Foresight, Complexity, and Strategy

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FORESIGHT, COMPLEXITY AND STRATEGY

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ABSTRACT

What is a strategy? The answer to this question ought to depend on the foresight horizon: how far ahead, and how much, the strategist thinks he can foresee. When the very structure of the firm's world is undergoing cascades of rapid change, and interpretations about the identity of agents and artifacts are characterized by ambiguity, we say that the foresight horizon is complex. We argue that strategy in the face of complex foresight horizons should consist in an on-going set of practices that interpret and construct the relationships that comprise the world in which the firm acts. Our discussion focuses on two intertwined kinds of strategic practices. The first is cognitive: a firm "populates its world" by positing who lives there and interpreting what they do. The second is structural: the firm fosters generative relationships within and across its boundaries--relationships that produce new sources of value that cannot be foreseen in advance. We illustrate the ideas advanced in the paper with a story about the entry of ROLM into the PBX market in 1975.

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What is a strategy? Once upon a time, everybody knew the answer to this question. A strategy specified a precommitment to a particular course of action. Moreover, choosing a strategy meant optimizing among a set of specified alternatives, on the basis of an evaluation of the value and the probability of their possible consequences. Business schools trained a generation of MBA's in optimization techniques, and strategic planning departments and consulting firms honed these tools to fit a myriad of particular circumstances. For a while, strategy as optimizing precommitment was a growth industry. And it still flourishes in some environments, both theoretical1[1] and practical.[2] But it is fair to say that this notion of strategy is falling into increasing disfavor in the business world, to the extent that the CEOs of some important and successful firms will not permit the word "strategy" to be uttered in their presence. It is not hard to find the reason why. Optimizing precommittment makes sense when a firm knows enough about its world to specify alternative courses of actions and to foresee the consequences that will likely follow from each of them. But of course foresight horizons are not always so clear. All too often too many agents[3] doing too many things on too many different time scales make for a combinatorial explosion of possible conse-

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[1] Within university economic departments, strategy as optimized precommittment provides the nearly unchallenged foundation for microeconomic theory.

[2] Senior partners in a leading consulting firm told us that 80% of their firm's strategic consultancies still culminate in a formal optimization exercise.

[3] In this paper, we use a few terms that may at first seem like unnecessary jargon, but for which we do not find ready, unambiguous substitutes in ordinary language. These include agent, actor, artifact, space, generative relationships, attributions and identity. When we introduce these terms, we will present definitions--generally in footnotes--that we think will at least orient the reader to what we have in mind; the full meaning we intend these terms to bear will, we hope, emerge as we use them throughout the article.

By "agent", we mean any collection of people that jointly engages in economic activity. Individuals are agents (we generally refer to them as “actors”) and so are firms--as are the marketing group assigned to a particular product in a firm, a team of researchers working together to develop a new product, or an industry-level trade association.

quences--and when that happens, foresight horizons get complicated. If you cannot even foresee a priori all the important consequences of a contemplated course of action, never mind carry out expected gain calculations, you must constantly and actively monitor your world--and react quickly and effectively to unexpected opportunities and difficulties as you encounter them. As a result, an essential ingredient of strategy in the face of complicated foresight horizons becomes the organization of processes of exploration and adaptation.[4] But suppose the very structure of the firm's world--that is, the set of agents that inhabit it and the set of artifacts[5] around which action is organized--undergoes cascades of rapid change. Then, the metaphor of exploration breaks down. The world in which you must act does not sit passively out there waiting to yield up its secrets. Instead, your world is under active construction, you are part of the construction crew--and there isn't any blueprint. Not only are the identities of the agents and artifacts that currently make up your world undergoing rapid change, but so also are the interpretations that all the agents make about who and what these things are. What can strategy mean, when you lack even a temporally stable language in which to frame foresight?

Our paper offers a partial answer to this question. The paper proceeds as follows. In the first section, we distinguish between three kinds of foresight horizons: the clear, the complicated and the complex. Our problem is to formulate a notion of strategy that makes sense for complex foresight horizons. Any such notion must be premised on an understanding of how changes come about in these situations. So in Section 2, we tell a story that will help us to identify some of the mechanisms underlying these changes: in particular, we highlight the role of what we call attributions[6] and

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[4] The recent burst of literature on the "learning organization" testifies to the growing importance of this conception of strategy [1-5].

[5] By "artifact", we mean any object or service around which economic activity is organized--in particular, objects and services designed, produced and exchanged by economic agents. And by "object", we mean not only cars, movies and telephones, but software systems, architectural blueprints and financial instruments as well.

[6] An “attribution” is an interpretation of meaning by an agent to itself, to another agent or to an artifact. An agent has meaning in so far as its actions can be interpreted coherently in terms of an identity: that is, the functions towards which the agent’s actions are directed and the “character” that informs the ways in which these actions are carried out. An artifact’s meaning concerns

generative relationships.[7] In Section 3, we extract four lessons from our story, which we apply in Section 4 to arrive at a partial formulation of what strategy means in the face of a complex foresight horizon. Our discussion focuses on two intertwined kinds of strategic processes. The first is cognitive: a firm "populates its world" by positing which agents live there and constructing explicit interpretations of what these agents do. The second is structural: the firm fosters generative relationships between agents within and across its boundaries--relationships that produce new attributions and, ultimately, sources of value that cannot be foreseen in advance.

1. FORESIGHT HORIZONS

- Picture an eighteenth-century general perched on a hill overlooking the plain on which his army will engage its adversary the next day. The day is clear, and he can see all the features of the landscape on which the battle will be fought--the river and the streams that feed it, the few gentle hills, the fields and orchards. He can also see the cavalry and infantry battalions positioned where he and his opponent have placed them, and he can even count the enemy guns mounted in the distant hillsides. The battle tomorrow will consist of movements of these men across this landscape, movements determined in part by the orders he and his staff and their opposite numbers issue at the beginning of the day, and in part by the thousands of little contingencies that arise when men, beasts, bullets and shells come together. While he cannot with certainty predict the outcome of all these contingencies, nor of the battle that together they will comprise, he can be reasonably sure that one of a relatively small number of scenarios he can presently envision will actually come to pass.

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the way in which agents use it. See Section 4.2 for more discussion of these ideas; examples are provided there and in Section 2.

[7] By “generative relationship”, we mean a relationship that can induce changes in the way the participants see their world and act in it and even give rise to new entities, like agents, artifacts, even institutions. Moreover, these changes and constructions cannot be foreseen from a knowledge of the characteristics of the participating agents alone, without knowledge of the structure and history of the interactions that constitute the relationship between them. See [11] for an extended introduction to this concept.

- Now think about a U.S. cavalry column marching through an uncharted section of Montana in the early 1870s. The commanding officer cannot know the location of the nearest river or whether there will be an impassable canyon on the other side of the hills looming over his line of march. Nor does he know where the Indian tribes who inhabit this country have established their camps or whether they are disposed to fight should he come into contact with them. He knows the general direction he wants to take his men, but it would not pay him to envision detailed forecasts of what the next days might hold, because there are too many possibilities for unexpected things to happen. Instead, he relies on his scouts to keep him informed about what lies just beyond his own horizon, and he stays alert and ready for action. He is confident that he will recognize whatever situation he encounters, when he encounters it.

- Finally, imagine the situation of the Bosnian diplomat in early September, 1995 trying to bring an end to the bloodshed in his country. It is very difficult to decide who are his friends and who his foes. First he fights against the Croats, then with them. His army struggles against an army composed of Bosnian Serbs, but his cousin and other Muslim dissidents fight alongside them. What can he expect from the UN Security Forces, from the NATO bombers, from Western politicians, from Belgrade and Zagreb, from Moscow? Who matters, and what do they want? On whom can he rely, for what? He doesn't know --and when he thinks he does, the next day it changes.[8]

Uncertainty figures in all three of these stories, but it does so in ways that differ in two important respects:

- *Time horizon of relevant uncertainty.* In the first story, the general's uncertainty has a clear terminal date: tomorrow, when the battle will have been fought and either won or lost. After that, other problems will surely arise and occupy his interest, but for now everything focuses on the battle, the matter at hand. The cavalry commander is concerned with getting his troops

[8] Since we wrote this paragraph, many things have changed. But it only reinforces the point that we are trying to make to emphasize to our reader that, whenever you are reading this paper, we are practically certain that the Bosnian diplomat is in nearly the same situation of uncertainty, but with a different cast of relevant entities.

to their assigned destination, a matter perhaps of several days or weeks. For the Bosnian diplomat, there is no obvious end in view.

- *Knowledge of relevant possible consequences.* The general knows what he is uncertain about: not only just which side will win the battle, but also the kind of events that will turn out to be decisive in determining the outcome--which troops will move to what locations, engaging which adversaries, under what conditions. The cavalry commander too could probably also frame propositions about almost anything likely to be relevant to the completion of his mission, but it would amount to a very long list, most items of which would not turn out to matter anyway. In contrast, the Bosnian diplomat would be at a lost to name all the actors and events that could affect the outcome of the drama of which he is a part. In fact, no one could name them, because in the working out of the drama, new actors keep getting drawn in, and they create new kinds of entities--like the Rapid Deployment Force or the abortive Moscow Peace Meeting--that simply could not be predicted in advance.

The general, the cavalry commander and the Bosnian diplomat face three different kinds of foresight horizon. The general's horizon is clear. He can see all the way to the end of it, and the contours of all the features from here to there stand out in bold relief. This of course does not mean that he knows what is actually going to happen; but he can be reasonably sure of what might happen and about how his actions will affect the likelihood of the various possible outcomes. In contrast, the cavalry commander's horizon is more complicated. He knows the kinds of things that might happen before he arrives at his destination, but because of the sheer number of possible geographical, meteorological and social combinations it is difficult to imagine them all at the outset of his mission. Nonetheless, he thinks he knows how to find out about the eventualities that are likely to matter in time to respond efficaciously to them. The Bosnian diplomat's horizon is certainly complicated, but there is more to it than that. Unlike the cavalry commander, his problem is not just to negotiate his way through a fixed landscape composed of familiar if presently unknown features. The social landscape through which he moves constantly deforms in response to the actions he and others take, and new features, not previously envisioned or even envisionable,

emerge. To understand where he is going--and where he has been--he has to generate a new language even to describe these features, and he must also reinterpret many things that he had been regarding as fixed, but whose character has been changed by their relation to the features that have just emerged. Since his destination is always temporally beyond his current foresight horizon, the connection between what he does and where he is going is always tenuous and hence ambiguous. Inhabiting as he does a world of emergence, perpetual novelty and ambiguity, the Bosnian diplomat's foresight horizon is complex.[9] The emerging world of “multimedia”[10] well illustrates the key features of complex foresight horizons as they present themselves in business. This world, like any other business domain, is characterized by a space[11] of agents and artifacts, which are structured by various relationships--between agents, between artifacts, and between agents and artifacts. In some domains, like the textile or oil industries, these spaces are relatively stable. In contrast, multimedia’s is changing very rapidly. New firms come into being almost daily. Boundaries between existing firms are reshuffled through mergers and acquisitions--and interpenetrated through strategic alliances and other kinds of joint enterprises. What is emerging is a complex cross-cutting network of collaborative and competitive relationships, and it is sometimes unclear which is which. Moreover, it is hard to classify the artifacts these agents are producing into such previously separable categories as telecommunications, computers, electronics, media, entertainment, software, or banking. Even the very identities of key multimedia artifacts are up for grabs: is the

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[9] The new sciences of complexity are concerned with describing and explaining phenomena associated with emergence and self-organization. For an engaging introduction to some of these ideas, see [6], while [7] provides a synthesis of recent developments from the biological perspective. [8-10] relate aspects of complexity to economics.

[10] Just what this world ought to be called is still under negotiation by the agents that are playing a part in its construction. Some refer to it as “the information superhighway”, while others prefer a more prosaic description as the merging of voice, data, graphics and video. From our point of view, this linguistic confusion is symptomatic of the fact that the attributions of the artifacts around which this world is being organized is still “under construction.”

[11] We use "space" to denote a structured set. For agent and artifact space, the set consists of all the agents who are involved in some industry activity and the artifacts are the things these agents design, make or exchange, while the structure is provided by the various kinds of relationships that exist between these agents and artifacts.

“set top box” at which the consumer will explore the information superhighway a television, a personal computer, or some entirely new device? But more is changing in multimedia than the structure of its agent/artifact space: how agents perceive their own and each other's functionality--that is, who does what, to (and with) whom (and what)--is changing as well. Telephone companies are no longer sure about what they ought to be providing to their customers: is it primarily connectivity, or is it content? Conversely, cable companies wonder if they should be providing voice communication service. In the face of challenges from software vendors and credit card companies, banks have to rethink just what roles they’ll be playing in five years--and how they’ll be doing it. Structurally, then, multimedia is emergent; cognitively, it is ambiguous. Emergent structure and cognitive ambiguity generate complex foresight horizons for firms caught up in--or plunging into--the multimedia vortex.

2. THE ROLM PBX STORY[12]

After enough time passes, complex foresight horizons can be made to look clear, at least in retrospect. In this section, we tell an old story that illustrates some essential features of the process whereby agent/artifact spaces change their structure. The story describes what happened when ROLM, a small California computer company, decided to enter the PBX market in 1973. The 1968 Carterphone decision had sent a shock through the telecommunications world whose effects were to be felt for years to come. In particular, foresight horizons in the PBX business got complex, and ROLM was able to take advantage of the situation. Within five years of its first PBX sale, ROLM challenged giants ATT and Northern Telecom for leadership in the then $1 billion PBX market. ROLM had a strategy when it launched its PBX product, but events quickly invalidated many of the assumptions on which this strategy was based. In particular, the primary line of long-term product development envisioned in the strategy was shelved within a year of their first shipment. Certainly ROLM managers made some right moves as they scrambled to keep up with the consequences of what they had initiated. But the lessons of our story are not about

[12] Our version of the story relies on various ROLM marketing and strategy documents currently in the possession of one of us (RM), a co-founder of ROLM who led its PBX division, and material collected in a Stanford Graduate School of Business case prepared by Professor Adrian Ryans.

ROLM managers as strategists; in fact, it won’t even be clear what strategy has to do with what happens, a point to which we will return in section 3. Instead, our story is about how change happens in the presence of complex foresight horizons--and in particular, about how and where the understanding of new possibilities for artifacts and the social arrangements to which they give rise come into being.

2.1 The US PBX Business in 1973: Agents and Artifacts

A PBX is a private telecommunication system that manages an organization's incoming, outgoing and intraoffice telephone calls. It connects outside lines that are provided by the local telephone company, which in 1973 would have been an ATT operating company or a so-called independent like General Telephone. Before 1968, all PBX's were provided by the local telephone company. ATT companies used PBX equipment manufactured by ATT subsidiary Western Electric; General Telephone had its own manufacturing subsidiary, Automatic Electric; and the smaller independents bought the PBX's they installed from a handful of producers, including Automatic Electric, Northern Telecom and Stromberg Carlson. In large part because of the supply monopoly enjoyed by the local telephone companies, PBX technology had not kept pace with innovations in semiconductors and computers. Most PBX's still used electromechanical switching technology and had only a few "convenience" features like call-forwarding. In 1968, the Federal Communication Commission's historic Carterphone decision broke the monopoly on PBX's. Now businesses and other organizations were free to lease or buy their internal telecommunications systems from any purveyors, not just the local telephone company. The Carterphone decision gave a jolt to the space of agents organized around PBX's. Many new companies entered the PBX business. In particular, a whole new kind of business was created: the interconnect distributors, who configured, installed and maintained business communications systems. By 1973, there were more than 300 interconnect distributors, competing with the telephone companies for shares in the nearly $500-million PBX market. These distributors came in many different sizes and shapes, from "mom-and-pop" local suppliers to $25-million-a-year-revenue national subsidiaries of large conglomerates, several of which--like ITT and Stromberg Carlson--also manufactured PBXs. Most local or regional distributors sold mainly to small companies with less than 30 telephone extensions, while the

largest national distributors targeted big customers with up to several thousand extensions. Other distributors specialized in particular niche markets, like hotels or hospitals. Unlike the flurry of change in distribution channels, PBX products did not change much after Carterphone. Several large established foreign PBX manufacturers entered the US market and quickly captured a small market share. But the equipment they sold was quite similar to what was already in the American marketplace, and competition was primarily centered around price. By 1973, some firms--most notably ITT in America and IBM in Europe--were producing PBX's with superior technology, like analog electronic switching, and enhanced functionality, like limited customization capacity. But the really big anticipated technological innovations were widely regarded as still being well over the horizon. In particular, it was thought that neither digital switching nor computer-based control would be feasible in terms of cost and reliability for at least seven or eight years. Digital switching would provide the means to integrate voice and data into a single system, while computer control would make possible such additional functions as least-cost routing of long-distance calls, automatic dialing, and call-detail recording--and would permit an organization to move telephone numbers from office to office just by typing commands at a keyboard, rather than by ripping out and rewiring cable.

2.2 How Telecommunications Managers and PBXs Defined Each Other

It is worth pausing here to ask why PBX design changed so slowly after Carterphone. "Technological limitations" is an easy answer, but it is wrong, as ROLM's success with both digital switching and computer control was soon to show. Certainly there is a lag between the decision to go with a new design and a product launch, but this cannot be the explanation either, since ROLM shipped its first system within 18 months of its decision to make a PBX--and ROLM had nothing like the human, dollar or infrastructural resources of an ATT, an ITT, an IBM or even a Stromberg Carlson. We think the right explanation is social, not technological: PBX buyers had no incentive to ask for a system that could do anything other than what existing PBX models already did. To see why this was so, we need to look at the role of the telecommunications manager (TM), the officer who was responsible for administering the PBX system in larger firms. In particular, the TM initiated PBX purchase orders, subject to the approval of his higher management.

Before 1968, the TM had had few choices to make about the system his company used and little opportunity to maximize the system's cost- effectiveness. His main duty was to monitor his company's needs for outside lines and internal telephones. When a change was needed, he called the local telephone company, gave them the information, and accepted whatever recommendations the telephone company had to offer. Even though telecommunications costs were substantial, often around 3% to 5% of a company's revenues, there were almost no opportunities for effective telecommunications management. As a result, TMs tended to be ex-telephone company employees, with little incentive to be creative--or training or experience in how to be creative managers, even if the will were there. TMs stood in stark contrast to information systems managers, who played a major role in most companies in devising strategies to enhance the productivity and effectiveness of all parts of the company through the use of computers. Carterphone ended the enforced dependence of the TM on the local telephone company, but it could not change patterns of interaction that had formed over decades between the TM and his suppliers, or between him and his higher management. Nor could it change attributions that the TM, his higher management, and his suppliers all shared: in particular, that a PBX is just a switchboard connected to telephone sets at one end and an outside line at the other; and that managing a PBX means making sure that there is a servicable telephone on each desk where one is needed. After Carterphone, when vendors of PBX systems with over about 100 extensions competed for sales, they pitched their products to TMs, who passed purchase recommendations up the line to higher management. The pitch was made to and from actors who shared the attributions we have just described. Within the framework of these attributions, existing PBX systems did exactly what PBX systems ought to do.

2.3 ROLM Enters the PBX Business

In 1973, ROLM was a 4-year-old Silicon Valley company manufacturing militarized minicomputers, with annual revenues around $4 million and fewer than 100 employees. The firm's top managers had decided to diversify because they felt that, for a variety of reasons, they could not grow beyond about $10 million a year in the military computer market, and they were seeking larger growth opportunities. ROLM had developed competencies in designing and manufacturing computers, but it was prohibited from entering the

general purpose commercial computer market by licensing restrictions on a base technology it had obtained from Data General. So top ROLM managers were seeking to find a market opportunity in which they could build a product using embedded computer technology. The PBX market attracted them, because it was large enough so that even a small market share would represent significant growth for ROLM. For ROLM management, the attraction of making a PBX was precisely the opportunity of introducing computer control and digital switching. The electrical engineers who ran ROLM were convinced that a PBX based on these technologies was feasible now. In June, 1973, ROLM hired two engineers from Hewlett-Packard to begin designing their PBX, and in August it recruited an HP marketing manager to do a market analysis. The analysis was very encouraging: computer control would not only permit a variety of desirable "convenience" features, but would result in such substantial cost savings in long- distance tolls and in moves and changes that the cost of the PBX would typically be recovered in less than two years. Since a single design could not possibly span the whole PBX market, ROLM management decided to target the 100-800 extension range, because the computer at the heart of its system would be too expensive for small installations, while systems with thousands of extensions would mean long selling cycles, few buying decisions per year, and credibility problems for a tiny company like ROLM taking on the ATT giant. In November, the market analysis and the engineering group's technical feasibility study convinced the ROLM Board of Directors to go ahead with the PBX project.

2.4 ROLM’s Marketing Strategy: Building Relationships with Telecommunications Managers

ROLM management now had to decide how to market their system. ROLM was simply too small a company to establish its own sales/installation/service network from the start. ROLM managers were unwilling to become dependent on a single national distributor, all of which were losing money and had poor service reputations anyway. Trying to sell to the independent telephone companies did not seem like a good first step: first, these companies had glacially slow decision-making procedures; and second, even if ROLM were able to win contracts with all of them, it would still be excluded from the major market areas under ATT control. The only remaining alternative was to contract with local and regional interconnect distributors, which is what ROLM decided to do. But

this decision posed a difficult marketing problem. Most of the local and regional distributors were only selling small systems, and so they lacked experience and contacts with the kind of companies that would need a 100-800 extension PBX. ROLM adopted a two-pronged approach to this problem. First, it sought to educate its local distributors to the special problems involved in selling to larger firms with multiple levels of decision- making. When ROLM contracted with an interconnect distributor, it required the distributor's sales people to attend a ROLM training program, staffed by instructors recruited from IBM and Xerox. Second, ROLM sought to establish direct relationships with the TMs of large firms such as General Motors, Allied Stores, and IBM. It did this by creating a group of "national accounts" representatives, ROLM employees whose mandate was to provide "liaison and support" to major customers. But the representatives’ first task was to start talking to their targeted TMs, to let them know what the ROLM technology would be able to do for them, to find out what their problems were, and to figure out how ROLM could help solve them. When the ROLM representatives first contacted the TMs, they faced an uphill task: they were asking these managers to give up a safe and easy relationship with the local telephone monopoly in favor of a new product embodying fancy new technology, manufactured by a tiny California computer company, and installed and maintained by a small, young, local interconnect distributor. Needless to say, the initial progress was slow. Many TMs were too risk-averse to look seriously at the ROLM alternative. But some were convinced, and after their initial ROLM PBX installations verified the representatives' claims of dramatic cost savings and productivity enhancements, the TMs became eager converts and pushed to purchase more systems for other company sites.

2.5 The Relationships Become Generative: Transformations

ROLM targeted the TMs because they needed to sell systems to them. But the relationships between their account representatives and the TMs yielded far greater dividends than ROLM managers had ever envisioned. Here, we recount some of the innovations--in products, attributions, and even identities--to which these relationships gave rise.

New Products: The pioneering TMs who had taken a chance on ROLM found that the ROLM PBX did indeed produce substantial cost sav-

ings, which the system computer even helped to calculate. When the TMs reported these savings to their higher management, they became corporate heroes, as had their information system counterparts in the early days of computerization. As a result, these TMs were rewarded with increased budgets and responsibilities and were encouraged to continue to drive down telecommunications costs as rapidly as possible. Some responded to the new challenges and began actively to seek new opportunities for savings and productivity gains. Their search was channeled by their understanding of the technological possibilities of the digital-switched, computer-controlled PBX, derived from their ongoing discussions with their ROLM account representatives. One TM had been interested in purchasing an Automatic Call Distribution (ACD) System, like those used by airlines to handle reservations. Such systems route a large number of incoming calls among many specially trained employees, and permit supervisory monitoring and the collection and analysis of traffic patterns. Unfortunately, existing ACD systems were very large and very expensive. So the TM posed a question to his ROLM account representative: could the ROLM PBX be programmed to do basic ACD functions? The account representative took this question back to ROLM engineers, who said yes, the idea was technically feasible--and ROLM marketers found, through a series of conversations with other national account representatives and their customers, that almost every company had the possibility, scattered around its organization, for small clusters of agents to use ACD functions (order processing, customer service, account information and so on). Consequently, ACD features were incorporated into the third release of ROLM software, and it became a smash hit. Another TM worked for a large retail chain with many stores in an urban area. She wanted to be able to provide 24 hour phone answering but could not justify the expense of having an operator in each store. So she asked whether it would be possible to have all the operators at a central location, with incoming calls automatically routed there by the PBX in each store, and then rerouted, when appropriate, back to a particular store. This idea led to what came to be called Centralized Attendant Service, which turned out to be useful to customers in a variety of industries.

An Emergent Product Attribution: Over the next several years, a whole set of product enhancements came out of the interactions between customer TMs and ROLM account representatives. These en-

hancements fulfilled new functionalities that were invented in response to new understandings about what a PBX could be, combined with an intimate knowledge of the business environment in which particular PBX systems were being used. In time, the very idea that users had about what a PBX was changed--from a telephone system, to an intelligent interface between a company and outsiders, to a tool that could be adapted to solve a wide range of "line of business" voice-based applications, providing productivity improvements in many aspects of customers' operations. It is interesting to note that ROLM's idea of what a PBX could be changed too. In the original business plan for the ROLM PBX, much was made of the potential that digital switching offered for integrating a company's voice and data systems. While ROLM engineers were eager to realize this enticing vision, their efforts in this direction were side- tracked for several years, as the customer-generated voice applications were given top priority.

A New Identity: As attributions about what a PBX was changed, so too did attitudes about the role and status of TMs. From a relatively low-level "custodian" of a company's telephonic system, the TM began to be perceived as a major factor in the ability of a company to enhance its productivity and to respond to customers. In many companies, the position became equal in importance to the information systems manager, often with a vice-presidency attached. For those TMs who personally experienced the growth in their own status and responsibilities as a result of their involvement with ROLM products, the relationship with ROLM intensified--and often these managers became more loyal to ROLM than to their own employers.

Relationships Generate Relationships: The “new” TMs not only bought new ROLM products for their own companies, but helped to extend ROLM's market penetration in other ways as well. For example, many were active in the International Communication Association (ICA), an organization for the TMs of large companies. Each year, the ICA held a convention, at which the members discussed topics of professional interest and product vendors were invited to display their wares. At these conventions, ROLM backers in the association gave formal presentations describing productivity-enhancing applications of the ROLM system--and afterwards, over drinks in the bar, talked about the personal rewards and recognition they had won for championing ROLM inside their companies. As

a result, other TMs actively sought out ROLM and its distributors. The relationships ROLM had established between the targeted TMs and its account representatives had other positive effects for ROLM as well. First, ROLM had targeted the large, progressive companies for their initial efforts. When they succeeded with these companies, they greatly enhanced their credibility with smaller, less sophisticated customers. More importantly, ROLM's ties to the TMs enabled its strategy for expanding distribution coverage into secondary and tertiary markets to succeed. ROLM first concentrated on the largest metropolitan markets, where it relied on local and regional interconnect companies for sales, installation and service. In smaller markets, ROLM intended to use independent telephone companies as its distributors of choice, since these companies had advantages in finance, experience and contacts over local interconnect companies. The idea was to first win over the big independents--GTE, United Telephone, Continental Telephone. Then, the 1500 or so smaller telephone companies would be easier to convince, as they tended to look to their bigger brethren for leadership. Unfortunately, GTE was highly bureaucratic and owned its own manufacturer, Automatic Electric. To get GTE to carry the ROLM PBX, its engineering department had to certify product quality, and the approval process could take years. To accelerate the process, ROLM got a few of its "national accounts" customers with sites in several GTE territories to call their GTE marketing representatives and advise them that they would not be allowed to bid on their PBX installation projects unless GTE could propose ROLM equipment. As the number of such jobs mounted, GTE Marketing besieged Engineering with requests that the ROLM evaluation process be expedited. The tactic worked: in record time, GTE announced it was adding the ROLM PBX to its list of approved products. Shortly after, many other independents jumped on the bandwagon, significantly increasing ROLM's market coverage.

2.6 The US PBX Market in 1980

All of these transformations greatly changed the PBX market. While in the past, around 7% of the installed base of existing PBX's turned over every year, the technological innovations that ROLM introduced (and other companies adopted as quickly as they could) led to a huge bubble of demand. Within seven years of ROLM's entry into the PBX market, virtually the entire installed base was replaced. In 1980, the PBX sales totaled nearly $1 bil-

lion. ROLM's PBX business vastly exceeded management's most optimistic predictions. The original business plan's best-case forecast was $12 million in revenues in the third year; the actual figure was $50 million, and two years later revenues exceeded $200 million. Less than 5 years after installing its first PBX, ROLM had attained a 23% share of the US PBX market, second only to ATT. In complete contrast to the situation in 1973, the PBX market throughout the 1980s had a quite stable structure: three firms--ROLM, ATT and Northern Telecom--virtually shared market leadership, with very little left over for any other competitors.

3. LESSONS FROM THE ROLM STORY: HOW CHANGES IN AGENT/ARTIFACT SPACE HAPPEN

When foresight horizons are complex, the structure of agent/artifact space undergoes cascades of rapid change. Benefiting from these changes requires understanding something about how they happen. In this section, we highlight four lessons from the ROLM story that bear on this question, and we point out four implications of these lessons for strategy in the face of complex foresight horizons.

Lesson 1: Structural change in agent/artifact space is mediated by new attributions about the identity of agents and the meaning of artifacts.

Discussion: Attributions about what an artifact “is” and what agents “do” matter. The meaning that agents give to themselves, their products, their competitors, their customers, and all the relevant others in their world determine their space of possible actions--and, to a large extent, how they act. In particular, the meaning that agents construct for themselves constitute their identity: what they do, how they do it, with and to whom. Of course, every action is not necessarily preceded by an explicit interpretation of the agents and artifacts that inhabit the context in which the action takes place. Far from it: particularly in relatively stable worlds, recurrent patterns of agent interaction are triggered by the sheer familiarity of the situations in which the agents find themselves. In such situations, the role of attributions in guiding action may recede into the background, and participating actors may never consciously interpret the agents and artifacts with whom they interact. When foresight horizons

become complex, though, every situation contains some elements of novelty. If agents register this novelty, they engage in conscious deliberation to make sense of the situation before they commit themselves to act in it.[13] Of course, this deliberation does not necessarily lead to new attributions: often, instead, a situation's apparent novelty can be interpreted away by dredging up old attributions that are misidentified as "facts" or common knowledge, thus locking agents into ways of thinking and acting that blind them to emerging threats to their market position or to new opportunities for value creation. In the ROLM story, this is what happened to ITT, Stromberg Carlson and other companies that were in the PBX business before 1973--and were out of the business by 1980. Alternatively, agents may indeed generate new attributions when they encounter new entities or relations in agent/artifact space. These new attributions may lead to actions that in turn give rise to further changes in the structure of agent/artifact space. Here are some examples of this phenomenon from the ROLM story:

- ROLM managers in 1973 interpreted a PBX differently than did ATT and other manufacturers. ROLM's attribution came out of its understanding of computer control and digital switching: they saw a PBX as a flexibly configurable communication system with both voice and data potential. This attribution informed their initial product offering and their early development projects. The successful launch of the first ROLM product had a major impact on the future configuration of the PBX agent/artifact space. As a result of some of these changes, ROLM management changed its attribution about PBXs--and with it, the direction of their development efforts.

- The TMs who were early adopters of a ROLM PBX saw ROLM as an ally in innovative system-building, an attribution that no TM extended to ATT. Of course, this attribution led to the joint conception of a series of new PBX features and products.

- Changes in the way in which many companies' top management interpreted the role of TMs led to new value creation opportunities for ROLM and its competitors in the mid-1980s.

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[13] See [11] for an account of agent cognition that underlies what we are saying here.

By emphasizing the role of attributions, we do not mean to imply that causal relations between attributions and action go only one way. Clearly, attributional shifts depend upon particular action histories: for example, it would have been impossible for TMs to come to see their jobs as innovating productivity-enhancing communications systems had they not purchased and installed systems capable of generating and documenting substantial cost- savings and subsequently worked with ROLM account representatives and applications engineers to develop modifications of these systems. We emphasize the role of attributions in causing action, rather than the other way around, because we believe that agents can learn how to “control” the process whereby they form new attributions more effectively than they can “control” directly the effects of action on attributions or on structural change--and strategy, as we shall argue in section 4, is about control.

Lesson 2: Generative relationships are the locus of attributional shifts.

Discussion: This lesson is well illustrated by the attributional shifts that transformed the PBX from a switchboard connecting telephone sets with outside lines to a suite of productivity-enhancing line-of-business voice applications. Neither the TMs nor the various ROLM actors involved in this transformation--account representatives, development engineers, top management--could have achieved it by themselves. The transformation arose in the context of the relationships among all of these agents. Consider in particular the generative relationship between TMs and ROLM account representatives. The account representatives worked to establish discursive relationships with TMs, in the context of which the TMs could come to understand the technology on which the ROLM system was based and the new functions and opportunities for cost-savings this technology offered. This understanding took time to develop. During the conversations that led up to it, the account representatives also learned a lot from the TMs, about the complex patterns of voice communication inside large companies and the ways in which TMs interacted with their managers and the suppliers and users of the systems they administered. The shared understandings that emerged from these conversations underlay the PBX feature innovations that emerged from the TM - account representative relationships. It is important to realize why the ROLM account representative--TM relationships became generative, and

those between, say, ATT salesmen and the TMs were not. In terms of their attributions about the role of PBX systems and their administration, the ATT salesmen and TMs saw everything eye-to-eye, at least before the changes unleashed by the ROLM PBX after 1975. This attributional homogeneity meant that the ATT salesmen and the TMs had nothing to learn from each other--and certainly no basis on which to establish a relationship around conversations that could challenge how each viewed what a PBX was and what it meant to administer a PBX system. The problem was not that ROLM listened to its customers and ATT did not: it was that the customers had nothing to say to ATT that could change how either ATT or the customers thought or acted. In fact, the interactions between ATT and the TMs were channeled into recurrent patterns in which their underlying shared attributions played no explicit role and so could never be up for negotiation. As this example illustrates, not every relationship has the potential for generativeness. At a minimum, there must be some essential heterogeneity or distance between the participants--in attributions, competence, even access to artifacts or other agents; and then there must also be some shared directedness, to make the participants want to bridge the distance between them. The TMs and ROLM account representatives had very different attitudes towards and knowledge about digital technology and the problems of voice communications in large companies, but they were both directed towards a notion of a “cost-saving PBX system”. In their conversations, they began to construct a common understanding according to which the ROLM PBX was, or could be made to be, such a system. As their relationship developed, they changed the whole conception of what “cost- saving” might mean, culminating finally in the idea of “productivity-enhancing”. As we discuss in more detail in section 4, monitoring and maintaining the generativeness of relationships constitute essential strategic competencies, especially in the presence of complex foresight horizons. Monitoring must be an ongoing activity, since there is no guarantee that a relationship that at one time is generative will stay so forever. In fact, there is always a danger that the very success of the relationship in bridging the distance between its participants can destroy its potential to continue to generate anything new. Just which relationships can be generative at any given time depends in subtle ways on the current structure of agent/artifact space, on agent attributions and competencies, and on the opportunities agents have to communicate with other agents, about what. The firm is not the right unit in

which to think about generative relationships, which makes the task of monitoring relationships for generativeness even more difficult. There can be generative relationships between component agents--groups, departments or divisions--of the same firm, as well as generative relationships that cross firm boundaries. Moreover, different relationships between components of the same agents may have very different generative potentials: for example, the drug safety departments of some pharmaceutical firms may have generative relationships with units of a national regulatory agency, while the firms' legal department or marketing division or top management may have nongenerative, essentially adversarial relations with the same unit or even the agency as a whole.

Lesson 3: Structural change in agent/artifact space proceeds through a "bootstrap" dynamic: new generative relationships induce attributional shifts that lead to actions which in turn generate possibilities for new generative relationships.

Discussion: This is the key feature of the dynamics of structural change under complex foresight horizons: they are characterized by "constructive positive feedbacks." That is, new configurations in agent/artifact space breed further configurations, mediated by the generation of new attributions: generative relationships among agents give rise to new relations between artifacts (including new artifacts!), which provide new opportunities for generative relationships between agents. The whole ROLM story can be read as an example of this phenomenon. These constructive positive feedbacks have an obvious cognitive counterpart: as the structure of agent/artifact space undergoes ripples of change, new agents and artifacts come into being and old ones acquire new functionalities, so identities change--and hence old interpretations of identity bear an increasingly strained relationship with observable actions, the facts of the world. Different agents respond differently: some respond to the resulting ambiguity by generating new attributions to make sense of experienced novelty, and so attributional heterogeneity increases--increasing further the possibility that participants in other relationships will achieve sufficient attributional diversity to become generative. In general, sooner or later "hot" zones in agent/artifact space cool off, as other, negative feedback processes come to dominate the constructive positive feedbacks we are emphasizing here. Since our intention here is to focus on strategy in complex foresight horizons, we

will not discuss these negative feedback processes. From the strategic point of view, the important thing is to learn to recognize what kind of foresight horizon is appropriate for the current situation and to employ strategic practices adapted to the requirements posed by that horizon.

Lesson 4: The “window of predictability” for the attributional shifts and structural changes that characterize complex foresight horizons are very short--and virtually nonexistent outside the particular generative relationship from which they emerge.

Discussion: No one can foresee what can emerge from the kind of constructive dynamics we have just described. Before a particular generative relationship has even come into being, there is no perspective from which one could imagine the new attributions it will create, much less the new possibilities for artifacts and agent relationships that these attributions will permit. Thus, during periods of rapid structural change, when the rate of creation of new generative relationships is high, windows of predictability for the phenomena to which they give rise must be very short. Even after new structures arise in agent/artifact space, it is only the structures themselves--new agents, new artifacts, new functional relationships between agents and artifacts--that are publicly observable, not the attributional shifts that made their construction possible. Frequently, these shifts have a cumulative aspect--new attributions lead to actions that in turn induce changes in the attributions. When this aspect is most pronounced, there is a strong cognitive barrier preventing other agents from breaking into the innovative cycle, which may be exclusively confined to a particular set of generative relationships. In fact, this is what happened to ATT. They were able to imitate new features already built into ROLM products, but not to “catch up” attributionally in a way that would allow them to conceive of features ROLM was about to innovate--or to form their own generative relationships that would give rise to an alternative framing of a future direction for business communication products.

Our four lessons describe the dynamics of structural change in agent/artifact space. These dynamics have important implications for the meaning of strategy under complex foresight horizons:

Implication 1: The first requirement for successful strategizing in the face of complex foresight horizons is to recognize them for what they are. Failing to detect changes in the structure of agent/artifact space, or interpreting the new structures through the lens of old attributions, are sure paths to failure.

Discussion: From our after-the-fact perspective, it is clear that firms in the PBX business in 1973 faced a complex foresight horizon. Although the pace of technological change in PBX's had not yet picked up from its pre-Carterphone, monopoly-induced crawl, there was little reason to think that this situation would last much longer. In particular, the mushrooming growth of interconnect distributors since 1968 made it ever more likely that technology-intensive companies like ROLM could successfully enter the PBX business, without any previous experience in the telecommunications industry. After that happened, who could know what PBX's would become? But existing PBX manufacturers do not seem to have interpreted their situation in this way. They acted as though they expected the rate of PBX technological change to continue to be what it had been in the past--perhaps accelerated a bit if IBM should decide to enter the American market. Their main concern seemed to be with pricing their products competitively, with some companies placing a secondary emphasis on establishing superior reputations for service. They envisioned their competition coming from exactly the same companies and on exactly the same terms as the current ones. In short, to them, the foresight horizon seemed clear, and they could afford the luxury of "optimizing" pricing and R&D-allocation strategies. As a result, most of them were out of the PBX business by 1980, and the ones that were left had to change course dramatically to survive. How about ROLM? What they saw in 1973 was a technologically backward industry, populated by a set of firms that, for a variety of reasons, was not likely to react quickly to the technological opportunities that the ROLM managers themselves believed were already realizable. They also came to appreciate, with somewhat more difficulty, that the post-1968 changes in PBX distribution provided them with an opportunity to market their PBX system. That is, from the outside, they perceived the PBX agent space as structurally unstable. This perception motivated their decision to enter the PBX market, despite their small size, lack of communications experience and inability to field their own distribution and service system.

Implication 2: Recognizing the existence of structural instability is not enough: it is also necessary to realize that the complex path through which some semblance of stability will eventually be attained is not predictable a priori. It is not good strategizing to formulate and stick to a strategic plan that is premised on a particular scenario about how a complex situation will play itself out.

Discussion: As the fourth lesson would lead one to expect, ROLM failed utterly to predict the effects of their entry into the PBX business. They expected to carve out a small, high-tech market niche, enough to justify their decision to enter but very far from what they actually achieved. Moreover, the trajectory of PBX development after their first product launch turned out to be quite different from what the 1973 business plan foresaw. Fortunately for ROLM, their success in the PBX market did not depend on their ability to foresee far into the future. ROLM managers abandoned the schedule for software revisions that they had set in the 1973 business plan and to which their development engineers were highly committed in favor of the “line of business voice applications” that arose from the TM - account representative generative relationships. ROLM managers did not allow strategic plans to channel these relationships; instead, they let the relationships channel their strategic plans.

The final two implications follow from the critical role that attributions and generative relationships play in the “bootstrap” dynamics of rapid structural change characteristic of complex foresight horizons:

Implication 3: Agents must engage in ongoing interrogation of their attributions about themselves, other agents and the artifacts around which their activity is oriented. They must develop practices that offset the easy, but potentially very costly, tendency to treat interpretations as facts.

Implication 4: Agents must monitor their relationships to assess their potential for generativeness, and they must commit resources to enhance the generative potential of key relationships. Fostering generative relationships is especially important when foresight horizons are complex.

The implications we have just described underlie the notion of strategy under complexity that we outline in the next section.

4. STRATEGY AND COMPLEXITY

Our aim in this section is to sketch a new interpretation of what strategy means when foresight horizons are complex. Since the word "strategy" already carries around a lot of interpretational baggage, we start in subsection 4.1 by abstracting out a core concept that we think runs through almost all the meanings that strategy has taken on: the notion of strategy as control. The realities of complex foresight horizons alter the everyday meaning of control and thus lead to a new conception of strategy as the means to achieve control. According to this conception, strategy is a process consisting of a set of practices, in which agents inside the firm[14] structure and interpret the relationships, inside and outside the firm, through which they both act and gain knowledge about their world. In subsections 4.2 and 4.3, we focus on two kinds of strategic practices: populating the world, in which agents explicitly construct attributions about the identities of the agents and artifacts with whom they share their world; and fostering generative relationships, in which agents monitor their current and future relationship possibilities for generative potential and allocate human and material resources to those relationships whose generative potential appears high.

4.1 Strategy as Control

Most managers situate strategy within a suite of concepts that includes at least the following: vision, mission, goals, strategy and tactics. In the language we have been using in this paper, vision and mission together determine a firm's directedness in agent/artifact space. That is, they pick out a particular kind of artifact that the firm commits itself to create, identify the kind of agent to whom the firm intends to sell these artifacts, and es-

[14] Actually, any agent, not just a firm, can strategize: for example, a component of a firm--a division or even a research or marketing group--can have a strategy. And even when people talk about a "firm's" vision, mission or strategy, they really mean the vision, mission or strategy of some top managers, who are trying to make them the vision, mission or strategy of the rest of the agents that comprise the firm. Nonetheless, for expository convenience, we refer to the strategizing agent as the "firm".

tablish the directions in which the firm would like the current structure of agent/artifact space to change. Goals specify what constitute desired outcomes for the firm: resources, returns, or even particular reconfigurations of agent/artifact space. Tactics determine how the actions in which the firm intends to engage will actually be executed by its various component agents. Strategy lies between directedness and execution. It lays down “lines of action” that the firm intends to initiate and that are supposed to bring about desired outcomes. Since outcomes depend on the interactions with and between many other agents (inside and outside the firm’s boundaries), strategy really represents an attempt to control a process of interactions, with the firm’s own intended “lines of action” as control parameters. From this point of view, the essence of strategy is control. How to achieve control, and how much control is achievable, depends upon the foresight horizon. When the foresight horizon is clear, it may be possible to anticipate all the consequences of any possible course of action, including the responses of all other relevant agents, and to chart out a best course that takes account of all possible contingencies. If so, strategy as control becomes the classical conception of strategy as optimizing precommitment. If foresight horizons are a little more complicated, “adequate” can substitute for “best”, without surrendering the idea of control as top-down and predetermining. But as foresight horizons become even more complicated, the strategist can no longer foresee enough to map out courses of action that guarantee desired outcomes. Strategy must include provisions for actively monitoring the world to discover unexpected consequences, as well as mechanisms for adjusting projected action plans in response to what turns up. At this point, control is no longer just top-down: some control must be delegated to those who participate directly in monitoring, for their judgements of what constitute unexpected consequences trigger the adjustment mechanisms and thus affect the direction of future actions. In addition, the adjustment mechanisms themselves usually extend permissions to a variety of component agents to initiate new, experimental lines of action. The dynamics of structural change associated with complex foresight horizons have a much more radical impact on the meaning of control. Constructive positive feedbacks make a complete nonsense of top-down control: marginal agents, like ROLM in 1973, can have huge effects; "powerful" agents like ATT may lose control over what happens to them; subordinates like the account representatives, even acting "under or-

ders", may effect changes through their interactions with other agents that their superordinates never envisioned. In such situations, control is not so much delegated as it is distributed throughout agent space. Then, the everyday way of talking about strategy can be very misleading. For example, people usually talk about strategy as something that is "set" by strategists. When control is distributed, it is more appropriate to think of it as something that emerges from agent interactions. As an example, think of ROLM's PBX strategy. The 1973 decision of the ROLM Board of Directors to make a computer-controlled, digitally switched private telephone system is a typical example of top-down, precommitting strategy setting. Within the next eight years, a strategy shift had taken place. ROLM top managers now saw the company’s business as developing productivity-enhancing, line-of-business voice-data applications for the office. How did this change come about? Though top management recognized and embraced the change, they did not initiate it. Rather, the change emerged from a process of attributional shifts occurring in a network of discursive relationships that had been established to execute, not to make, strategy. This network cut across departmental and authority lines inside ROLM and across ROLM's boundaries, including as it did the national account TMs. In contexts like this, the relation between strategy and control is very different from the classical conception. It is just not meaningful to interpret strategy as a plan to assert control. Rather, strategy must be seen as a process to understand control: where it resides, and how it has been exercised within each of its loci. From this point of view, strategy can be thought of as a set of practices, which are partly exploratory, partly interpretative, and partly operational. These practices can generate insight into the structure of the agent/artifact space that the agent inhabits and into the way in which control is distributed through that space. With the insights gleaned from these practices, the agent can orient itself in agent/artifact space--and figure out how it might reorient itself there, in the future.

Two kinds of strategic practices are particularly important when foresight horizons are complex. Through the first, agents seek to construct a representation of the structure of their world that can serve them as a kind of road map on which to locate the effects of their actions. Through the second, agents try to secure positions from which distributed control processes can work to

their benefit. We now look a little more closely at these two fundamental classes of strategic practices.

4.2 Populating the World

When foresight horizons are complex, agents cannot take knowledge of their worlds for granted. They need information, of course--hence the strategic need for exploration and experimentation. But information takes on meaning only through interpretation, and interpretation starts with an ontology: who and what are the people and things that constitute the agent's world, and how do they relate to one another? When the structure of an agent's world is changing rapidly, unexamined assumptions are likely to be out-of-date, and actions based on them ineffective. Hence the strategic need for practices that help agents "populate" their world: that is, to identify, criticize and reconstruct their attributions about who and what are there. These practices have to happen in the context of discursive relationships, and so they will clearly consist at least in part of structured conversations. We will have something to say below about who should participate in these conversations, but first we want to be a bit more precise about their substance.[15] Populating the world goes on at a micro- and a macro-level:

- At the micro-level, populating the world consists of constructing a list of agents and artifacts that matter and attributing an identity to each of them. Agent identity: An agent's identity has two components: its functionality (what it does) and its character (how it does it). For example, take the attributions that ROLM’s founders and top managers had about their own identity. Initially, the four engineers who founded ROLM wanted primarily to build a company that could keep expanding, by finding market niches in which they could apply their engineering skills to develop a new approach to an existing problem. They saw ROLM’s functionality, then, in terms of their own technological competences. Later, after the PBX business had taken off, they reinterpreted their identity in an artifact- rather than competence-centered way, as a company that developed line-of-business voice-data applications. In terms of character,

[15] We will not say anything about the shape of the conversations. Clearly, this is a practical question of the first importance. Our purpose here, though, is just to say what strategy means, not how to do it.

ROLM saw itself as a fast-moving, technology-driven company. The details of this self-attribution partly derived by emulation from the ROLM founders' interpretation of their model, Hewlett-Packard; and partly derived by contrast to their interpretations of ATT's monopolistic, "bullying" character and IBM's plodding, top-down bureaucratic way of doing business.[16] Attributions of functionality are oriented in time. The agent is not only what it does now, but what it will be doing into the foreseeable future. In the early days, ROLM interpreted what it did primarily in terms of its orientation to growth opportunities.

Artifact identity: For most agents, an artifact's identity is determined by its use-- who uses it, for what purposes, together with (or in place of) which other artifacts. A PBX could be regarded as a set of switches between outside lines and inside telephone sets; or as an interface between outside callers and information and services that can be supplied internally; or as a system consisting of productivity-enhancing voice- and voice-data applications. For agents who design and make artifacts, of course, a purely functional attribution is not enough: the artifact must also be related to the other artifacts that physically comprise it.

- At the macro-level, populating the world means describing the structure of agent/artifact space.

Agents do things by interacting with other agents. The recurring patterns of agent interaction define the structure of agent space. These patterns cut across organizational boundaries. For example, two of ROLM's great sources of strength in the PBX business involved recurring interactions between people in its marketing and engineering departments--and between its national account representatives and the TMs. To understand the structure of agent/ artifact space, then, "firms" cannot be taken as the primary agent unit. Instead, the focus must be on relationships defined by recurring patterns of interaction, which happen inside firms, across their boundaries, and sometimes even beyond them, in places like university departments and government agencies. Developing a vocabulary to describe the structure of agent/artifact space is no

[16] Of course, these phrases are only caricatures of the much richer attributions that actually informed ROLM's actions with respect to these other companies.

easy task. This is partly because these relationships between agents have two features that are not easy to describe together in ordinary language: they are recursive, in that many relationships are comprised of other relationships (as a firm is comprised of divisions and departments); but they are not hierarchic, in that an agent may participate in a whole set of cross-cutting relationships, with no strict inclusion-ordering among them--like a TM who works for a particular company, participates in professional activities through the International Communication Association, and collaborates with his ROLM national accounts representative on a new product idea. It would be particularly valuable to describe recursive, nonhierarchic networks of relationships in terms of a taxonomy that would help distinguish between structures that are likely to remain stable and those that are teetering on the edge of cascading change.

Who should populate the world? Every agent facing a complex foresight horizon needs to populate its world in order to understand what opportunities it has for action, what constraints affect what it can do, and what effects its actions may have. Inside the firm, the agents and relationships that matter differ from agent to agent, so populating the world is not an activity that should be reserved just for the CEO and his staff. Rather, it ought to be top management's strategic responsibility to make sure that interpretative conversations go on at all relevant levels of the company--and that sufficient cross-talk between these conversations happens that attributions of the identities of the same agents and artifacts made by people or groups with different experiences and perspectives can serve as the basis for mutual criticism and inspiration to generate new and more useful attributions.

4.3 Fostering Generative Relationships

Generative relationships may be the key to success and even survival in complex foresight horizons, but fostering them poses two problems. First, how can agents decide which relationships have generative potential? And second, once they’ve determined which relationships seem promising, how can they foster them?

Monitoring relationships for generative potential If the benefits that accrue from a generative relationship are unforeseeable a priori, on what basis can an agent decide to foster it? Part of

the answer is that many relationships that turn out to be generative are formed for quite other reasons, reasons that justify in expectational terms the social and financial investments required to develop them--for example, the relationship between ROLM and the targetted TMs. Once a relationship begins to generate unexpected returns, it makes sense to expend effort and funds to enlarge its scope and increase its intensity. But relying solely on fortuitous unintended effects of existing relationships certainly ought not to be the whole story. While it may not be possible to foresee just what positive effects a particular coupling might yield, it may nonetheless be possible to determine the generative potential. of a relationship. Here are some essential preconditions for generativeness:

- Aligned directedness. The participants in the relationship need to orient their activities in a common direction in agent/artifact space. That may mean that the same kind of artifacts might be the focus of each of their activities, as was the case with the ROLM account representatives and the TMs, although in general, as this example illustrates, the participants need not have the same relationship to the focal artifact. Alternatively, the alignment may be brought about by a mutual orientation towards a particular agent, as is the case when a consultant works with a firm's top managers to restructure the firm to enhance its market position.

- Heterogeneity. As we pointed out in section 3, generativeness requires that the participating agents differ from one another in key respects. They may have different competences, attributions or access to particular agents or artifacts. We have already described some of the ways in which attributional heterogeneity can generate new attributions. Combining different competences can generate new kinds of competence that then reside in the relationship itself. Developing ties that bridge "structural holes" in agent space can lead to brokerage opportunities (see [12]), but even more can bring the bridged agents into contact with previously untapped sources of alternative attributions and competences. An example might help illustrate this idea. The Santa Fe Institute is a research institution that brings together many scientists engaged in the study of complexity. About 25 businesses belong to SFI's Business Network. Their affiliation with the Institute brings Business Network

members into contact with ideas and people that would otherwise be inaccessible to them, and out of their periodic meetings a number of joint projects between Business Network members and SFI scientists have been spawned.

- Mutual directedness. Agents need more than common interests and different perspectives to form a generative relationship. They also must seek each other out and develop a recurring pattern of interactions out of which a relationship can emerge. Their willingness to do this depends on the attributions each has of the other's identity. It helps, but isn't necessary, for the participants to start by trusting one another. Frequently, rather than a precondition, trust is an emergent property of generative relationships: it grows as participants come to realize the unforeseen benefits that the relationship is generating.

- Permissions. Discursive relationships are based on permissions for the participants to talk to one another about particular themes in particular illocutionary modes (requests, orders, declarations, etc.). These permissions are granted explicitly or implicitly by superordinate agents and social institutions. Unless potential participants in a relationship have appropriately matched permissions, or can arrogate these permissions to themselves, the generative potential of the relationship is blocked.

- Action. opportunities For all our emphasis on the importance of discourse, relationships built only around talk do not usually last long or affect deeply the identities of participating agents. Engaging in joint action focuses talk on the issues and entities of greatest interest--those around which the action is organized. And action itself reveals the identities of those engaged in it. In addition, new competencies emerge out of joint action, and these competencies can change agents' functionality and hence identity--even leading to the formation of a new agent arising from the relationship itself.

Agents can review new and prospective relationships to gauge the extent to which these preconditions for generativeness are met. If the relationship seems promising in other respects, but one or more of the preconditions are absent, it may be possible to devise ways to improve the situation, as we describe below. For ongoing relationships, agents must monitor not only these preconditions,

but also whether the relationship is actually generating new and interesting things--attributional shifts, new relationships with other agents, joint actions with the potential to change structural features of agent/artifact space. This kind of ongoing monitoring would thus be coordinated with the agent's "populating the world" practices: as the agent discovers changes in its own attributions over time, it also tries to uncover the locus of these shifts in the various relationships in which it participates--and then figures out how to foster the relationships that turn out to generate changes.

Fostering generativeness. What is a truism in personal relationships applies just as well to business relationships: it takes work to build and maintain them. If an agent sees the generative potential in a possible relationship, it must make sure that the future partners in the relationship see this too. Sometimes, the problem is simply to find incentives that make a relationship possible and attractive to potential partners. For example, Silicon Valley venture capital firm Kleiner, Perkins, Caulfield & Byers knows that the numerous current and retired successful Valley entrepreneurs represent a huge storehouse of competence in building companies and connections that can benefit any start-up. How can they develop relationships between these entrepreneurs and the companies in which they decide to invest? One way is to give these entrepreneurs a stake in the companies. So whenever KPCB and some other venture capital firms create a new fund, aimed primarily at institutional investors, they set up a parallel Founders Fund, in which a select group of entrepreneurs are invited to invest in exactly the same portfolio of companies, but at a lower dollar commitment than the institutional investors are required to put up. In this way, KPCB "aligns the directedness" of the start-ups and the Founders Fund investors. In other situations, it may be necessary to enhance the "mutual directedness" of the participants in a relationship. This can sometimes be done in quite simple ways, for example by explicit expressions of gratitude and appreciation for the contributions of coparticipants towards generative interactions. From 1976-1980 ROLM's PBX manufacturing department was under constant scaling-up pressures to meet rapidly increasing orders. The vice president of manufacturing relied on close cooperation with the engineering, marketing and human relations departments to carry out the scaling-up without undue shipment slippage. He made sure that the people in his department acknowledged

every piece of assistance they received from these other departments and suppressed their complaints and criticisms when they couldn't get what they wanted as soon as they needed it. He arranged regular ice-cream socials between units in different departments in recognition of effective cooperation, complete with appreciative plaques and public speeches. The result was the formation of informal "problem-solving" networks connecting people in these four departments and the generation of unusual and creative ways to integrate their activities. Of course, building compatibility and trust between relationship partners may require more substantial unilateral "gifts" than ice cream socials; calibrating what and how much to do is an important component of the strategic practices that go into fostering generative relationships. Sometimes, it is necessary to bring about the creation of the very agents with whom a generative relationship is desired. For example, ROLM sponsored the formation of user groups, representatives of companies that had purchased ROLM systems. ROLM hosted user group meetings at company facilities, but the groups themselves decided on the agendas for the meetings, invited speakers (sometimes from ROLM), and so on. The user groups accomplished two things for ROLM. First, it provided the opportunity for different users to enter into relationships with one another, directed around ROLM's artifacts. If some of these relationships became generative, they might lead to new product ideas or new functionalities for existing ROLM products, either of which would accrue to ROLM's benefit. In addition, the user groups themselves constituted agents with whom ROLM could enter into relationship, through the meetings and the institutional structures created at the meetings (officers, board, committees and so on). The relationships that developed between ROLM and the user groups extended the range of what could be achieved in the account representative - TM relationships, to include a much greater variety of customers, more action possibilities, and more intensive focus. We have described only a few examples of what an agent can do to foster generative relationships. They all stand in stark contrast, in terms both of resources required and probability of enhancing generativeness, to the tendency so obvious these days in "multimedia" to think that acquisitions and mergers are the way to go. We think that acquisition is in general much more likely to repress generativeness than to enhance it. To realize generative potential, relationship participants must have the right permissions, time and space to talk; they must do work together; and that work

must facilitate their coming to shared understandings about each others' competencies and attributions of identity; and their relationship must be embedded in a network of other relationships that can amplify whatever possibilities emerge from their joint activities. Fostering generative relationships means managing people, projects and events so that these conditions are realized.

4.4 Conclusion: Strategy under Complexity

When agent/artifact space changes structure rapidly, foresight horizons get complex. To succeed, even survive, in the face of rapid structural change, it is essential to make sense out of what is happening and to act on the basis of that understanding. Since what is happening results from the interactions between many agents, all responding to novel situations with very different perceptions of what is going on, much of it is just unpredictable a priori.[17] Making sense means that interpretation is essential; unpredictability requires ongoing reinterpretation. Hence our conclusion that the first and most important strategic requirement in complex foresight horizons is the institution of interpretive practices, which we have called populating the world, throughout the firm, wherever there are agents that initiate and carry out interactions with other agents--that is, at every locus of distributed control. But of course making sense isn't enough. Agents act--and they act by interacting with other agents. In complex foresight horizons, opportunities arise unexpectedly, and they do so in the context of generative relationships. In this context, the most important actions that agents can take are those that enhance the generative potential of the relationships into which they enter. As a result, agents must monitor relationships for generativeness, and they must learn to take actions that foster the relationships with most generative potential. Then, when new opportunities emerge from these relationships, agents must learn to set aside prior expectations and plans and follow where the relationships lead. We call the set of strategic practices through which agents accomplish these things fostering generative relationships, and they constitute the second cornerstone of our conception of strategy under complexity. Even in the most complex of foresight horizons, there will be regions of relative stability

[17] See [13] for an interesting discussion of the relation between attributional heterogeneity and what is there called indeterminancy.

in a firm's agent/artifact space, with respect to which it still makes sense to engage in optimizing (or at least satisficing) pre-commitment and to organize processes of exploration and adaptation. But it is hardly possible to know where those regions are, or to which relationships precommitted actions may be entrusted, without the understandings attained through the practices we have emphasized here.

References

1. R. Hayes, S. Wheelwright, and K. Clark, Dynamic Manufacturing: Creating the Learning Organization (New York: Free Press), 1988.
2. P. Senge, The Fifth Discipline: The Art and Practice of the Learning Organization (New York, Doubleday/Currency), 1990.
3. J. Redding and R. Catalanello, Strategic Readiness: The Making of the Learning Organization (San Francisco, Jossey-Bass), 1994.
4. M. Marquardt and A. Reynolds, The Global Learning Organization (Burr Ridge, IL: Irwin), 1994.
5. D. Garvin, Building a Learning Organization, Harvard Business Review, July-Aug 1993,78-91.
6. M. Waldrop, Complexity: The Emerging Science at the Edge of Order and Chaos (New York: Simon & Schuster),1992.
7. S. Kauffman, Origins of Order (Oxford: Oxford University Press), 1994.
8. P. Anderson, K. Arrow and D. Pines, eds., The Economy as an Evolving Complex System (Redwood City, CA: Addison-Wesley), 1988.
9. B. Arthur, Increasing Returns and Path Dependence in the Economy (Ann Arbor, MI: University of Michigan Press), 1994.
10. D.Lane, Artificial Worlds and Economics, Journal of Evolutionary Economics, 3, 89-107 and 177-197, 1993.
11. D. Lane, F. Malerba, R. Maxfield, and L. Orsenigo, Choice and Action, to appear Journal of Evolutionary Economics, 1996.
12. R. Burt, Structural Holes: The Social Structure of Competition (Cambridge MA: Harvard University Press), 1992 .
13. B. Arthur, Complexity in Economic and Financial Markets, Complexity, 1:1,20-25.