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Original Paper

A Proposed Complex Adaptive Systems (CAS) Methodology for Addressing Problems that Feature High Dynamic and Behavioral Attributes

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Abstract

Problems of high dynamic and behavioral complexity, also known as 'wicked problems' and 'wild messes', are the most difficult problems for society to address. This paper proposes utilizing the theory of Complex Adaptive Systems (CAS) as one avenue to address problems of high dynamic and behavioral complexity.

Keywords: Decision Making, Risk and Uncertainty, Social Media and Networks, Sociology and Choice, Complex Adaptive Systems

Introduction:

Renate Meyer (2025) in her recent article, "Wicked Crises and the (In)capacity to Act" has presented a provocative perspective on difficult problems of complexity. She has presented the reader with a thoughtful bibliography of current research, and has also suggested a roadmap for addressing problems of complexity. This reply to Myer's article follows along with her suggestions and offers a potential path forward.

Meyer's article suggests two interrelated forces addressing wicked problems; organizational fragmentation, and societal fragmentation. However, it is likely there are far more aspects to wicked problems than these two interrelated forces. Investigators should consider that wicked problems are actually structural in nature and not limited to two interrelated forces. That is, wicked problems are actually systems and should be addressed as systems.

It should also be considered that a problem is defined by the viewer. That is, a wicked problem to one individual might be considered an opportunity to a different individual. Also, one should consider that when we define a 'situation' as a wicked problem, we are comparing it to a previous state. Addressing a situation as a wicked problem is therefore likely a desire to return to a previous condition that existed before the situation became defined as a problem. As an individual addresses the changed state, that individual should consider whether the 'current' state being addressed is the 'final' state, or whether the 'current' state is a 'transitional' state. It must be noted that in this paper, an impersonal perspective to defining and addressing a 'wicked problem' is in no way diminishing the pain, suffering, and/or tragedy that is inflicted on those experiencing such a condition. The 'starkness' of the point above is intended to facilitate how to confront such situations in order to help achieve a 'state' that is less traumatic to those involved.

While Meyer's article utilizes the model presented by Rittel and Webber (1973) this paper will offer a different model from Senge (circa 1992). The proposed model delineates problems into four separate domains along two different axes. The axes represent behavioral and dynamic complexity and the four matrices created by the two axis are 1) simple problems, 2) complex problems, 3) wicked problems, and 4) wild messes. The proposed model is illustrated below:

		Behavioral Complexity	
		Low	High
Dynamic Complexity	Low	Tame Problems	Wicked Problems
	High	Messes	Wild Messes
			Source: Senge

Examples for each of these states might include deciding on 1) what entree to have for a lunch as a 'simple' problem, 2) coordinating the building of an airplane on time and budget as 'messes', 3) addressing healthcare costs as a 'wicked' problem, and 4) managing social media as a 'wild messes' problem. Deciding what to eat for lunch is not behaviorally and dynamically complex. Building a jumbo jet is not behaviorally complex, however because of the number of components needed at the right time, location, quality, and price it is dynamically complex. Addressing healthcare might be considered behaviorally complex because of the different perspectives of the players involved (politicians, doctors, insurance companies, suppliers, and of course patients), and although more dynamically complex as compared to simple problems and wild messes (with modern medical advances juxtaposed with traditional medicine), it might not be as dynamically complex as social media as will be addressed below.

Complex Adaptive Systems:

As Rau (2021) discusses in 'Exploring Problems of High Dynamic and Behavioral Complexity', a potential direction for investigation would be to pursue the theory of complex adaptive systems (CAS) as discussed by John Holland (1995) in his book Hidden Order: How Adaptation Builds Complexity. In his work, Holland proposes four properties and three mechanisms for complex adaptive systems. The properties include; flows, aggregation, non-linearity, and diversity. The three mechanisms include; building blocks, internal models, and tags. It is proposed in this paper, that focusing attention on properties and mechanisms, may be a fruitful source of research to address problems of high dynamic and behavioral complexity. It is likely that key leverage points will be in the aspects of mechanisms however it is possible that some attention to properties may also supply potential for corrective actions.

Regarding mechanisms, building blocks are small elements that may be assembled into larger structures and/or repeated in a multitude of configurations. Building blocks are small elements they may be reused and reconfigured. Building blocks are also about quality, prevalence, and quantity. Internal models help the larger structure to anticipate an outcome. Tags serve as recognition. This recognition is similar to a memory and helps provide guidance as how to 'act'.

Regarding properties, flows include nodes, resources, and connectors. Flows also address boundaries, interaction coordination, and generation of meta-interactions. Aggregation allows emergence of larger structures and standardization. Nonlinearity is the issue of randomness and the often noted 'butterfly' effect, while diversity is akin to evolution and the filling of niches and the potential for fitness landscapes. Implicit in the CAS model are two other features; information in its broadest sense, and energy.

Mechanisms are how CAS is achieved. Small elements provide the opportunity for larger structures to emerge. Internal models are the instructions for the small elements and tags provides means for all of the sub-elements to recognize other elements.

It is proposed in this paper, that when analyzing a wicked problem or wild messes, deconstruction of the system involved needs to occur. That is, what are the mechanisms within the system? How might

the larger structure be deconstructed into the underlying building blocks, internal models, and tags? By identifying these components of the system, leverage for addressing the problem might be discovered.

From ‘Exploring Problems of High Dynamic and Behavioral Complexity’, questions that might be asked regarding building blocks include:

Building Blocks (Generator, and Conglomerate)

- What are the basic components of which the larger system is constructed?
- What are the specific characteristics of the building blocks: the quantity, quality, and prevalence?
- Do the building blocks demonstrate autonomy (or decentralization) in co-joining and creating?
- Can building blocks combine with other building blocks?
- Do the newly created structures (from the joining of building blocks) demonstrate an ability to change the rules and procedures of the structure?
- Are the building blocks re-usable?
- How are the boundaries of building blocks created/determined?
- What are the density characteristics of the building block of the system?

Similar questions might also be explored for the two remaining mechanisms; internal models, and tags.

Internal Models

- What are the internal models and mechanisms of which the larger system is constructed?
- Where do the internal models reside? In a shared ‘repository’ or locally?
- Do the internal models demonstrate rationality or arbitrariness?
- Do the internal models demonstrate an ability to change the rules and procedures of the structure, or do they ‘lock’ the structure into a predictable state?
- Are the internal models re-usable in other structures?
- What are the density characteristics of the internal models of the system?
- If there are multiple internal models, are they internally consistent? Is there an hierarchical structure to the internal models (such as: if A, then B)?

Tags

- What are the tag’s the larger system recognizes?
- What are the specific characteristics of the tags: the quantity, quality, and prevalence?
- Are the tags always recognized, or are certain conditions necessary for the tags to operate?
- Do the tags demonstrate autonomy (or decentralization) in the creation of a larger structure?
- Do the newly created structures (from the recognition of tags) demonstrate an ability to change the rules and procedures of the structure?
- Are the tags re-usable in different situations?
- What are the density characteristics of the tags of the system?
- Can the tags be disrupted from their intended use?

There is also the potential to explore aspects of the properties, and the following questions might be useful in this regard:

Flows

- What are the boundaries of the organization?
- How are the interactions coordinated and directed?
- How do the aggregated interactions generate meta-interactions?
- What are the interactions of the 'agents' (i.e., static, dynamics, patterns, etc.)?
- What rate of change and longevity is demonstrated by the various flows?

Diversity and Fitness Landscapes

- Does the organization demonstrate evolving of components and sub-structures?
- Does the evolution of the components and sub-structures fill unexploited niches?
- If a function or pattern of the organization has been eliminated or disturbed, have the previous roles and outputs (products and/or services) of that function been filled by some other internally evolving structural component?
- Does the organization refine and perfect existing routines and practices?
- Does the organization willingly engage in activities that are different than normal activities?

Non-linearity

- Are aspects of the organization that are not predicted by normal cause and effect relations allowed and encouraged in the organization?

Aggregation

- Are multiple goals and purposes allowed or encouraged in the organization?
- Does the organization demonstrate flexibility and adaptability willingly?
- What are the behaviors of organizational members when confronted with contradictory requirements?
- Is anything left in reserve, or does the organization "run-to-the-max"?
- What are the human component factors like?
- Does the organization tolerate errors?
- What are the structures like?
- What patterns of cooperation are demonstrated (evolutionary stable strategy, etc.)?
- Does the system demonstrate a multiplier effect with energy and resources?
- How is energy recycled in an ecosystem perspective?

For each of the CAS elements noted above (the three mechanisms and four properties), three additional questions should be explored:

- What are potential near-term impacts from intervening in this action?
- What are potential mid-term and long-term impacts from intervening in this action?
- What are potential collateral damage from intervening in this action?

Clearly, there are other questions that might be asked in the enquiry of CAS systems, and the questions above merely serve as a beginning point for investigation.

Social Media:

As a thought experiment, it is proposed that looking at the wild messes of social media might illustrate how research could be potentially pursued. The assumption in this paper is that social media is a Complex Adaptive System (CAS). The section below is provided as an overview of social media, and this section is divided into 'blocks' that will hopefully facilitate the discussion that follows.

The Internet was invented in the late 1960s, with the development of ARPANET, which is considered the first version of the Internet. The 'official' birthday of the Internet is January 1, 1983, when the TCP/IP protocol was adopted, allowing different networks to communicate with each other. It is clear that this brief period of time (from its beginning to the present) tremendous growth and diversity has occurred. It is likely that the 'fitness landscape' of social media has not yet been exhausted, and that might provide an opportunity to address some social media 'wicked problems' and 'wild messes'.

Social media is clearly a complex area to investigate. From LIS Education Network 'What is Social Media? Examples, Types, and Its Importance' (https://www.lisedunetwork.com/what-is-social-media/#google_vignette,) (accessed 12/15/25) there are key characteristics which separates social media from other communication format including:

Block A

- Interactivity,
- user generated content,
- global reach and accessibility,
- virality,
- personalization,
- community building,
- real-time updates,
- integration,
- engagement and feedback,
- democratization of information.

Block B

Social media has significant purposes including:

- Communication and connectivity,
- information sharing,
- entertainment,
- networking, and relationship building,
- educational learning,
- marketing and business promotion,
- advocacy and social, activism,
- content creation and expression,
- feedback and customer interaction,
- socialization and community building,
- influence and trendsetting,
- job hunting and career development.

Block C

There are different types of Social media including:

- social networking platforms, such as Facebook and LinkedIn,
- media sharing platforms such as Instagram, YouTube and TikTok,
- micro blogging platforms, including Twitter and Mastodon,
- discussion formats, including Reddit and Stack Overflow,
- messaging platforms, including WhatsApp and Telegram,
- blogging and publishing platforms, including WordPress, Medium and Substack,
- live streaming platforms, including Twitch, YouTube and Instagram Live,
- collaborative and productivity platforms, including Slack, Microsoft teams and Trelio,
- social shopping platforms, including Instagram Shops, Pinterest and Etsy,
- gaming and virtual world platforms, including Discord, Roblox, and Second Life,
- interest-based platforms, including Good Reads, Behance and Strava,
- review and recommendation platforms, including Yelp, TripAdvisor, and Trust Pilot.

Block D

'What is Social Media? Examples, Types, and Its Importance' summarizes some common criticisms for this aspect of modern society including:

- spread of misinformation and fake news,
- privacy and data concerns,
- mental health issues,
- echo chambers and polarization,
- cyber bullying and harassment,
- digital addiction,
- exploitation of content creators,
- negative effects on children and teens,
- decline in authentic relationships,
- commercialization and consumerism,
- content moderation challenge,
- impact unintentional span.

Block E

However, there are benefits with using social media for individuals including:

- enhance communication and connectivity,
- access to real type information and news,
- opportunities for learning and skill development,
- creative expression and inspiration,
- professional networking and career opportunities,
- community building and emotional support,

- entertainment and relaxation,
- raising awareness and supporting causes,
- opportunities for monetization,
- personal branding and identity,
- exposure to diverse cultures and ideas.

The excellent summary of social media as provided in 'What is Social Media: Examples, Types and Its Importance' (https://www.lisedunetwork.com/what-is-social-media/#google_vignette) (accessed 12/15/25) indicates the breadth of publicly available resources. While the complexity of social media is apparent from the above, it must be noted that the above is estimated to only address approximately 4% of what is in the information 'ether' via public web sites. The 'Deep' web comprises approximately 90%, and the 'Dark' web comprises an additional 6% of content. It is therefore suggested that social media is a complex adaptive system, and also from Senge's model that it is a 'wild messes' with high dynamic and social complexity. And as-an-aside as suggested above, social media might be more dynamically complex that healthcare.

Exploring the 'structure' of the Deep web and Dark web a similarity is observed in that 'building blocks', 'internal models', and 'tags' are evident in design. However, the Deep web requires login credentials and are behind firewalls and/or paywalls, and Deep web information can not be accessed with a search engine. The Dark web goes a step deeper in that activity is anonymous via a variety of encryption and routing techniques.

As noted in 'The Dark Web Explained' (https://www.crowdstrike.com/en-us/cybersecurity-101/threat-intelligence/dark-web/) (accessed 12/29/25):

"The dark web is also unregulated, meaning that it is run and upheld by a vast network of individuals around the world. This network contains thousands of volunteers who operate proxy servers to route dark web requests. As such, no one is responsible for setting rules or ensuring their adherence. This operating model is what makes the dark web such a valuable and appealing tool for cybercriminals and other people with questionable intentions.

Though the dark web is part of the deep web, the inverse is not true. As such, the two terms should not be conflated. The dark web continues to be a valuable tool and exchange network for many groups around the world. Some consider it an outright necessity, as it helps encourage free speech, maintain a free press, and support the work of law enforcement and government agencies."

It appears that the configuration of the Dark web also follows a CAS structure. 'Thousands of volunteers' (building blocks) operating 'proxy servers' (internal models) routing 'requests' (tags). Note that no one sets obvious rules or monitors for compliance to those rules. The system (CAS) essentially operates with individual players acting independently. The Deep web is somewhat different regarding the internal model aspect, however, the building blocks and tags are identifiable.

Discussion:

The excellent delineation by LIS Education Network as noted above in the section 'Social Media" ('What is Social Media? Examples, Types, and Its Importance ' (https://www.lisedunetwork.com/what-is-social-media/#google_vignette,) (accessed 12/15/25) may help facilitate a CAS analysis. *Block 'C'* appears to be primarily the 'properties' aspect of diversity, and in that regard it is likely that leverage for change is not as evident in that domain. While *Blocks 'D'* and *'E'* might also be aspects of 'properties' of CAS, they appear to be an indication of the potential 'crisis' situation that require remediation.

Blocks 'A' and '*B'* seems to fit with the 'mechanisms' aspect of CAS, and there would likely be within these arenas focal points that may be exploited for change and disruption.

Drastic solutions to problems arising from social media are not tenable. Absurd solutions might include the extinction of all humans, the destruction of energy systems that power social media, or the complete

elimination of social media. It clearly is not possible to solve 'wicked problems' and 'wild messes' with these types of bizarre solutions. It appears that dictatorships have frequently attempted to eliminate social media to stifle information flow to their citizens, and have frequently failed in their efforts. Also, as noted above, the vast majority of social media (the Deep Web) on the surface appear benign. Drastic solutions (such as eliminating energy systems for powering social media) would have collateral damage far worse than that inflicted by malfunctioning social media.

Exploring for leverage points within *Blocks 'A'* and '*B'* utilizing the questions in the above section for mechanisms might proceed as follows.

Interactivity:

- If there are multiple internal models, are they internally consistent? Is there an hierarchical structure to the internal models (such as: if A, then B)?
- What are the basic components of which the larger system is constructed?
- What are the specific characteristics of the building blocks: the quantity, quality, and prevalence?
- Do the building blocks demonstrate autonomy (or decentralization) in co-joining and creating?

Leverage points include the individuals who are utilizing the structure, and the coding within the software that facilitates social media. The questions immediately above appear to be more appropriate for coding of the software. Therefore an understanding of the codes in the programs is required to modify the program:

- to perform a different function
- with how it relates to other codes within the program
- how it recognizes a precursor command and responds in a different way
- how it recognizes a precursor command and 'infect' the precursor command
- disrupt the existing program in some other manner

In a similar fashion but addressing the human actors involved with the program, how may their actions be altered to address the problem? Rau (2021) proposes a modification of the existing analytic tool PESTLE to assist in this endeavor. PESTLE is an acronym:

- P represents Political,
- E represents Economic,
- S represents Social,
- T represents Technological,
- L represents Legal, and
- E represents Environmental,

and Rau includes to the already existing PESTLE:

- 'C 'for Culture and all of the factors with a commonality to culture,
- 'U 'for barriers to Understanding the problem (such as hubris, not being aware of time delays, overconfidence, group think, etc.),
- 'R 'for Resources available, and
- 'N 'for the potential Non-linearity of the structure(s) including trajectories over time and inherent goals of the structural elements

becoming the additional' CURN'.

As we explore potential methods for addressing societal problems the following methods from G. Altshuller's TRIZ methodology may be of value and creatively engage Meyer's (2025) concern with fragmentation:

- fragmentation - does it exist, can it be created?
- increase the fragmentation
- isolate the fragmentation
- change the location in time and space of the fragment elements
- removal of elements to break the structure
- preliminary counter-action
- preliminary action
- pre-emptive action
- partial or satiative action
- periodic action
- turning the 'bad 'into 'good'
- replacement
- discarding and replacement
- aggregation

Conclusion:

It must be noted that the interpretation of CAS is the author's and does not necessarily reflect the intent of Holland. It must also be noted, that the author is unaware of any attempt to utilize a CAS methodology for analyzing 'Wicked Problems' and 'Wild Messes'. The author is proposing CAS as a potential avenue for exploration in the hope that a different perspective for addressing challenging problems might be of value. It might also be noted that the author has no expertise in software programming, and that significant areas for intervention in complex problems of social media are waiting to be exploited by individuals with that expertise.

If the suggested approach for addressing Wicked Problems and Wild Messes appears useful, a change in perspective is necessary. Individuals must accept that returning to a previous state may not be desirable, or even possible. The involved actors must begin to embrace a perspective of systems that are dynamic and constantly evolving. In alignment with this perspective is the realization that any changes achieved are likely not final changes, and the involved systems will continue to evolve and new systems and structures will emerge. This will require a change in behavior for those involved with moving from primarily identifying potential modes of failure, and addressing 'wicked problems' and 'wild messes' after they have occurred, to realize that these problems are evolving systems and must be addressed as systems. It also must be recognized that in contrast to what Ritchey (2013) stated with failure not being an option, multiple unexpected and unforeseen mistakes and failures will occur, but a fast response and resilience in creating change is of utmost importance.

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