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Boundaries & Boundary Conditions: Integration of Sources

for the System of Systems Processes (SoSP) General Systems Model

Purpose of This Poster & Work

• This poster tries to provide a sample of the many varied sources of information on the critical concept of boundary (& boundary conditions). It will provide a glimpse of the growth in workers, literature and institutions that specialize on defining boundaries, although unlike other systems processes, boundary is not a dramatic concept and the subject of popular books totally devoted to the topic as are network and chaos. Rather boundaries involves rugged working concepts like input or output for which there are also not dedicated books. However, since it is so basic, we will show it can have a very dramatic effect on either a systems' theoretical inquiry or a systems' application. We will suggest ways to organize, document, and synthesize information on this key systems process that is iso-morphic across many systems and how it interacts with some 80 other systems processes in a system of systems processes model (SoSP). The SoSP would provide several detailed general theories of systems at different levels of scope, span, and abstraction for application to bettering human and social systems. Thus, its hint of application to business systems in this poster.

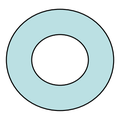
Working Definitions of System Boundaries

• A word like boundary is so common it is used in a multitude of ways. Everyone has a sense of what a boundary is so how do we pin down a meaning for systems work that is accurate and encompassing yet captures the its functionality? Here are some representative quotes from the nominal systems literature.

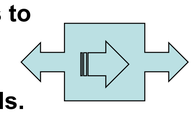
- "The subsystem at the perimeter of a system that holds together the components which make up the system, protects them from environmental stresses, and excludes or permits admission to various sorts of matter-energy and information." (J.G. Miller)
- "Interface is a more useful word than boundary…pay attention to the connection and not just the separation between system and environment." (G. Weinberg)
- "The boundary-surface for one property…will tend to coincide with the boundary surfaces for many other properties…because the surfaces are mutually-reinforcing." (J. Platt)
- "A sufficiently small system will always be dominated by the boundary conditions…(as in) the case of small-size fluctuation, boundary effects (will cause) flux to regress." (I. Prigogine)
- "The boundaries of a systems delimit the system space and set aside from the environment all those entities that make up the system." (B. Banathy)
- "a distinction made by an observer…(A)rtificial boundaries are drawn arbitrarily…Natural boundaries are still arbitrary, but tend to be robust under transformation. That is, natural boundaries coincide for many distinct criteria." (T. Allen and T. Starr)
- "…if boundary conditions of a nonconstant nature are maintained, the system may fina a proces which is either in steady state or which is dynamically fluctuating…It has begun to be realized that fluctuations and turnover are necessary conditions for the maintenance of form." (A. Iberall) [see Francois, Int. Encyclopedia of Systems & Cybernetics for more]

Identifying Features & Functions

• Our research on on the SoSP at the IAS describes each isomorphic process in terms of its special defining features rather than single word definitions or math in order to reach a larger professional audience in the natural and social sciences. To this end we use logo's like parables to capture the nature or essence of a systems process like boundaries. Below are an introductory four ID Features that could be used to define boundaries and boundary conditions.



• Physical Barrier: The most common sense of boundary. A material structure that clearly distinguishes in and out, included and excluded, limits and size as in the membranes around our cells, skin of our bodies, national borders, etc. In these cases boundary is easy to recognize & less subjective.



• Inclusion: Exclusion: This ID Feature is also a Function but as such refers to the set of subprocesses that enforce or realize what is to be included or excluded. For example, the cell membrane may be a barrier, but it is the proteins in the membrane that actively allow things in and out. Border patrols.

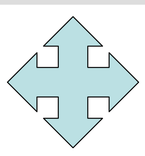
• Identity or Self-Non-Self: It is trivial to recognize subsystems inside a barrier, but less trivial to recognize the "properties" that the bounded entity has established or established for it that "judge" the characteristics for that decision.

• Entitation: One of the Founders of ISSS, the physiologist Ralph Gerard coined this much-neglected term to mean all of the possible influences that impact the subject system or which it impacts. Like the concept of niche for species.

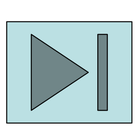
• Interaction Density or Intensity: One of the rationales for inclusion of parts in a system boundary is to increase the amount of interaction possible or probable as in the concentration of biochemicals in the first prebionts or current cells.

• Additional ID Features and Functions used in the SoSP further distinguish and provide a net of meanings to capture the breadth of meaning of boundaries.

Types and Taxonomies of Boundaries



• Farthest Extent of Influence: This defining feature emphasizes that the usual emphasis on physical barrier is too static and structural a definition for BC. A more dynamic view is the use the concept of entitation above to include the total "reach" or "dynamic influence" of an entity as reflecting its ultimate BC.

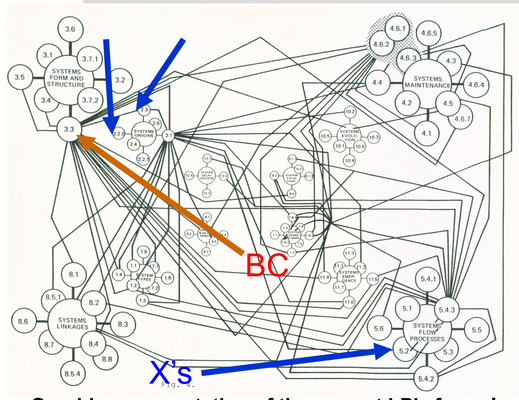


• Physical Constants & Limits: By these we mean those used in physics which by their very presence "bound" the possibilities in this universe. Thus the speed of light, Planck's constant, gravitational constant etc. actually provide universal boundaries on possibilities that bound the "fields" driving the origins of BC sets.

• Again there are additional Types & Taxonomic distinctions on boundaries used in the SoSP that provide insights for and expand understanding of BC.

Positions of Boundaries in the…

…SoSP-GST and General Systems Lifecycle

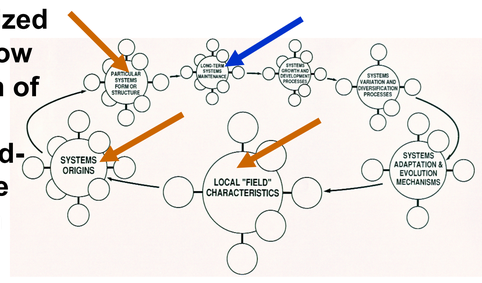


• Graphic representation of the current LP's for only four systems processes on 12 key systems behaviors or phenomena.

• The graphic at the left shows the SoSP, a System of System Processes, as a set of linkage propositions that describe mutual influences among isomorphic processes common to many systems.
• The node(s) and LP's that represent the "boundary" process are marked by red arrows and the node(s) and LP's that represent interaction mechanisms (which are described above as a special type of BC) are marked by blue arrows to show their positions relative to other systems processes.

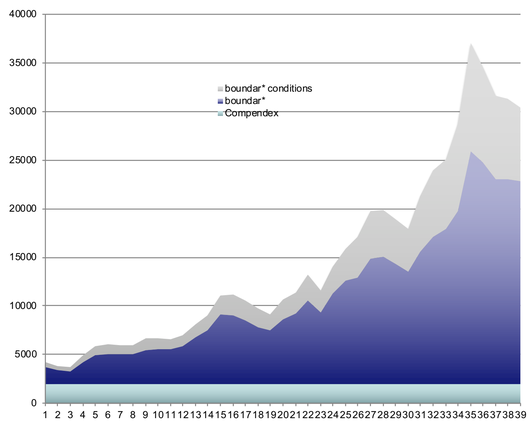
• The graphic at the right shows the proposed General Systems Life Cycle. These are the same 80 processes as shown above, but re-organized in a temporal, sequential flow that models how they act as steps or stages in the maturation of many different types of systems.
• Again the positions of boundaries and bonding or interactions are shown in red and blue respectively to show their role or function in systems development during the lifecycle.

• This graphic of the first iteration of basic stages in the GS Lifecycle shows only the main stages. Evolution and emergence of new systems is not shown. See poster # this session for more.



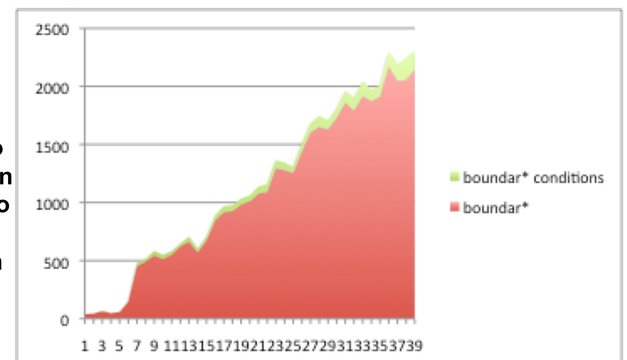
Sources & Scope of Literature: Trends

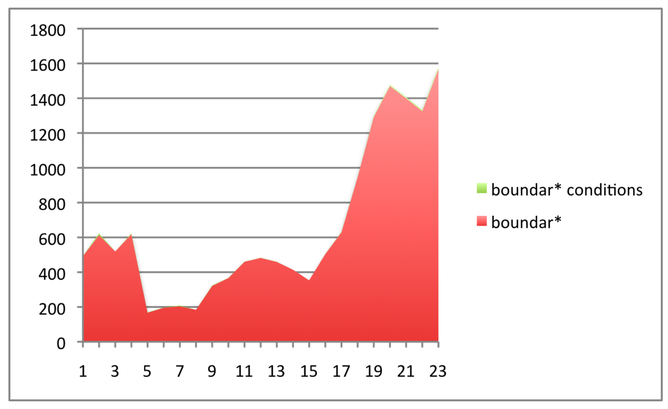
• The SSP & its GENSYSML tool is based on a massive data survey with its primary goal the synthesis & integration of the knowledge harvested. Here we try to get a overview sense of the # and scope of the extensive literature on just one key systems process, that is "boundar* or boundar* conditions" across a broad set of disciplines…….



• THE PHYSICAL SCIENCES, as viewed from the vantage point of math & engineering, has the largest literature on boundaries and especially boundary conditions. It shows total hits of 492,648 for "boundary" word in title for the 38–year period covered. "Boundary conditions" are 27% of the total showing much more attention to this formulation than the living and social sciences. There is a steady trend of increases across the sample period, 1970 to 2008 with a peak ca. 2004. Compendex favors engineering primary literature. To really test the physical sciences we would have to also include Chemical Abstracts, geological data bases, and SciSearch for physics & astronomy which are not shown here. It is important to note that the volume of attention to this systems process in physical sciences is more than ten times the volume for the biological sciences and >30x the sociological.

• THE BIOMEDICAL SCIENCES: At right is shown the primary lit hits for all living systems journals. Numbers are intermediate between the physical sciences and the sociological. Hits for boundary or BC in title total 44,414 for the 38-year period 1970 to 2008 indicating much less attention to this systems process even though the most immediate examples of boundaries that come to mind are biological. "Boundary conditions" in biology are only 5.5% of the total showing much less attention to this formulation than the physical sciences. There is a steady trend of increases across the sample period.





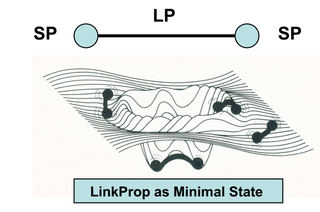
• THE SOCIAL SCIENCES: Just a glance at the total number of hits in this key data base on Sociological Abstracts indicates that despite the existence of professional societies on systems thought in human systems, there is very little penetration of these mechanisms in the sociological primary literature. And when these ideas appear, they generally are only superficially engaged. Total hits in both categories are only 15,055 for the sample 38-year period, only a third of that for biology and a thirtieth of that for the engineering sciences. There is an anomaly in the graph at left because the first periods are 5-year groups not annual as in the rest of the graph and the other graphs. Thus socio also shows a steady increase after about the mid-nineties. The "boundary condition" = only half a percent of references.

Some Conclusions on Literature Sampling

• Each of these posters on "Integration of Sources" in this student series have the same caveats. (1) The physical sciences are lumped together & perhaps poorly represented under engineering and not individually. (2) It is difficult to "capture" the true systems exclusive literature with some of these key words because they are found in common language. (3) The samples are too large to attempt search for redundancies in the databases because of overlap of journals or for only appropriate treatments.
• Still it may be interesting to note that it seems that systems-based terms (& the processes they represent) are steadily increasing in all three literature categories, and have especially good penetration as one goes from the so-called "hard" to "less hard" disciplines. Our unfortunate dilemma is that it is in the sociological area that we most need systems solutions today.

Sample Linkage Propositions on Boundaries

• Please see the explanation for Linkage Propositions (LP's) & their uses in the accompanying poster on the "Introduction to the Systems of Systems Processes" & 175 eg's in "Catalogue."
• Linkage Propositions are hypothesized to be as isomorphic as the systems processes themselves.



LinkProp as Minimal State

1.1. To be properly defined, Boundary Conditions must consider the full ranges of Inputs/Outputs acting on the bounded system.

1.2. Defining the Boundaries of a system is identical to identifying the included systems as components, entities, elements or subsystems.

1.3. Boundary Conditions must be known to properly define internal versus externally generated Goals/Purposes for the system.

1.4. Restructuring can only be defined if Boundary Conditions are clearly recognized.

1.5. Boundary Conditions must be known to define whether a system is open or closed.

1.6. Intrasystem Coupling contributes to the establishment of Boundary Conditions.

1.7. Life Cycles are a type of Boundary Condition that specifically defines temporal Boundaries.

1.8. Transitions/Phases/Modes are transformations in the predominant types of subsystem interrelationships that in turn change some but not all of the parameters used to define the system's Boundary Conditions.

1.9. Identifiable Boundary Conditions are in part the result of achievement of Steady State, whether this is achieved by static or dynamic Equilibrium.

1.10. Boundary Conditions contribute in part to the cause of the Exclusion Principle.

1.11. Hierarchical relativity is in part the result of applying different Boundary Condition parameters and getting different Bounded systems.

1.12. Hierarchical relativity is in part the result of applying different Boundary Condition parameters to a set of systems resulting further in differently Coupled subsystems.

1.13. Patterns in Incremental Trends are the partial result of comparing the magnitudes of parameters of Boundary Conditions (and forces acting across the Boundaries) across the levels of modular Hierarchies.

1.14. Temporal Boundaries of a system results from selection by its environment for the most optimal Cycling times. This means that temporal Boundaries and Cycling time are types of externally-generated goals of a system.

1.15. Recognition that a system has Components/Entities/Elements that are sometimes called subsystems is the same as recognizing the system as Decomposable.

1.16. For a Component/Entity/Element to be properly defined it must be placed in the appropriate Hierarchical level.

1.17. For a Component/Entity/Element to be properly defined all of its Linkages/Interrelationships must be documented.

1.18. This Diversification Processes are a partial cause of Transgressive Equilibrium. Systems organization allows a greater variety and higher level of behavior than can be achieved by any of the systems elements alone (paraphrased from Ackoff, 1971).

1.19. Boundary Conditions of a system are in part the result of the strength and duration of the linkages between its subsystems.

1.20. The participation of Entities/Components/Elements as subsystems in a supersystem is in part the cause of their transtemporal stability.

1.21. In cases of Synergy, Boundaries are expanded from tightly drawn around the bounded entity to a much wider Boundary including the other participants in the Synergy.

1.22. Intra-system Coupling contributes to the establishment of Boundary Conditions.

1.23. The mechanics of unity/wholeness is in part the result of Boundary Conditions.

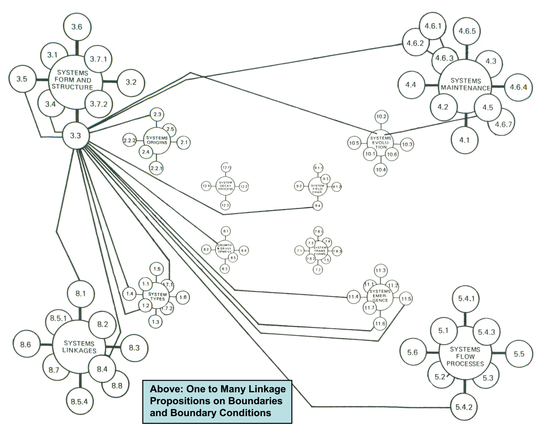
1.24. Boundary Conditions are involved in the distinction between insulated and non-insulated linkages.

1.25. Temporal capture of Energy Flux must occur within the Boundary of a system.

1.26. Concrescence Ratio can lead to the establishment of new stable Boundary Conditions by causing, in part, new levels of Transgressive Equilibrium.

1.27. Concrescence Ratio can lead to the establishment of new Boundary Conditions as well as the associated features of Transgressive Equilibrium.

1.28. Boundary conditions in part result from the establishment of a Steady State, whether it is the result of either static or dynamic Equilibrium.



Above: One to Many Linkage Propositions on Boundaries and Boundary Conditions

• SoSP Linkage Proposition Graphic: In the above, the LP's named at the left are the "edges" or lines that portray mutual influences between numbered small spheres (each a Systems Process) for which we have evidence from the natural systems literature or the sciences. The picture shows 17 LP's between Boundary or Boundary Conditions and 16 other systems processes. This picture maps only the SoSP interactions involving boundaries as opposed to all process interactions shown at far left.

Some Boundary Workers/Institutions

• A sample of some of the scientists and institutions who have worked on boundaries and boundary conditions in no particular priority or order include:
• All workers and their institutions listed in the sample working definitions understanding that some of these definitions are old and workers retired, & this is a more basic than advanced topic.
• G.J.Klir, State University of New York at Binghamton
• From Planck to Carnot to Emanuel to Prigogine in thermodynamics, or
• From Sturn, Liouville, to Dirichlet to Neumann in mathematics

Applications: Boundary Conditions

• The paucity of primary literature in the social science data base on boundaries and boundary conditions might indicate to some that there is great potential for applying the concepts to the social sciences, economics, human development, & solving crisis SoS problems. Ironically, it is likely that human systems workers and consultants think they know the most of all disciplines about boundaries as it is so common when the research record would indicate they know the least.
• Our Institute emphasizes the use of "motif's" or "circuits" of arrangements of systems processes proven effective in natural systems across a wide range of systems and across a wide range of scales of size and appearances in time. Their reoccurrence & sustainability across billions of years is an indication that they are, if not optimized, at least sufficient for healthy systems. The more specific motifs are discovered, the more they can be tried in our management of business and economic systems. But first they have to be discovered and disseminated as in the LP's above.