Towards endeavor architecture to support knowledge dynamics of societal adaptation

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Towards Endeavor Architecture to Support Knowledge Dynamics of Societal Adaptation

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Abstract. To facilitate societal adaptation, we need to establish the principles of Endeavor Architecture (EnA) in addressing the limitations of Enterprise Architecture (EA). To support the social perspectives that EnA adds, we propose establishing EnA directions and requirements, particularly epistemic relationships among the agencies. Furthermore, we assert that EnA must be open to new paradigms and technologies to facilitate societal adaptation. EnA also must accelerate data, information, knowledge, and wisdom transformation, integration, and sharing. We illustrate how the Upper Modelling Framework (UMF), an open, system-oriented upper ontology, along with ten principles of knowledge dynamics, may serve as a framework that sets the direction of EnA beyond EA.

Keywords: Endeavor Architecture, Enterprise Architecture, Upper Ontology, Knowledge Sharing

1 Context and Motivation for Establishing Endeavor Architecture

Societal changes (e.g., economic crises, climate change, racial issues, pandemics, escalating armed conflicts) painfully remind us that all elements of society, societal endeavors, and enterprises (big or small, private or public, profit or nonprofit) must be able to adapt to wide-scale, rapid and disruptive societal changes. These complex societal changes include all-pervasive problems (political, social, economic, technological, environmental, psychological, and cultural) that humanity faces and needs solving. Murray Gell-Mann [2013] pointed out that the solution to these problems cannot be achieved by advancing only one field; the transdisciplinary approach and collaboration of people from various domains are necessary to face these challenges. With this paper, we contribute to the discussion that has its goal inauguration of the new manner of study of complex domains and further articulation of the new meta-level studies of global Data-Information-Knowledge-Wisdom (DIKW) space [Gidley, 2013]. The expectations are that these studies will support societal adaptation by integrating understanding complexity, problem-solving, innovation, discovery, and research. These changes are pertinent to Endeavor Architecture (EnA), hence how we need to create it, thereby setting the foundation of EnA.

This paper is organized as follows. First, we describe the context and the motives for establishing EnA to facilitate adaption (or evaluation of adaptational and transformational capacity). In that context, we focus on the development of cities, the rise of their citizens, rapid and widespread societal changes (e.g., pandemics), and Artificial Intelligence (AI) impacts as AI enters the mainstream, as they are all increasing the complexity of societal endeavors. Then we briefly describe Enterprise Architecture (EA)–a tool used by ICT and ICT-management communities to model and overcome the complexity of ICT-intensive enterprises. We discuss EA's limitations and elaborate on the necessity to introduce Endeavor Architecture (EnA) to model complex societal changes and facilitate societal adaptation (or evaluation of the capacity for adaptation). We also introduced the Upper Modelling Framework (UMF) to serve as an upper ontology of EnA. We elaborate on the DIKW dynamics (supported by the UMF) that facilitate societal adaptation as new directions and principles for the creation of EnA. We illustrate how EnA's four functions and ten principles of DIKW dynamics may be used to guide the evaluation of DIKW in relation to the adaptation and transformation of societal agencies. At the end, we answer some of the elementary questions of EnA and outline our research agenda in the forward-looking statement.

2 Environmental Adaption

In articulating our motives, we begin by defining environmental adaptation as an effort of an agency (which may be a society, an individual, any group, or any organization) triggered by specific events that are being translated into actions that aim to reduce the distance between the agency and its environments (e.g., economic, natural, civil liberty, health) in a satisfactory way. In this context, acceptable environmental adaptation is a variable term and may mean anything from bare survival to thriving in new environments.

Human societies have adapted to environmental changes throughout their existence. Environmental adaptations vary according to the system and environment in which they occur. At the point when the environmental changes become insurmountable, adaptation may happen at multiple (overlapping) levels:

- Social: an individual's or group's behavior changes to conform with the prevailing system of norms and values in their social environment, e.g., group, class, collective. It is reinforced by social control, which includes social pressure and state regulation.
- Cultural: an individual or group tries to gain knowledge or change behavior that enables them to adjust, survive, and thrive in their environment. The scale of culture changes depends on the extent of the environment changes. It could vary from slight modifications in livelihood systems (technology, productive and procurement activity, mode of life, and so on) to the principal transformation of the whole cultural system, including its social, ethnic, psychological, and ideological layers.

- Organizational or Enterprise: intentional decision-making leading to observable actions that aim to reduce the distance between an organization and its economic and institutional environments
- Societal: Interplay between cultural and other societal-scale changes, including economies, infrastructures, public and political spheres with mass social outcomes

We tailored these definitions informed by research on organizational adaptation [Smith et al., 2011; Sarta et al., 2020], relationships between social learning and adaptation [Boyd et al., 2011; Richerson and Boyd, 2020], adaptation related to climate change [Simonet and Duchemin, 2010; Few et al., 2017; Puong et al., 2017], adaptation as understood in semantic web-technologies [Tran et al., 2006], and studies in genetic adaptation [Orr, 2005].

We also acknowledge the interdependencies of the environment, for example, the interplay of premature mortality (i.e., health) and socioeconomic inequalities [Shahidi et al., 2020]. Furthermore, we do not separate the agency from its environments; to be successful, the agency's adaptation must be satisfactory for the environments from which it has evolved and emerged (e.g., climate changes). Besides, evaluating societal adaptation's actions, outputs, and outcomes implies ethical considerations [Lacey et al., 2015]. Ethical considerations are also implied in the societal use of technology (particularly emerging technologies) in anticipation that these technologies will improve the outcomes, but they carry risks [Heintz et al., 2015; Kendal, 2022].

Our definition distinguishes adaptation from generic strategic change. It refocuses adaptation research around a specific type of intentional change aimed at increasing convergence between the agency and (some of) its environment(s). Equipped with this definition, we may distinguish adaptation from its motives and triggers (e.g., pursuing change, responding to environmental pressure) and results that may be expressed as outputs, outcomes, or consequences (e.g., performance, survival). Ultimately, we cannot assume that every change is necessarily adaptive and not every adaptive move is necessarily successful—changes imply risk that sometimes may lead to maladaptation [Boyd et al., 2011].

Similarly, as a result, our discussion guides readers toward consistent uses of adaptation that can resolve certain ambiguities and promote new insights in relation to DIKW dynamics for both disciplinary and interdisciplinary research [McMahan and Evans, 2018]. We assert that to facilitate societal adaptation, all societal agencies must stay open to new knowledge and technologies, stimulate research, innovation, and adaptation to the ecological environment, but also find ways to deal with forces that might oppose the development of societal and individuals' wellbeing.

Our discussion focuses on evaluating and creating environments where adaptation can occur and from which adaptation may emerge. We bring forward the necessity of rethinking and evolving models and practices to support societal adaptation and facilitate innovation during rapid and widespread periods of change. Enterprise Architecture (EA) has been one of these models used by ICT communities to overcome the complexity. However, we discuss the deficiencies of EA. We are proposing Endeavor Architecture (EnA) to emphasize the gap between an endeavor (i.e., a sincere attempt, a determined or assiduous effort towards a specific goal) and an enterprise (i.e., a company, business, organization, or other purposeful endeavors.) We elaborate on four functions that support ten principles for evaluating DIKW dynamics as they are necessary to facilitate adaptation. In other words, we propose new requirements and directions for EnA to explore societal adaptation, particularly DIKW flows of adaptation. We begin by using urban development examples to illustrate the necessity of establishing and evolving EnA to facilitate the emergence of new enterprises and endeavors and dealing with urban development complexity.

2.1 Urban Development

According to the World Bank, some 55% of the world's population (i.e., 4.2 billion inhabitants) live in cities. If this trend continues, by 2050, with the urban population more than doubling its current size, nearly 7 of 10 people worldwide will live in cities. This phenomenon has attracted multifaceted research and the creation of the Smart City concept. However, still, the analysis of the smart city literature revealed ambiguity of the relevant ideas of the interdisciplinary science of smart cities [Mircea et al., 2017]—global language norms and clarity of concepts have yet to be achieved [Moir, 2014; Lom and Prybil 2021; Mora et al., 2022]. Although it appears that integrated ICT infrastructure is a common denominator for all smart cities, the opinions on ICT prominence and level of sophistication and innovation in smart cities vary. For example, according to Giffinger et al. [2007], ICT is not that crucial. On the other hand, other authors [Hall et al., 2010; Harrison, 2010; Mircea et al., 2017] recognized it as one of the fundamental factors. Furthermore, a school of thought is that an ever-evolving and innovating ICT plays an essential, perhaps even leading role, in a smart city [Toppeta, 2010; Washburn et al., 2010; Batty et al., 2012; Chourabi et al., 2012]. Ultimately, the concept of city collective intelligence [Mohanty et al., 2016] was accentuated and empowered by integrating city infrastructures (e.g., social, ICT, business.) Chourabi et al. [2012] considered ICT the “inner” and “meta-factor” of smart cities. Since it has the potential to impact each of the other “inner” factors (i.e., management and policy) and all seven “outer" factors (i.e., governance, people and communities, natural environment, infrastructure, and economy), they reasoned those innovations must happen across all smart city factors to ensure success.

Thus, there is a need for meta-paradigms; that is, sets of concepts and propositions that sets forth the phenomena with which a discipline is concerned that have expressiveness to integrate all factors of urban development, perpetual innovation in all domains, interdisciplinary collaboration, technology, and collective intelligence. Particularly, there is a need to create meta-paradigms whose discourse of interest is an endeavor that is influenced by multiple (or all) societal agencies, rather than driven by the interests of the (public or private) enterprises. For example, the COVID-19 pandemic impacted all elements of society; elected governments, bureaucracies, political parties, international health organizations, scientific organizations, healthcare organizations, organizations that support vulnerable populations, private sector organizations, public sphere and media, communities, and individuals. To facilitate observation of the pandemic, Polovina R. [2022] used the UMF as an upper-ontology that helped break down the discourse of interest and create new concepts of societal knowledge.

2.2 Complexity

However, Nam and Pardo [2011] warned of an omnipresent risk generated by complexity and innovation, emphasizing that organizational and policy innovation must match technological innovation. Other authors acknowledged risk too. For example, Dawes et al. [1999] established that ICT innovations are more rapid than management and organization innovations and that policy innovations are even slower than organizational ones. Chourabi et al. [2012] reasoned that the "meta-factor" ICT success positively impacts all other smart city factors. However, the risk of ICT failure may increase all other risks. In addition, due to unanticipated events of complex endeavors (e.g., when new information flows are created), ethical and moral questions may emerge [Cecez-Kecmanovic and Marjanovic, 2015].

Consequently, the importance of applying adequate methods for reducing complexity and mitigating risk has been recognized [Kakarontzas et al., 2014]. Needs for new methods had been identified [Dawes et al., 1999], including a need to pay attention to "unforeseen consequences and unanticipated effects which were ignored because the systems in question were treated to immediate and simplistic terms" [Batty et al., 2012].

Again, there is a need for meta-paradigms that reduce complexity, for example, by introducing only crucial concepts from multiple domains and creating new, condensed, and optimal discourses of interest pertinent for DIKW-intensive societal endeavors. We brought forward the UMF [Polovina R., Wojktowski, 1999] as an upper ontology to facilitate our research by breaking down the discourse of interest according to its main principles (i.e., object essence, contrasted object, relationships, system, time, memory, bliss, thought, being, reality). This breakdown further enables the identification of the main generators of the endeavor complexity (e.g., structural complexity, the complexity of DIKW dynamics), and in that way, facilitates the management of complexity risk [Polovina R., 2022].

2.3 Wide-Spread and Rapid Societal Changes

Moreover, the recent COVID-19 pandemic reminded us of a need to collaborate across the globe and share data, information, knowledge, and wisdom to respond to the pandemic and other rapid and widespread societal changes [Polovina S. et al., 2020; Singer-Velush et al., 2020] emphasizing the importance of ecological adaptation. Other authors also warn us of the necessity to mitigate the risks that societies worldwide face [Callaghan 2016, 2020]. Furthermore, these recent developments accelerate fine-tuning of Enterprise Risk Management (ERM); as Andersen pointed out that when actual developments take an enterprise by surprise and organizational decision-makers must deal with influences from unexpected events–like pandemics and climate effects–formal control-based guidelines and practices are insufficient as they are only convenient and

make the decision makers feel safe but provide a false sense of security [Andersen et al., 2021; Continuity Central, 2022].
In our case study of the COVID-19 pandemic [Polovina R., 2022], we looked at the pandemic through the UMF as a prism and identified societal agencies that participate in the societal endeavor (i.e., response to the pandemic) and created the model of the pandemic principles in relation to DIKW sharing. The next step might be to look at the DIKW flows among these agencies; that is, the principles of DIKW dynamics described in this paper may further facilitate the evaluation of the societal DIKW dynamics in relation to the pandemic response and support subsequent decision-making (e.g., to strengthen social and technological interfaces between research organizations and governments).

2.4 Artificial Intelligence (AI)

Furthermore, as Artificial Intelligence (AI) enters the mainstream, Vinuesa et al. [2020] pointed out that AI may have a positive impact on 82% of the United Nations (UN) Sustainable Development Goals targets. These targets include poverty reduction, quality education, clean water and sanitation, and affordable and clean energy. However, according to the same source, AI technologies may inhibit 38% of the targets, including high energy consumption, due to the massive computational resources required for AI. There is also a concern that AI may trigger inequalities that inhibit poverty reduction. Furthermore, AI may enable nationalism, hate towards minorities, and biased election outcomes damaging social cohesion, democratic principles, and even human rights. Dignum [2018] called for responsible AI, which requires social values, moral deliberation, and methods to link moral values to systems requirements in traditional systems development.

The UMF is an upper ontology (or meta-paradigm) that facilitates the integration of ICT and AI paradigms by classifying their expressiveness according to the UMF principles [Polovina R., 2022]). Moreover, the UMF facilitates the generation of EnA instances whose domains may be any human endeavors (e.g., enterprise, societal, global). Last but not least, EnA principles allow the creation and evaluation of pluralistic perspectives (e.g., ethical, risk, impact on the environment).

3 Enterprise Architecture

ICT communities have traditionally used EA to overcome the complexity of ICT-intensive endeavors. For example, Nam and Pardo [2011] proposed EA as an organizational and managerial strategy for encouraging innovation in urban interoperability initiatives. However, Gong and Jannsen [2019] pointed out that poorly understood EA value claims are used to justify EA initiatives, often without empirical verification. Kaisler [2005] identified multiple EA challenges, including insufficient motivation for EA modeling techniques.

At the same time, Gell-Mann [2013], who researched complexity, pointed out that the solution to the world problems: pandemics, climate changes, widespread economic crises) cannot be achieved by advancing only one field; the collaboration of people from various domains is necessary for these challenges. Moreover, Mowles [2014] identified another challenge; evaluation of complex social actions, seeing non-linearity in the social as the norm rather than an exception, and what the evaluators may do to assert that social interventions work. Significantly, La Palme et al. [2012, 2016] pointed out most EA frameworks' insufficiencies in modeling complex adaptive systems.

Furthermore, it has been noted that although numerous authors extensively wrote about the EA principles, frameworks, and management, it is significantly more difficult to find empirical evidence that supports the promises of EA [Gong and Janssen, 2019].

Since potential failures of endeavors to adapt to widespread, sudden, and disruptive societal changes (e.g., pandemics, climate change, natural disasters, armed conflicts) include human lives, public health, social justice, and taxpayers' money, we cannot avoid ethical questions on EA applicability and implementation. Therefore, we offer a brief analysis of the EA limitations.

3.1 Evolution of Enterprise Architecture

In the 1980s, John Zachman advanced the idea of EA by describing enterprises as "a set of architectural representations produced over the process of building a complex engineering product representing the different perspectives of the different participants" [Zachman n.d.]. The motivation for Zachman's EA framework was "for rationalizing the various architectural concepts and specifications to provide clarity of professional communication, to allow for improving and integrating development methodologies and tools, and to establish credibility and confidence in the investment of systems resources" [Zachman 1987]. Zachman's framework models any social or technical system consisting of people only, people and computer systems, or computer systems only [Sowa and Zachman, 1992]. That is, all types of enterprises, from consortia of companies or governments, commercial organizations, business firms, and social ventures, to start-up businesses and undertaken projects (or to be undertaken.)

Even in those early days of ICT architecture, it has been noted that ICT architecture needs to be put in the context of a broader business context [Hammer & Co., 1986]. Later, the authors, such as Tapscott and Caston [1993] or Ross and her colleagues [2006], argue that EA has a broader position than ICT, EA still stayed deeply rooted in a business context.

As predicted by Zachman [1987], not only did the evolution of EA, both as a concept and organizational activity, result in heterogeneous EA frameworks, but also heterogeneous EA schools of thought and communities of practice emerged [Lapalme, 2012, 2016].

- Enterprise ICT Architecting—models ICT of an enterprise only; the universe of discourse is the enterprise-wide ICT platform.
- Enterprise Integrating—integrates all enterprise factors (e.g., governance structure, production, ICT capabilities); the universe of discourse is the enterprise as a whole
- Enterprise Ecological Adaptation—models the enterprise and its environment, including relationships between the two. The universe of discourse is the whole enterprise in which innovation is understood as an adaptation to its environment. In

addition, the universe of discourse includes the way the enterprise impacts its environment.

4 Four Functions of Endeavor Architecture

To explore the properties of EA and EnA in relation to environmental adaptation, we identified four architecture functions (relevant to adaptation). The report informed us of the environmental adaptation Smith at al. prepared [2001]. The authors identified technology and research as the factors relevant to the adaption response. The integration function relates to the multiple communication and educational response options, i.e., diffusion of DIKW in our context.

Table 1. Four architecture functions relevant to adaptation

Architecture Function	Description
Development	Advancement and development of digital technologies (e.g., ICT and AI)
Integration	Communication and sharing of acquired DIKW (i.e., integration of societal agencies across human and digital interfaces)
Environmental Adaptation	Facilitation of agencies' innovation and adaptation to the environment, purposeful or accidental. Both development and integration support environmental adaptation
Research	Generation of new scientific DIKW (i.e., quest for new knowledge and conclusions) and technologies necessary to adapt to (immediate or future) environmental changes and address complex phenomena, in general

5 Exploring the Limitations of EA

We evaluated how the EA authors addressed four architecture functions (if they addressed them at all) in the following table. We also included some EA standards and tools (Table 3).

Table 2. EA authors and their positions concerning four functions relevant to societal adaptation (i.e., development, integration, ecological adaptation, and research)

EA Authors	Architecture Functions Addressed
Clive Finkelstein [2006]	**Development:** ICT development, particularly data-oriented **Integration:** Integration of enterprise data, aligning business and ICT, integration of enterprise functions via data (i.e., through an ICT platform by using XML and Web Services)

EA Authors	Architecture Functions Addressed
	Enterprise adaptation: Adaptation limited to data-oriented methods
James Martin [1995]	**Integration:** Enterprise integration is achieved by implementing organizational management methods, such as strategic visioning, human and culture development, ICT development, enterprise redesign, value-stream reinvention, procedure and redesign, and Total Quality Management methods **Enterprise adaptation:** The enterprise capabilities limit environmental adaptation (i.e., to get the right enterprise strategic vision and transform accordingly)
Dirk Frosch-Wilke and Sina Tuchtenhagen [2016]	**Development:** ICT development, particularly Business Intelligence (BI)
Inge Hanschke [2010]	**Development:** ICT process-based management achieves enterprise integration (of ICT into the enterprise). Focused on ICT strategic management
Martin Op 't Land, Erik Proper, Maarten Waage, Jeroen Cloo, and Claudia Steghuis [2009]	**Integration:** Integration of EA management with enterprise management
Col Perks and Tony Beveridge [2003]	**Development:** ICT development (used TOGAF as its foundation) **Integration:** Integration with enterprise management (primarily aligning ICT and business)
Jeanne W. Ross, Peter Weill, and David Robertson [2006]	**Integration:** Integration of ICT and enterprise strategy **Enterprise adaptation:** Advancing enterprise strategy and environmental adaptation
Marlies van Steenbergen, Martin van den Berg and Sjaak Brinkkemper [2007]	**Integration:** Integration of EA management and enterprise management (i.e., assessing EA maturity)
Ronald E. Giachetti [2010]	**Integration:** Advancing enterprise systems design and integration of its functions by describing enterprise engineering methods (e.g., strategizing, process modeling, information modeling, organizational modeling). **Enterprise adaptation:** Advancing enterprise strategy and environmental adaptation
Jamshid Gharajedaghi [2006]	**Integration:** Advancing enterprise system design and integration of its functions **Enterprise adaptation:** Advancing environmental adaptation. Raising awareness of socio-cultural en-

EA Authors	Architecture Functions Addressed
	terprise facets and self-organizations and acknowledging the need for innovations and the importance of social aspects of an enterprise. **Research:** Encourage holistic research of social systems and use systems science as a logical starting point for enterprise design, emphasizing that (enterprise) systems design cannot be separated from the system's principles. Encourages research of systems concepts (e.g., openness, purposefulness, multidimensionality, emergent enterprise properties)
Jan A. P. Hoogervorst [2009]	**Integration:** Establishes enterprise (as a system) design and its integration with enterprise governance. Integration with enterprise strategy. View an enterprise as a socio-technical system.
Zachman's Enterprise Architecture Framework [Zachman, 1987; Sowa and Zachman, 1992; Kappelman and Zachman, 2013]	**Development:** Classification of ICT paradigms **Integration:** Establishes enterprise (as a system) and its integration with enterprise governance **Enterprise adaptation:** Zachman's enterprise ontology establishes an understanding of the EA domain and facilitates environmental adaptation (by modeling an enterprise and its context). **Research:** Zachman's enterprise ontology (as an upper ontology) may facilitate research of new paradigms, for example, by proving that new concepts are outside of the domain defined by Zachman's ontology.
Jan Dietz [Dietz, 1999]; Dietz and Mulder 2020]	**Development:** Design and Engineering Methodology for Organizations (DEMO) developed in the 1990s, focuses on the requirements determination for software development. **Integration:** Integration with management **Enterprise adaptation:** DEMO may facilitate organizational adaptation to the environment from the management point of view.

Table 3. EA standards and tools, and their relation to four functions relevant to societal adaptation (i.e., development, integration, ecological adaptation, and research)

EA Standard/Tool	Architecture Functions Addressed
TOGAF [The Open Group, 2022]	**Development:** In the context of governance only **Integration:** Primarily integrate ICT and ICT governance and support alignment with other enterprise functions, such as strategic management. It includes gap management in relation to alignment to other enterprise functions (e.g., financial, human resources).

	Enterprise adaptation: Supports Business Transformation Readiness Assessment
ArchiMate [The Open Group, 2019]	**Development:** In the context of governance only **Integration:** This is an enterprise architecture modeling language. It facilitates the integration of business, business processes, technology, and governance.
Enterprise Architect [Sparx Services]	**Development:** Strong support for UML (Unified Modeling Language) and round-trip engineering that synchronize related software artifacts, such as source code, models, configuration files, and even documentation **Integration:** Supports ArchiMate, TOGAF and some other EA standards. IT also integrates ICT development and ICT governance. Since it is extended with EA frameworks, it can fully support ICT integration with management and business. **Enterprise adaptation:** Multiple modeling diagrams may be used to model environmental adaptation. **Research:** Being an open tool and since that can integrate all levels of ICT development with other enterprise facets, it may be used to support research activities
Essential Project [Enterprise Architecture Solutions]	**Development:** Conceptual, logical, and physical layers based on ontology and a meta-model **Integration:** Integration of ICT and management, with a support layer for management (e.g., strategy). **Enterprise adaptation:** End-user views of environmental adaptation from an extended metamodel. **Research:** Open-Source choice enables the community to conduct their research and development.

The domain of EA is an enterprise in its organized professional and administrative form in which people work and interact with institutional authority. This relates to Habermas's “system” of predefined situations, or modes of coordination, in which the demands of communicative action are relaxed in this way within legally specified limits [Bohman and Reig, 2017]. That is, the system that comprises common patterns of strategic action that serve the interests of institutions and organizations [Baxter, 2013]. In other words, EA concerns are neither communities, citizens of urban or rural areas, individuals, and their interactions, nor other elements that relate to Habermas's lifeworld – facets and patterns of our social and personal life outside of institutions and organizations. Neither EA concern is the public domain, which relates to Habermas's public sphere–the domain of social life where public opinion can be formed and all citizens can access [Habermas, 1991]. In other words, environmental adaptation in EA is limited to the enterprise’s adaptation to its environment.

During disruptive, widespread societal changes (e.g., pandemics, natural disasters, armed conflicts, hardships), these worlds can collide, exposing an individual (or citizens, groups, or other societal elements) to tremendous pressure. Under this pressure, these societal elements must adapt or face doomed outcomes. Therefore, we reject the concept of having the enterprise, lifeworld, and public domain separated. This does not mean that we reject reductionism in general. Still, we acknowledge that reducing complex realities to specific (simplified) views may ideally be purposeful in some situations but not in all situations. Neither do we limit the number of views (i.e., worlds). Still, we acknowledge that the models (of complex realities) should be determined by their purpose–contribution to solving the problems at hand, ultimately leading to the most optimal adaptation. There will be situations where simplified models will lead to the optimal solution, but there will be situations where only holistic views (and synthesis of views) will work. Instead of relying on the prescriptive nature of architecture, we acknowledge that there are times and situations when societies must exert efforts and collective intelligence to develop new solutions.

6 Endeavor Architecture

We, therefore, introduce the concept of Endeavor Architecture (EnA) to enhance the discourse of interest (from enterprises) towards more complex domains where enterprises, the lifeworld, and the public sphere are not separated. This unavoidably shifts focus towards general intelligence (which comprises different cognitive abilities and allows intelligent beings to acquire knowledge and solve problems). Artificial General Intelligence (AGI) models general intelligence. There are numerous theories of intelligence and intelligence types. Still, for this article, the most important abilities are general ability (also referred to as "g'), an overarching ability that is theorized to be relevant to and involved in an extensive variety of cognitive tasks [Sternberg, 2012]. That is, the concept of general intelligence proposes that one intelligence is measured by a 'g factor' that underlies performance in all cognitive domains. The performance comprises performances in different but interrelated cognitive tasks, all contributing to the 'g factor'.

At this point, we must mention that the early work of Zachman [1987] and Sowa [Sowa and Zachman 1992] contained some considerations of general intelligence, such as defining the views of the Zachman EA Framework by using primitive interrogatives (i.e., What, How, When, Who, Where, and Why) and using some concepts of upper ontologies (i.e., objects). Still, as previously discussed, the primary discourse of interest has been deeply rooted in enterprises and limited to business and organizational domains.

Now we will return to the four functions that facilitate adaptation (Table 1). These are: (i) advancement and development of digital technologies (e.g., ICT and AI), (ii) communication and exchange of acquired DIKW (i.e., integration of societal agencies across human and digital interfaces), (iii) facilitation of agencies' innovations and adaptation to the environment, purposeful or accidental (i.e., environmental adaptation), and (iv) research and generation of new scientific DIKW (i.e., quest for new knowledge and conclusions) and technologies, as necessary for adaptation to environmental changes, including societal changes and addressing complex phenomena, in general. The following table illustrates the need to establish Endeavor Architecture (EnA) practices to support these four functions.

Table 4. Endeavor Architecture (EnA) properties and examples relevant for societal adaptation

Function	Endeavor Architecture (EnA) Properties and Examples
Development	Everything that is represented by EA plus the development and implementation of new technologies (e.g., new programming languages, new platforms, new knowledge representation methods, AI modeling). This implies the following: • Openness to accept novel scientific and technological paradigms (e.g., AI paradigms) • Classification of ICT and AI paradigms (e.g., by using Upper Modelling Framework [Polovina R., 2022]) Examples: • Development of digital technologies for new types of organization and management (e.g., new alliances and establishing new knowledge flows among agencies) • Development of digital technologies that explore and support societies and broader alliances (e.g., global endeavors that transcendent geopolitical boundaries) • Development of technologies that might reduce social conflicts in public discussions [Heng and de Moor, 2003] • Development of methods (e.g., ontologies) that may facilitate the emergence of collective intelligence among individuals and groups focused on the advancement and development of ICT, such as groups of developers in an organization, open-source (code) communities, or city hackathons.
Integration	Everything that is facilitated by EA plus the sharing of the DIKW space, including the dynamics of its sharing among societies and their elements, such as social groups, movements, minorities, and broader formal and informal alliances. Examples: • Implementation of platform and infrastructure that facilitate DIKW sharing of smart cities • Creation of social ontologies to evaluate societal response to pandemics [Polovina R, 2022])

Function	Endeavor Architecture (EnA) Properties and Examples
	• Creation and development of ontologies that support various domains, and ultimately integration of those ontologies. including EA ontologies [Baxter et al., 2022] • Exploring domain ontologies and ways to communicate with broader audience, such as FinTech [Stojakovic-Celustka, 2022] • Domain modeling (e.g., city utilities, traffic, finance) often takes some forms of knowledge repositories or reference models, making its implicit knowledge explicit. Typically, these models are made reusable to realize their value. • Undertaking activities that develop human interfaces among certain societal groups (e.g., scientific communities and government) • Undertaking activities that develop technological interfaces among systems (e.g., developing trust [Groza and Pomarlan, 2022]) • Implementation of ontologies that facilitate DIKW sharing among various communities (e.g., health ontologies for sharing health information among medical practitioners and patients) • Exploring DIKW patterns (e.g., propaganda patterns that may be propped up by any element of a society)
Environmental adaptation	Everything facilitated by EA plus facilitation of efforts to encourage implementation of scientific innovations and monitor their impact (e.g., on citizens' social lives, environment) Examples: • Endeavors that deliberately facilitate inadequate government policies (e.g., environmental policies), such as organizing government propaganda to cover up fundamental inadequacies • Endeavors organized by citizens to reveal inadequate government policies (e.g., environmental policies) • Modeling and creating endeavors that oversee environmental changes by mobilizing multiple societal elements (e.g., citizens, organizations, governments). The new DIKW obtained may not comply with what is publicized (e.g., posted by governments or marketed by various organizations [Global Forest Watch] • Open Data • Open Platforms (e.g., Global Forest Watch)

Function	Endeavor Architecture (EnA) Properties and Examples
	• Endeavors facilitate the integration of scientific innovations, societal agencies, and digital technologies. Developing human interfaces that enable these integrations and therefore making them available to various elements of the society • Facilitating collaboration, knowledge discovery and sense-making across multiple organizations [de Moor et al., 2022] • Exploring DIKW sources and use them to advance research in other fields (e.g., exploring health-related data [Jani et al., 2022; McGagh et al., 2022]) • Exploring societal health issues through social media mining • Exploring the impact of social media on adolescents [Kelly et al., 2019]
Research	Searching for DIKW is necessary to adapt to societal changes and address complex phenomena in general. In this way, we are changing EA's discourse of interest and moving it from business domains toward general intelligence and Artificial General Intelligence (AGI). We also do not separate enterprise, life-world, and public domains, which add complexity to the research necessary to support the endeavor. It is also noticeable (from these examples) for architecting endeavors that we need to consider research that comes from various faculties of science, as noted by Gell-Man [2013]. Examples: • Creation of new concepts to serve as determinants of societal capabilities (e.g., smart city success factors [Chourabi et al., 2012]) • Advancing organizational concepts by using ontology-driven methods (e.g., advancing strategy ontology [Caine, 2022] • Research on the limitations of the existing paradigms and the creation of new paradigms • Exploring new organizational and societal transformational initiatives (e.g., undertaking an initiative to enhance the capacity of the government to use scientific innovations) • Exploring methods to verify the consistency and success of government policies • Exploring methods for social media mining [Xiong et al., 2021] • Research on social media design that mitigates the risk of harming their users • Research on social media political influence

Function	Endeavor Architecture (EnA) Properties and Examples
	• Research on methods to identify false knowledge • Creating methods that facilitate competencies on social networks • Explore individual views, 'citizens' experiences, and similar that support adaptation to societal changes • Research on collective intelligence • Research on collective emotion [Lan et al., 2022] • Research on general intelligence and Artificial General Intelligence (AGI) [Latapie et al., 2021] • Exploring social media's impact on political activities and geopolitical development, in general [Lan et al., 2022] • Research on knowledge patterns in the humanities [Jakobsen and Graf, 2022]) • Research on relationships among big data and ethnographies [Hong et al., 2022] • Research of DIKW patterns and DIKW diffusion (e.g., propaganda patterns that may be propped up by any element of a society)

7 Influences on Endeavor Architecture

We started by exploring some societal drivers that generate societal changes and impose societal adaptation. Then we explored the limitation of Enterprise Architecture (EA), which was recommended for modeling complexity, and concluded that we need to enhance the discourse of interest and include other societal facets (i.e., enterprises, lifeworld, and public domain) to be able to respond to widespread and abrupt societal changes (e.g., economic crises, climate change, racial issues, pandemics, escalating armed conflicts).

We asserted that it is necessary to introduce the concept of Endeavor Architecture (EnA) to model the complexity of societal changes that trigger societal adaptation. That is, if we apply the definition of adaptation (Section 2), EnA reduces the distance between an agency and its environment by reducing the complexity of the endeavor and by facilitating the creation and development of the solutions.

Thus, EnA is not prescriptive; that is, EnA may use any available paradigms to create and organize its models. EnA may also include meta paradigms (i.e., sets of concepts and propositions that set forth the phenomena with which a discipline is concerned). This enhances our discourse of interest and moves it toward general intelligence and Artificial General Intelligence (AGI). At the same time, it makes it open to research and accepts new paradigms (Table 4).

Therefore, at this point, we will introduce the Upper Modeling Framework (UMF), a system-oriented framework, and an upper ontology to shed light on relationships and dependencies of the drivers for societal adaptation within complex domains, i.e., societal endeavors.

7.1 Upper Modelling Framework

The Upper Modelling Framework (UMF) was initially proposed by Polovina R. and Wojtkowski [1999] to study models (i.e., objects) that human minds create, which not only depend on a modeler's cognizance but also reflect the modeler's social relationships and dynamics. It is also a study in Artificial General Intelligence (AGI) [Goertzel, 2014; Yaworski, 2018], inspired by general human intelligence. The UMF facilitates modeling complex domains; its rules, complexity of the universe of discourse, and cognitive activities generate knowledge flows, explananda, creation, and transformation of the models. An object is defined as anything that may engage any faculty of someone's mind or anything and everything distinguished from the observed domain. A model is understood as a “vessel” that contains a chunk of knowledge. Polovina R. and Wojtkowski [1999] considered cognitive activities carried out by the modelers (e.g., thinking, reasoning, learning); their universe of discourse; the 'model’s principles (or dimensions), created objects and relationships among the objects, and presented these cognitive activities from an intuitive point of view. The term “system” “was applied to encompass social, technical, physical, and natural systems, or any combination.

7.2 Four Sphere of Model's Existence

The UMF distinguishes four spheres of the model's existence: principal, conceptual, formative, and manifestation spheres (Figure 1). The foundation for this separation is based on insight gained by observing the modeler's cognitive activities (e.g., thinking, reasoning) and the modeler's universe of discourse, as described in the following text.

Cognitive activities (modeling) with a tendency to generate or impact a system may be initiated by deciding the essential idea the system enacts. The essential idea's determination occurs at the highest sphere of system existence, the principal sphere, which presents the system's most abstract (i.e., principal) representation. In the next sphere, the universe of discourse (i.e., domain) is conceptualized, which initiates the concept's formation, thus denoted as a prototype. Prototypes are particularized, concretized, and constrained in the third sphere until desired forms are obtained. These forms will serve as molds (of ideas) at the lowest sphere of the system instantiation. In the physical sphere, where the actual manifestation of instantiation occurs – the abstract (forms of) ideas are becoming a reality. Thus, a typical, top-to-bottom knowledge transformation flow occurs; from abstract spheres (i.e., principal, conceptual, formative) to the instantiated manifestation in the physical sphere. The process is denoted as systems generation.

At the same time, cognitive activities may also be triggered by stimuli from the physical world (e.g., sensing the environment). Selected stimuli may be put into context to create information. This information may be examined (e.g., summarized) at the lowest level (i.e., formative sphere) and molded until a concept can be recognized and further abstracted to its essential idea (at the highest level of its existence in the principal sphere). Thus, the cognitive activities and knowledge transformation may also follow bottom-up patterns: from the physical sphere to higher levels of abstraction. Also, cognition and knowledge transformation do not necessarily follow any sequential order:

changes may be initiated at any level, and changes may be directed either towards their instantiation in the physical world or towards higher levels of abstraction, depending on what opportunities for change are presented.

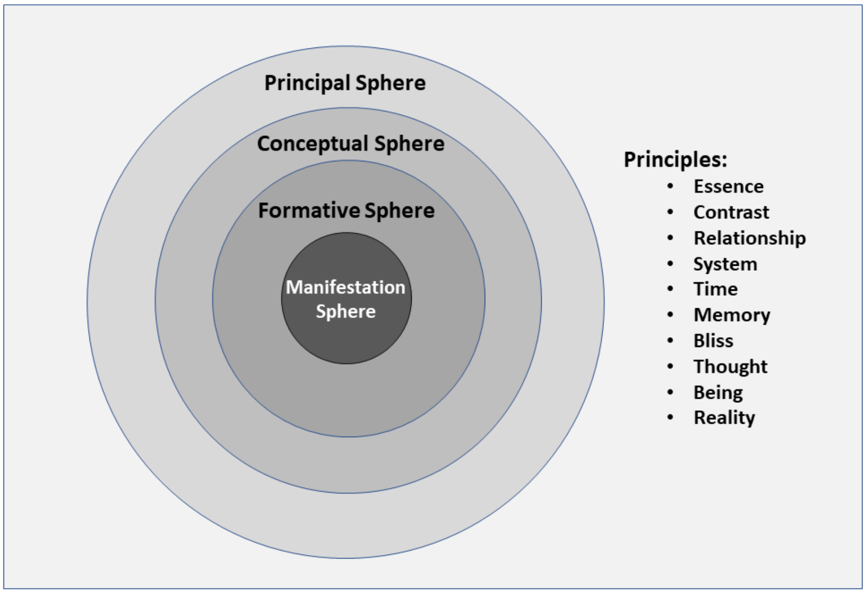

Fig. 1. Four Spheres (or Levels) of Model Existence and Ten Modelling Principles of the Upper Modelling Framework (UMF)

Since every modeler may have their interpretation of the universe of discourse (i.e., their world), then, depending on the modeler's world (e.g., individuality, knowledge, preferences, creativity, social relationships, bias), multiple interpretations of the UMF spheres may exist. It is up to the modelers and their social circles to decide the universe of discourse and set its boundaries. However, to make this framework operational, less ambiguous, and pragmatic distinctions must be established for communication and knowledge generation among the participants (e.g., community). For example, a pragmatic interpretation for system development may be that the principal and conceptual spheres contain abstract models of the universe of discourse. The modelers express their view of reality, either existing or desired vision, focusing on understanding the universe of discourse in its entirety. Considerations may include the system's environment, integration (e.g., social and technology), impact on the environment, or environmental constraints.

In contrast, focused models of the formative sphere may contain actionable knowledge to build, maintain, or change the system, including its environment. Finally, the manifestation sphere contains the physical, instantiated implementation of the system. In addition to four spheres or levels of the model's existence (i.e., principal, conceptual, formative, and manifestation), the ten main modeling principles are observed within the spheres: object *essence*, *contrasted* object, *relationship*, *system*, *time*, *memory*, *bliss*, *thought*, *being* and, finally, *reality*. These principles may also be considered views or modeling dimensions that enable recursiveness and generation of fractals (i.e., similar pattern structures across all spheres [Polovina R., 1999; Polovina and Wojtkowki, 1999]).

7.3 Knowledge Dynamics that Support Societal Adaptation

It is beyond this paper's scope to describe all features of the UMF [Polovina and Wojtkowski, 1999; Polovina R., 2022]. The goal is to bring forward the underlying principles of DIKW dynamics relevant to societal adaptation. Thus, as supported by the UMF, these principles may set directions and requirements for EnA. For example, we may accept the idea of smart cities' collective intelligence [Mohanty et al., 2016]. The underlying assumption of collective intelligence is that the citizens will tend to form groups and strive to be smart together. Discovery and modeling of emerging epistemic relationships among the agencies, and DIKW transformation are supported by the UMF, which serves as an upper ontology. Thus, any subsequent domain ontology that facilitates societal adaptation should inherit these properties and facilitate collective intelligence and the discovery of emerging epistemic relationships.

8 Ten Principles of Knowledge Dynamics

We can thus specify the discovery of the above relationships through the following ten principles of knowledge dynamics, categorized by the character of the DIKW flows and transformations in the UMF spheres. We consider DIKW omnipresent in the UMF as well as DIKW transformations. In this context, learning implies the inclusion of new DIKW, and it is associated with an agency (e.g., individual learning, organizational learning).

8.1 Top-Down

A modeling approach starts at the higher level of abstraction, that is, by establishing the principles and moving towards creation, followed by formation, and finalized by instantiation of a system. This flow relates to cognitive activities that lead to the materialization of an abstract idea. The rows of the Zachman Framework [Zachman, 2015] and TOGAF [The Open Group, 2018] are described in this way. This top-down knowledge movement is typical for corporations and governments, where most initiatives and articulation of an enterprise are expected to start with the executives.

8.2 Bottom-up

As societal adaptation invites new forms of organization—not all endeavors are expected to follow traditional patterns in which initiatives and articulation of the system start from the top. For example, suppose we assume that the citizens want to achieve a "higher quality of work, study, life, and social relations" [Toppeta, 2010], then, as the first step. In that case, the citizens' participation must be increased [Vacha et al., 2016]. To shape the endeavor, their ideas must flow via various channels [Knauss et al., 2012]. It is thus a DIKW generation that is bottom-up, which resembles abstraction. Another example includes city sensors, which send data from the physical world to be processed and transformed towards higher levels of abstraction (i.e., UMF formative sphere). One of the requirements may be to recognize new patterns (for which the system has not been designed) and changing models of the UMF conceptual sphere (e.g., detecting new patterns of water pollution).

8.3 Inclusion

We concur with Quick and Feldman [2011], who favor public endeavors to engage in problem-solving. Inclusion also implies that someone has been excluded in the past, but now, they may bring new actionable knowledge to problem-solving. Since many of these groups cannot have in-depth knowledge of modeling and technology, the EnA methods must be relatively intuitive and flexible to encourage problem-solving. Otherwise, insisting on formal modeling may pose a cognitive burden for the participants. For example, it might be necessary to develop and share models that include both elements from the conceptual and formative sphere to encourage inclusion as a principle (i.e., formal or semi-formal vocabularies of terms covering a specific domain and shared by the communities of the users.) Moreover, it is necessary to enable assigning the meaning to these models, resolving semantic ambiguity among modeling paradigms.

8.4 Individuation

Enabling the manifestation of a person's potential, improving quality of life, and realizing dreams and aspirations may also positively impact problem-solving. A different conception of individuation [Gaß et al., 2015] calls for the synthesis and productivity of technologies. For example, generating code from executable specifications [Polovina R. and Wojtkowski, 2002] and orchestrating cloud SaaS services may enable individuals to realize their ideas in relatively short periods. In this case, complex DIKW transformations are hidden from the individual, although these transformations may happen at all UMF levels.

8.5 Openness

When previously excluded groups or individuals can bring forward their problem-solving ideas, the endeavoring organization (formal or informal) opens to these new ideas, discoveries and paradigms, no matter how outrageous or disruptive they appear. We are not limited to technological discoveries but all society's agencies—new ideas will be born in organizations, environmental projects, new forms of government, and elsewhere. Ultimately, all agencies will need appropriate venues to validate new paradigms (e.g., validation of scientific knowledge [Munafo et al., 2017].) Thus, EnA must stay open to new concepts, ontologies, paradigms, or technologies, including changes in the EnA foundation itself. Thus, all four spheres of UMF models must stay open.

8.6 Integration

If burdened by legacy systems, standards, and complex planning, technology infrastructure may needlessly complicate EnA. Such an infrastructure may not be open enough to new technologies and paradigms. The same is true for social norms and stereotypes. Instead, to encourage the integration of new paradigms, these legacy infrastructures and stereotypes may constrain new endeavors and prevent seamless integration of various communities and groups of citizens striving to engage in problem-solving and bringing new, sometimes disruptive solutions. Indeed, the need for integrating interdisciplinary research into the ecosystem has been highlighted [Knauss et al., 2012], which increases the complexity of social interaction and calls for research methods that enable contact points between social and digital. Notably, it will be essential to reconcile the semantics of multiple models. EnA needs to separate the perspectives and facilitate their integration and synthesis, for example, by embracing methods that integrate EnA artefacts. Again, these transformations impact all four UMF spheres.

For example, multi-jurisdictional endeavors that require coordinated efforts of provincial government and municipalities might encounter numerous operational risks due to too cumbersome and bureaucratic business processes. This may only discourage the integration of city groups. For instance, legislation for the use of a pesticide may exist. Still, the collaboration between the municipal and state government may be inadequate to the point that the citizens are left to their own means to fight the use of pesticides on their properties without their consent.

In another example, the city of Melbourne, Australia, assigned trees email addresses so citizens could report problems [Blakemore, 2015]. In addition to reporting problems, people started writing thousands of love letters to their favorite trees. As this Melbourne case shows, emotional attachments to the city trees are essential for the citizens' well-being. The feedback received (i.e., citizens' appreciation for individual threes) should be quickly integrated into the city policies and regulations.

8.7 Opportunism

Integrating physical, technological, and social systems create a new space (and cyberspace) for numerous threat agents and potential negative tendencies. For example, micro-opportunism includes an unethical appropriation of one's authentic knowledge by the community (or vice-versa) and micropolitics. Macro-opportunism may include national security threats and macro politics. There is a broad range of threat agents—from malicious individuals to organized crime and terrorists who attempt to misuse the system's vulnerabilities. These threat agents may even form informal or semi-formal alliances with legitimate participants. They together emerge as a new, unanticipated, threatening form of collective intelligence. EnA needs to include perspectives and methods to deal with these negative tendencies (e.g., recognition of false knowledge

[Conroy et al., 2015; Groza and Pop, 2020; Groza, 2022; Groza and Pomarlan, 2022]. Again, all UMF spheres are impacted.

8.8 Collaboration

So far, we have discussed how citizens may get included in problem-solving, decision-making, and all societal activities, which leads us to collaboration—two or more agencies working together to achieve something. However, in an older research paper on demography and diversity in organizations, Williams and O'Reilly [1998] concluded that diversity might impede group functioning. Most importantly, these authors pointed out the importance of distinguishing two types of group performance. They are idea generation (i.e., creativity) and the implementation of the ideas that might be differently impacted by diversity; that is, creativity may be boosted by diversity; in contrast, implementation of the ideas may be weakened by diversity. If a group cannot intuitively find a way to accommodate the diversities in complex problem solving (e.g., organizational, educational, and cultural), the separated EnA views may further emphasize diversity. The result may be a negative impact on the collective intelligence of the group. In other words, it seems as if collective intelligence must be in place should the group want to take advantage of EnA, not the other way around.

We still lack a deep understanding of all the intricacies of collective intelligence and collaboration. For example, newer research, particularly in dispersed groups that communicate via technology platforms, showed that communication that boosts collective intelligence occurs on different levels. Chikersal et al. [2017] pointed out that synchrony of facial expressions is essential and predicted that technologies enabling participants to see their faces may boost collective intelligence. Furthermore, they found that synchrony of electro-dermal activities and heart rates are associated with group satisfaction rather than performance. They also reinstated that a significant relationship between collective intelligence and group satisfaction was not observed [Woolley et al. 2015; Chikersal et al., 2017]. Therefore, it is necessary to further collective research intelligence [Søilen 2019], and in parallel, EnA needs to explore, discover, and establish less obvious epistemic relationships in agencies supporting collective intelligence. Although the UMF is generic, it allows exploring epistemic relationships across all its spheres, and may guide the research of phenomena, such as collective intelligence [Polovina R., 2022].

8.9 Adaptiveness

Previously, we defined adaptation as an effort of an agency (which may be a society, an individual, any group, or any organization) triggered by specific events that are being translated into (spontaneous or deliberate) actions that aim to reduce the distance between the agency and its environments (e.g., economic, natural, civil liberty, health) in a satisfactory way. In other words, the challenge is to obtain (and enable) technology and create (or participate) in an endeavor needed to adapt. In this paper, we are discussing the dynamics of DIKW sharing for adaptation; that is, establishing epistemic relationships among agencies. These epistemic relationships may be obvious (e.g., as in top-town manage enterprises), or less apparent (e.g., as bottom-up DIKW flows in enterprises), or even latent (e.g., as DIKW flows among individuals or informal groups). This study's contribution is synthesizing observations from a wide range of studies to describe the principles of DIKW dynamics relevant to societal adaptation.

An example of a less apparent epistemic relationship between technology and organization is articulated as a tendency that (i) technology of a complex system and (ii) organizational structure (which produces or maintains the system) mirror each other. Colfer and Baldwin [2016] connected this epistemic relationship with an organization's ability to innovate and adapt to environmental changes. The conclusions of their study may be summarized as follows:

- If a technological system is changing and complexity is increasing rather slowly, mirroring (of the technology architecture), and organization may be common and cost-effective.
- If technologies are changing and complexity is increasing, integration (into an enterprise) may require broader DIKW than necessary to manage the technological system components only. In this case, too rigid mirroring may be a “trap” because there is no potential for innovation and research. Partial mirroring, which allows for research and innovation beyond the technological system’s boundaries may be a solution. For example, mirroring may be broken by establishing relational contracts among organizations to acquire new DIKW.
- If technologies are changing rapidly and complexity increases, mirror braking may be inevitable. Besides strategic investments in relational contracts beyond the existing organization, high levels of communication and collaboration among allies may be necessary to obtain new DIKW. When technical interdependencies are growing, pre-emptive modularization and implementation of patterns that may reduce technological and organizational complexity may be explored.
- In open, collaborative endeavors, technology may boost new organizational patterns, such as various transient organizational structures or stigmergic endeavors. New models are anticipated yet to be developed, as underlying technologies remain dynamic and innovative.

Therefore, EnA must support discovering and exploring new epistemic relationships (among the agencies) and adapt as necessary.

8.10 Emergence

Under this emergence principle, new forms of agencies (e.g., governments, organizations, communities, movements) are anticipated. They can be highly organized due to various undelaying technologies and exhibit collective intelligence properties that individual agencies could not achieve. On the one hand, these new organizations may more efficiently manage physical systems (including their environment) due to numerous sensors, integration of physical (including live [Raphael and Posland, 2019]), digital and social, and vast volumes of data collected. On the other hand, the threat agents will also organize. They will use new technologies and integrated networks and explore vulnerabilities in a way that could not be anticipated. In other words, as new forms of legitimate endeavors emerge, new alliances of threat agents or (not long ago unlikely) alliances of threat agents and legitimate enterprises may also emerge. Thus, recognizing emerging patterns that have not been predicted in the original technological, enterprise, and societal systems design may become crucial for societal adaptation and design endeavors to respond to the merging situations. Ultimately, EnA should enable these perspectives. The UMF allows for the creation of new perspectives.

9 Discussion

At this point, we will address further questions pertinent to EnA.

9.1 Why do we need EnA, and why is EA unsatisfactory?

EA is firmly rooted within the enterprise domain, as demonstrated in Table 2. For example, TOGAF is intended for "small, medium, and large commercial businesses, as well as government departments, non-government public organizations, and defense agencies" [The Open Group, 2022]. Therefore, an EA domain (i.e., the discourse of interest) may include any businesses, groups of countries, governments, or governmental organizations (such as militaries) working together to create common or shareable deliverables or infrastructures. An EA domain may also be a partnership and alliance of businesses working together, such as a consortium or supply chain.

EnA discourse of interest is broader and may include any elements of societies; individuals or groups, organizationally differentiated (e.g., communities) or undifferentiated (e.g., demographics that describe populations and their characteristics). Furthermore, we are not imposing any limitations on the UMF discourse of interest. Ultimately, the UMF may be used to model any system, social, technical, natural, or any combination of these. Thus, we need EnA to model or evaluate models of societies, global and isolated phenomena and undertakings, social changes, and similar.

Most importantly, by including the UMF, we highlight the importance of general intelligence in human endeavors, as they are crucial for adaptation.

For example, Reader et al. [2011] "highly correlated composite of cognitive traits suggests social, technical and ecological abilities have coevolved in primates, indicative of an across-species general intelligence that includes elements of cultural intelligence". Furthermore, they argue that the abilities observed in primates, such as discovering novel solutions to environmental or social problems, learning skills and acquiring information from others ('social learning'), using tools, extracting concealed or embedded food, and engaging in tactical deception are ecologically relevant measures of behavioral flexibility. They pointed out that human intelligence may greatly rely on language or another uniquely human capability.

Richerson and Boyed [2020] researched connections between individual intelligence, learning capacity and cultural adaptation. They argued that when a "new desirable innovation is rare… the role of individual learning is maximal. In a recently changed environment, many individuals may use individual learning/creativity to adapt relatively rapidly". Thus, individual learning is important for cultural adaptation, and "human life history is adapted to exploit the adaptive advantages of culture"; that is,

individual learning and cultural learning are complementary. Boyd et al. [2011] also indicated that social learning is essential for human adaptation.
Therefore, we include the UMF as a meta-paradigm of AGI into EnA, as it appears that general intelligence has been in the human lineage for a long time, and it may be one of the underlying factors of human adaptation.

9.2 How EnA differs from EA, and whether is it supposed to incorporate or replace it?

EnA is also not prescriptive in that it does not call for artifacts or actions that are not directly related to problem-solving. Therefore, if any of the existing EA models or frameworks may resolve the problem at hand, there is no reason not to use them. However, if the problem at hand calls for more-expressive modeling, EnA may guide modelers to choose better-suited paradigms and create artifacts of that EnA instance.

For example, good indications that the modelers may need to choose paradigms beyond the traditional EA paradigms (e.g., Zachman's EA Framework [Zachman, 2008] or TOGAF [The Open Group, 2022]) may be:

- Societal or organizational transformations that call for profound cultural changes and affect the fabric of a society or an enterprise (e.g., enhancing a capacity of a government to use scientific research)
- All-pervasive and wholistic societal changes, such as transformation that require integration of enterprises, people's lifeworld (e.g., citizens and communities), and public sphere, including traditional and social media [Polovina R, 2022]
- An overarching context of human endeavor where the scope of transformation is bigger than a single enterprise and may include society as a whole or global endeavors, such as a response to natural disasters, pandemics [Polovina R, 2022], or global economic crises.
- When multiple segments of society are involved (e.g., environment, economy, health), and the solutions require collaboration across multiple sectors.
- To identify gaps between fundamental and applied science or a theory and its applications (e.g., the Enterprise Risk Management (ERM) field is dominated by the private sector, but it is necessary to outline ERM for the public sector [Continuity Central, 2022; Andersen et al., 2021]).
- Strategic elements and communications that are less signified (if addressed at all) in EA (e.g., privacy [Cavoukian, 2011] or safety architecture [Stewart et al., 2021]).

9.3 Why do we need UMF, and how does it differ from other upper ontologies?

Being an upper ontology, the UMF facilitates the generation of domain ontologies. In other words, the UMF discourse of interest is general intelligence, and it contains ge-

neric semantics, such as principles, objects, relationships, systems, and similar. Therefore, the UMF may facilitate the creation of EnA instances and, ultimately, an overarching EnA ontology.
In this context, an EnA ontology is considered a domain ontology whose discourse of interest contains semantics pertinent to human endeavors. For example, an EnA ontology includes four functions of EnA in relation to adaptation (Table 1) and the principles of DIKW dynamics pertinent to an endeavor, (e.g., human collaboration, individuation, dealing with opportunism). EnA may also include other domain ontologies, such as EA frameworks, to facilitate the modeling of enterprise architectures of an endeavor.

However, an EnA ontology also includes the UMF. It may include other paradigms of AGI because general intelligence is important for EnA, especially when EnA must facilitate solving complex and important societal problems. At that point, ethical considerations and sound judgment are unavoidable, as Habermas [Habermas, 2003] pointed out: “No science will relieve common sense even if it is scientifically informed, of the task of forming a judgment….”

The UMF differs from other upper ontologies [GUA, n.d.] because it does not contain enterprise semantics. For example, Zachman’s EA Framework [Zachman, 2015] contains Executive Perspective, Business Management Perspective, and Architecture Perspective. In contracts, the UMF discourse of interest is general intelligence, and its discourse of interest contains generic terms, such as object, relationships, and similar. The UMF also does not limit DIKW flows through its four spheres-DIKW may move in all directions. In contrast, the Zachman EA Framework implies top-to-bottom movements [Zachman, 2015]. Furthermore, the UMF allows the creation of new perspectives in EnA (e.g., strategically important safety view and architecture) and the creation of artifacts that contains DIKW from different spheres to facilitate human creative thinking.

9.4 What are the requirements for good EnA, and how can approaches be evaluated?

Ideally, EnA will provide a simple (or seemingly simple solution) for a complex problem. For example, the EnA models may intuitively break a complex domain and identify the observables that will become measurable and manageable. Furthermore, a complex pandemic response may be broken down, and the interfaces among the involved agencies may be identified. These interfaces may be observed as we advance, and DIKW flows may be evaluated. That is, new observables may also be determined as necessary, such as the societal capacity to share knowledge [Polovina R., 2022]. Ideally, the EnA should be modeled in a way that is (relatively) easily observed and tested, although the discourse of interest may be complex.

However, the models of EnA are not predetermined but rather problem-solving oriented. That is, the set of chosen EnA models (and their organization) is context-dependent. For example, the model of the EnA instance principles may be an informal diagram of the involved agencies. Still, it can also be a computer simulation of the interaction of the involved agencies. Whatever suits the agencies better helps them reduce the complexity and guides them towards the solution. We assume the modeling includes ethical

considerations, and the solution should also be acceptable for all affected agencies and their environment.
Last but not least, we aim to encourage problem-solving that allows adaption of pluralistic societies in a manner that is acceptable for all elements of the society, rather than encourage single-sided adaption by imitation that may turn into maladaptation for some elements of the society.

9.5 How EnA differs from other societal approaches such as KAOS, or linguistic approaches such as DEMO?

Knowledge Acquisition in Automated Specification (KAOS) methodology focuses on modeling goal-oriented agents [Lapouchnian, 2005]. Thus, from the UMF point of view, KAOS is a domain ontology whose domain is the intersection of an organization (including social aspects), agent-oriented technology and requirements acquisition, and particularly goal-oriented agents. For example, if the models of the UMF principles call for a goal-oriented agent methodology, the modelers may incorporate KAOS models in their instance of EnA. However, suppose during the creation of the UMF principles, the modelers realized that they needed need to focus on the properties of the societal DIKW systems and the qualities of DIKW itself. In that case, other approaches may be chosen or researched. That happened when we modeled the societal pandemic response [Polovina R., 2022]. We realized we needed methods to evaluate the overall societal DIKW system, particularly to separate “true” knowledge from “fake” knowledge. Thus, we needed the paradigms that may support these distinctions. The importance of the UML principles is to facilitate this discovery and lead the modeler to choose the conceptual paradigms that better suit their intentions.

Similarly, from the UMF point of view, Design and Engineering Methodology for Organizations (DEMO) [Dietz, 1999; Dietz and Mulder, 2020] is a domain ontology whose domain is an intersection of an enterprise and requirements acquisition (for software systems development). The authors favor Habermas’s theory of communicative action. The UMF allows for modeling these principles and concepts and various other human properties, such as deception or irrationality.

9.6 How EnA aligns with other social sciences?

The UMF originated as a systems science concept. The authors wanted to explain the differences between Object-Oriented models and mental models created by the modelers. The authors were aware of the modelers’ cognitive processes (e.g., thinking, reasoning) and worldview in general [Polovina R., 1999; Polovina and Wojtkowski, 1999]. The UMF is primarily a meta-paradigm that may be used to model various social theories and situations, but the UMF itself stays rooted in systems science.

We aim to support modelers’ creativity regardless of their positions and beliefs. For example, a modeler may be an objectivist and believe that the world exists fully independent of them. Or, a modeler may be a subjectivist, who believes there is no reality outside of them, who is the subject. A modeler constructivist may believe that there is some rather semi-objective reality. We aim to support all three approaches by providing a modeling meta-paradigm (i.e., UMF) that may serve all of them.

9.7 What literature has been used?

The literature informed us from multiple domains, including systems science, enterprise architecture, systems development, future studies, philosophy, anthropology, and management science. We found that knowledge about human adaptation is scattered over multiple faculties of science. Our contribution would be to collate this scattered knowledge as pertinent for the architecture or architecting, or in discovering the architecture of complex societal endeavors in one place.

Notably, we tried to present this knowledge and principles so that heterogeneous scientists and practitioners could work together and concentrate on resolving the problem at hand. The modeling at the principle UMF levels should be intuitive. In contrast, the modeling at the conceptual UMF level may be dominated by the logic of the scientific field. We assume that, at that point, collaboration among scientists and practitioners from different research fields will be more difficult.

As Habermas pointed out [2003]: "…most fields of practice were impregnated and restructured by the "logic" of the application of scientific technologies". Habermas also raised the question: "Will common sense, in the end, consent to being not only instructed but completely absorbed by counterintuitive scientific knowledge?"

10 Concluding Remarks

ICT communities have used EA as an organizational concept to advance ICT and communications across an enterprise and, to a lesser extent, to facilitate ecological adaptation. However, the rise of urban areas (and the rise of their citizens), rapid and widespread societal changes (e.g., pandemics, economic crises), and interruptive AI technologies call for the undertaking of new endeavors to adapt to these changes. It has been anticipated that new agencies (i.e., governments, enterprises, communities, individuals) will emerge. We noticed that a new type of architecture is required, i.e., Endeavor Architecture (EnA). We identified ten principles of DIKW dynamics relevant for creating new epistemic relations among agencies that support societal endeavors: top-down, bottom-up, inclusion, individualization, openness, integration, collaboration, opportunism, adaptiveness, and emergence. We propose to apply these principles in setting the directions and requirements for the evolution of EnA to support ecological adaptation, research, learning, and creation of new knowledge leading to the acceptance of Endeavour Architecture (EnA) beyond Enterprise Architecture (EA).

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