Selected Aspects of Russell L. Ackoffs System Thinking and Management in the Context of the WUMM Project's System Theory

Seminar Assignment for the Module 10-202-2312
Applied Computer Science *Co-operative Planning and Action*

Jannis de Riz

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Contents

1 Introduction

This assignment is presented as an extension of a previous talk held in the seminar "Co-operative planning and action" as part of the Applied Computer Science module 10-202-2312. The seminar is held as part of the WUMM project [3]. There is not one final definition of a system but rather a vast collection of many different sources from different times and with a different emphasis. Therefore, one can not always assume that every participant in a discussion is argumenting based on the same concept of a system. In each individual frame of reference certain notions might carry a slightly different character. It is even possible that very similar concepts can be expressed using different terms, as will be shown later. It is for that reason, that a shared understanding of concepts and notions needs to be established first in order to communicate ideas consistently.

The "System movement" as Schedrovitsky calls it [19] originated for the most part between the 1950s and 1960s with the notion of general systems theory by Ludwig von Bertalanffy and system dynamics (industrial dynamics) by Jay Forrester [21] [11] [12] [10]. Russel Lincoln Ackoff was an american Scientist, Consultant and one of the contributors to the aforementioned movement. He received his Bachelors degree in architecture in 1941. He later went on to teach mathematics and philosophy at the Wayen State University and became a Professor for Operations Research at the Case Institute of Technology. His biggest contribution to the sciences was the socio-systemic approach to organization theory. His works concentrated on systems thinking and its implications for operations research and management [4] [5] [18] [7]. He pointed out that after the second world war, western culture shifted into a systems age where everything had to be taken apart and analyzed. Thinking about purpose was considered unproductive and meaningless [4]. He hypothesized that all failure in management resulted from that purely analytical line of thought and not thinking systemically [1].

This assignment's aim is to clarify the relation between Russell Ackoffs approach to systems theory to the one developed in the context of the WUMM project. Therefore, both viewpoints on the notion of a system are presented and compared. Further, a selection of two system theoretic sub topics concerning co-operative planning and action is presented and implications from both frames of reference (Ackoff, WUMM) are discussed. The first detailed analysis will be on the notions of Analysis and Synthesis in contrast to immersion and submersion. In Ackoffs words: *understanding HOW something works* (Analysis) and *understanding WHY something works* (Synthesis) [6]. The second matter will be the topic of Problem solving and transition pathways and how the understanding of a system influences these.

2 Comparison of Russell Ackoffs and the WUMM Projects System Defintions

In this section, Ackoffs understanding of systems is examined from the perspective of the WUMM systems theory approach. Therefore, both System Theories are presented. Then similarities as well as differences are pointed out and their overall interconnectedness is discussed. It should be noted that Ackoff stated his notion of a system in the 1970s whereas the WUMM projects definition of a system is from 2019.

2.1 Systems as understood by Ackoff

Ackoff puts forward the notion that, in contrast to the common view, a system is the result of its parts *interactions* rather then their sum. This is actually a lot closer to Aristoteles initial statement *...the totality is not, as it were, a mere heap, but the whole is something beside the parts...* which led to the common notion of *the whole is more than the sum of its parts* which might not emphasize the emergent phenomenon as much as the initial statement of Aristoteles. He further distinguishes between three types of systems, there being the mechanical, the organismic and the social system [6]. He defines a system as follows:

> A system is a whole consisting of two or more parts
>
> (1) each of which can affect the performance or properties of the whole,
> (2) none of which can have an independent effect on the whole, and
> (3) no subgroup of which can have an independent effect on the whole. In brief, a system is a whole that cannot be divided into independent parts or subgroups of parts.

There are several implications that arise from this definition. For example, a system can consist of several subsystems that in themselves form a system. Also, all parts of a system are interdependent which follows from (2). That means changing one part can never be seen in isolation. A change in one, say subsystem, is always accompanied by at least one counteraction. In other words, all parts and their contribution to the system has to be seen in the context of at least one other part. Parts without which a system can not perform its function are called *essential*. As already mentioned Ackoff discriminated three types of systems.

Mechanical systems. Mechanical systems are open or closed, as in, they can or cannot interact with or be influenced by their environment. Newton saw the universe as a closed system. In contrast the earth was seen as an open system as its trajectory is influenced by its surroudning stars and planets. Mechanical systems have no purpose on their own, instead they serve the purpose they where designed for. A car has no purpose on its own but serves the purpose of transportation that it was designed for.

Organismic systems. The organismic system has one goal or purpose that is inherent to it. As humans our body-systems purpose is assuring to survive, or to continue being. Each individual part of our body in contrast has no purpose but a function. Organismic systems are open and therefore react to, or interact with, the environment.

Social systems. Ackoff [6] defines social systems as follows. They "are open systems that

(1) have purpose of their own,
(2) at least some of whose essential parts have purpose of their own, and
(3) are parts of larger (containing) systems that have purpose of their own."

Those three representations of a system are both concept and entity. This enables to think of any system in terms of any of these types [6]. It should be noted that Ackoff develops these three perspectives in front of a historical context, where one developed after another in consecutive order as stated. This implies that both organismic as well as social systems are to some extend descendents of the mechanical system view.

2.2 Systems as understood by the WUMM project

The WUMM project orients its system view on the TRIZ methodology [9]. The (Business) TRIZ methodology is focused on technical and socio-economical systems. Although there is no unique system definition in TRIZ the WUMM project defines a system in its ontology [2] as follows:

> A system is a set of elements that are in relationship and connection with each other and that constitute a well defined unity, an integrity. The necessity of the use of the term "system" occurs when it is required to emphasize that something is large, complex, immediately not wholly comprehensible, but at the same time a unified whole. Unlike the notions "set" or "aggregate", the concept of a system emphasizes the ordering, the integrity, the regularity of construction, functioning and development.

A definition by itself is prone to misunderstanding due to the reasons mentioned in the introductory section. Therefore, its embedding in further explanations from [14] will be discussed briefly. The authors in [14] are developing their notion of a system in a dynamic socio-economical and socio-technical context. Much like Ackoff, the TRIZ terminology distinguishes different perspectives on a system. In [14, p. 69] the authors mention technical-, engineering- and man-made systems. Buth those are not the only system notions discussed in the WUMM project. This general approach of establishing a system definition that serves as an architectural skeleton which then is concretized by further explanations is the same as in Ackoffs writings. Yet, the WUMM projects elaborations are more human focused then Ackoffs perspective in general. Ackoff develops the social system, over a mechanical and then in general organismic system. Both do not have a clearly defined human aspect. Of course the mechanical system can be build by humans, but that is not a central part of the concept. The TRIZ system elaborations mentioned in [14, p. 69] are in contrast all including the human as a central entity in one or the other way.

2.3 Comparison of definitions

Both notions of a system share many commonalities. One could summarize both definitions in three major points.

(1) First and foremost both state that systems have a set of entities (parts, elements).

(2) These entities interdepend (have relations, are connected) on each other.

(3) The system has integrity, forms a unity, in other words *cannot be divided.*

Now, as the common characteristics are established, what are the differences between both understandings? Statement (2) of Ackoffs definition is unmirrored in the WUMM system definition. No single part can have an independet effect on the whole and neither can any subgroup of parts. From a graph theoretical view this is the case for connected graphs, as there is a path (way of interaction) from any one point to any other. This strict constraint articulates Ackoffs emphasis. In contrast the distinguishing emphasis in the WUMM system definition lies on the overall, at first uncomprehensible, complexity of a system. Although it has order, integrity and regularity of construction, functioning and development. In other words, WUMM emphasises "uncomprehensible" complexity (emergence) despite comprehensible description. And Ackoff emphasises the cause of that complexity, which is strict interdependency. We know from the three-body problem that systems with only 3 elements or parts already show complex and chaotic behavior and cannot be analytically determined, in other words no closed form can be found but only numerical solutions. To summarize, both definitions are fairly well aligned, but in WUMM putting emphasis on the observed behavior and in Ackoffs case on the cause of such observed behavior.

3 System-Theoretical Implications of System Perspectives for Co-operative Planning and Action

Following the seminars title *Co-operative Planning and Action* this section discusses how the systemtheoretical framework can influence the process of designing (planning) and managing (acting on) an actual *real world* system. Specifically the concepts of analysis and synthesis as stated by Ackoff are compared to the submersive and immersive approach to systems in WUMM. Consecutively, possible implications of these concepts for planning and action are discussed.

3.1 Analysis and synthesis or submersion and immersion

In this section Ackoffs notions synthesis and analysis are presented and set into relation with the WUMM concept of immersive and submersive system theory [14, p. 21]. The terms submersion and immersion have distinct meaning in many different fields [20] [15]. Therefore, the notions have to be explained in this system theoretical context.

Synthesis is putting the system together with other systems (parts) and properties of the supersystem are derived in order to understand the function as inputs and outputs of the initial system of interest.

Analysis instead is taking the whole apart and concentrating on managing every part individually. Understanding a system cannot be reduced to the analysis of its parts, but the function of each individual part is an important ingredient for the overall understanding of a system.

Immersive system theory is characterized by embedding and is in this context understood as the direct sum of system components.

Submersive system theory is characterized by cascaded complexity reduction and projection of system components. It is in this context to be understood as the product of system components, and thereby does not equal to the sum of its parts.

To now link those two terminologies and concepts, one can think of immersion and synthesis to be a pair of concepts. Understanding is comprehension of *why* something works and is based on synthesis in Ackoffs writings. It focuses on the sum (direct sum from WUMM immersion) of the inputs and outputs of system components which define its role in the supersystem.

Analysis and submersion is the other pair. Analysis yields knowledge in Ackoffs studies and is comprehension of *how* something works. It focuses on emergent phenomena and is the product (direct product from WUMM submersion) of the system components interactions.
Ackoff writes, and one can easily follow this line of argument, in order to manage properly these views requires to be followed but a combination of at least two as they both shine light on *different* aspects of the system. It should be noted that this approach of analysis and synthesis or submersion and immersion can be exercized in a recursive fashion. So when analysis is conducted of any given system S consisting of S_i and S_j their respective parts can be evaluated from an immersive context such that we ask what are the I/O properties (direct sum) of e.g S_{ij} and S_{ik} that contribute to the purpose of S_i.
The authors in [14, p. 21] write that the theory of dynamic systems is a submersive system theory. Yet, in the moment of purpose/function definition the system is static and therefore an immersive approach can be taken. It should be noted that the terms purpose and function are very distinct in Ackoffs terminology but they are not subject of this discussion and therefore left for another time to evaluate.

3.2 Transition- and transformation-pathways and problem solving

In this section the connection between WUMM's projects discussion on transition and transformation pathways and Russell Ackoffs approach to problem solving is elucidated. But first the seminar's title of co-operative planning and action is brought into connection with the terms management and design as we will use this terminology analog. In this context the term action can be understood as active management in a dynamic context. On the other hand planning can be understood as a design step much like envisioning, it has a more static character.
Ackoff states in 1972 [6] that

> managers are educated to believe that a social systems's performance can be improved by improving the performance of each of its parts taken separately – that is, if each part is managed well, the whole will be. This is seldom if ever the case, because parts that appear to be well managed when viewed separately seldom fit together well.

Ackoff describes four essential solutions (managements) to problems or messes.

Absolution ignores the problem with the expectation that it "solves itself" given enough time.

Resolution can be seen as a quick fix. If focuses on clinical measures and is an approach that results in a situation that is merely satisfactory. Its focus is on the very specific problem rather than the general mechanism behind it.

Solution is within the given context the optimum. It is led by a research approach and focuses on the general aspects of the problem.

Dissolution redesigns (planful) the entity or the environment where the problem arose. This enables for a future state that is superior to the best possible in the current one. It focuses on generality and uniqueness of the problem equally and uses whatever technique seem to be fit.

The very concrete toolset that Ackoff provides stands against a more general theoretical line of thought in the WUMM project. Where it is less the ambition to give concrete means of action, but rather to aggregate several ways in wich change can happen. This is, in contrast to Ackoff, not even determined to be governed by management in form of a managing entity, but can also happen organically. As a starting point WUMM choose transition pathways as proposed by [13].
The WUMM project is concerned that the notions of transition and transformation are not clearly distinguished in the systems literatur. From other sciences they take that transition preserves system components whereas transformation changes every componenent in a system [14, p. 78]. As both notions are yet to be defined in the WUMM ontology they are handled loosely and largely interchangeable here.

1. In production, if no landscape pressure, systems stays dynamically stable and reproduces itself.
2. In transformation, under moderate change in landscape, actors modify the direction of system development and innovation.
3. In de-alignment and re-alignment, under large sudden change in landscape, actors loose faith. De-alignment occurs, if no strong niche-innovation space exists, otherwise parallel niche-development compete, finally one niche-winner takes over in re-alignment to a new system.
4. Under technical substitution, large change in landscape occurs, a niche is developing, will break through and replace the current regime.
5. Reconfiguration appears, if no accute landscape pressure exists, niche-innovations are used to solve local problems, then the new solution spreads through the basic architecture of the system.
6. Disruptive change, large change in landscape, leads to a sequence of transitions and transformations and finally to a reconfiguration or possibly de- or re-alignment.

In Ackoffs approaches one can determine some sort of quantitative structure. If one was to apply a measure that indicates how ideal a solution to a problem is in the most elaborate context (most detailed and comprehensive system view) the ordering would most likely be in ascending order absolution, resolution, solution and dissolution. In contrast, the extended transition pathways from [13] are only qualitatively structured, as there is no generally better or worse way.
Of course, Ackoffs ways of dealing with problems and messes can be optimal within each given context. Imagine some problem on a cardiovascular machine that needs to be fixed instantly before maybe redesigning the machine such that the malfunction does not arise, but that holds for every thought possible. The question therefore arises, do, and if so, in which way Ackoffs real world approaches relate to the transition pathways described and which role does a submersive or immersive perspective play in this context?

In [14, p. 77] the authors discuss some of the findings in [13] and evaluate them against the seminar and especially Holling's model of adaptive cycles in [16]. A similar approach is taken here, and Ackoffs ways of dealing with problems and messes are mapped to Geels et al. transition pathways [13].

P0: In Production. This transition pathway can be linked to Ackoffs notion of absolution. There is no external need for management as the system's inherent capabilities are sufficient to adapt to a given situation.

P1: Transformation. This transition pathway relates to Ackoffs solution and resolution. There is a change in system components that can be either local or global in the system, but no redesign of the supersystem is taking place.

P2: De-Alignment and Re-Alignment. This transition pathway involves two main components:

1. The possibly of coexisting niche-innovations that can be understood as solutions.
2. A solution that dominates and thereby triggers possible dissolution.

P3: Technical Substitution. This transition pathway can be seen as a local change and then matches best to Ackoffs notion of a solution/resolution. It is a research driven change. It can also be seen globally as a complete redesign and thereby would map to dissolution. More specifically, if S is the system under reference and its component S_i is substituted it would be a resolution or solution. But if S itself would be substituted or even changed to S' it would be a dissolution.

P4: Reconfiguration. This transition pathway is a combination of resolutions (local, niches) that results in a sort of bubble up dynamics that can potentially lead to a solution in the broader (basic) system. It might even extend to a dissolution depending on the scope of basic change introduced. It could as well lead to new problems and messes in the broader system.

P5: Disruptive change. This transition pathway is the most complex and branched pathway in Geels et al. explainations due to its many conditionalities. There is no direct mapping as it can potentially involve all of Ackoffs concepts of problem solving.

It is appareant that the relation of these pairings highly depends on the level from which one observes and is not very stringent. Nevertheless, it shows that linkages between those terminologies can be found. In any of the aforementioned approaches two basic steps need to be taken. First, an entity, and this can be one person, many persons or no person at all, is defining some goal. This is happening either as a momentary snapshot or as a series of those, e.g. a series of system states that are envisioned. This happens best in a immersive/synthetic system context. As it is for the moment a vision of where the system should be positioned in its super-system and what its I/O properties should be. Then either the same entity or a different one needs to actually implement this vision. This happens best in a submersive/synthetic context as interaction relations and possible synergies need to be understood to best deliver the given envisioned system state.

4 Discussion

In this section the findings from sections 2 and 3 are discussed. While Ackoff intended to develop a coherent terminology, WUMM tries to elucidate the relation between different terminologies from different groups over the course of decades [14]. Further Ackoffs approach is predominantly based on his own thinking, without drawing connections to other authors. This is of course probably due to the comparatively underpopular field of system sciences in his time. Nevertheless we find that key concepts in system theory have persisted and are shared between the WUMM system view and Ackoff. Especially the connection between analysis/synthesis and submersion and immersion shows that the aspect of perspective has an important role in system theoretical thinking.

This in some sense triggers a switch of perspective from a quantitative to a qualitative world view yielding tools such as Fuzzy Cognitive Mapping (FCM), that finds a lot of use in the realm of participatory modeling [17]. They are supposed to bridge the gap between shared vision finding and implementation [8].

5 Conclusion

To begin with it should be stated that complex systems are dynamic and can not be analytically solved. Static systems can be solved given enough compute power. Complex socio-techonological systems as discussed in WUMM can partially be approximated using differential equations but likely not be solved in a closed form. therefore optima are only local wich aligns with the projects findings in [14, p. 79]. further, only systems in motion (dynamic) can be managed if one follows [19]. so depending on the possibility if and where one draws the line between management (action) and design (planning) one comes to the following conclusions. if dynamic systems are submersive, then immersion is static. immersion is comparable to ackoffs synthesis. ackoffs states that management should not merely rely on analysis. Consequently, a mixture of submersive (dynamic) and immersive (static) system views is needed, although we discuss dynamic systems. This seems like a contradiction. But, in any given discrete moment a vision of some system state S is static although the system itself remains dynamic. So one could argue, that a vision definition (design, co-operative planning) should focus on synthesis and immersion whereas management and implementation (action) should focus on analysis and submersion.

This leads to the conclusion that any system theory that merely takes on one of the aforementioned perspectives is insufficent for successful management in the broader sense (planning and action).

References

[1] Ackoff at an event to honoring the legacy of Dr. W. Edwards Deming. `https://www.leancompetency.org/video/russell-ackoff-on-systems-thinking/`. 2021-05-05.

[2] The TRIZ Ontology Project: `https://github.com/wumm-project/RDFData/blob/master/Ontologies/GeneralConcepts.ttl`.

[3] The WUMM Project. `https://wumm-project.github.io/`.

[4] R. L. Ackoff. A note on systems science. *Interfaces*, 2 (4):40-41, 1972.

[5] R. L. Ackoff. From data to wisdom. *Journal of applied systems analysis*, 16 (1):3-9, 1989.

[6] R. L. Ackoff. Systems thinking and thinking systems. *System Dynamics Review*, 10 (2-3):175-188, 1994.

[7] R. L. Ackoff. Why few organizations adopt systems thinking. *Systems Research and Behavioral Science*, 23 (5):705, 2006.

[8] J. Aguilar. A survey about fuzzy cognitive maps papers. *International journal of computational cognition*, 3 (2):27–33, 2005.

[9] G. Altshuller. *40 principles: TRIZ keys to innovation*, volume 1. Technical Innovation Center, Inc., 2002.

[10] J. W. Forrester. Industrial dynamics — after the first decade. *Management Science*, 14 (7):398-415, 1968.

[11] J. W. Forrester. System dynamics, systems thinking, and soft or. *System dynamics review*, 10 (2-3):245-256, 1994.

[12] J. W. Forrester. Industrial dynamics. *Journal of the Operational Research Society*, 48 (10):1037-1041, 1997.

[13] F. W. Geels and J. Schot. Typology of sociotechnical transition pathways. *Research policy*, 36 (3):399-417, 2007.

[14] H.-G. Gräbe and K. P. Kleemann. *Seminar Systemtheorie: Universität Leipzig, Wintersemester 2019/20*, Rohrbacher Manuskripte, volume 22. Books on Demand, 2020.

[15] K. Hakuta and L. J. Gould. Synthesis of research on bilingual education. *Educational leadership*, 44 (6):38-45, 1987.

[16] C. S. Holling. Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4 (5):390-405, 2001.

[17] B. Kosko. Fuzzy cognitive maps. *International journal of man-machine studies*, 24 (1):65-75, 1986.

[18] S. S. Sengupta and R. L. Ackoff. Systems theory from an operations research point of view. *IEEE Transactions on Systems Science and Cybernetics*, 1 (1):9-13, 1965.

[19] G. Shchedrovitsky. Principles and general scheme of the methodological organization of system and structural research and development. *Sistemnye issledovaniya. Metodologicheskie problemy: Ezhegodnik 1981*, p. 193-227, 1981.

[20] E. F. van Beeck, C. M. Branche, D. Szpilman, J. H. Modell, and J. J. Bierens. A new definition of drowning: towards documentation and prevention of a global public health problem. *Bulletin of the World Health Organization*, 83:853-856, 2005.

[21] L. von Bertalanffy. General system theory. *General systems*, 1 (1):11-17, 1956.