Systems Methodology

A Holistic Language of Interaction And Design
Seeing Through Chaos and Understanding Complexities[1]

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What is going on? Nobody seems to know. Some are winning while others are losing both for the wrong reasons. A looming prospect of randomness is creating a nasty feeling of insecurity. Even the successful ones are not sure of themselves any more. Games keep changing, but despite all the rhetoric to the contrary, a dominant management culture, by default, keeps reproducing the same non-solutions all over again. We see the world as increasingly more complex and chaotic because we use inadequate concepts to explain it. When we understand something, we no longer see it as chaotic or complex. Maybe playing the new game requires learning a new language.

During the last 50 years we have been confronted with a dual shift of paradigm. Not only there has been a shift in our understanding of the nature of the beast from a mindless *mechanical* system to a multi-minded *socio-cultural* system. But, there has also been a profound shift in our way of knowing: from *analytical thinking*, the science of dealing with *independent* sets of variables, to *systems thinking*, the art and science of handling *interdependent* sets of variables. While the analytical approach has remained essentially intact for nearly four hundred years, systems thinking has gone through three generations of change: from Operations Research to Cybernetics and finally Interactive Design. This evolution has been a response to challenges of socio-cultural systems. Systems methodology had to deal not only with the imperative of interdependency and the complexities of self-organizing systems, but also with the question of purposeful behavior of multi-minded systems.

The realities of highly developed social systems are fundamentally different from those of other forms of living systems. Members of societies that have outgrown the secure, unifying web of a paternalistic culture display real choice. Unless we understand the implications of multi-level purposeful behavior, the multi-minded beast will out-maneuver any attempt to tame it. On the other hand, contrary to a widely held belief, the popular notion of a multi-disciplinary approach is not a systems approach. In fact, the ability to synthesize separate findings into a coherent whole seems far more critical than the ability to generate information from different perspectives. Without a well-defined synthesizing method, however, the process of discovery using a multi-

[1] Although my work has its origin in the colorful tradition of Russ Ackoff, but it also has been greatly influenced by the works of Stafford Beer, Kenneth Boulding, Jay Forrester and my own fascination with the complexities and engaging potency of a phenomenon known as culture. J.G

discipline approach would be an experience as frustrating as that of the blind men trying to identify an elephant. Positioned at a different part of the elephant, each of the blind men reported his findings from his respective position, as "It's a snake"; "It's a pillar"; "It's a fan"; "It's a spear!"

Consider the futility of trying to make sense of the whole by using the above story without the prior conception of "elephant." But I am sure you experienced no frustration in sorting out the distorted information and putting it in perspective because the storyteller had already told us that the subject is an elephant. It seems we need a preconceived notion of the whole before we can glean order out of chaos.

A different version of the same story, found in Persian literature, narrated by Molana Jalaledin Molavi (Rumi) captures the level of complexity produced when we have no preconceived notion of the subject. The story is about a group of men who encounter a strange object in complete darkness. Since the storyteller is in the dark himself, he cannot provide a clue about the object. Here, all efforts to identify the object by touching its different parts prove fruitless until someone arrives with a light. The light, which in this context is a metaphor for methodology, enables them all to see the whole at last.

Rumi's version of the story means that the ability to see the whole somehow requires an enabling light in the form of an operational systems methodology. Rumi, in his mystical wisdom proposed that to get the light one needs to tune oneself with the universe. Yet the operational meaning of tuning, for our purpose here, is that one should be able to make his/her underlying assumptions about the nature of the socio-cultural systems explicitly known and verifiable to oneself. Then one needs to develop an *iterative search* process that would help to evolve the initial assumptions until a satisfactory vision of the whole is produced.

Systems Methodology

The version of systems methodology presented in this paper is a holistic language of interaction and design developed to face the dilemma of social systems where the whole is becoming more and more interdependent while the parts display choice and behave independently. The methodology gives us a way to see through **chaos** and understand **complexities**.

The foundation of this exciting conception is the interaction of four elements of systems thinking:

- Holistic Thinking—iteration of structure, function and process
- Operational Thinking—understanding chaos and complexity
- Systems Theories—a socio-cultural view
- Interactive Design—creating a feasible whole with infeasible parts

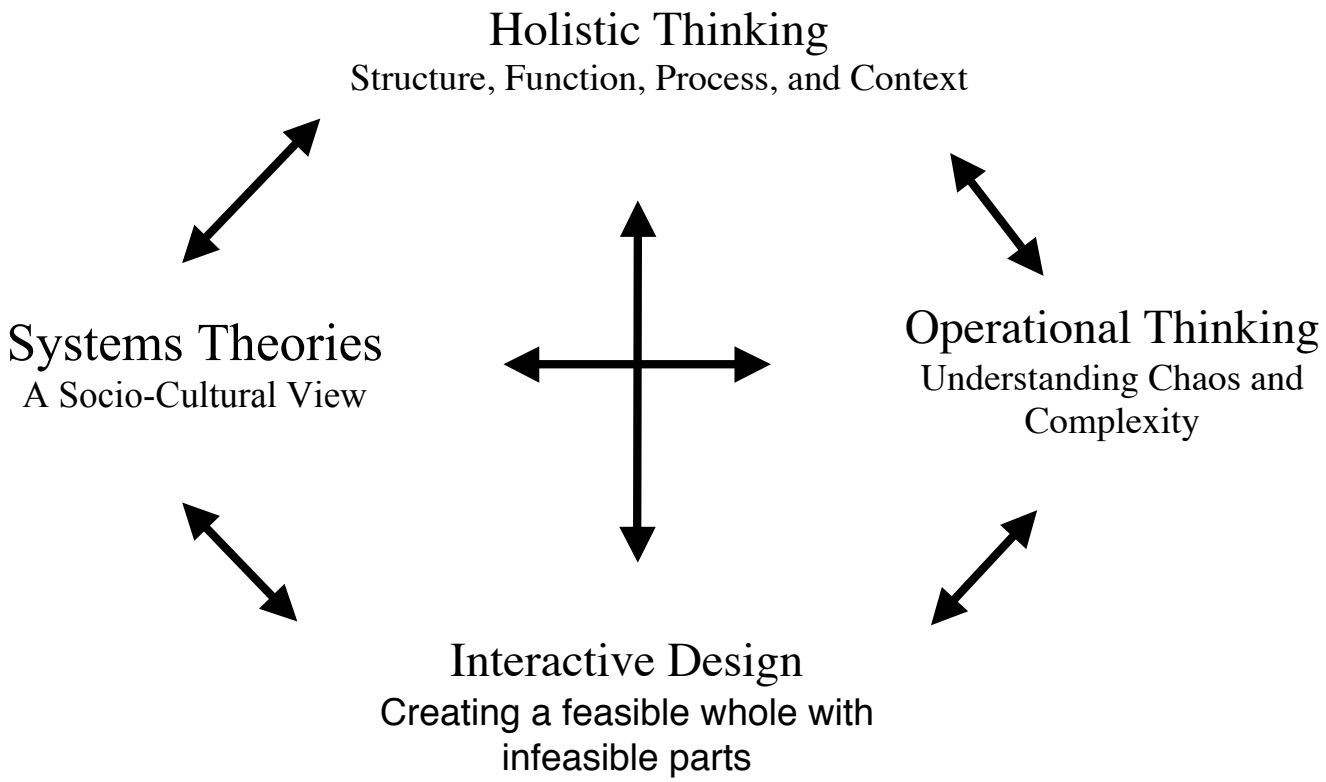

Figure one: The Four Foundations of Systems Methodology

1: Holistic Thinking

Structure, Function, Process and Context

Analytical thinking assumes that understanding *structure* is sufficient to understand a system. For synthetic thinking *function* is the key for seeing the whole. The behaviorist, on the other hand, looks to the *process*, the how question, for the necessary answer to define the whole. Each one has been used as the core concept of a different inquiring system producing a tremendous amount of information and knowledge.

- **Analysis** has been the essence of classical science. The scientific method assumes that the whole is nothing but the sum of the parts, and thus understanding the structure is both necessary and sufficient to understanding the whole.

- **Synthesis** has been the main instrument of the functional approach. By defining a system by its outcome, synthesis puts the subject in the context of the larger system of which it is a part, and then studies the effects it produces in its environment.

- **Process** orientation, on the other hand, has long been the focus of behavioral science. It

basically deals with the *how* question.

On more familiar and practical territory, we could perhaps say that the classical school of management, with its input orientation, deals basically with structure. The neo-classical school, with its notion of "management by objective," is concerned with functions. And the total quality movement, with its concern for control, is preoccupied with the process.

It is my contention that structure, function, process represent three aspects of the same thing and with the containing environment they form a complementary set. Together they define the whole or make the understanding of the whole possible. Structure defines components and their relationships; function defines the outcomes or results produced; process explicitly defines the sequence of activities and the know-how required to produce the outcome.

A set of interdependent variables forms a circular relationship. Each variable co-produces the others and in turn is co-produced by the others. Which one comes first is irrelevant because none can exist without the others. They have to happen at the same time. To fail to see the significance of these interdependencies is to leave out the most important aspect of the challenge. Therefore, to handle them holistically requires understanding each variable in relation to the others in the set at the same time**.** This demands an **iterative inquiry**

Iteration is the key for understanding complexity. An iterative process of applying simple rules is at the core of nature's mysterious ability to produce complex phenomena so effortlessly. Iterations of structure, function, and process in a given context would examine assumptions and properties of each element in its own right, then in relationship with other members of the set. Subsequent iterations would establish validity of the assumptions and successively produce an integrated design. See Figure Two, below.

Iterative Process of Inquiry

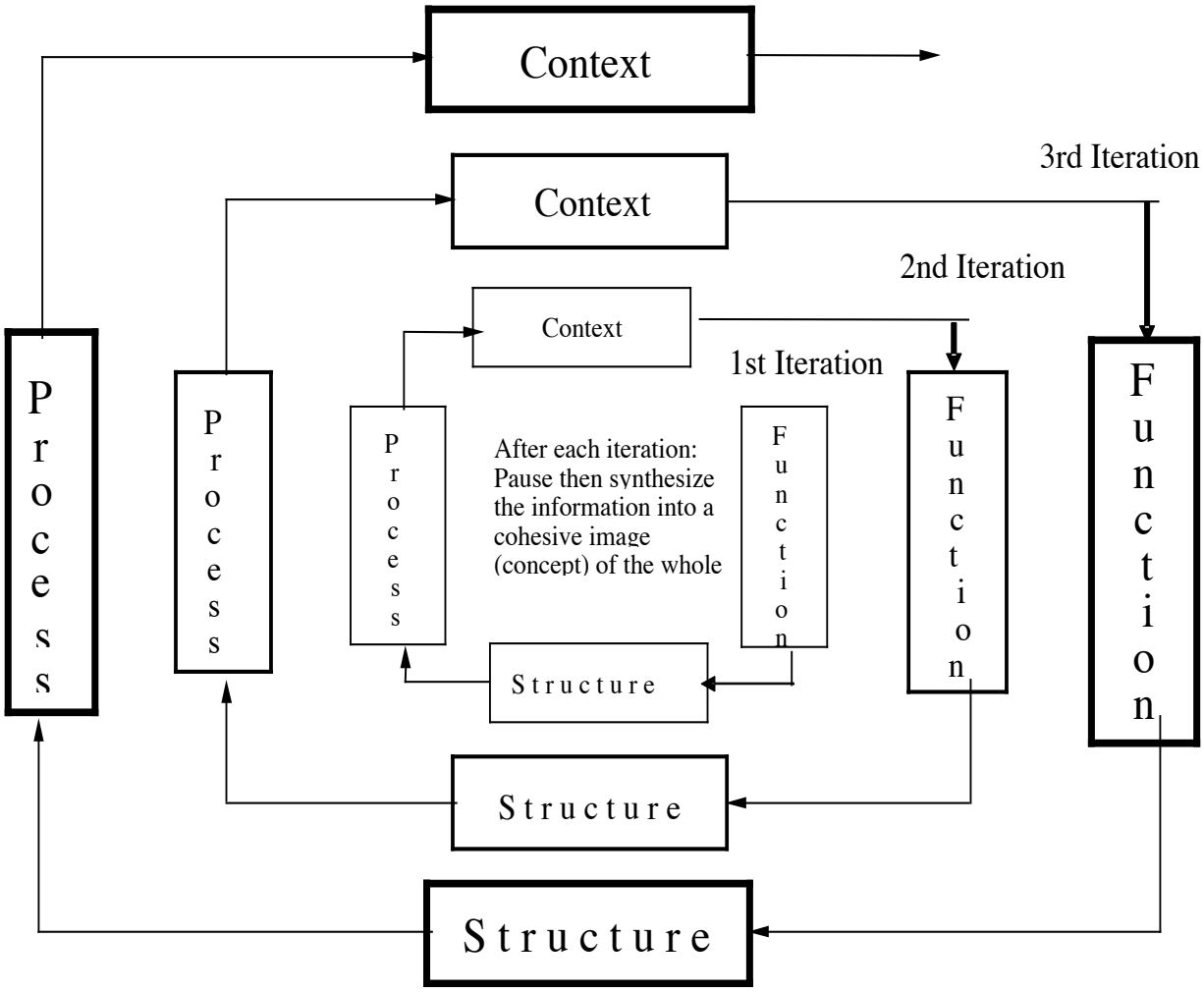

Figure Two: Iterative Process of Inquiry for Understanding Complexity

The principle of iterative inquiry is reinforced by *Singerian experimentalism*: there is no fundamental truth; realities first have to be assumed in order to be learned; truth is not the starting but the end point of an inquiry. Successive iterations would yield a greater understanding and more closely approximate the nature of the whole.

2: Operational Thinking

Understanding Chaos and Complexity

Complexity is a relative term. It depends on the **number** and the **nature** of interactions among the variables involved. Open loop systems with linear, independent variables are considered simpler than interdependent variables forming non-linear closed loops with a delayed response. Key words in the above statement are *closed loop, nonlinear,* and *delayed response.* The first

step for understanding complexity is to appreciate the iterative and thus dynamic nature of closed loop systems and their counterintuitive behavior. Consider the following two simple examples:

1) A saving account in a bank earning simple 10% interest reflects an open loop behavior. Both yearly earnings and the amount of principal remain constant and total sum would increase at a slow pace.

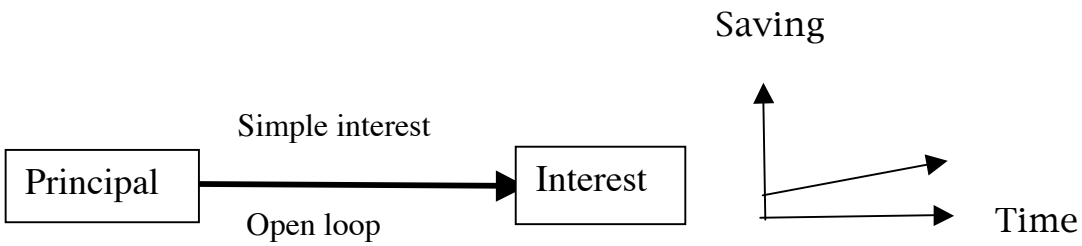

Figure Three: Open Loop System

2) However, if the savings in the bank were to earn 10% compound interest, it would represent a closed loop behavior and the money in the saving account will grow exponentially, doubling every seven years. The initial principal of $10,000 would amount to $1,280,000 if left there for 56 years. Compare this amount with $66000 that would be accumulated by simple interest.

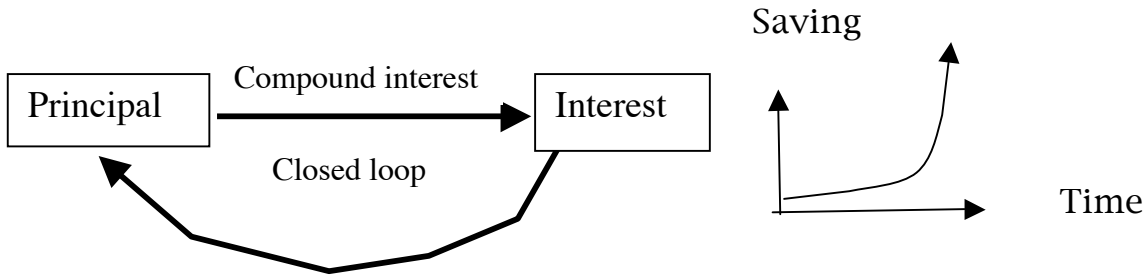

Figure Four: Closed Loop System

Now, if the interest rate in the above example varied according to market conditions then we would be facing a nonlinear system. Please note that in closed loop thinking linear and nonlinear refer to the rate of change, not the state of a system.

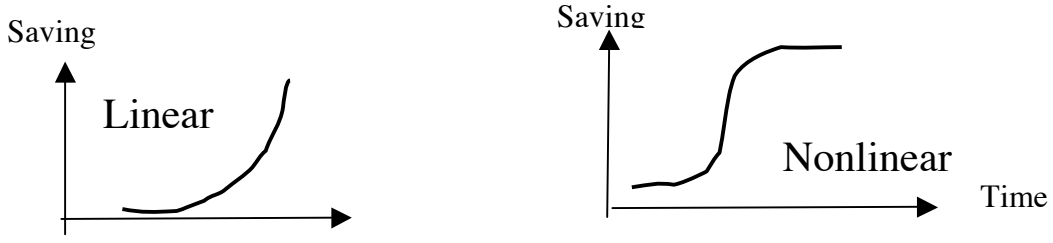

Figure Five: Linear vs. Nonlinear System

Now let us look at the dynamic behavior of a simple negative feedback loop (goal seeking). Please note the counter-intuitive impact (oscillation) of introducing a delay function to our simple negative feedback loop.

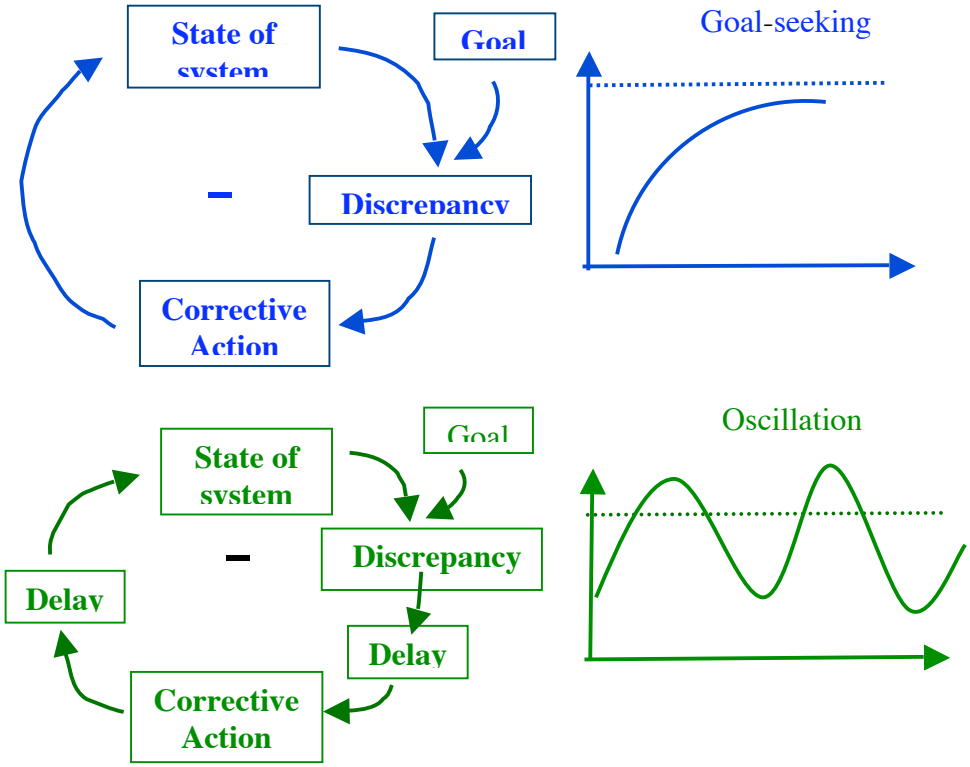

Figure Six: Goal-Seeking Behavior and Counterintuitive Effect of Delay

Now let us consider a common phenomenon known as positive feedback loop. We know that it will result in an exponential growth curve.

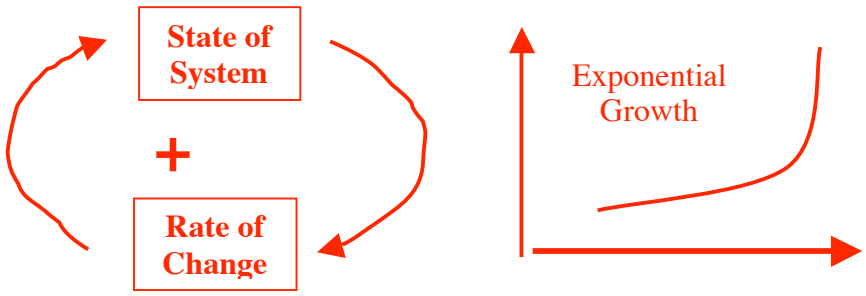

Figure Seven: Positive Feedback Loop Producing Exponential Growth Curve

However, if we just add the impact of carrying capacity, or the imperative of market potential, and superimpose the reality of a delay function to our simple positive feedback

loop. We would create a monster, the infamous "multi-loop nonlinear feedback system." This is the system that according to chaos theory produces chaotic behavior. It explains the collapse of Dotcoms, fiasco of Enron, and faith of thousands of corporations who pursue a blind short-term growth strategy with no regard for the limitations imposed by carrying capacity of the system and/or its environment. The *overshoot and collapse* scenario reflects the cases where the growth strategy has an additional negative impact on the carrying capacity of the system.

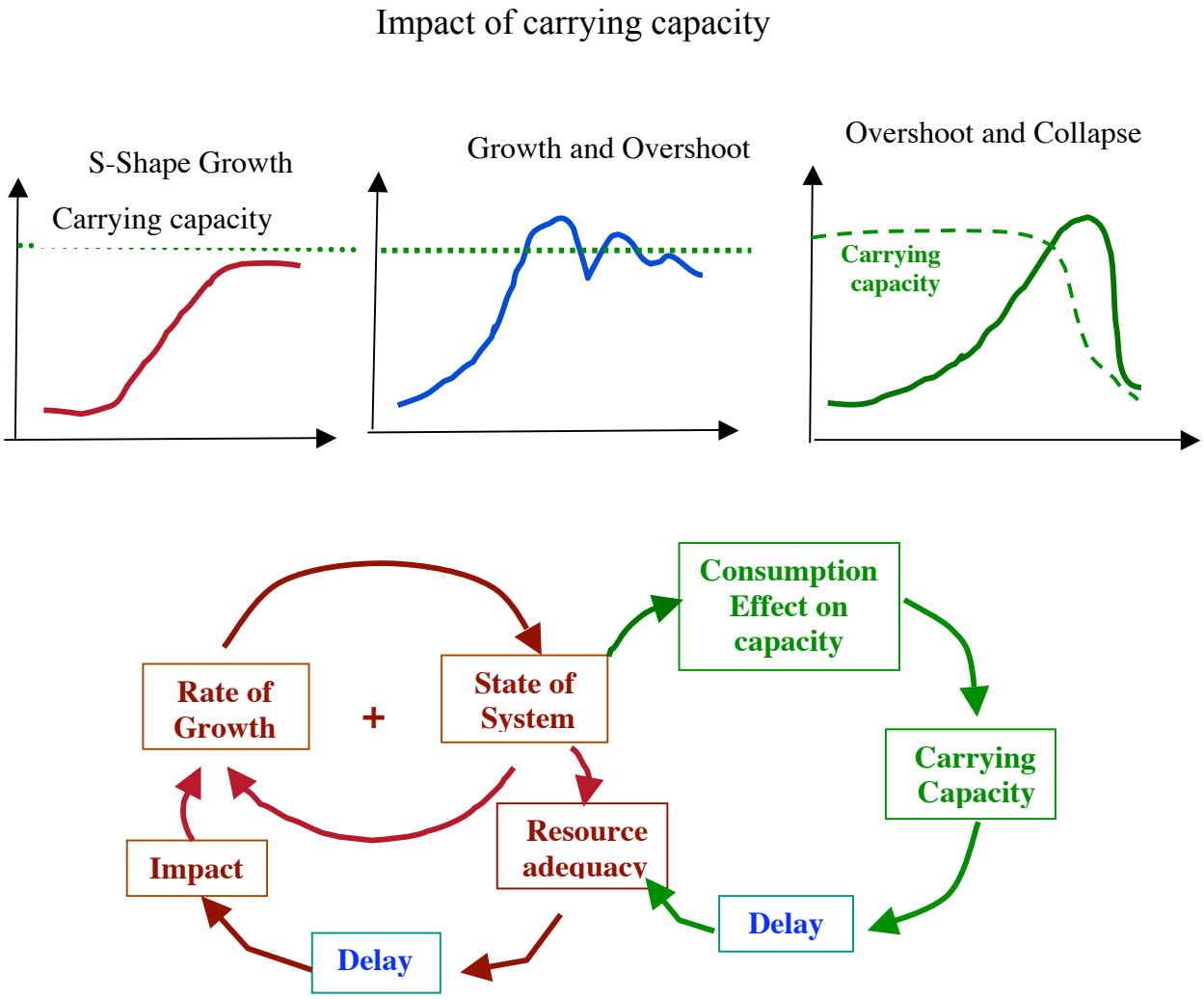

Figure Eight: Impact of Carrying Capacity on the Behavior of a System

The point of emphasis is that the interaction of multiple feedback loops is the prime source for generating chaos and complexity. Understanding this dynamics is the essential step to get a handle on the notion of interdependency and counter-intuitive behavior of social systems.[2]

2- For a good discussion of the dynamic behavior of systems see chapter 4 of John D. Sterman, *Business Dynamics*, Irwin, McGraw Hill. 2000.

Unfortunately our cognitive ability has evolved around assumptions of unidirectional causality or open loop thinking. It has primarily been concerned with independent variables. Therefore, we do experience extreme difficulties in visualizing the behavior of interdependent variables or the outcome of closed loop systems.

According to Barry Richmond, creator of the *i-think* model, "The way we think is outdated. As a result, the way we act creates problems, and then we are ill-equipped to address them because of the way we think."

Thinking consists of two activities: constructing mental models and simulating them in order to draw conclusions and make decisions. We certainly need help in both accounts.

Apparently our highly regarded mathematical tools are not doing the job. Otherwise how can we explain the sorry fact that we have been applying the same set of non-solutions to the crucial social problems such as drugs, poverty, crime, illiteracy and maldistribution of wealth for most of the last fifty years?

Stephen Wolfram, in his book, *New Kind Of Science* (2002) has a critical observation:

> "The idea of describing behavior in terms of mathematical equations works well where the behavior is fairly simple. It almost inevitably fails whenever the behavior is more complex. Indeed, there are many common phenomena about which theoretical science has had remarkably very little to say. Degree of difficulty encounter in mathematical representation of a phenomenon increases exponentially by the degree of its complexity." (Chapter one page 3)

He then goes on to demonstrate how systems too complex for traditional mathematics could yet obey simple operational rules. He also shows how remarkably simple iterative computer programs capture the essential characteristics of complex phenomena.

Operational Thinking[3] is an ingenious way to overcome the difficulties encountered in constructing and simulating complex mental models. Relying solely on mathematical representation for dealing with complex phenomenon has been a practical nightmare. Combining operational thinking with more manageable forms of mathematical representation, programs such as *i-think* software have made it practical to get a handle on multi-loop nonlinear feedback systems.

It is important to note that although multi-loop nonlinear feedback systems exhibit chaotic behavior, there is an order in this chaos. Such systems seem to be attracted to a particular pattern of behavior. By operational thinking we can discover this pattern and recognize the "Second Order Machine" (the attractor in action) that is locking the system to its existing pattern.

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3 see Barry Richmond, *An Introduction to Systems Thinking*, ithink software, High Performance Systems, Inc.

The Second-Order Machine--an implicit set of organizing principles, residing at the core of organization's collective memory--is most resilient stuff. The triumphant resurgence of old patterns of behavior despite the concerted efforts of change agents is an uninterrupted saga of despair. Unless the implications of these principles (the attractors in action) are made explicit and dismantled, the nature of the beast will outlive the temporary effects of interventions. The pattern recognition is critical for understanding and changing the undesirable behavior.

To recap, remember that mapping the dynamic behavior of a system is to capture the interaction of positive and negative feedback loops. This interaction, in essence, defines the critical interdependencies among the variables involved. The mapping process would help us change the default setting and overcome the shortcomings of our cognitive abilities.

3: Systems Theories

A Socio-Cultural View

I have argued extensively elsewhere (Jamshid Gharajedaghi 1999) that five systems principles of *openness, purposefulness, multidimensionality, emergent property,* and *counter-intuitiveness,* along with five systems dimensions define the essential characteristics and the behavior of a socio-cultural system

Openness means that the behavior of open (living) systems can be understood only in the context of their environment. Therefore no problems or solutions can be entertained free of context. However, a tendency to define the problem in terms of the solution, and a strong preference for the context-free solution, that is tried and true, keep producing the same non-solution all over again. Open (living) systems exhibit a tendency toward a predefined order. Left alone they reproduce themselves. Cultural codes are the social equivalent of biological DNA. Self-organization by default will invariably reproduce the existing order.

Purposefulness. W*hy* people do what they do is the matter of purpose, that of choice. And the choice has rational, emotional, and cultural dimensions.

Rational choice is the domain of self-interest, or the interest of the decision maker, not the observer. A rational choice is not necessarily a wise choice. It reflects only the perceived interest of the decision maker at the time. The emotional choice is the domain of beauty and excitement. We do lots of things because they are exciting or, more precisely, because they are challenging. If the excitement of a good challenge were not part of our decision criteria, life would be a bore. In other words, setting and seeking attainable goals is a banal existence.

Culture defines both the cognitive and the normative behavior of the collectivity. Just like a high-level computer language that provides default parameters when the programmer fails to choose one, the culture provides default values when actors fail to choose one explicitly.

Multidimensionality is probably one of the most potent principles of systems thinking. It is the ability to see complementary relations in opposing tendencies. The mutual interdependence of opposing tendencies is characterized by an "***and*** " instead of an "***or***" relationship. Unfortunately, for the majority of cultures, a fallacy has dominated the treatment of opposing tendencies as a duality in a zero-sum game. Everything seems to come in a pair of opposites: collectivity/individuality; security/freedom; modernity/tradition, order/complexity; art/science and so on. They are cast in such a way that a win for one is invariably associated with a loss for the other. If *X* is true then *NX* cannot be true. This represents an "*or*" relationship. Multidimensionality states that lose/lose and win/win as well as win/lose are possibilities and it denies the fallacy that if x is good more x is even better.

Counter–intuitiveness. Social dynamics stand on a level of complexity beyond the reach of the analytical approach. Counter-intuitiveness means that actions intended to produce a desired outcome may, in fact, generate opposite results. Things can get worse before getting better, or vice versa. One can win or lose for the wrong reason.

To appreciate the nature of counter-intuitive behavior, one needs to understand the practical consequences of the following assertions:

- Cause and effect may be separated in time and space.
- Cause and effect can replace one another, displaying circular relations.
- An event may have multiple effects. The order of importance may shift in time.
- An effect may have an independent life of its own. Removing the cause will not necessarily remove the effect.

Emergent Properties are the property of the whole, not the parts, and thus cannot be analyzed; they are the product of interactions among the parts. The mere notion of interaction signifies a dynamic process. In other words, the emergent phenomenon is a time-dependent state reproduced continuously *online* and *real time*. Therefore, life, love, happiness, and success are not a one-time proposition; they have to be reproduced continuously. If the processes that generate them come to an end, the phenomena cease to exist as well. They cannot be stored or saved for future use.

Systems Dimensions[6]. The parameters that coproduce state of a socio-cultural system are found in the following five dimensions: wealth, power, knowledge, beauty, and values,

[6] Ackoff, in his discussion of ideal seeking systems identifies four classes of societal activity individually necessary and collectively sufficient for progress toward the ideal of omnicompetence. Aristotle in "pursuit of happiness " implicitly recognizes the same five elements as necessary to achieve a good life. John Dewey

in my experience, form a comprehensive set of variables that collectively describe the organization in its totality.

- The generation and distribution of **wealth**, or the production of necessary goods and services and their equitable distribution.
- The generation and dissemination of **truth**, or information, knowledge, and understanding.
- The creation and dissemination of **beauty**, the emotional aspect of being, the meaningfulness and excitement of what is done in and of itself.
- Formation and institutionalization of **values** for the purpose of regulating and maintaining interpersonal relationships: cooperation, coalition, competition, and conflict.
- Development and duplication of **power**, the question of legitimacy, authority, and responsibility or, in general, the notion of governance.

4: Interactive Design

Creating feasible whole with infeasible parts

Interactive design is essentially identified with Russell Ackoff. He explicitly recognizes that choice is at the heart of human development. "Development is the capacity to choose; design is a vehicle for enhancement of choice and holistic thinking. Designers seek to choose rather than predict the future."

Interactive design is about creating feasible whole with infeasible parts. It is both the art of finding differences among things that seem similar and the science of finding similarities among things that seem different. Designers try to understand rational, emotional, and cultural dimensions of choice and produce a design that satisfies a multitude of functions.

Four distinct elements of interactive design are: 1) Participation, 2) Formulation of the Mess, 3) Idealization, and 4) Realization. Each one of these elements adds a unique characteristic to this captivating process.

Participation

Self-organizing, purposeful, socio-cultural systems are self-evolving. They do not simply adapt to their environments but co-evolve with them. They can change the rules of interaction as they evolve over time. However, like all open systems a purposeful socio-cultural system exhibits a tendency toward a predefined order. Its behavior is guided by an implicit, shared image. In the short term it tends to approximate and reproduce its pattern of existence very closely. To change this pattern of behavior the implicit shared image or (the organizing

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in his discussion of freedom and culture explicitly refers to these five dimensions as the elements of the culture.

attractor) needs to be changed. This can only be done by a **participative design** process. People are more likely to accept an idea when they have had a hand in shaping it.

Formulation of the Mess

Separation of defining problems from designing solution is a unique characteristic of interactive design. According to Ackoff, "We fail more often not because we fail to solve the problems we face but because we fail to face the right problem." Problem is defined neither as deviation from a norm nor in terms of the universal constraints (lack of time, resources, or knowledge). It is defined as a *mess*, an interactive set of problems reflecting the future implicit in the present operation.

Idealization

The distinctive characteristic of idealization is the notion of backward planning. It starts with the assumption that the system has been destroyed overnight and that the designers have been given the opportunity to recreate the system from a clean slate. The only constraints are that the outcome be technologically feasible and operationally viable.

Design is a process for operationalizing the most exciting vision of the future that the designers are capable of producing. It is the design of the next generation of their system to replace the existing order.

Realization

Successive approximation is at the core of realizing an ideal design. Realization takes place in a real-world environment. Therefore, designers must identify all the constraints that might interfere with proper implementation of the design. These constraints usually fall into the following three distinct categories.

Type I Constraints

Type I constraints cannot be removed within the existing framework. Such constraints would require revisions and improvisations of the design in order to create a target design capable of being implemented. Target I would be the first approximation of the unconstrained design. If necessary, subsequent approximations will identify Target II and Target III generations of the desired design. It is critical that Type I constraints be continuously monitored so that the target design can further approximate the idealized design as soon as these constraints are removed.

The realization effort, therefore, will not be a one-time proposition. Successive approximations of the desired state make up the evolutionary process by which the transformation effort is conducted. It may take a number of attempts before the desired design is implemented.

Type II Constraints

Type II constraints are those constraints whose removal will require extensive preparation. They consist of activities that consume considerable time and resources, as well as knowledge and management talent.

These activities usually involve redesign of the products (if necessary), redesign of throughput, and redesign of organizational processes. Design of the measurement and reward system with variable budgeting and target costing seems to be an integral part of all successful realization efforts. This usually is the most resource-intensive part of the change effort. For control purposes, all critical assumptions and expectations about the selected course of actions must be explicitly recorded and continuously monitored.

Type III Constraints

Type III deals essentially with behavioral constraints. These are the constraints that can be removed if designers so desire. Selling the idea, removing resistance to change, ensuring acceptance, cultivating support, and providing training are among the efforts targeted at constraints that are basically self-imposed. These constraints, taken together, act as the cultural default of the organization, and their function is to reinforce the status quo. Without a prior foundation of trust and commitment, the system would simply refuse to undergo the planned transformation irreversibly. And in this context, dissolving the "second-order machine" is the most critical phase of realizing the design.

Conclusion

The beauty of interactive design and the magic of the iteration of structure, function, and process when combined with the power of operational thinking, and profound understanding of systems principles and dimensions, in my experience, create a competent and exciting methodology that goes a long way in dealing with emerging challenges of seemingly complex and chaotic socio-cultural systems.

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