

A SYSTEMS SCIENCE OF NETWORKED ORGANIZATIONS

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A doctoral study 20 years ago (*Holonomy*) revealed some basic metapatterns among the writings of the first generation of cross-disciplinary (physical/biological/human) system thinkers. Widely-recognized patterns in all complex systems included hierarchy, complementarity (duality), synergy (holism), and process. These metapatterns in turn provided a lens to observe a fundamental change occurring in human organizations—an emerging paradigm shift from hierarchy-bureaucracy to networks and virtual teams. This epochal shift is chronicled in six books over two decades. Now, at the dawn of the third millennium, human networks are not only emergent but ascendant as the signature form of organization of the Information Age, powered across the threshold of irreversible change by the Internet.

Principles, frameworks, architectures, processes, and relationships—the strengths of systems thinking—reign supreme in the ephemeral 21st-century world of organizational and technological networks. Systems principles playing a key role in the practical expression of these newly connected ways of working are examined in this paper. Systems principles for network organizations will be described. A general model of networks—nodes, links, purpose, and time—is expanded as a "Periodic Table of Network Elements" and applied to one type of human system, a virtual team. We then look at the powerful role of the hierarchy principle in managing complexity, including a re-telling of Simon's famous parable of the watchmakers. In the final section, we look at the core complementarity of our time, cooperation/competition, through the perspective of Rapoport's "Tit-for-Tat" strategy.

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Systems and Networks

General systems provides the infrastructure for the principles of a network science.

Networks—defined generally as nodes in purposeful relationships—are systems, pure and simple. Anywhere a systems concept will work, so will a network concept. Indeed, for many systems, particularly social systems, networks are an easier sell.

In the social world, people do not much love the word “system.” It’s easy—and often justified—to hate “the system.” Some people hate it so much that they are blind to their aversion.

Little wonder. Most traditional systems are “black boxes.” Think of the tax system or the international monetary system or even the municipal transit system. Most systems portray themselves as beyond the comprehension and control of ordinary mortals. Traditional systems science often offers an obfuscating self-portrait of systems as black boxes, unfortunately too complicated for just anyone to understand.

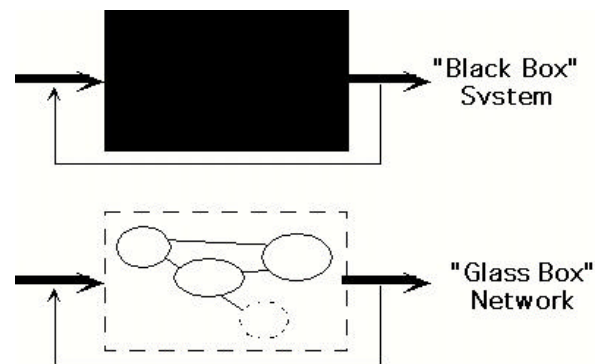


Figure 1: "Glass Box" Network

With networks, you take the wraps off systems. Instead of “black box” systems, you see “glass box” networks. The outer boundary of the network whole is transparent. See inside to the parts—the nodes—and to the relationships—the links—between the parts. The more clearly you lay out the network-system elements, the easier it is to understand.

Some key general network-system concepts are reflected in the most complex class of networks, human networks, including synergy, hierarchy, complementarity, relationships, and process.

SYNERGY

“The whole is more than the sum of the parts.” This systems principle is so popular that it’s a cliché. In networks, purpose is the “more than” that defines the whole, or synergy. Together, synergy is possible; in isolation, it is not.

To function, a system—no matter how minimal—has to have some synergy or purpose.

Purpose relates very practically to how people become legitimized in networks through contribution to the shared purpose. People develop purpose as a resource for their organization, just as people develop procedures and policies using law as a resource. People who participate in planning and decision making internalize the purpose for themselves. They externalize the purpose through explicit plans, information access, and by creating symbols—logos, nicknames, acronyms. Instead of controlling one another through one-way orders or endlessly detailed policies, boundary-crossing virtual team members exercise control through their shared process.

HOLONS: HIERARCHY AND COMPLEMENTARITY

Each of us is a *whole* person who plays a *part* in families, businesses, and communities. Arthur Koestler, the author and systems thinker, coined the word “holon” to stand for this whole/part characteristic of everything (Koestler, 1967). In one brilliant term, Koestler incorporates and binds into a dance the two great metapatterns of systems thinking: levels (hierarchy) and complementarity (Stamps, 1980).

And, as we see in the Parable of the Innovators below, complex boundary-crossing organizations *are* “systems of systems within systems.” Every human group is a hierarchy of wholes and parts. Complex group members are themselves systems of systems. The systems principles of segmentation and inclusion apply every time a group splits up into task teams or an alliance jells.

Nothing in groups is as complicated as leadership. One way to simplify complex wholes is to grasp a part that represents the rest. In the search for simple ways to “grasp a group,” leaders come in handy. Leaders are people who stand for a group. All organizations have leaders, even self-directed groups, where leadership is assumed from within rather than appointed from without. Networks are rife with leaders.

RELATIONSHIPS

Relationships are elusive “things.” For some people, relationships are real; for others, they are not. Some people literally cannot see relationships, even indirectly. These people do well in organizations with rules to govern behavior. They don’t fare well in virtual teams and networks, where relationships are at reality’s core.

There are so many relationships involved in life, and so many different kinds of them everywhere you look. To simplify this vast interconnected mess, traditional organizations have many one-

way signs. Hierarchies and bureaucracies take an extremely limited approach to how parts interconnect. Generally speaking, orders and information flow in a minimal number of formal channels. Information flows up and commands flow down. This traffic pattern gives rise to the walls, stovepipes, silos, and other hard-to-penetrate boundaries in organizations. By contrast, in networks, connections are many rather than few. Information and influence flow both up and down the levels through links, as well as horizontally within levels.

As with networks, "Systems thinking's fundamental concept is the connecting relationship—what things are doing to each other" (Mandel, 2000). Relationships, in the systems view, are ontologically prior to things, entities. The International Society for the Systems Sciences (ISSS) Primer Group, after an intensive effort, defines systems thusly:

"A System is a Family of Meaningful Relationships (between the members acting as one whole)."

PROCESS

The generic concept of "networks-in-time," or process, derives from a key common pattern found in physical, biological, and social systems. The popularly-known "S" curve, a representation of the logistic growth curve, which we use in our network models to represent the change process (see Figure 2), appears in the original 1949 paper von Bertalanffy wrote establishing the concept and field of general systems (von Bertalanffy, 1968). It is his first example of an "isomorphy," a general principle that holds across scientific disciplines. An isomorphy crosses boundaries.

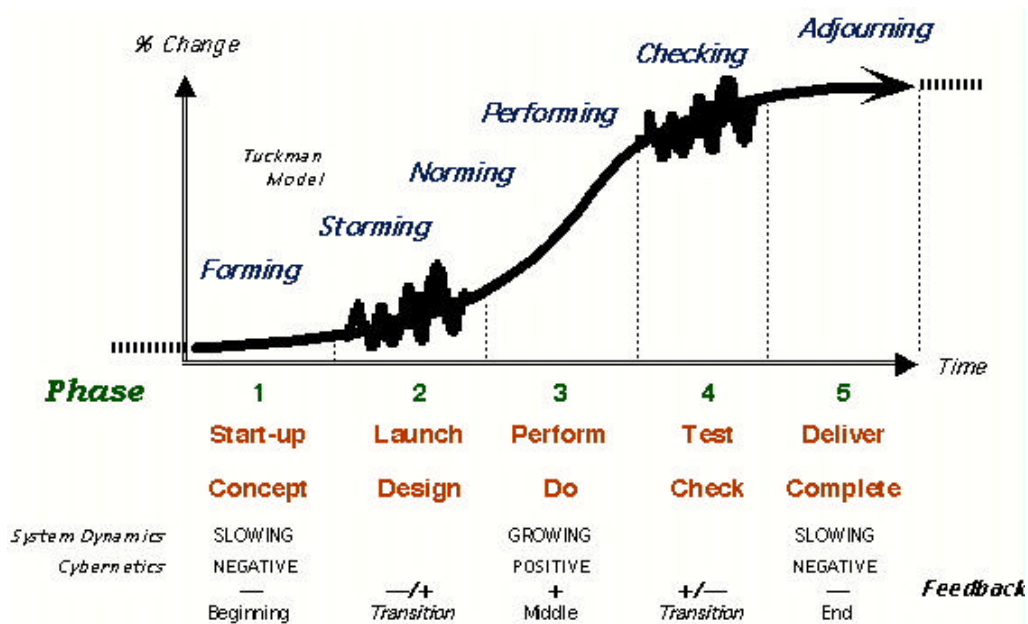


Figure 2: "Stressed S" Logistic Life Cycle

Well understood in a wide variety of scientific disciplines, the "S" curve offers accumulated knowledge, available to those who want to deepen their understanding of process.

Taxonomy of Network Elements

For the past twenty years, we've been researching and developing a science of networked organizations (Lipnack & Stamps, 1982, 1986, 1993, 1994, 1997, 2000). Here we summarize the underlying principles of this science.

The classic, von Bertalanffy approach to systems is to view them as "elements in mutual interaction." (Mandel, 2000). In this tradition, we have developed a simple network model with four dimensions—*people* (nodes, entities), *purpose* (wholeness, synergy), *links* (relationships, patterns), and *time* (process).

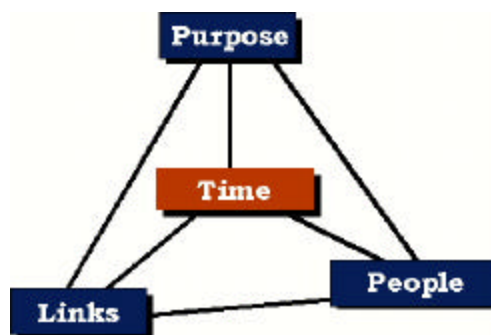


Figure 3: Four-Dimensional Network Model

The four dimensions of the model are plugged into the bedrock of general patterns of organization.

To account for all the essential characteristics that comprise virtual organizations, we go down a level, expanding each dimension into three elements. These 12 elements are arrayed in the familiar systems model of inputs, processes, and outputs (Figure 4). This generates a matrix of organizational elements, a "periodic table" providing the conceptual infrastructure for practical approaches to creating and managing virtual groups at any scale.

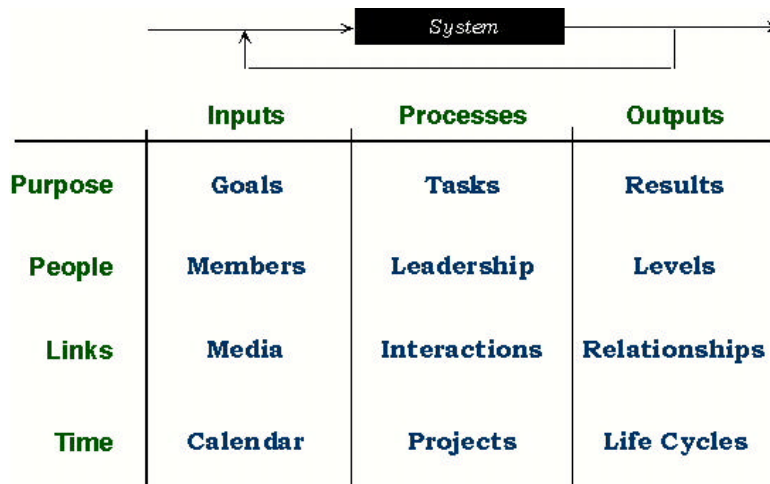


Figure 4: Periodic Table of Network Elements

This taxonomy (a principle-based classification of categories) provides the basic architectural language for creating and sustaining a wide variety of networked organizations. Brief descriptions of the elements as applied to one type, a virtual team, follow:

PURPOSE

- Cooperative goals *Do*
- Interdependent tasks *Doing*
- Concrete results *Done*

Purpose establishes why a particular group works together. Purpose implies some minimal level of interdependence among the people involved. A virtual team is far more reliant on its clear purpose than is a face-to-face one. Because they operate outside the bounds of traditional organizational life without bureaucratic rules and regulations to guide them, virtual teams require a common purpose to stay in tune.

Cooperative goals are what purpose looks like at the beginning of any successful teaming process. This is why so many books about teams begin by focusing on goals. A set of *interdependent tasks*, the signature feature of teams, connects desires at the beginning with outcomes at the end. When a team finishes, it has its *concrete results*, the final expression of its purpose, the measurable outputs of joint effort. These three elements—cooperative goals, interdependent tasks, and concrete results—enable virtual teams to stay focused and be productive.

PEOPLE (NODES)

- Independent members *Parts*
- Shared leadership *Parts-as-wholes*
- Integrated levels *Wholes*

Special challenges face virtual team members. *Independent members*, the people and groups that make up the team, must act with a significant degree of autonomy and self-reliance. While virtual team leadership tends to be informal, it also is pervasive. The diversity of technical and management expertise required means that members share leadership at different points in the process. In cross-boundary work, *shared leadership* is the norm.

A team is a complex human system with at minimum two levels of organization—the level of the members and the level of the group as a whole. Teams also are parts of larger systems, growing out of and embedded in organizations. To be successful, virtual teams must *integrate levels* both internally (sub-teams and members) and externally (peers and super-groups).

LINKS

- Multiple media *Channels*
- Boundary-crossing interactions *Communicating*
- Trusting relationships *Bonds*

What gives *virtual* teams and other networked types such distinction as new forms of organization is the proliferation of their "links." Relatively suddenly, multiple, constantly enhanced modes of communication are widely available. Links provide access to vast amounts of information and unprecedented possibilities for interaction. Twenty years ago, we chose the term *links* for this defining relationship and connectivity feature of networks because it bridges three key aspects of communication.

First, people need the actual physical connections—wires, phones, computers, and the like—that provide the potential for communication; they are the prerequisite for interaction. *Multiple media* are moving virtual teams from the extraordinary to the ordinary as the technology wave of Information Age change reaches the mainstream. Connections make *boundary-crossing interactions* possible. The back-and-forth communication among people—the activities and behaviors—constitutes the actual process of work. It is here—at the boundaries of interaction—that virtual teams are truly different.

Through interactions near and far, people develop *trusting relationships*, the invisible bonds (and baffles) of life. People's patterns of behavior mark the outlines of relationships that persist and feed back into subsequent interactions. As important as positive relationships and high trust are in all teams, they are even more important in virtual ones. The lack of daily face-to-face time, offering opportunities to quickly clear things up, can heighten misunderstandings. For many distributed teams, trust has to substitute for hierarchical and bureaucratic controls. Virtual teams with high trust offer this valuable social asset back to their sponsoring organizations for use in future opportunities to cooperate.

TIME

- Coordinate calendars *Dates*
- Track projects *Durations*
- Follow life cycles *Phases*

Collaboration requires parallel work and mutually agreed-upon dates, which in virtual practice means a need to *coordinate calendars* to have conversations and execute work. Virtual teams naturally *track projects* as they carry out their activities largely in cyberspace that insures collaborative feedback and learning. The most successful virtual teams consciously *follow life cycles* of team behavior. Forming, storming, norming, and performing all require extra effort and higher awareness and participation by group members in the management of the whole. Each team has its unique clock.

PRACTICAL PRINCIPLES

The ability to adapt to the rapidly changing environment of virtual work is enormously enhanced by the use of principles. Experience meshed with theory offers principles for a coherent and testable approach to understanding this new world of work, a scientific approach.

These principles are not sacred, but since publication of our first book on the subject (Lipnack & Stamps, 1982) they have in some form been reviewed, used, and practiced extensively by people in every sector—business, nonprofit, government, religions, and grass-roots. Together they constitute a tested set of principles of virtual work and distributed organization.

The leverage provided by general principles lies in their great power of applicability, enabling speed, adaptability, and customizability. Principles allow you to take knowledge from one situation and transfer it to another.

Pattern Language for Networks

The word “network” is so common that some Internet search engines eliminate those words from any search. The network idea is a general concept like “system,” and applies to nearly everything: molecules, neurons, waterways, transportation, television stations, and computers.

Truly fundamental patterns of thinking reflect an underlying configuration to how we understand the world around us—a “pattern language” (Alexander et al, 1977). This shared language simplifies complexity. One such complexity-busting pattern is the systems principle of hierarchy.

This is “hierarchy” in the big picture, different from the conventional meaning in a social context. It’s about organization generally—how the right design gives both cooperative and competitive advantage.

Nobel Prize-winning economist Herbert Simon told the most famous parable of systems theory, a story of two Swiss watchmakers (Simon, 1965). Simon calls them Tempus (whom we call Linda), meaning “smooth time,” and Hora (our character Sam), meaning “serial time.” Our adaptation of this story shows the power of hierarchy of the scientific sort. Simon names this pattern the “architecture of complexity.”

THE INNOVATORS

Two young technologists, feeling the limits of their then crude craft, begin to develop breakthrough products for their market. Soon, both develop splendid prototypes of awesome versatility and complexity. Indeed, Sam Serial, the prized protege of the traditional masters in the field, finishes his model noticeably sooner than Linda Levels, the challenger of orthodoxy.

Clearly, Sam has the edge in what could be a very big market. The business press eagerly looks forward to the unfolding story.

News of the revolutionary demos spread, and people start to call for information, interrupting the young entrepreneurs with questions. Within a few months, Linda is delivering to delighted customers, while Sam struggles to complete the first production copy as orders pile up. Both decide to hire apprentices and to train new workers in their respective methodologies to meet the demand. Linda is able to train new people quickly and boost production enormously, while Sam sinks further into minutiae as training crawls and products only occasionally appear.

After Sam Serial's bankruptcy, observers begin to investigate to learn what they can from this epic story of success and failure. The key difference, they discover, is in how each designs the work of constructing the product—the organizational advantage.

Sam simply extends the “Old Way” of fitting pieces together into a whole by adding many more pieces. The effect is somewhat like a rich mosaic, a thousand parts put together intricately, just so—a beautiful but fragile assembly.

Linda, however, borrows a method from nature and constructs a series of subassemblies, 10 pieces to a group, intermediate components of the product. The extra steps spent putting subassemblies together account for the initially longer time needed to build the prototype. Nevertheless, this integrated approach produces a design both elegant and resilient.

When assembly is interrupted, the partially completed unit is put down and naturally it falls *a-part*. It *dis-assembles*. What works well in isolation does not always work well in the real world that is full of interruptions—otherwise known as change. For each thousand steps of process, Sam risks hundreds of steps at every interruption, while Linda loses only an average of five steps when she resumes the assembly process. Linda has designed “stable structures” between the elementary pieces and the product as a whole, specific points in the process that hold together without the next step.

The power of Linda's method of chunks within chunks becomes clear as volume increases and markets change. Linda Levels, with a probability of just one interruption per 100 steps, gains a 4000-to-1 advantage over Sam Serial.

COMPLEXITY

Systems within systems within systems. Why is this design principle so universal and so powerful?

Simon says that complexity evolves much more rapidly from simplicity if there are “stable intermediate structures,” subsystems sturdy enough not to pull apart. Hierarchies predominate in nature, he says, because “hierarchies are the ones that have the time to evolve.”

This is a profound, basic, natural design principle: a hierarchy of levels.

In the scientific sense of levels, hierarchy is basic to astronomy: planets and satellites in solar systems in galaxies in galaxy clusters that are part of super-clusters and even greater amalgamations. Hierarchy brings us molecules, atoms, particles, and quarks in physics. Biology has cells, tissues, organs, organisms, ecologies, and environments. Pennies make up dimes that make up dollars in the U.S. currency system. Time comes in subassemblies of minutes, hours, days, weeks, months, and years. Libraries shelve books according to the Dewey Decimal System version of this theme. We even build our community communications systems this way with trunks, feeders, and drop lines to the house.

Levels within levels—hierarchies—permeate every aspect of the core technology of the Information Age. Computer hardware is built in levels—from binary switches to chips to logic boards to computers to systems with peripherals. We design software in levels of complexity from machine languages to assemblers to operating systems to applications; structure files hierarchically in folders; and connect PCs in local-area networks plugged into wide-area networks linked to virtual private networks on the global Internet.

We use the hierarchy principle every time we analyze a problem or break something complex into smaller parts. We also use it to put things together, for synthesis, to create new wholes out of parts. When we outline our thinking, we use hierarchy.

It is no surprise, then, that the same level structure permeates organizations. As individuals, we are parts of families who make up communities and neighborhoods, which in turn are included in local, state, and national jurisdictions. All of these are points of natural cleavage—stable intermediate structures, as Simon says—in the hierarchy of society.

All networks and virtual teams are hierarchical in the scientific sense. Even the simplest ones are made up of interacting parts that are themselves complex—people or groups.

Interruption is a metaphor for change in the story of the inventors, Linda Levels and Sam Serial. The need to organize in stable clusters, modules, and levels increases as the pace of interruption picks up. Subassemblies—distinct components that can stand on their own—become more

necessary, while rigid control structures become liabilities under the unrelenting push of ever-increasing change.

Networks do not throw the baby out with the bath water. They directly incorporate the powerful principle of hierarchy in its timeless sense—the *force behind stable structures*—into the organizational form of networks, a key legacy of the Agricultural Age of hierarchy.

HIERARCHY RULER

To get a grip on size and scope, apply the “Hierarchy Ruler.”

The Hierarchy Ruler (Figure 5) is one of the most useful mental tools you can employ. On the Hierarchy Ruler, the anchor is in the middle instead of at one end. Set a point of reference and then look up, down, and across. Each boundary offers an opportunity for multiple perspectives, like that of Janus, the ancient Roman deity who could simultaneously see both inside and outside the walled city from his palace portal.

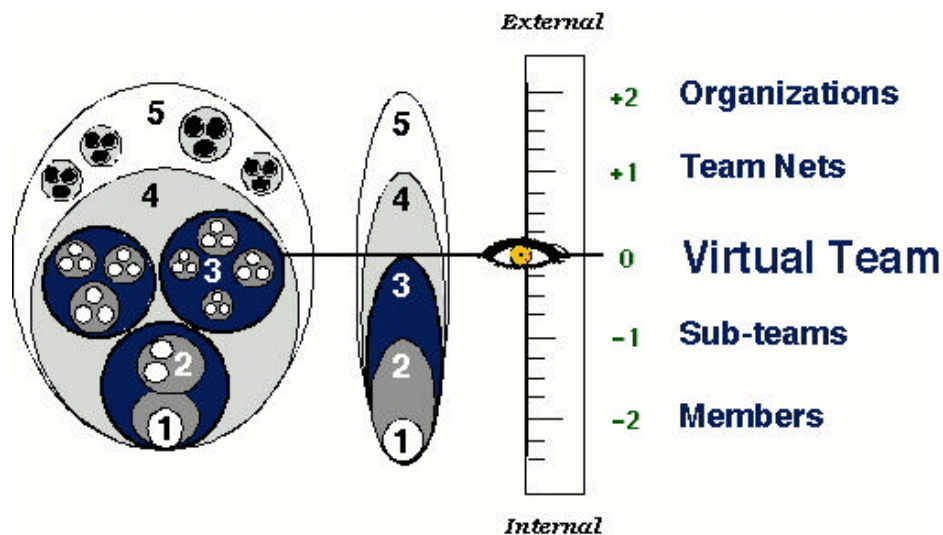


Figure 5: Hierarchy Ruler

This mental ruler is a portable, general-purpose tool that can measure complexity in many kinds of things. Its anchor—its point of reference—is a movable one. Indeed, to tap this ruler’s power, you *must* move the reference point.

Place it at different boundaries to assess situations from other points of view. This is a critical cross-boundary networking skill that many people already use well intuitively.

The hierarchy ruler is a powerful tool for resolving conflict.

The corporate boundary is a common point of reference. From the CEO view, the whole organization is your responsibility. From that boundary, you can see both the internal complexities—strategies, budgets, politics, love affairs—and the external ones—competitors, markets, global upheaval. Anchored at the reference point:

- *Look Up.* Externally, ask what significant relationships the company engages—strategic alliances, associations, and coalitions; further out, see the enterprise in the context of whole industries and markets.
- *Look Across.* At the same level of organization, survey other enterprises, your peers as competitors, collaborators, customers, and vendors; see yourself as a center and view others from core to peripheral relationships.
- *Look Down.* Internally, look for the major components, the departments or divisions that tell the broad story of what the enterprise does. Each internal division itself may be made up of groups within groups within groups.

Now move the reference point from the corporate boundary down to your own organization and drop it again to your team, then perhaps yet again to subgroups within the team. Or go up from the enterprise to alliances, coalitions, markets, industries and regions—ever-wider circles of associations.

"RULE OF TWO"

Wholes and parts are gifts from the universe. They make it possible to simplify the complex.

The network itself embodies this valuable mental tool of levels within levels, a whole composed of people and small groups that are themselves complex.

While whole-part pattern-recognition enables a group to better cope with complexity, too much of a good thing will eventually lead again to information overload and breakdown. Too much focus on ever-smaller parts leads to deadly, time-consuming micro-management and planning inefficiency. Similarly, the meaning of myriad wholes that a team can be considered a part of can get lost in the global ever-after, in which boundaries abound.

In our experience, the Hierarchy Ruler works best when you observe the "Rule of Two." This means that from a given point of reference, two levels up and two levels down usually provide about the right measure of scope and detail. The trick, of course, is to set points of reference at the most relevant levels of organization, those that reflect relatively stable structures and have internal coherence.

This prospective practical "rule" of thinking is akin to the experimentally established observation of the "Rule of Seven"—people can easily keep about seven categories (e.g., numbers, details, points, names) in mind at once.

A Systems Strategy for Real Life

Although we have spent 20 years stressing the benefits of cooperation over competition, we also know that in reality these two tendencies dance with each other. "Co-opetition" is the newly coined term for this uneasy dynamic of simultaneous cooperation and competition (Lipnack & Stamps, 1993).

Co-opetition, the complementarity of competition and cooperation, is the "yin/yang" systems dynamic at the heart of our global economic and social system.

While complements, competition, and cooperation cannot be evenly matched. If they are, progress stagnates and change recedes. One tendency or the other must dominate to carry the process forward. In networks large and small, cooperation provides the greater driving force.

Cooperation is the survival strategy for networks. When necessary, the smart cooperator is also an excellent competitor.

Cooperation sounds nice in theory, but should we heed the conventional wisdom: "Nice guys finish last?" Apparently not. The mad partnering evidenced by Internet companies indicates that cooperation with competitors may be the only way to finish.

The tooth-and-claw competition of Darwin that many assume to be the natural condition of life is giving way. There is accumulating evidence that cooperation is evident at all levels of biology's kingdoms—from cells to big-brained mammals. It may be particularly evident in humanity's remarkable spurt of evolution over the past few million years. Cooperators seem to be the survivors. It's a strategy.

In the original logic of games, an aggressive competitor invariably wins over a willing cooperator because they only played single games, one at a time. However, if the game expands with more rounds of play involving more people, people's behavior has consequences. When the behavior

in past games is known prior to future games, it carries a self-correcting social consequence. If you do in another person and no one else hears about it, you can probably get away with it. Yet when your behavior becomes public, it suggests how you will play in the future. Other may not want to play with you.

The reasoning is common sense. If people know that I cooperate, they will want to associate with me. Together we can do more than we can separately. Cooperators win.

Perhaps the most famous event in game-theory history illustrates this view. In the 1950s, Robert Axelrod, a leading practitioner of games, stages a series of contests to find the best strategy for logically combining competition and cooperation. People propose various strategies that are translated into lines of code. These are in turn put into the equivalent of an open cyberspace market so that games can undergo many repetitions. Anatol Rapoport, the mathematician and one of the original four founders of the Society for General Systems Research, predecessor of ISSS, submits the winning strategy. It remains the undisputed champion.

With both a catchy name and the shortest code, Rapoport's "Tit-for-Tat" strategy is simple: Cooperate on your first move, then match the other player's response with the same strategy. You might call it "tough cooperation." In short:

Reach out, then respond in kind.

Open with friendship then respond to opportunities with cooperation and challenges with competition. This strategy works even where there initially are only a few cooperators in a sea of competitors. Tit-for-tat cooperation slowly accrues benefits while competitors can at best achieve a standstill as they beat up on each other.

The advantage of cooperation will only grow in the years ahead. At the same time, the payoffs from purely competitive strategies likely will diminish. In the age of information, the foundations that support competition are shifting dramatically :

- From material scarcity to information plenty;
- From limited information to information access; and
- From anonymous players to trusted partners.

Cooperation is the winning strategy, as true within systems science as in the world outside us.

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