Systems Thinking

"A journey in the realm of systems"

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Systems Thinking

An Operational Perspective of the Universe

Yes, I admit the title may be a bit presumptuous on my part. I do have to start somewhere though, don't I? I suppose the difficulty I have been having with this article is somewhat based on the intimidation factor presented by the great minds that have evolved our understanding to this point. Great minds such as Descartes, Newton, Bertalanffy, Wiener, Bateson, and Forrester. And, should I be so presumptuous as to believe I can add to what they have wrought? So, with humility I continue.

The Universe is! And, for some it is meaningful to seek an understanding of the origins of the Universe. From my perspective the meaningful question is, "How does it work?" This is not to indicate that I have an answer. Yet, the answers we find, and the understanding we develop, are shaped by the questions we ask.

Systems Thinking is, more than anything else, a mindset for understanding how things work. It is a perspective for going beyond events, to looking for patterns of behavior, to seeking underlying systemic interrelationships which are responsible for the patterns of behavior and the events. Systems Thinking embodies a world-view. A world-view which implies that the foundation for understanding lies in interpreting interrelationships within systems. Interrelationships which are responsible for the manner in which systems operate. Interrelationships which result in the patterns of behavior and events we perceive.

Descartes and Bacon provided us with an analytic framework for understanding, and the scientific method. Newton, with the discovery of the laws of motion and gravity, provided us with a clockwork paradigm for understanding the universe. A paradigm which is not so much wrong as it is incomplete. The Newtonian paradigm embodies essentially a linear cause and effect relationship. A paradigm which is reinforced by the way in which we view daily events. The difficulty with this paradigm is that it provides a very limited short term perspective for understanding how things really work.

When we go beyond the linear cause and effect paradigm to study patterns of behavior and then to study the systemic interrelationships among the parts of systems we develop a much deeper understanding of the nature of the way things operate. An operational understanding which can allow us to work with the system rather than against it. An understanding which allows for the development of interventions to create lasting change within the system, if that is the desired intent.

I have repeatedly referred to system(s) without an explicit definition. The definition with which I have become most comfortable is as follows.

A system is an entity that maintains its existence through the mutual interaction of its parts.

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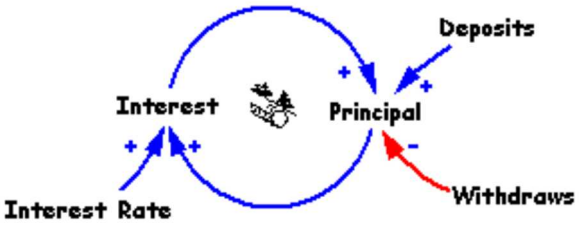
The key part of this definition is that of interaction. A system is much more than a heap or a lump. It is the interactions which are responsible for the characteristics of the system, not the parts. The interactions of the parts become more relevant to understanding the system than understanding the parts.

Savings Account

Consider how we traditionally think about a savings account. We put money in the bank and periodically we receive interest on the money. This represents a very traditional linear cause and effect relationship between principal and interest, which is appropriate, to a point. The following diagram represents a more complete way of viewing the relationships, and the system. If this is your first introduction to systems thinking diagrams, bear with me for a moment, for they're not nearly as difficult as they might first seem. Introduction to Systems Thinking might also be helpful.



Arrows between elements of a system represent the direction of influence. Thus the arrow between **Deposits** and **Principal** implies that **Deposits** influence **Principal**. An influence arrow also has either an "+" or an "-" affixed to it. A "+" indicates the influence adds to while a "-" indicates the influence subtracts from. Thus, the implication of the influence between **Deposits** and **Principal** is that as **Deposits** add to the **Principal**. If **Deposits** decrease they will still add to the **Principal, only not so much**. One should be careful not to add implications that are not represented by the diagram.

Withdraws also influence **Principal**, yet in an inverse or opposite manner. That being, **Withdraws** subtract from **Principal**.

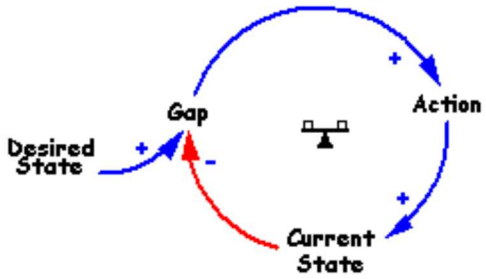
Additionally, **Principal** and **Interest Rate** interact to create **Interest**, and each of them act in a direct relationship. As **Principal** or **Interest Rate** increase **Interest** increases. **Interest** then adds to the **Principal** causing it to increase further, and the cycle repeats.

Emergence

Systems exhibit characteristics which can not be found in any of its parts. These characteristics emerge from the interactions of the parts of the system. Consider the interactions in the previous diagram. **Principal** and **Interest Rate** interact to create **Interest**. **Interest** then serves to increase **Principal**, which then interacts again with **Interest Rate** to create more **Interest**. The characteristic exhibited by this system, which can not be found in any of its parts, is one of growth. **Principal** and **Interest** interact in a reinforcing fashion. The snowball rolling down hill in the center of the diagram is intended to indicate that this is a reinforcing structure.

Achieving Results

It should be rather obvious that things simply don't grow forever. There is always a balance somewhere. Consider the following structure which represents what is called a balancing loop.



In this representation there exists some **Current State** which is assumed to be less than some **Desired State**. The influence arrows indicate that the **Current State** and **Desired State** interact to produce a **Gap**. The interaction is such that as the **Desired State** adds to the **Gap** and the **Current State** subtracts from the **Gap**. This **Gap** then influences **Action** intended to move the **Current State** toward the **Desired State**. As **Action** moves the **Current State** closer to the **Desired State** the **Gap** decreases. A decrease in the **Gap** adds less influence resulting in less **Action**. When the **Current State** reaches the **Desired State** the **Gap** is reduced to zero and there is no longer an influence causing **Action**. The emergent character of this structure is one of balance as the structure promotes a balance between initial differences. The balanced lever in the center of the structure indicates it is a balancing structure.

The System and External Influences

There is only one system, the Universe. All other systems are simply subsystems of this larger system. When we investigate interactions it is essential to determine where to draw the boundaries to limit consideration. In doing this there is always a trade-off. If we excessively limit the domain of interactions considered, what remains may be so narrow as to omit some of the relevant interactions essential to understanding the system. If we make the domain of interactions considered too broad, the system under consideration is quite apt to be of such complexity as to limit our ability to understand the interactions amidst the complexity.

In the above reinforcing loop the interaction of **Principal** and **Interest** was the object of the investigation. **Interest**, **Deposits**, and **Withdraws** appear as external influences on the system being considered. It is understood that each of these external influences is actually a component of some other subsystem. The choice was made to omit considering the operation of these other subsystems to allow a focus on the interaction between **Principal** and **Interest**.

The intent of investigating systems is to develop understanding. Often the understanding is an emergent result of trial and error. If the desired understanding isn't developing try expanding or contracting the domain of consideration. As far as I can tell there is no formula for determining what's appropriate. When understanding emerges the domain of consideration is

likely to be appropriate.

Identifying Reinforcing and Balancing Structures

Often when balancing loops and reinforcing loops are part of a complex structures it is difficult to determine the types of loops. The easiest way to make this determination is to count the "-" signs. Simply move around the loop counting the number of "-" signs. If there are zero, or an even number, of "-" signs then it is a reinforcing loop, otherwise there is an odd number of "-" signs and it is a balancing loop.

It is also important to realize that reinforcing loops can create either growth or decline. Which is the case depends on whether the interactions are increasing or decreasing the parts of the system they influence. Reinforcing loops are also often classified as virtuous or vicious depending on whether they are moving the system is a desirable or undesirable direction.

Balancing loops may begin with the current state being greater than or less than the desired state. Depending on the initial conditions a balancing loop may represent an increase in the current state toward the desired state or a decrease in the current state toward the desired state.

Interaction Delays

It is also important to note that there may be delays, possibly of different durations, associated with the interactions between the parts of a system. These delays will determine the length of time it takes for the characteristics of the structure to become evident.

Consider the Savings Account example above. Interest is generally created periodically rather than continuously. There is a delay between **Principal** and **Interest**, and after this delay, at some specific point in time, **Principal** interacts with **Interest Rate** to produce **Interest**. There is no apparent delay between **Interest** creation and its effect of increasing **Principal**.

When dealing with intricate combinations of balancing and reinforcing structures delays are responsible for creating characteristics which are very nonlinear and often very counter-intuitive.

Archetypes

The reinforcing and balancing structures represent the first two of a set of structures first postulated by Ludwig von Bertalanffy in the 1930s. These structures were developed and finally labeled as Archetypes by Peter Senge in his 1990 work entitled "The Fifth Discipline: The Art and Practice of the Learning Organization."

As I understand Bertalanffy's initial premise it was that there are fundamental structures which act across all branches of science. And, if one learns the structures, when transferring from one discipline to another, much of the learning could be transferred. When studying a new discipline one would simply have to learn the labels on the structures in the new discipline. This was the foundation of what was to become General Systems Teaching, but ended up being called General Systems Theory due to a translation error.

When I first came across this perspective I considered it rather profound. Yet, as I pondered it for a time I rather resolved that, how could it be any different? There is but one Universe. The disciplines of science are a creation of ours, not the Universe.

You can consider the balancing and reinforcing structures as building blocks which can be combined in numerous ways to describe more intricate interactions. The Archetypes article describes some of the most common combinations of balancing and reinforcing structures, though theWay of Systems provides a more organized treatment of these archetypes.

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