packard (HP), and Fuji Xerox the color laser engines to EPSON. HP and EPSON have superior technologies in other aspects of printers beyond the printing engines (for example in image processing), and they can produce printers that compete effectively with those produced by Canon and Fuji Xerox, integrating their own technologies with printer engines. HP and EPSON can save at least three years and more than \$10 million of investment, which is the amount required to develop a new laser-printing engine. On the other side, Canon and Fuji Xerox can obtain the advantages of scale economies in mass-production without spending the resources to develop new channels and customers. This is not only an example of technology outsourcing, but Technology Chain Designing is a strategy to save costs and resources through controlling production volume and the life-cycle of modules.

Figure 4 shows the relation between Product Chain Designing and Technology Chain Designing in the OA industry, as described above. Both designs are indispensable for business strategy in this example. If I chose the PC instead of the printer and redrew this chart, it would show the map in the computer industry performing under the conditions of open-architecture.

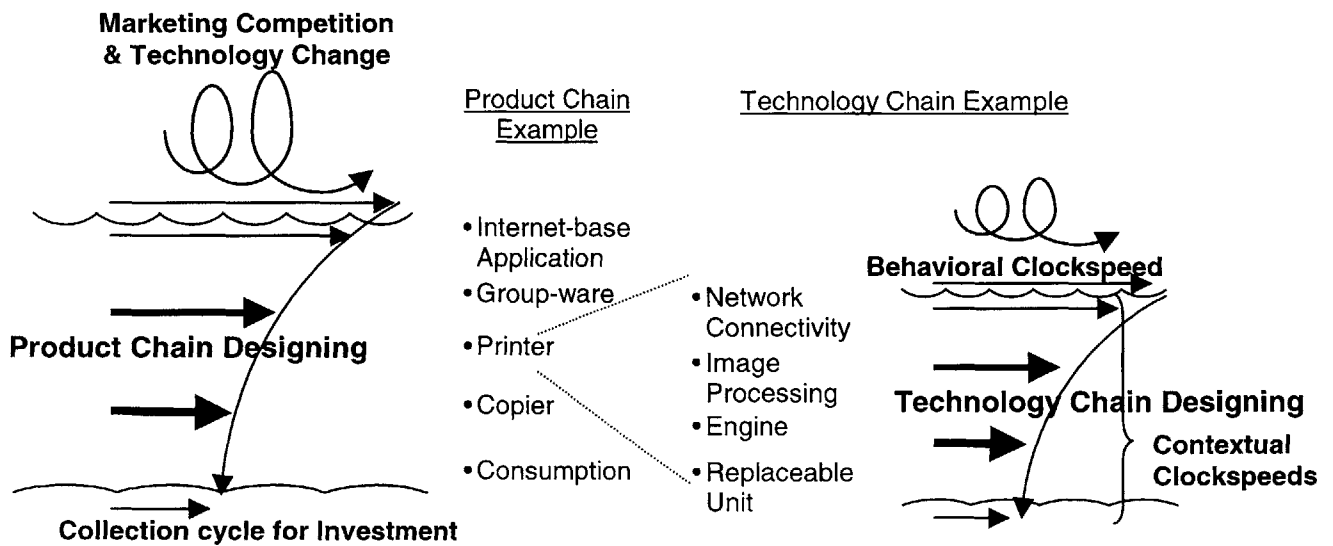


Figure 4: River Model of Clockspeed in A Product

Feedback to the Business Operations:

The Product Chain should be designed to target competitive products in higher clockspeed segments and profitable products in much slower clockspeed segments. Such an approach enables companies to maintain stable profitability for as long as possible, and lower competition allows market dominators to lead the product price. On the other hand, the Technology Chain should be designed based on the definition of core-competency and it should be set on the most profitable modules. This makes engineering companies concentrate on the technologies and clockspeed in which they have advantages.

Finally, product architecture should be designed to incorporate considerations of clockspeed. This helps not only by clarifying outsourcing strategy but also by simplifying clockspeed management in engineering complex products. For example, a company can consider taking an open architecture in the fast clockspeed to maximize competitive power while minimizing risks, even though this option is not likely available without having the political power to manage cooperation with other companies.

An Advanced Example to Manage Clockspeed in Product:

Fuji Xerox has moved to develop Clockspeed-based Product Architecture commonly applied to its main products. It established in-field upgradability from printer or scanner to copier using standardized interfaces. The full system consists of three sub-systems: Client/Server, Controller, and Device, whose characteristics are different because of their respective clockspeeds, as shown in Figure 5. The purpose of this architecture is to cope with decreasing lifetime cost and to obtain customer satisfaction. Specifically, development costs can be decreased by increasing the reusability of developed assets, lengthening the product lifecycle by producing infield upgradability to follow customer needs, and maximizing the practical use of external resources. With the definition of interfaces separating the three sub-systems, the products can maximize customers' value by updating short lifecycle sub-systems or modules.

Another advantage of this architecture is easier management of technologies and operations by separating skills into three sub-systems. For example, the Client/Server sub-system requires both engineers who have professional expertise in software technologies and software managers who can manage standardization and alliances, while Device requires those who are good at mechanics and xerographic technologies. It is commonly said that to know more than two technologies deeply is quite difficult, and the technologies integrated into the OA products are too wide to be managed as a whole. Separation into three sub-systems provides managers with greater ease of designing and management without having super architects or system engineers.

Adding to this, Clockspeed-based Product Architecture provides easier separation of engineering organizations to cultivate their own competencies and to share their experimental knowledge. I describe this later in the section on Clockspeed in Organization.

On the other hand, this architecture can create difficulties in project management. For example, what would happen if each sub-system was engineered autonomously and each engineering organization developed its own marketing channels? Probably no one could explain to customers the benefits of the system as a whole, and no one can support customer s effectively if the system fails. As products become more complex, focused project management is needed as a result.

Furthermore, this architecture might restrict the possibilities for designing better products. For example, who can design successive systems that are incrementally improved to meet customers' emerging needs? The company might be unable to accomplish this without changing the three sub-systems architecture, which carries huge implications for the organizations and products. It is important to organize the engineering management supervising architecture continuously, from an integrated viewpoint.

To solve the above-mentioned two problems, Fuji Xerox organized a system-designing group, which supervises the system specifications, technologies, and architecture for the system overall, separate from the project management. This is also described in the section Clockspeed in Organization.

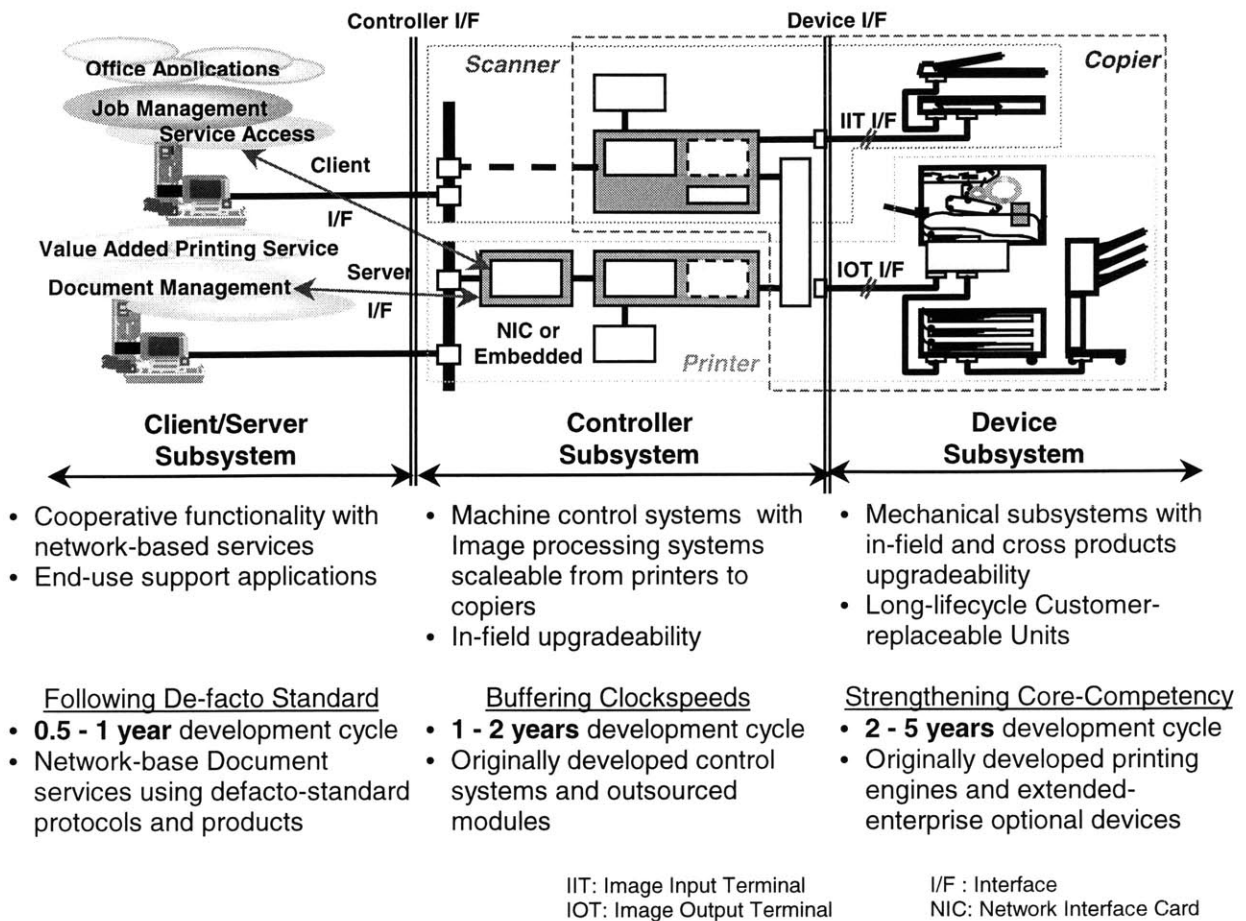


Figure 5: An Example of Clockspeed-based Architecture

Clockspeed in Process

The factors that accelerate the clockspeed in process are market competition and technological evolution; and what brakes it is the recovery cycle for investment, even though directly accelerating the former and braking the latter are both involved in clockspeed in product.

Reflecting the clockspeed in product, the slower the clockspeed the more repetitious the process, and the faster the clockspeed the more innovative the process. In the fast clockspeed the product lifecycle is so short that it is rare to

reproduce same kind of products. A simplified product in the fast clockspeed also makes it less necessary to establish a repetitious process, since it also makes process shorter and can have fewer phases in it.

On the other hand, it is interesting that clockspeed in process doesn't always follow the product in same clockspeed. For example, Boeing, a company in a slow clockspeed business, takes same kind of manufacturing process as Compaq, which is a leading player in a fast clockspeed business, in that they assemble key modules whose production is outsourced. This is because their processes have a basis in their similar supply chain designing. In fact, the actual process is controlled with many operational factors and is difficult to characterize without defining specific viewpoints; for example, in this example we can be say that Boeing and Compaq have a similar manufacturing process from the supply chaining point of view. In other words, one viewpoint can only chain some factors in process but cannot define whole process.

However, I believe that clockspeed is now a primary viewpoint in chaining factors, even though it cannot describe the details, because clockspeed is an internal factor running through the process. This viewpoint must explain why the process to develop a nuclear power plant, in slow clockspeed, is different from that to develop Internet service applications, in fast clockspeed, even though it has a similarity with the slow clockspeed development of aircraft. As I have said earlier in this thesis, information and communication technologies, whose clockspeed is fastest, are now going to be integrated across many other industries. And industries in the middle clockspeed, such as the OA industry or the automobile industry, are now facing difficulties in process caused by the integration of different factors influencing clockspeed in ways that transcend the traditional categories. Again, I believe that clockspeed is now a primary viewpoint to think about process.

My characterization of clockspeed in process mainly focused on engineering. In the following sections, I separate this into three clockspeeds. Figure 6 may help in understanding the descriptions throughout the section.

Process in the Slow Clockspeed:

We can see traditional development process called the “Waterfall” in the slow clockspeed, and many companies in this sector have adopted “Production for order”. Production for order takes the sequential process of ordering and planning, engineering, and manufacturing, and usually it requires the research and technology development process to support the whole process. In other words, the engineering period is longest and technology dominates the entire process.

There is no assurance of achieving product goals when the project starts, and the longest time is used to identify and establish the technologies needed to achieve the goals. Therefore, funding and resource scale increase as the process proceeds, and a major reason for setting phase-gates and reviews is to check on progress and to make the decision to transfer the project into the next step. The total investment is huge and the turnover cycle is long. A product failure can put the entire company at risk.

To avert this potentially fatal outcome, the operational process has its basis in technology development rather than product development. In particular, products are the fruit of continuous development of technology and investment, and the company’s turnover is managed based on the business opportunities opened up by the technology. Therefore, process itself is technology oriented and basic resources and funding are required regardless of the specifics of particular product development projects.

The engineering process takes a top-down approaches, and system designing from product goals to disaggregated goals and functions is a most important process. All technological reviews, which are usually included in the phase-gate reviews, check the progress both from the viewpoint of disaggregated goals and from the system designing viewpoint. The process management style is top-down, even though the operation itself might be functionally parallel.

Helped by the continuity of technology development and the fact that many products in the slow clockspeed are produced for national projects, many techniques to support process management have been developed. Typical examples are QFD (Quality Function Development) and/or RDD (Requirement Driven Development)

for system designing, and MRP (Materials Requirements Planning) for operational management.

Process in the Fast Clockspeed:

Because of the short lifecycle of each product, the process in the fast clockspeed doesn't take a traditional sequence, which starts from planning and proceeds through engineering, manufacturing, and marketing respectively. Like the video game industry I described in the section on Clockspeed in Customer Value, there is no typical order in functional processes and every process goes in parallel. This is because every process is required to face the market directly and has to operate with a careful observation of those transitions.

In other word, gathering the required at the starting point is the key for success, and the goals created at this point lead the engineering and other operations throughout the process. The faster the clockspeed, the shorter the engineering period and clearer the goals. Even the funding should be adequate at the start to accomplish the project. And project reviews should focus on removing obstacles by allocating whatever skills are required rather than using obstacles as a way to make a "go-no go" decision.

On the other hand, concept making is more important in the faster clockspeed, which is related to the clockspeed in customer value in that it is qualitative and ambiguous. It is not rare to start a project triggered by an idea created by some particular person. The Sony Walkman is an example which took this pattern. It was started by Chairman Morita with his request to engineers whether they can develop a music-tape replayer (not a recorder) sized within the cassette-case. Receiving his request, engineers searched for technologies existing inside Sony and finally succeeded in integrating small speaker technology, flat motor technology, and long-lifecycle small battery technology, which had been developed individually, into the Walkman. This might not seem an example unique to the fast clockspeed; however, concept oriented products with great originality cannot live long if they have no

other advantages. Walkman's competitive advantage was guarded with engineering technologies and manufacturing technologies.

This kind of engineering process should be started after defining a clear product concept, since the engineering period is too short to change the basic specifications. And, of course, the lifecycle of exact needs itself might be short. This short engineering period requires higher technology readiness at the beginning to minimize the risks of failing to accomplish the goals. For To reduce both technical risks and the engineering time frame, it is usual to introduce outsourcing and alliance partners into the process, which requires joint work with planning, engineering, manufacturing and even a pipeline to the higher management. The pipeline is required since the decision sometimes directly affects corporate strategies; for example, Microsoft had already decided to use Pentium-III when it announced the production of X-Box.

A process management technique widely used in industry was "Prototyping," which develops some prototype models that enable developers to obtain customers' feedback to incorporate their requirements into the next models. However, this technique has become a methodology for the middle clockspeed products to add value, since purely following customers' opinions makes products highly customized. Rather, the techniques supporting process in fast clockspeed are relatively few, since the process is so dynamic that it is rare to repeat any particular "recipe" in the future. Quantitative data obtained in the past don't always help in future projects, even though experimental know-how stored as human skills is useful if the skilled person uses it with some adaptations. Like product concept oriented engineering, the process in this clock-speed is quite human oriented.

An interesting trend affecting engineering process in this clockspeed-band is the increasing salience of software. Its development process is different from more traditional processes developed for hardware engineering. Software differs from many other technologies in that it has a basis in mathematical theories and doesn't follow any natural laws (except human behavior applicable to its users.) This principle makes the engineering process difficult to manage, since software itself is invisible and the progress can be measured only through the documents engineers

produce and by reviewers who have software skills and are well informed about the development. Software engineering follows human behavioral process.

Related to the software engineering, a new set of initiatives in marketing process can be observed today: the Internet is organizing interactive communication channels between suppliers and customers. This communication channel is helpful not only for marketing but also for engineering and for product distribution; for example, some current software products are distributed via the Internet upon request from customers, and many suppliers set a bug-fix process after launching their products into the market. Using homepages showing the latest bug information, which is available for downloading in the form of the latest software, suppliers have become able to release a product without fixing bugs completely. (On the other hand, this new channel made it difficult for suppliers to define release criteria.)

This use of the Internet can also be categorized as an innovation in distribution channels. Helped by the growth of e-commerce, new distributors, such as FedEx or DHL, are providing suppliers with low cost direct-distribution channels from their factories or inventories direct to customers. Combined with the telephone-based and/or Internet-based ordering system, anyone can engage in business without having a shop and/or owning distribution channels. This combination can solve the suppliers' dilemma of how to cope with mass-production and wholesale in a short time. It was well known that the reason why Compaq had lost market share was the delay in introducing this marketing channel, because the company gave higher priority to its existing retailing channels. The innovations in information technologies and communication technologies are also providing innovative channels linking suppliers and customers.

At all, the process in this clockspeed-band is so varied that the "business model" itself becomes a source of competitive advantage, and so dynamic that repeating the same process is quite difficult. As a result, standardizing process is quite difficult, indeed rather meaningless, in this clockspeed-band. Process in the fast clockspeed is quite human oriented and knowledge oriented, and there are few tools to support process management

Process in the Middle Clockspeed:

Process in the middle clockspeed had been evolving through Quality Control in the 80's and Reengineering in the 90's. However, it is still facing serious problems, since many of industries in this clockspeed are trying to integrate information technologies and communication technologies, which have very fast clockspeeds, into their products. Those industries are caught in a dilemma between the pressures accelerating the clockspeed in order to integrate the latest technologies to gain advantage in market competition and braking the clockspeed to maintain their collection cycle for investment. They are still on the path of process innovation; however, some typical process can be seen in this clockspeed that differ from the fast clockspeed.

The processes in the middle clockspeed are those that have been applied to producing longer-lifecycle products in commercial markets such as automobiles, OA products, or home electronics products. And these processes have been heading for the improvement of productivity that started from handicraft engineering. Therefore, the general process has a basis in the "Waterfall" sequential process from planning, engineering, manufacturing to marketing, just like that in the slow clockspeed, and many advanced process techniques can be seen in engineering and manufacturing.

This direction of "improvement of productivity" provided systematic approaches and statistical techniques in process. Product goals first specified in the planning process are disaggregated into specifications, which are the targets of downstream processes and the criteria for transferring the process. Drastically changing goals in the late stage is almost impossible, since many industries taking this systematic flow use huge budgets and capital equipment for development. Because of this importance in specifying goals, a statistical technique called "mass-customization" is used for planning. Huge amounts of market data are gathered to find mass-customized goals in the diversifying customer needs. Also, helped by product characteristics such that many of the products are deeply embedded in daily life, this statistical production process can be repeated continuously to produce successors.

On the other hand, this systematic flow realizes concurrent processing. Helped by the disaggregated goals, each process -- engineering, manufacturing, and marketing -- can start when it wants. Phase-gate reviews to transfer the process are mainly set to check the risks to advance to the next steps and not set to transfer the information to the next process. Budgets, resources, and related organizations gradually increase along the process advances and risks go down. In contrast, the later a problem is found, the larger the impact under this process.

Adding to this concurrent processing and the continuity of production both mentioned above, it is popular to organize projects in parallel. Particularly, several projects go in parallel but facing different phases. For example, when car White is in the planning phase, car Black is in the engineering phase, and car White moves to the engineering when car Black is transferred to manufacturing. Using this process, with its organized matrix of functions and projects, many projects can go ahead concurrently with minimized overhead resources. Also, this matrix provides advantages in both storing competencies inside each function and transferring them from project to project. However, this process requires critical schedule management for all projects, since one schedule-slip affects other projects.

Given the importance of industries in this clockspeed, many innovative techniques, using systematic theories and statistical theories, have been developed so far. TQM (Total Quality Management) for engineering and JIT (Just In Time) for manufacturing and inventory management are but a few of those widely introduced industries, and CMM (Capability Maturity Model) is one of the latest techniques focused on the productivity in software engineering. Also, there are many standardized processes by ISO (International Organization for Standardization) in this area, and obtaining ISO certification is useful for suppliers, not only for them to manage process but also to demonstrate their quality and reliability to potential customers.

One difficulty that is now increasing in magnitude in engineering process is friction between hardware development and software development. The hardware engineering process has a basis in producing physical elements, and sequentially consists of designing, drawing, fabrication, and assembling. On the other hand, the

software engineering process consists only of designing, which is usually performed as documentation, and programming, which is performed with iterative coding, debugging, and installing. This process difference in time-scale makes for problems in actual development. For example, Fuji Xerox fell into one of the most serious problems it ever experienced when it slipped the launch of a main product by one year because of a software problem that was not identified until very late in the development process. It was not found until just one month before the planned date for starting manufacturing. The biggest reason for the problem was that software engineers had found themselves spending most of their time maintaining software for a series of hardware models instead of engaging in software system design. Fuji Xerox's standard development process puts great importance on modeling, since xerographic technology has a basis in the ambiguous natural laws and improving quality using actual models is indispensable.

Also, this increasing importance of software affects not only the engineering process but also a wide range of business operations. Software is now changing a product not only by adding functionality but also by accelerating the behavioral clockspeed of products, which requires merging fast clockspeed business operations with those with a middle clockspeed. For example, if a company provides Internet-based software upgradeability, which I mentioned in the section on "Process in the Fast Clockspeed", the company has to provide customer support systems to ensure the performance of products whose configurations cannot be ensured. And, of course, customer communication channels such as providing product distribution, guiding bug fix, or collecting customers' information should be integrated into the entire business operation. However, it can be said that merging the software engineering process with the hardware process is the first step in establishing an innovative process to remove the barriers facing large companies entering into fast clockspeed operations.

Overall, process in the middle clockspeed takes systematic approaches and uses statistical methodologies aimed at increasing productivity. And it has been standardized mainly by focusing on having hardware engineering, which requires a large investment, repeat many times. However, many industries in this clockspeed-

band are facing difficulties in integrating technologies in fast clockspeed into their traditional processes. And now, there are few truly useful techniques with which to establish this new process.

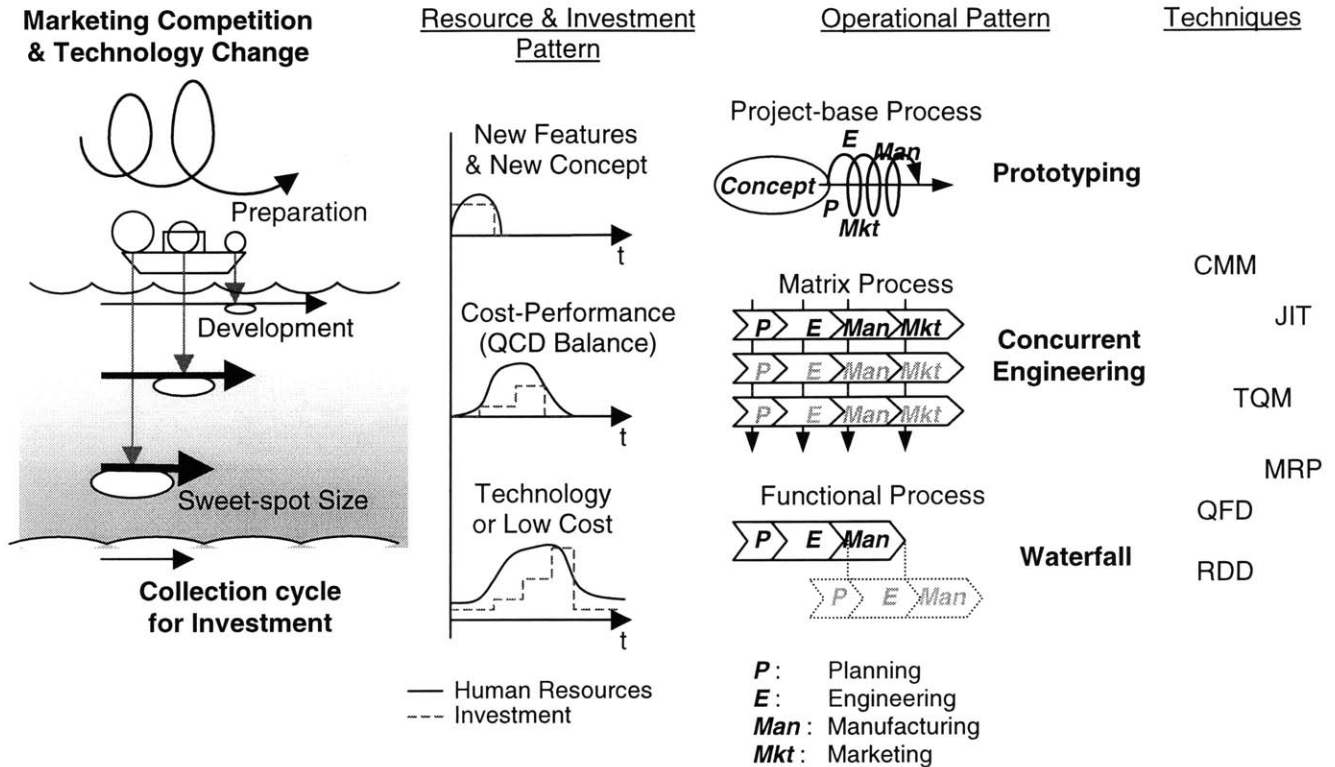


Figure 6: River Model of Clockspeed in Process

Feedback to the Business Operations:

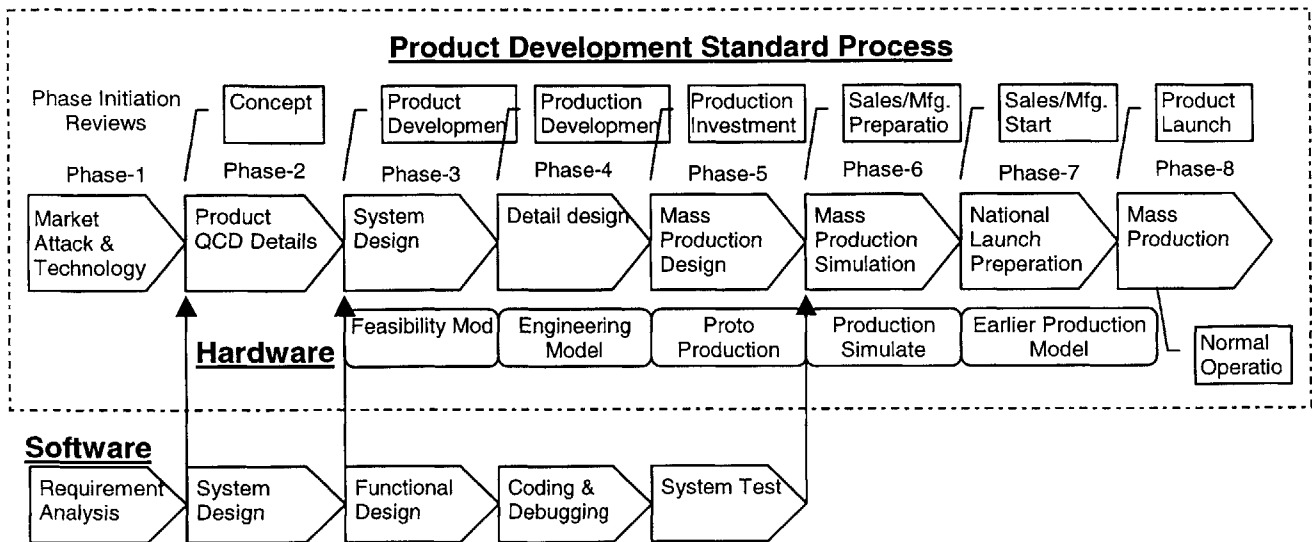
No process fits all clockspeeds, and trying to establish a standardized process to fit all clockspeeds is almost nonsense. The abilities required, the scale of resource, budgets, and timing are all different if clockspeed is different. Therefore, different processes are needed if clockspeed is different, and managing resources across the different clockspeed projects is quite difficult.

Gathering a wide range of knowledge before starting the project is important in the fast clockspeed, but on the other hand, gathering technical knowledge to check the progress throughout the process is more important in the slow clockspeed.

An Advanced Example of Managing Clockspeed in Process:

After experiencing the problem in merging software development into existing process described earlier, Fuji Xerox rearranged its Product Development Standard Process, shown in Figure 7, to meet the characteristics of software development. It didn't make up a new standardized process, mainly because the existing process has a basis in the investment process, and changing it would require changing the structures for corporate-wide decision making. However, reducing friction between hardware development and software development is indispensable to develop technologies in the fast clockspeed, since many of them depend on software. It is significant that the software-engineering process was established separately from the modeling process, since it means that executives recognized the differences in process between software and hardware.

Generally, the newly developed process for software engineering goes one phase ahead of the Standard Process. This is because software functionality is now so large that its development should be finished before starting the system test integrating the software into the models, which mainly consist of hardware and machine control software. One ideal approach would be to outsource model development, allowing in-house engineers to concentrate on software development for the final product.



Principle Activities: Items reviewed at the end of each phase

Phase-1

- Business plan, including target market, estimated revenue and cost, and sales channels
- Technology assessment
- Specifying budgets, resources, development duration, and organization

Phase-2

- Collecting Voice Of Customer, and defining detailed customer needs
- Establishing product specifications, namely Quality, Cost, and Delivery date
- Selection of technology set and identifying technology challenges and potential countermeasures

Phase-3

- Confirming detailed business plan and project size
- Establishing market strategy
- Establishing the level of technology readiness

Phase-4

- Tracing QCD progress
- Reviewing any additional constraints and investments required for production

Phase-5

- Performing basic customer tests, and clarifying QCD achievements and tradeoffs
- Preparing distribution plan, sales plan, and service plan

Phase-6

- Perform full customer tests, and commit to the final specifications
- Start sales training and service training

Phase-7

- Improving Quality or Cost if targets not yet reached
- Starting sales activities

Phase-8

- Support of production and sales by project team until Normal Operation Initiation Review
- Finalizing all project activities

Figure 7: An Example of Software Arranged Product Development Process

Clockspeed in Organization

An interesting observation about organization is its similarity with the functional structure of the process it operates and (if it is an engineering organization) with the product architecture it develops. This occurs simply because any organization has a basis in its operation: it is organized for how it should perform and what it should accomplish. This also implies that what I clarified in the prior chapter about product and process should help to clarify the organizational characteristics of clockspeed.

The long product life-cycle and the long collection cycle for investment in the slow clockspeed allow a long time for development and a very large investment to produce truly superior products. However, they also require exact operations that do not fall into very serious problems, because any fatal failure relates to the corporate-wide business failure. These characteristics make a functional organization useful for clarifying responsibilities and a vertically centralized organization best for following the corporate-wide decision-making structure. These two features make it rather engineering oriented. Vertical communication is more important than horizontal or cross-functional communications.

On the other hand, the short product lifecycle in the fast clockspeed requires operations to produce products fast, keep inventory small, and sell fast, with quick decisions. The influence of failure in one project is not so dangerous, because of the small investment and resources if the project resources are transferred to the other projects and those projects succeed. And with the necessity of cross functionally parallel operations, the organizations in the fast clockspeed should be project-oriented and empowered, and the structure should be flat. Also, considering the sensitivity to the market, the decision-making structure should be market oriented rather than engineering oriented.

A matrix process in the middle clockspeed can force the organization to emphasize both function and project. The organizational characteristics of the functional line of the matrix are similar to those of the slow clockspeed organization: for example, vertically centralized, even though it differs in having responsibilities allocated to several projects. Because of this, the main budget for product

development is managed by the project line, and the basic operational budget is managed by the function line. As a result, the organization has two decision structures: one for projects, focused on profitability, and another for resources and technology focused on productivity. The organization also needs both vertical and horizontal communications. The structure can be said to be modular, because each group is required to carry out fairly autonomous operations.

Figure 8 shows typical structures of organizations with the pictures summarizing prior descriptions. This should help the reader to understand what is described in the following sections.

Organization in the Slow Clockspeed:

Organization in the slow clockspeed is like a baseball team. Members share different but clear responsibilities and each of them works as a specialist in his/her area, according to decisions made by a supervisor. This system takes on a vertical structure to simplify the decision-making structure and concentrates the managing power in the top management. The structure provides highly disaggregated responsibilities and workloads that minimize overhead. The organization is designed to achieve a maximized goal when each group works to its maximum. It is entirely systematic.

Because of this systematic design concept, organizational operations are based on top-down strategies. Corporate goals are disaggregated to organizational goals by executives and their staffs, and are distributed to the groups with resources, budgets, and equipment, which are also disaggregated to meet the operational requirements. The responsibility of each group is to achieve the given goal and to cultivate functional competency in order to keep long-term competitive advantage. And the managers in each group are required to have professional skills in the organizational functionality. The higher the position, the higher the decision rights. Corporate-wide managing power is highly centralized, while operations are functionally decentralized.

In this management structure, communication is largely unidirectional; namely, information flows vertically from bottom to top, while decisions go down from top to bottom. Horizontal communication across the organization is not particularly useful, because the organizational functionality is highly disaggregated and the operational process is sequential. From a knowledge management point of view, creating bottom-up ideas is difficult, even though accomplishing given goals can be done effectively.

Organization in the Fast Clockspeed:

Organization in the fast clockspeed can be compared to a basketball team. Each member is versed in all kinds of plays and cooperatively plays with other members, whose abilities are well known to every member of the team. Also quick movement with searching the whole operation and reading the next move in the particular situation are both important. The operation is based on teamwork and empowerment, and its process is dynamic. Because of these characteristics, the organizational structure should be flat and separated by project, which includes all functions inside its boundaries, and sometimes the organizational structure itself is somewhat unclear. The structural characteristic is, rather, subjective in the fast clockspeed organization, even though operational characteristics are objective. More particularly, the key organizational capability is the power to break through emerging problems and to follow unexpected changes, even though actual operations are focusing on the shared goals.

With the above-mentioned characteristics and the shorter operational cycle, the fast clockspeed organization tends to maximize outputs using given inputs. In particular, the operation in the fast clockspeed has a tendency to plan for maximizing outputs based on the given resources, budgets, and materials, compared to the slow clockspeed organization, which takes systematically disaggregated goals. To reduce risks and reviews and to encourage teamwork throughout the process, product goals should be set at achievable levels. They could be accomplished without having any technology developments or political problems which require

huge investment or long time. Managers should motivate teamwork and encourage members to find potential issues and solve them before serious problems emerge. Their responsibility is human management rather the management of plans. Organization in the fast clockspeed is quite human oriented.

On the other hand, these organizational characteristics force large companies to combine this type of organization with other types if they want fast clockspeed organizations. Because, it is not always certain that all fast clockspeed organizations can achieve success. Ideally, the fast clockspeed organization should be organized partially based on the Product Chain Design, and the project should be stopped as soon as possible if the failure becomes likely.

Also, this organizational structure makes for huge overheads between groups and difficulties in sharing knowledge between groups. Consequently, top-management has to pay attention to the resource management and the knowledge management. One of the effective approaches is exchanging members when the project restarts. Horizontal human networks across groups are also indispensable for maximizing stored knowledge and for stimulating creativity.

Another difficulty in management is encouraging sustained commitment to the company. Affected by the working style in this clockspeed-band, which is similar to that in Silicon Valley, keeping outstandingly capable people for a long time in any one organization is quite difficult. Not only providing a comfortable work place, condition, and reward, but also cultivating a work ethic oriented to the company is important.

Organization in the Middle Clockspeed:

Organization in the middle clockspeed is just like a soccer team. While the team itself seems a unified whole, each member shares different responsibilities which are loosely overlapped with those of some other teammates. Relaying a ball from player to player by connecting each fielding position, the team accomplishes shared objectives. Just like the soccer field, which is one of the largest playing fields in sports, this organization works well for industries whose operational field is large

and whose related technological areas are wide. And they usually have a matrix organization of Project-line, which is responsible to produce a product in short-term, and Function-line, which is responsible to cultivate functional competency focused in long-term. The Project-line consists of some project groups, each of which includes several functional teams dispatched from Functional groups.

Those companies whose business life-cycle is long and product life-cycle is medium, such as the automobile industry or the OA industry, have their organizational basis in the functional structure rather than the project structure, because they focus on long-term stability for the organization and set up projects as temporal formations. And the project structure is only clear in planning and engineering functions, since the other organizations have responsibilities in functional operations more strongly than in project oriented operations. In particular, each person in manufacturing and marketing organizations is usually handling several products in parallel. For these reasons, the decision-making structure is usually function-oriented and the functional managers are stronger than the project managers are. In other words, decision-making structure in the middle clockspeed organization is close to that of slow clockspeed organization.

Adding to this, the standardized development process, which I discussed in "Process in the Middle Clockspeed", helps to simplify the decision-making structure. Applying the process to all projects, which are disaggregated from corporate strategies, both engineering progress and the expected return values in investment are checked throughout the product reviews, settled at the phase transfer gates in the process. And the system for checking business decisions is assimilated into the development process by setting the review steps to follow the business decision-making structure. This means that the operational clockspeed follows the standardized development process and that the organization can be designed considering only the operational decision-making structure.

A project-function matrix is more commonly introduced only in the engineering organization, it since this structure easily provides both product development and technology development in parallel. However, this organizational style is now facing some difficulties in managing issues that cross individual projects. For

example, developing a platform chassis, in the automobile industry, for a series of automobiles can save total costs by developing it individually. But it is too expensive to assign all the costs to a single product. Another example is standardizing the registration to set the document on a copying machine, at the front-side, at the another side or at the center, which is important to provide customers with an operational commonality. But it might produce some impact on products in terms of their cost or size, or on functions for developing new technologies. These kinds of common designs are important from company-wide point of view but difficult to handle for a project or a function; namely, the existing matrix organization cannot manage them smoothly and one more structure is required to do so.

The responsibility of this third structure partially overlaps with the purpose of Product Chain Designing and Technology Chain Designing mentioned in the previous sections. Seeing this latest trend in organization from a different angle, this is a force to make organizations more top-down in style or to make them try to orient themselves to a slower clockspeed. In the “bleeding edge” of the middle clockspeed, organizations are facing a contradiction between adapting fast clockspeed and reverting to the slow clockspeed characteristics.

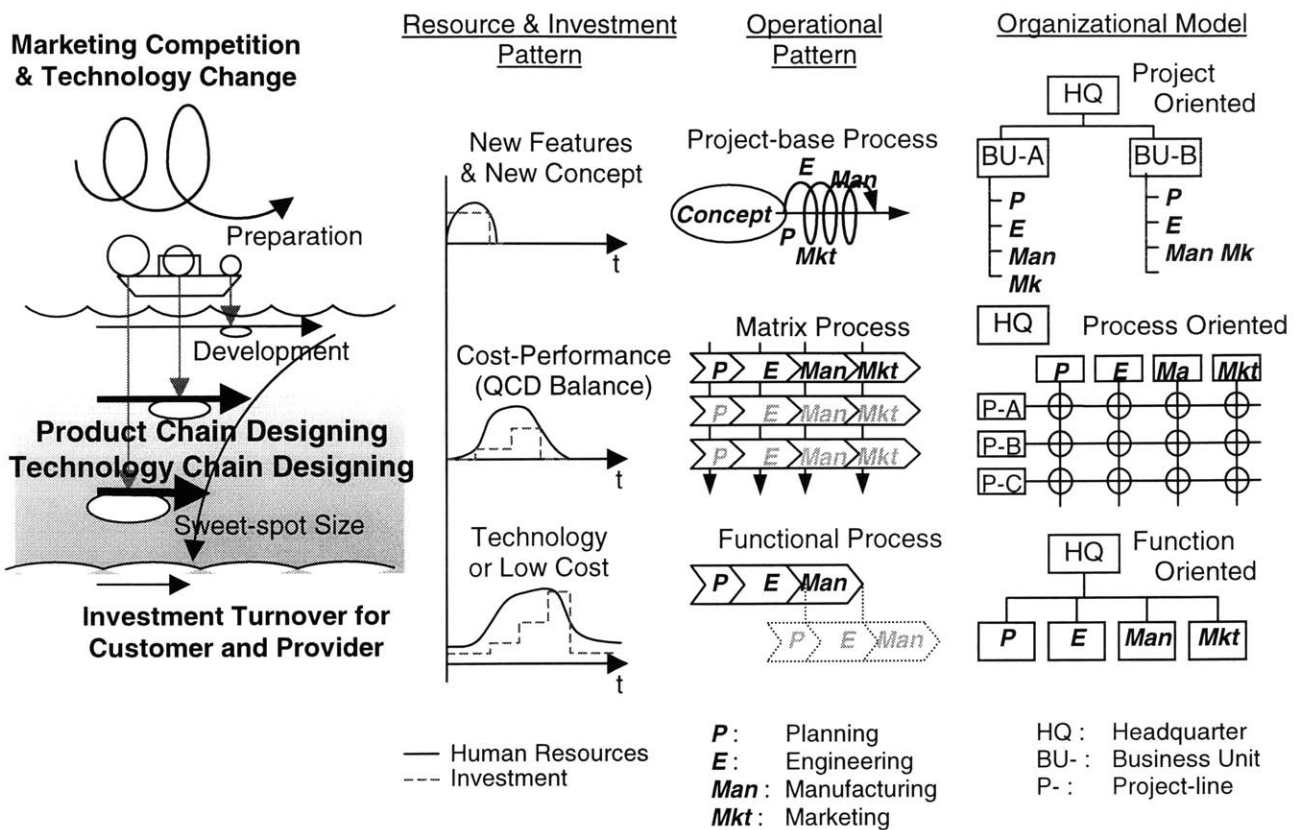


Figure 8: River Model of Clockspeed in Organization

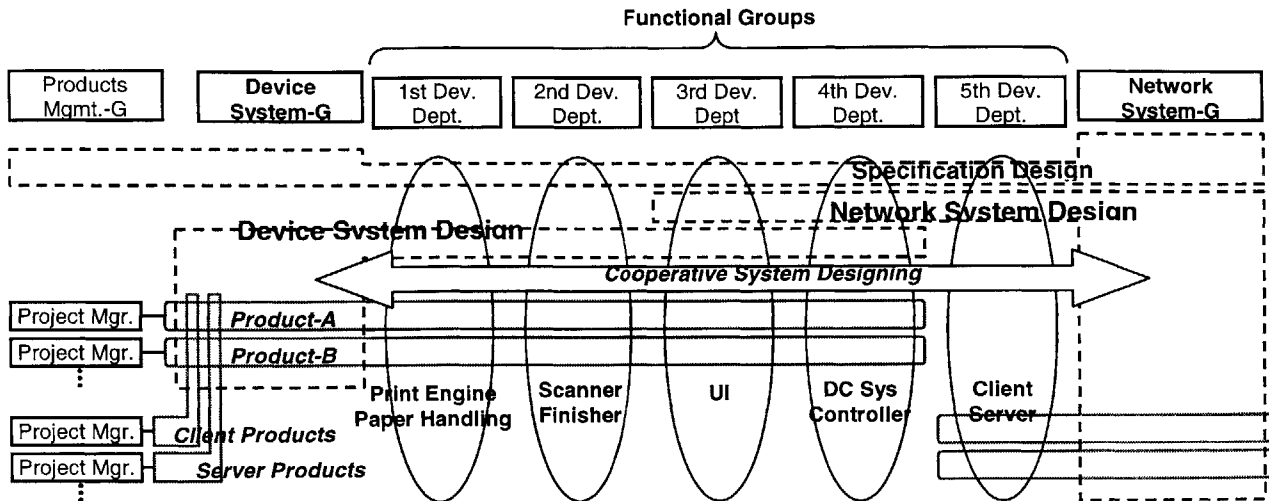
Feedback to the Business Operations:

Managing projects whose clockspeeds are different under one organizational system should be avoided. Operational clockspeed follows decision-making speed. One organizational structure should have only one operational clockspeed in order to avoid operational time-frictions; therefore as clockspeed goes up, the more decision rights for accomplishing responsibilities should be owned by each organizational unit. The higher the clockspeed, the more serious the impact of operational time-frictions on the company.

In the project-function matrix organization, the operational clockspeed follows process clockspeed. The project and the function differ in the focusing time range but operate on the same clockspeed.

An Advanced Example for Managing Clockspeed in Organization:

Based on the Clockspeed-based Product Architecture, which I mentioned in the prior section, Fuji Xerox redesigned its matrix organization in engineering and added the third structure, which manages across products or functions as described in Figure 9. The matrix structure is organized with Project-Managers (Project-Mgrs) under Products Management-Group (Products Mgmt-G) and five Functional Groups, which can be plotted to one of three sub-systems, namely Client/Server, Controller, and Device, whose clockspeeds are different. And the third structure consists of Device System-G and Network System-G sharing system designing across the products. Even though each functional group has a general manager, the product management group and two system groups are directly managed by senior executive who are also managing those general managers. With this structure, the responsibilities of each group are clarified as shown in the figure and are expected to harmonize the further development of technology , product development, and system designs across products, which are operating in the different clockspeed. However, this organization still had some operating difficulties associated with the standardized development process, and it was dissolved when the corporate structure was changed to a Business Unit structure.



Roles and Responsibilities

- Each Project Manager in Project Management Group manages his/her own project
- Functional Group is responsible for distributing modules to projects
- Device System Group and Network System Group are responsible for developing common architecture and review technologies and system design for each project
- Functional Group is responsible for the establishment of core-competency, knowledge exchange across projects, and education. It manages resources across projects
- Common features applied to a series of products are defined by task force led by Network System Group. Because Network System Group is most sensitive to industries

Figure 9: An Example of Three-dimensional Engineering Organization

Organization

There is no exact definition of “organization.” A “company” has a legal definition, but organization does not. One way to define it is as a system organized to achieve certain purposes through the collaboration of its members. An organization is a functional system with resource inputs, budgets, and materials, and output of products or services, like a PC system. If this PC metaphor were actually true, then accelerating clockspeed would increase productivity just as CPU power follows the internal clock, and in fact, we would be able to improve productivity by accelerating clockspeed without changing the organization in any fundamental way. However, we now face a tremendous acceleration of clockspeed never experienced, and the acceleration is almost entering the terminal velocity which could break existing systems, especially in those companies which have a large amount of their business in the middle clockspeed. I believe we have to create New Organization now to break through this crisis.

In the previous chapter , I clarified the clockspeed characteristics in customer value, in product, in process, and in organization . I have also argued that any industry faces a dilemma of how to balance the clockspeed, between accelerating it to obtain latest technology and competitive power or braking it to keep profitability and long-term stability, whose range is also spreading. Because of these incidents, the New Organization has to have sensitivity to a wide clockspeed-range and capabilities for designing the Product Chain and the Technology Chain. Differentiation in order to play in the different clockspeeds and systematization to manage a wider range of clockspeeds as a whole – coping with these potentially antithetical concepts is now required for the New Organization.

Learning from Existing Organizations

A most serious difficulty adjusting clockspeed can be seen in those companies that produce a wide Product Chain and must integrate a wide Technology Chain in the middle clockspeed. Here I explore key learning in organization for such companies with references to Fuji Xerox, which cyclically organized two typical structures -- development process oriented organization, and market oriented organization.

Development Process Oriented Organization:

This organizational model, as shown in Figure 10, is same as that described earlier as an organizational model in the slow clockspeed. In fact, this model has been organized in Fuji Xerox while it was operating in the slower clockspeed in the early stage when it started the business and when it focused increasing internal competencies on performing product-out marketing.

One of the advantages of this organization is that it systematically disaggregated operations with less overhead. Helped by the simplified structure of organization which directly related operational groups with top-management and the vertical decision-making structure consistent with this organizational structure, the top-down management is easy both for understanding top decisions and monitoring the operational status. Clearly separated responsibilities for each unit also help to accomplish the disaggregated goals and expand internal competencies.

On the other hand, this organization makes the responsibilities of the strategy planning unit heavy, because it has to plan actual operations with the consideration of capabilities in the operational units. Also, this organization constrains various operations because of its unified process with its presumption of unified clockspeed. Even if it tried to have several processes with different clockspeeds, it would face problems in the management of functional units caused by the clockspeed mismatches, by which I mean very different characteristics in customer value, in product, in process, and in organization (as explained in the previous chapter).

Advantages

- Systematic operation with less overhead
- Easier penetration of top decisions
- Good at cultivating functional competencies

Disadvantages

- Hard to introduce several processes, markets, or clockspeeds
- Time lags to capture customer needs into the strategies and to communicate across the functions

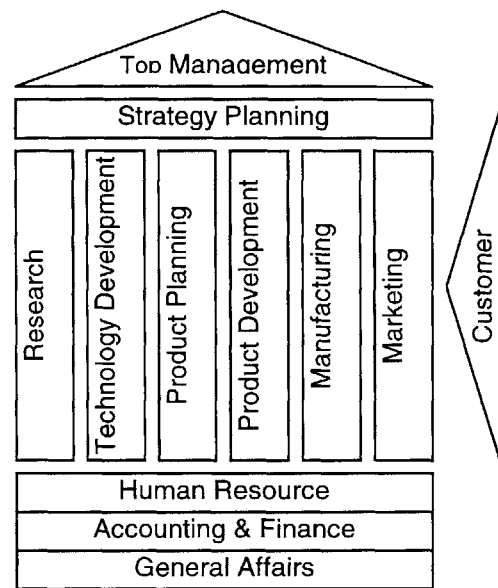


Figure 10: Development Process Oriented Organizational Model

This experience suggests that a functionally separated organization doesn't meet the requirements of the various operations with wide-range of clockspeed. On the other hand, it provides a hint of how to approach the New Organization, with its separation of a purely strategic planning from the management of actual operations, effectively enabling the company to set fundamental strategic directions that transcend the immediate interests of any single business. An example of this kind of strategy was shown in EPSON, which was described in the last chapter, that strengthened its ink-jet printer business without producing profits while obtaining profits from wire-dot matrix printers. This strategy was fundamental and affected EPSON's business results; however it didn't target developing new products or technologies and didn't dominate business operations. This strategy-planning unit seems work well to develop coherent and systematic approaches to company strategy and to design the Product Chain in the roles required for clockspeed management.

Market Oriented Organization (Business Unit model):

This organizational model, shown in Figure 11 and widely called the Business Unit model, separates engineering, manufacturing, and marketing functions into market-oriented multi-functional units. In the case of Fuji Xerox, the actual separation of manufacturing could not be made on a one-to-one correspondence to the markets, because of the limited capability of factories and the similarity of products; however, the organizational structure itself was market oriented. Fuji Xerox has used this style when it aimed at increasing customer satisfaction, expanding market share, obtaining competitive power, or storing market oriented competencies.

An advantage of this organization is empowered business operations based on the higher rate of direct/indirect operations. Since actual business operations are planned in each business unit, the overhead required for strategy planners to know operational conditions is avoidable, and the conflicts between strategies and operational conditions become fewer. And the business operation itself becomes powerful because of the concentration on the specified market and the ability to ignore constraints related to the other markets.

This advantage also provides other strengths, in that the workloads in headquarters become less, and capable people who had worked at headquarters can be distributed to the direct business operations. Also monitoring profitability of business operations becomes clearer, since each business unit is evaluated by its achievements against the revenues and profits planned at the headquarters and distributed to the business units. In this style of organization, the main responsibilities of the strategy planning unit are planning the portfolio and disaggregating it to the business units, which are accounting and funding activities rather than the actual strategy formulation.

On the other hand, this organization creates overheads between the business units and might cause internal competition. For example, if two business units sell similar products at different prices, the company faces a huge duplication in sales and development. Also, this organization might miss opportunities to develop new markets, because the development requires investment before any clear indication

of revenues, and since the ownership of the new business is not yet clear, a unit could invest in developing a new business that would then be allocated to another business unit just as it was becoming profitable. So business units may well seek to avoid this risk by focusing on expanding existing businesses rather than developing new business. This organization is appropriate for stimulating operations in the existing businesses but doesn't meet the need to develop new businesses.

Advantages

- Activated operation with reliable plan
- Closer operation to the customers
- Easier introduction of several processes, markets, or clocks

Disadvantages

- Hard to introduce corporate-wide strategies
- Operational overhead and friction
- Short-term-focused operations
- Lesser knowledge exchange across the markets

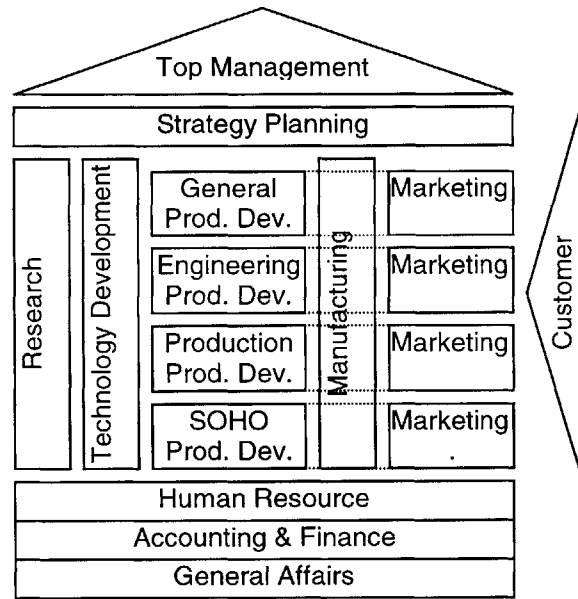


Figure 11: Market Oriented Organizational Model

Summing up, the Market Oriented Organization has advantages for energizing business operations and reducing indirect management loads through front-line empowerment. And, several processes or clocks can be held by the distributed operational units. On the other hand, strategic approaches, such as holistic operations, systematic operations, or long-term focused operations, are difficult to organize on a corporate-wide basis, and actual operations tend to focus on the individual profitability of distributed operational units. This tells us the importance of empowerment to energize various operations. The wider the operations or the deeper the technologies, the more important is the empowerment to manage those challenges. And these also give us a hint of how to approach the New Organization,

in that the operational overhead can be targeted to the higher opportunities to find new markets. In particular, even if several units face the same conditions in the market, they may find different product concepts because of their different backgrounds. And clockspeed seems one of the important differences in this background to map the opportunities facing the firm.

Clockspeed-based Organization

One solution for integrating capabilities for managing widely spreading clockspeeds into the New Organization is the organizational separation of the empowered organizations based on their clockspeed. At least, the decision rights regarding business operations must be separated into the different units and each unit should have its own decision-making structure, even if they share some of engineering or manufacturing operations efficiently. I call this Clockspeed-based Organization.

In addition to this, the Clockspeed-based Organization has to have a strong top-down structure in the mixed clockspeed organization, while simultaneously providing individuality at the local units. This structure is especially important not only for designing Product Chain and Technology Chain, but also for concentrating the top-managers of business units on their business operations. Giving the responsibilities of challenging their organizations and playing the “rebel” role to the top-managers will result in failure, since it causes frictions in his/her management. I place “Chain Architect” on this role.

Structure of Clockspeed-based Organization:

An important point of Clockspeed-based Organization is that its structure is based on the responsibilities. This is especially important for realizing empowerment in business operations while having a strong top-down structure in the mixed clockspeed organization. A strongly differentiated “Class of management” in the structure would prevent the sound work of the organization, just as in a complex software system, which never has any abstract module. “Power balance” is only a matter to stimulate smooth work and to consider assignments.

Responsibilities are largely categorized in terms of corporate governance, corporate operation, and business operation, as shown in Figure 12. Corporate governance is organized with shareholders and Directors to review overall corporate operations, which includes business results, business goals and strategies, vision and policy, and business ethics. Only few operational executives, including the CEO or President, can hold this responsibility as Directors. Reviewers in the corporate governance are operating executives, namely the President and the top-managers in the business units and headquarters who are responsible to corporate operations. Chain Architects work for them, as one of units in headquarters; in other words, their outputs are certified by operating executives and accepted by Directors. And actual business operations are the responsibility of business units led by top managers. Even though President and top-managers in the business units have duplicated missions, they are responsible to the higher operational hierarchy while having important roles to lower hierarchy.

Clockspeed-based Business Units should be classified into three speed-classes and each unit should have all functions required to accomplish its business. This does not prevent subdivision or partial merger based on the function or the market with the consideration of overhead. Also the structures under the business units should be defined individually to meet their operational styles.

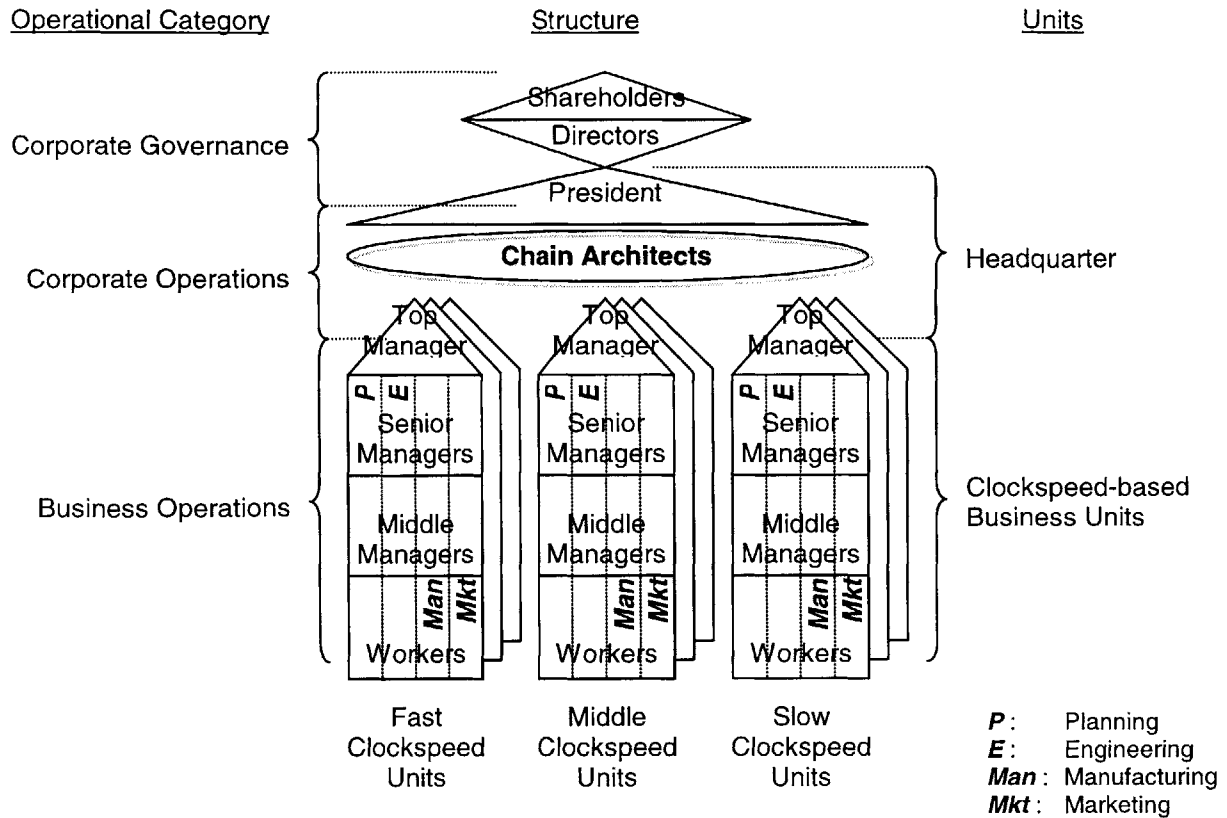


Figure 12: Clockspeed-based Organizational Model

Chain Architect:

The Chain Architect is a core element of the Clockspeed-based Organization and is responsible for designing business architecture across functions in the mixed clockspeed organization, and for distributing it with specified goals to the business units. Just like a system architect in software engineering, his/her unit is responsible for designing high quality architecture, which demonstrates strategic linkage across the business units, and introduces it to the business units, even though it is not responsible for the implementation, which involves direct operational planning and its accomplishment and therefore falls under the direct responsibility of the business unit managers.

The first responsibility is Product Chain Designing and its integration into the business units. This Product Chain Design doesn't mean simply mapping the entire

product mix. The Chain Architect, in other words, is very concerned with the product portfolio of the business units, especially new products rather than with incremental product improvements, and with the appropriate allocation of resources, and therefore has the responsibility for assessing the product portfolio as a whole.

Related to this Product Chain designing, the Chain Architect is also responsible for strategic marketing. For example, if a product mission is defined as penetrating the market within a short time, even without producing profit, the advertisement, channels, and sales incentives must be controlled strategically over the operation aimed at profitability. To have effective decision rights for the Product Chain and related matters, the Chain Architect needs to have a voice in the Business Unit's financial strategy, so as to ensure that needed resources are in fact allocated to the appropriate targets.

The second role is overall responsibility for capability chains, which include the supply chain, Technology Chain, and extended enterprise. These chains define the organizational linkage regarding engineering and manufacturing. Even though the basic idea and knowledge for designing these chains exists in the business units, holistic integration over the local interests is indispensable. The Chain Architect gathers related strategies developed at business units and redistributes them after coordinating, with a holistic point of view.

The third role is ensuring consistency of the technology strategy, market strategy, and supply chain strategy across functions within each business unit. These strategies are developed by business units; however, checking consistency across them is important, since they are counter proposals to implement disaggregated chains and these functional strategies require coordination across the business units.

To accomplish above-mentioned responsibilities, the Chain Architects also have additional roles. One is negotiation with top-managers of business units. The Chain Architect is placed in the corporate operations and works with President and the top-managers of business units. Even though the responsibilities are up-stream of the top-managers, their power is lower than that of top-managers; therefore, close negotiation is indispensable. In addition to this, their outputs should be placed as

subjects to be reviewed by Directors. This positioning makes their mission clearer and helps them obtain cooperation with top-managers and participants in the business units.

Another important role is organizing continuous communication with the strategy planners and the engineering architects in the business units. Since the Chain Architects don't always have a higher position than those planners and architects, human relationships help not only to prevent frictions but also to raise output quality. Related to this, to add political power to work among top level managers, Chain Architect should directly report to the President.

Finally, the responsibilities and roles of Chain Architects might seem similar to those of existing strategists; however, it is different in that they don't make any operational plan focused on a specified market. They design a corporate-wide chaining map in operations, products, technologies, and organizations: they are different from existing strategists just like engineering architects are different from engineers. Furthermore, the definition of their responsibilities helps ensure that corporate governance, which is becoming an increasing concern in Japanese companies, is separated from corporate operations.

Clockspeed-based Business Unit:

In this New Organization model, actual business operations targeted to specified markets should be allocated to Clockspeed-based Business Units. Headquarters should be as small and as smart as possible. The Business Units are responsible for making business plans, merging with the disaggregated goals from the Chain Architect, and accomplishing them. Also, the business units are responsible for designing the Technology Chain led by the Chain Architect, because this requires advanced skills in technologies and well-versed knowledge of the internal competencies, and of course it directly reflects their product designs.

Each business unit has all the functionality needed to accomplish its responsibilities, and its top-manager should perform as if he/she were a company president. Even though they are also responsible in the corporate operations as

certificators, these top managers have missions as executives in the business units. Helped by the Chain Architects, their mission in the operational category becomes clear, and they can concentrate on both corporate and operating unit missions without experiencing contradictions.

To make sure the individual business operations target their own clockspeed and market, each business unit has its own organizational style with an appropriate decision-making structure and process. Probably what I described in the previous chapter helps us to think about this, except the consideration of human networks across the business units. Considering their diversities of functions, business, organizations, and clockspeeds, the networks should be based on two management classes; namely, among senior managers, and middle managers and workers.

Regardless of the organizational structure, middle management is the core of business operations. As described by Professor Ikujiro Nonaka, the middle managers are the key to knowledge management. They are responsible for promoting operational strategies, since the clockspeed is usually sensed at the front-end of operation and at the bottom of the structure. They should be able to work freely and responsibility as a bridge between front-end operation and higher management. Senior managers should observe those front-end operations with experimental knowledge rather than leading actual operations.

Issues for Establishing Clockspeed-based Organization

Here, I would like to repeat the definition of Organization before stating the issues: "Organization is a functional system a functional system with resource inputs, budgets, and materials, and output of products or services, to achieve certain goals through the collaboration of members." This covers adequately the business operations, which is a matter of course because the organization is originally designed to follow business operations. This means that organizations followed top-down strategies planned under the executives managing whole organization. However, now we can see some cutting edge organizations whose strategies could be affecting the operations and the organizational structure, and those are created by the middle management. In those organizations, the processes of sensing the market, creating strategies, and even synergizing engineering or marketing operations are all the results of the interactions that occur quite normally and naturally in the organization –at least in terms of ideals. Each organization should have a regular planning cycle, whose timing is determined by the budget cycle; however, significant changes occur in the market or in technology that do not occur in phase with the planning cycle. An organization whose key actors at the "front-line" of company and middle managers are sensitive to change in the market or environment can quite naturally respond with the appropriate shift in strategy. Clockspeed-based Organization should include such dynamism and grow by itself without having master organizers. However, the organizational structure itself doesn't have such dynamism, and the shifts in organization can be very slow; therefore, the synthesized effects of human networks become indispensable.

Knowledge Chaining

As I mentioned in prior chapters, the key point of the Clockspeed-based Organization is dividing the organization into multiple empowered business units and setting the actual operations in the middle-to-lower level in the units. However, it doesn't work without having a dynamic capacity for sensing markets, creating strategies, improving technologies, synergizing functions, and developing products. Furthermore, the Clockspeed-based Organization should have internal dynamism that enables it to reform itself. This dynamism should be integrated into human networks separated from the formal organizational structure so as not to make contradictions in the business operations.

In particular, encouraging knowledge chaining and dynamically processing it internally is important, since the network itself can be static. For example, the Internet is useful because it allows dynamic connecting networks and circulates information freely, while itself being rooted in physical equipment. And it is going to be more useful since the network is expanding. If this metaphor tells us something of the truth, we may organize human networks as another structure in the organization and utilize them for knowledge chaining. There might be such networks called "the second organizational structure" rather than the "underground activities" in task-works or some of other temporal activities that have previously been analyzed by technology management experts.

Scalar Knowledge and Vector Knowledge

There are many kinds of definitions for knowledge, for example, Tacit knowledge and Explicit knowledge are widely accepted definitions. Professor Ikujiro Nonaka developed a model of a knowledge chaining process as shown in Figure 13, with this definition of "Knowledge Creation". However, now I would like to analyze knowledge chaining based on the dynamism of human networks, which might be a bit more specific than his explanation. The organization of knowledge chaining has

two patterns: gathering knowledge to accomplish a certain purpose, and simply exchanging or storing knowledge without having clear purpose. I call the former Vector Knowledge Chaining and the latter Scalar Knowledge Chaining. In the business world, knowledge has value when it is used for something; namely, Vector Knowledge Chaining is regarded as the more important.

One of the typical Vector Knowledge Chaining aspects is task activity. Task is a temporal network organized by higher management to accomplish a certain purpose, and each participant has some mission. The process of organizing the task is top-down; however, the decision making process is not always top-down, since the task is organized to cover the shortfall of the official organization and the decision-making structure for its outputs is not always clear. Tasks differ from Project Oriented Organization in this point even though some of them are similar to it.

An example of Scalar Knowledge Chaining is what is called information sharing. Even though the information itself is not required for objectives, it enables future knowledge creation synergized across knowledge clusters. For example, corporate business status doesn't help in solving engineering problems but it might be helpful to define some trade-off in specifications caused by the problems. In exchange for not to having clear purpose, the process of Scalar Knowledge Chaining is bottom-up and the network exists routinely.

Similarly, knowledge is categorized to Vector Knowledge and Scalar Knowledge. The former includes some specific purpose or goal. With this definition, Vector Knowledge Chaining is organized gathering knowledge based on the Vector Knowledge, and Scalar Knowledge Chaining is organized exchanging knowledge without having such a task-oriented basis.

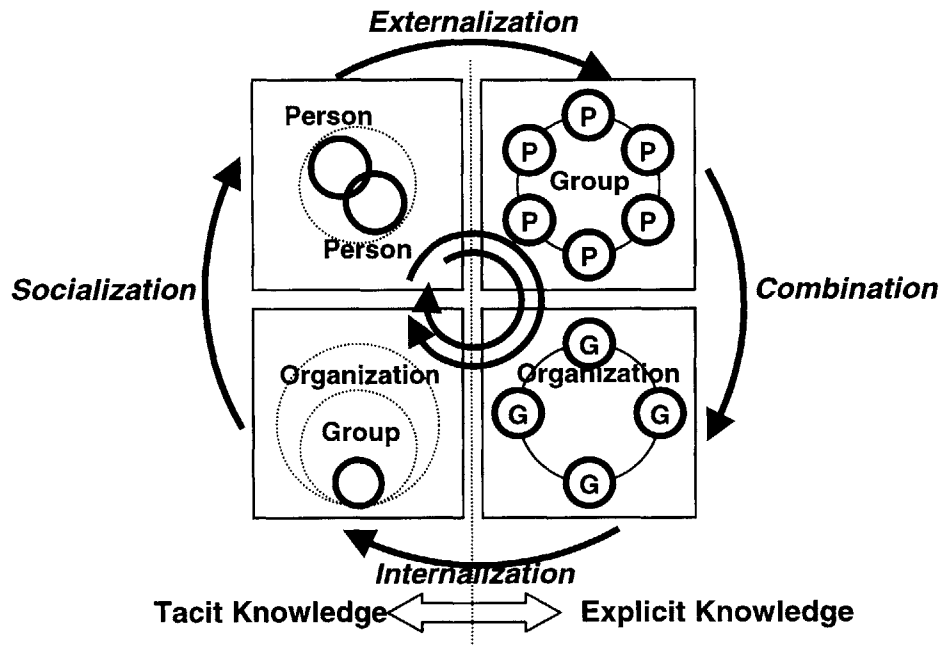


Figure 13: Knowledge Conversion (Nonaka's Model)

Examples of Knowledge Networks in the Clockspeed-based Organization:

As I said, human networks might be the second organizational structure since its importance is becoming ever higher, and no one can manage knowledge without knowing its structure. In the following descriptions, I use the word "network" to include the meaning of team, task, and communication route. One of the important knowledge networks is regarding business information. Not only the vertical communication along the organizational structure but also horizontal information sharing across organizations is important to know the current status and to find what problems are being tackled. This also helps to know clockspeeds in customer value, product and organization.

Another important knowledge network is the one regarding professional knowledge such as engineering, manufacturing, or marketing. These networks generally handle explicit knowledge and are not restricted to inside the Business Unit but also cross Unit and even more extend outside the enterprise (for example,

to industry or academia). Of course, this kind of knowledge must be gathered onto the vector knowledge when the goal has been set; however, ceaselessly storing this scalar knowledge helps to define better goals.

One more important kind of professional knowledge is experience, including know-how. Organizing networks for this kind of knowledge is quite difficult, since much of it is tacit and hard to share even if some of it can be shared as descriptions of case-facts. Personal communication through so called "Mentorship," is a common path taken in companies instead of informal networks. Holding discussions when experimental knowledge is required might be a form of temporal networking.

Regarding networking areas, not only the vertical communication along organizational structure but also horizontal information sharing over the processes and across the organizations are quite useful for individuals to know what is happening around them and to estimate what the effects will be on their activities and career. This also helps to feel operational clockspeeds in the organization.

Finally, all the above-mentioned knowledge is scalar knowledge generally, because it is rare that vector knowledge networks exist continuously. Those are usually organized temporally and dissolve when they have achieved their goals. Even though gathering scalar knowledge into the vector knowledge network is common, it is difficult to connect both networks directly since the participants of scalar knowledge network are not clearly identified.

Knowledge Chaining Dynamism

Productive knowledge chaining (which has been defined here as Vector Knowledge Chaining) is organized in terms of two patterns: one top-down, and another bottom-up, and Vector Knowledge exists as a concept in each case. In the top-down case, the concept is first created by a decision-maker, and the required knowledge is gathered to realize the concept. A famous example is the Sony Walkman. One day, President Morita put a cassette case on the table where his engineering managers were meeting and said, "Can you make a cassette tape deck in

this size?" It might seem to be a simple engineering question, but the managers were strongly interested in the tape deck. They started to draw rough sketches of system while collecting technological information available, of course hopefully inside the company but reaching more broadly where necessary. On the other hand, they asked planning managers and marketing managers to make product concepts analyzing customer usage and the benefit of using a cassette case sized tape deck. All activities were undertaken in parallel, since technologies and tape deck features are all trade-offs against the size and related to the product concepts. Many product concepts and designs were built and scrapped. And all activities went underground until all participants felt convinced of the value of promoting the activity to a project. The marketing managers finally made the product concept as a music playbaker and denied recording functionality in order to keep the cassette case size and to make clear the usage. And the engineering managers had found the key technologies -- flat motor, small rechargeable battery, and micro speaker -- inside Sony to realize the cassette size music playbaker. Eventually they got a successful review by President Morita about Walkman.

The Walkman story tells a typical pattern of the top-down approach. At first, a core team is put together based on an idea or a mission handed down from a top manager. The team members are capable enough to establish basic concepts and share the wide area of their professional expertise. Then, based on the established concepts or by clarifying basic concepts, they gather the information needed to realize those concepts and make an operational plan. Finally, the director reviews the plan and decides whether go to the next steps and organize an official project. In other words, abstract goals exist and the direction is set, if conditions are clarified at the starting point, and knowledge chaining is smoothly performed by the core members. If I use Nonaka's model to examine the Walkman case, Externalization, even it might be of a relatively primitive kind, exists at the first stage, and core members performed Combination. All knowledge is explicit and core members integrate Scalar Knowledge into Vector Knowledge after evaluating it with the vector.

On the other hand, it can be difficult to promote bottom-up productive knowledge chaining and to move activities from this domain into the official portfolio of projects. This doesn't simply mean that there is no direction at first, but only that the knowledge chaining has to be organized by the individual vector knowledge creator. Finding additional knowledge from wide area on one's own is quite difficult, and potential knowledge contributors are not always cooperative.

Another difficulty in the bottom-up productive knowledge chaining is the phase transfer from scalar knowledge to vector knowledge. This phase transfer is similar to Externalization, from tacit to explicit knowledge, according to Nonaka's Model. In the above-mentioned case, it is more difficult to gather the additional knowledge if the vector itself is yet unclear or if helpful scalar knowledge is yet uncertain. Often the scalar knowledge owners are not aware of how they could be helpful to the vector knowledge. The opportunity for integrating scalar knowledge into vector knowledge simply depends on the possibility the two domains of knowledge meet each other.

Considering both the difficulty of bottom-up knowledge chaining and the tremendous opportunities it offers if it can be promoted, there are some companies trying the middle-way of combining top-down and bottom-up. For example, Fuji Xerox produced "Virtual Hollywood," which consists of four stages: the first is advertising for candidate, the second is selecting the idea, the third is advertising for contributors, the fourth is project formation. This is a kind of contest to encourage the transfer from scalar knowledge to vector knowledge and lead creative vector knowledge into the business; in fact, there have been many applicants. However, the results were not so useful in terms of business development, considering the cost and the time spent for the contest (although the company was pleased with the demonstrations of employee creativity). One reason is that the vector knowledge is not naturally emergent. Therefore the company experienced what sociologists have called "goal displacement": the original goals were displaced by emergent goals. In this case, in spite of its original motivation of creating new business, the purpose of the sponsoring organization became holding a successful contest, while the goal of participant became winning the contest. The criterion for starting the projects were

ultimately defined according to the budget, namely the maximum number of projects allowable under the allocated resources, not the idea itself. Another problem was a mismatch of opportunities for people who have creative ideas and who can create good ideas. Many of them probably could not apply to the contest because they were too busy with their regular work. It is usually the case that truly capable persons are always busy.

Finally, ideally, Knowledge Chaining Dynamism is naturally emergent: Vector Knowledge Chaining emerges from Scalar Knowledge Chaining. This dynamism can make the organization grow while producing various opportunities to integrate bottom-up idea into business operations and strategies. An example similar to this kind of dynamism but in a different function is Kaizen, which is an activity to promote naturally emergent ideas on the production floor to the official organization. However, it differs in that Kaizen spotlighted the line-workers, and the decision-makers, who decide whether or not to use the idea, are their managers. The truly ideal dynamism should be realized as a system to start some structured activity when the accumulated or synergized knowledge reaches a critical level. However, without having some facilitating system, expecting this kind of transformation from scalar to vector knowledge chaining to emerge spontaneously is quite hopeless.

Issues for Installing Knowledge Chaining

An issue of productive knowledge chaining is how to create a system that continuously generates Vector Knowledge Chaining. Adding to this, we must face another issue if we succeed in encouraging knowledge chaining: that the friction between official activities and underground activities would become critical. In the Clockspeed-based Organization, all members have their own responsibilities in business operations. and they must balance these with any underground activities that they undertake on their own. From the viewpoint of top management, each person's formally assigned organizational responsibilities are more mission-critical than underground activities. However, encouraging productive knowledge chaining might actually threaten the salience of organizational responsibilities, because if

creative individuals manage to link with each other spontaneously in the course of their underground activities, their interest must be amplified by this support. Activating personalities and encouraging diversity might be essential for increasing organizational capabilities; however, the increased entropy might become uncontrollable and interfere with organizational missions.

Adding to this, the same kind of friction might be created across Clockspeed-based Business Units. As I argued, Product Chain Designing and Technology Chain Designing across the business units are essential in the Clockspeed-based organization; however, clockspeed conflict usually makes for fundamental problems.

In short, we have to reduce friction across units of the Clockspeed-based Organization and between business operations and knowledge chaining. And this becomes more important in encouraging knowledge chaining, as shown in Figure 14.

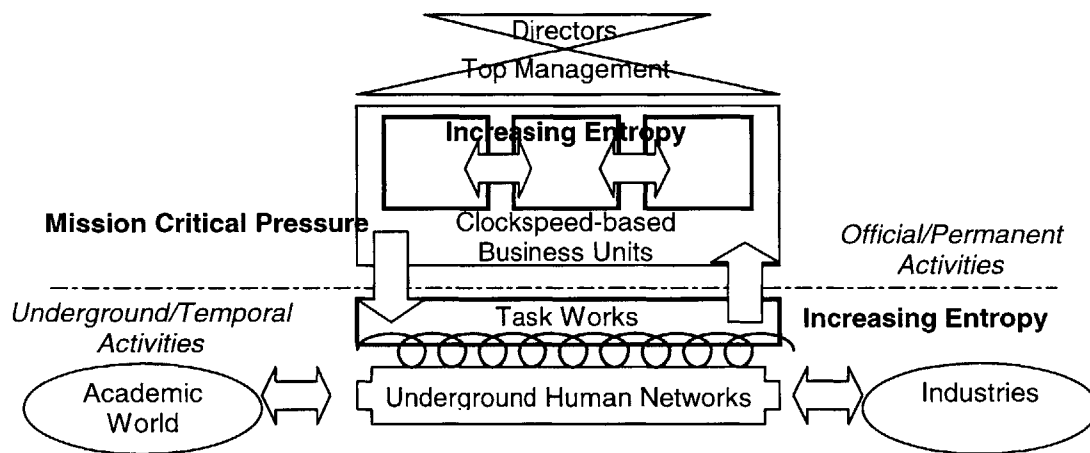


Figure 14: Frictions between Business Operations and Knowledge Chaining

Chain Integrator

I place the “Chain Integrator” into the two key roles of working as a catalyst in the knowledge chaining and buffering friction across business units and between business operations and underground activities. The Chain Integrator’s first responsibility is helping knowledge chaining by identifying and linking networks or activities that have the potential to be mutually helpful. As I once said, bottom-up productive knowledge chaining is difficult, since it relies on the possibility that mutually helpful knowledge meets serendipitously. Chain Integrators increase that possibility by introducing the knowledge sources to each other. Also, they take and relay the knowledge of the small number of outstandingly capable individuals, who don’t have time to join underground activities. Their work is just like the “Search Engine” in the Internet (which I used earlier as a metaphor for knowledge chaining). The main work of Chain Integrator lies not in joining the actual operations, but coordinating and promoting productive knowledge chaining by knowing where the knowledge is located, who has the knowledge, and how valuable the knowledge is in a particular context.

On the other hand, this “intelligent switch” role of Chain Integrators provides a connection between the two kinds of human networks across business units identified earlier: one among senior managers, and the other connecting middle managers and the operational front-lines. Generally the knowledge of senior managers is scalar knowledge rather than vector knowledge since most of them are senior persons and have long experiences in their fields. In contrast, most of middle managers tend to create vector knowledge, since they are facing actual problems in their operations. Their youth also helps to provide productive knowledge chaining, since the knowledge stored and problems faced are both rather explicit. The existence of Chain Integrators could make both networks clearer than before. So far, it is generally recognized that the higher the management level, the higher the responsibility to find the solution, and that senior managers have seemed to be responsible for creating a solution by gathering all knowledge under his/her management.

Also, Chain Integrators advance underground activities into official activities by integrating the results into Product Chain Designing or Technology Chain, through activities such as recommendations to the Chain Architect, or offering counsel to the top-management of Business Units. It is usual that the outputs of underground activities, for example, "Tasks," are shrunk to be manageable for participants since true decision-makers are not involved to such activities. By providing an information route to the correct decision-makers, they maximize the work of underground activities and motivate the participants. They should be catalysts for productive underground activities.

Finally, Chain Integrators bridge the formal organization and underground activities by preventing friction which may develop between organizational missions and interests produced through knowledge chaining. They should not actually bridge individuals into organizational missions or to higher-level managers, since those are the roles of the formal organizational managers. However, the above-mentioned roles of Chain Integrators include making individuals feel comfortable in coping with the pulls between official activities and underground activities. The main troubles of those who are motivated to diverse knowledge creation activities are barriers against expanding their idea into the official operations. The provision of a seamless pipeline between organization and individuals must decrease the kind of entropy which may explode organizational roles. Chain Integrators also help smooth communications across Clockspeed-based Business Units, since many of the underground activities and human networks they observe straddle the Units.

Shadow Organization

The concept of the Clockspeed-based Organization has been developed in this thesis as one that combines differently structured business units and human networks, and also dynamically encourages productive knowledge chaining and smoothly promotes it into the business operations. Furthermore, this dynamism leads to the self-renewing of organization. However, drawing such a complex organization and writing up the responsibilities in it are quite difficult without changing the basis of organizational design. If we cannot draw an organization on paper, no one can manage it.

Here, I introduce three-layered organizational model, which is shown in Figure 15, extended from the previous version in which I introduced human networks as the second organizational structure. I am now adding a second layer, intermediate between the other two. I name those layers; Clockspeed-based Organization, Shadow Organization, and Human Networks respectively. The Shadow Organization is the middle layer and has its own formal structure connecting the Chain Integrator with the Chain Architect. It has overall responsibilities to distribute knowledge selectively through the Human Networks to the Clockspeed-based Business Units.

So far, much of the literature on technology management has been simplifying activities in companies by separating the organization into two layers: official activities clarified with organizational missions, and other activities performed underground. And such underground activities as tasks were seldom recognized as organized in their own right, even if their responsibility was important. We have been designing organizations based on managing structure coincident with the responsibilities in the official activities. However, this three-layered model recognizes human networks as an organizational structure and separates certain knowledge management activities from the management of regular business operations.

I use two different organizational charts to explain Shadow Organization. One is intended to explain the strategic roles and political roles, shown in Figure 16, and the other to explain the cultural roles, shown in Figure 17.

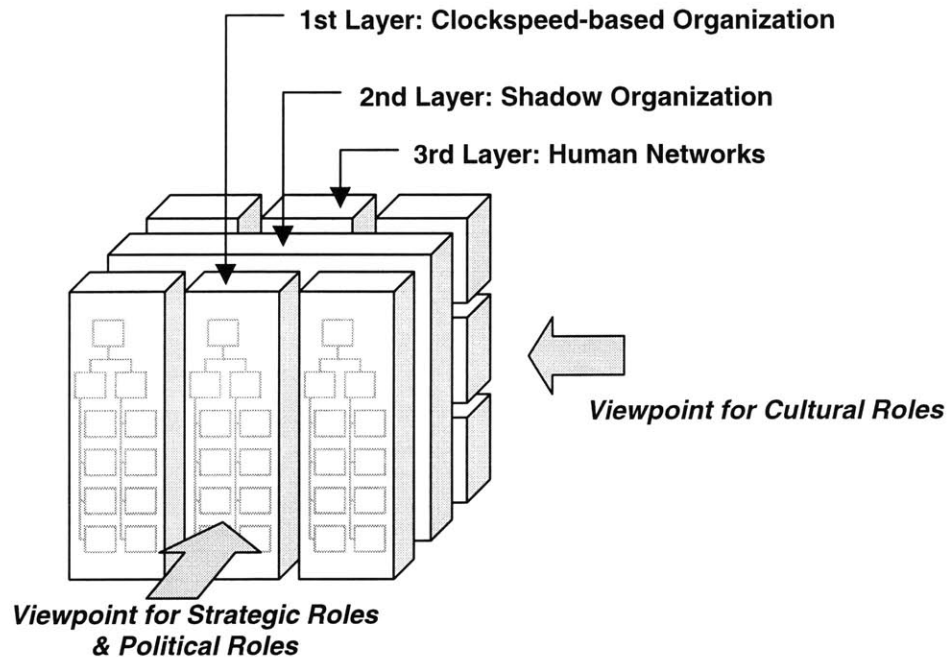


Figure 15: Three-layered Organizational Model

Strategic Roles

The strategic role of the Shadow Organization is managing Clockspeed, and its first mission is designing the Product Chain and leading Technology Chain Designing. This design directly means generating the corporate-wide revenue and profit strategies, and relates to the other strategies regarding supply chain management, including extended enterprise and alliance, and branding and advertisement, all considering future growth. To accomplish this mission, Chain Architects operate as a brain by creating original plans and negotiating with the President and the top-managers of Clockspeed-based Business Units. Chain

Integrators work as a nerve system to sense current conditions and future trends in each business operation. Chain Architects and Chain Integrators work together, regardless of their positions in the organization, sharing responsible areas. The former takes a centralized position and the latter take distributed positions.

The second mission in Clockspeed management is raising a signal when business operations are estimated to face corporate-wide problems, based on continuous observation of industrial developments and business operations. No well-designed Product Chain or Technology Chain is permanent, since it covers a range from fast clockspeed to slow clockspeed, and fast clockspeed always has wide effects because of its ambiguity. For example, in the case where a Business Unit has found a new business market estimated to grow quite rapidly, but where entering the market requires a capability which another Business Unit possesses, it is not only a matter for discussion by those two units but also a matter affecting the Product Chain. Of course, actual operations are the responsibility of the Business Units and the Shadow Organization doesn't have the decision right to capture the new business, but such matters should be reviewed at least once from the corporate-wide strategic viewpoint. Planning resource exchanged across the units is also a part of the Shadow Organization's responsibilities.

Finally, the strategic roles of the Shadow Organization are stating the business roles of Clockspeed-based Business Units and coordinating the balance of actual operations. Any problems across Clockspeed-based Business Units should be discussed under the leadership of the Shadow Organizations. Chain Architects and Chain Integrators require cooperation with the sense of fast clockspeed and the insight focused on the long term. In other words, they have to "Move fast and make long term solutions."

Political Roles

Identifying the political roles of the Shadow Organization is especially important to prevent interruptions caused by power struggles. The Shadow Organization seem can seem obstructive to those in power -- for example, to executives in the Business Units, since its roles act against any intentions they might have to demand more power for their Business Units and to increase their own influence in the corporation. It is important that the Shadow Organization takes a position working for the CEO and Directors, such that cooperation with it is valuable for those who want more power. For this, Chain Architects have an office in headquarters even if their daily work is performed at different locations. Separating Directors from operating executives is also useful for this point.

Chain Integrators mainly perform the actual political roles of Shadow Organization. They work for the top management of Business Units, in addition to working with Chain Architects. As I once said, they are the nerve system of the Clockspeed-based Organization and are responsible for informing the brain, the Chain Architect. On the other hand, they should solve problems inside the Business Units at an early stage, to prevent them from becoming critical or corporate-wide, just like autonomic nerves. This role is useful for both top management in the Business Units and for Chain Integrators themselves, since contribution to the Business Unit are indispensable to gain acceptance in the business operations.

However, Chain Integrators should not be involved in the regular operation in the Business Units. Such avoidance is necessary to keep themselves free from fetters in the business operations. Hopefully, they should be access points for top management in the Business Unit to its operational front-end and its underground activities, a role which is described in the next section, and they should also be a pipeline for senior managers to capture corporate-wide information. Their assets are information and knowledge and they should perform quite politically instead of managing real resources.

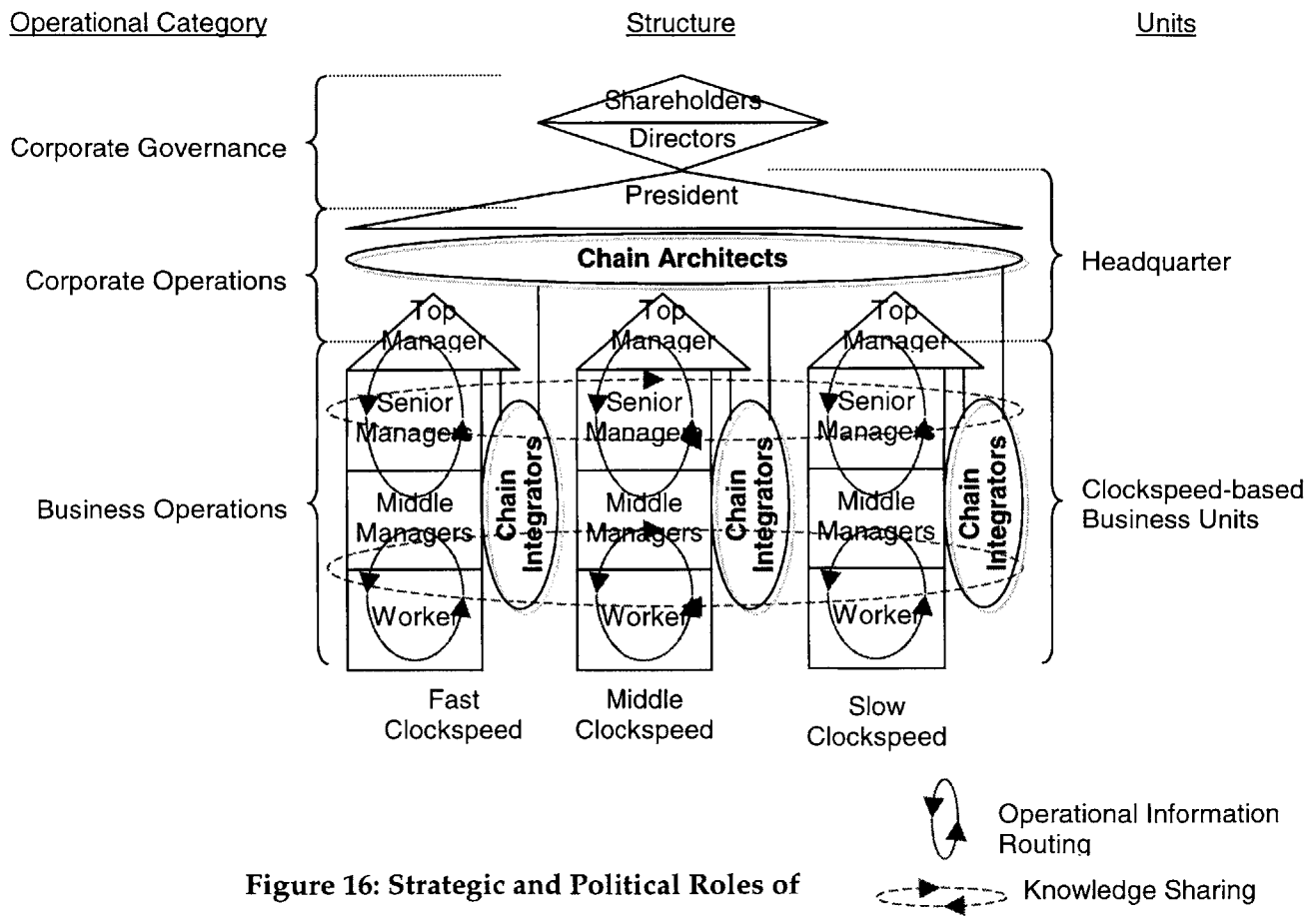


Figure 16: Strategic and Political Roles of Shadow Organization

Cultural Roles

The most important cultural role of Chain Architects is their very existence. I by this I mean that the existence of the position signals clearly that corporate-wide strategies are separate from operational strategies and top managers of Business Units are mainly responsible for managing business operations. Even though they must contribute to the corporate-wide strategies, and the strategy defines their responsibility in this regard, the quality of the strategy itself is not their responsibility. Their existence clarifies operational categories and responsibilities of

managers, and not only makes them concentrate on their roles but also clarifies to all participants who is responsible for what in management.

Chain Integrators have additional important cultural roles, because they operate in the business units with the operators to synergize their work. Their operations in the business unit would lead the culture in the Clockspeed-based Organization.

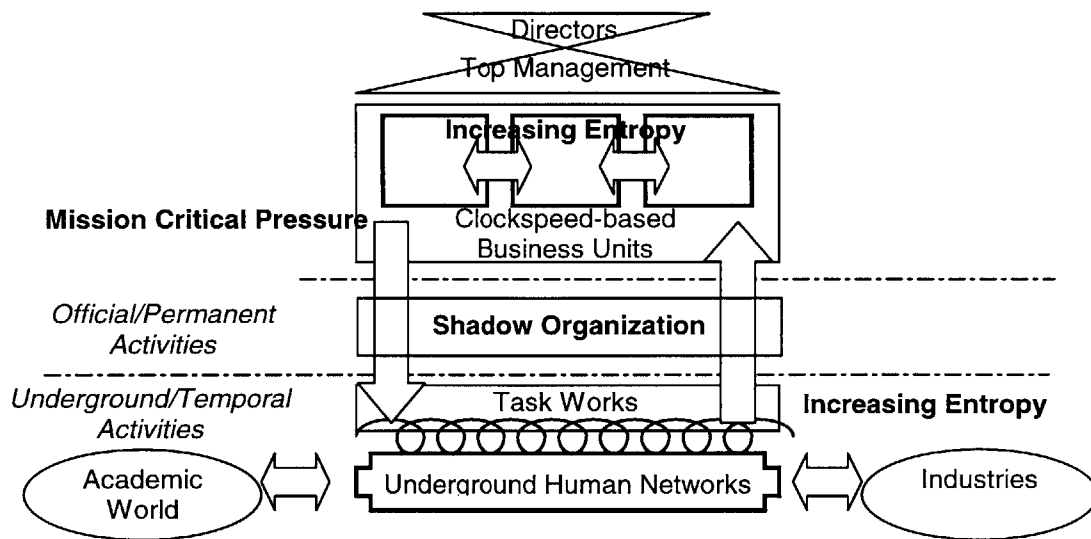


Figure 17: Cultural Roles of Shadow Organization

Conclusion

In the last two decades, industries have been shifting the focus of their improvement activities upstream in their process: Quality Control (which was mainly focused on manufacturing) in 80's, Reengineering (which was focused on management and support activities) in the 90's, and Knowledge Management (focused on R&D and upper-level management) in the current decade. This also can be seen as a shift from hardware to process, and towards ever more highly developed human abilities. The increasing complexity and ambiguity in products and customer values has gone beyond the area controllable by one manager, even a genius. Now everyone knows that we should establish systems and techniques to enable organizations to perform remarkable tasks with ordinary people. However, few new organizational models have been produced so far, in spite of their importance in energizing people, creating synergies, and maximizing human abilities.

In this thesis, with the clarification of the characteristics of Clockspeed, which is becoming a fundamental factor in business operations, a new organizational model was introduced, focused on the dynamic integration of knowledge and the creation of ideas to relay into business operations. It proposed building an intermediate layer of organization to mediate between the formal Business Unit structures, which are separated into three clusters based on the operational clockspeeds, and the informal human networks that have long been recognized as crucially important for technical organizations. The key elements of this new layer are the Chain Architect and the Chain Integrator. The role of the Chain Architect is to add strong top-down integration into the mixed clockspeed organization and the Chain Integrator role was proposed to manage knowledge chaining and encourage Scalar Knowledge Chaining to shift into Vector Knowledge Chaining.

On the other hand, this modeling might be interesting in that it shifts the definition of organization from the structure of formal units or the hierarchy of management to the system of human process and adds system designing techniques in engineering into organizational design. In particular, it adds clarified

responsibilities through creating new positions without increasing the burden on the established roles of “managers” and organizational layers without increasing “underground activities.” The principle of this modeling is that the more complex the functions in organization, the more clarified the responsibilities of positions should be. Clarifying responsibilities is more important than simplifying the organizational structure (as is done, for example, in re-engineering). From now on, gathering engineering skills through effect management roles and processes will be indispensable not only in the organizational design but also in the challenge of managing knowledge across clockspeeds.

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