Enterprise Meta-Architecture for Megacorps of Unmanageably Great Size, Speed, and Technological Complexity

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Abstract. The discipline of enterprise architecture (EA) provides valuable tools for aligning an organization's business strategy and processes, IT strategy and systems, personnel structures, and organizational culture, with the goal of enhancing organizational agility, adaptability, and efficiency. However, the centralized and exhaustively detailed approach of conventional EA is susceptible to failure when employed in organizations demonstrating exceedingly great size, speed of operation and change, and IT complexity – a combination of traits that characterizes, for example, some emerging types of "technologized" oligopolistic megacorps reflecting the Industry 4.0 paradigm. This text develops the conceptual basis for a variant form of enterprise architecture that can be used to enact improved target architectures for organizations whose characteristics would otherwise render them "unmanageable" from the perspective of conventional EA. The proposed approach of "enterprise meta-architecture" (or EMA) disengages human enterprise architects from the fine-grained details of architectural analysis, design, and implementation, which are handled by artificially intelligent systems functioning as active agents rather than passive tools. The role of the human enterprise architect becomes one of determining the types of performance improvements a target architecture should ideally generate, establishing the operating parameters for an EMA system, and monitoring and optimizing its functioning. Advances in Big Data and parametric design provide models for enterprise meta-architecture, which is distinct from other new approaches like agile and adaptive EA. Deployment of EMA systems should become feasible as ongoing advances in AI result in an increasing share of organizational agency and decision-making responsibility being shifted to artificial agents.

Keywords: Enterprise architecture, Organizational complexity, Unmanageability, Industry 4.0, Megacorps, Parametric design.

1 Introduction

This text develops the conceptual basis for a specialized form of enterprise architecture that – unlike conventional approaches to EA – can be applied to organizations demonstrating otherwise unmanageable size, complexity, and speed of activity and change. The fundamental feature of this variant of enterprise architecture – described here as

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"enterprise meta-architecture" (or EMA) – is the fact that it removes human enterprise architects by one step from the detailed work of analyzing an organization's current architecture and designing and implementing an improved target architecture. Such a model builds on existing approaches to adaptive and semi-automated EA and parametric design. Before presenting the details of the EMA model, we first consider the elements of conventional EA and the challenge posed by those organizations (including some emerging types of technologized oligopolistic megacorps reflecting the Industry 4.0 paradigm) whose size, complexity, and dynamism render the application of traditional EA unfeasible.

2 Elements of Conventional Enterprise Architecture

The goals of EA include (1) increasing an organization's capacity for managing complexity [1-3], (2) enhancing the organization's ability to resolve internal conflicts [4-5], and (3) more effectively integrating the organization's various subsystems and constituent units, thereby providing enhanced agility that allows the organization to quickly adapt to rapidly evolving environmental conditions [5-7]. A well-designed enterprise architecture seeks to accomplish these goals by increasing the organization's degree of *alignment*. In principle, a comprehensive EA initiative strives to increase alignment between such diverse elements as an organization's business strategies, IT strategies, personnel structures, information system structures, decision-making processes, values, and organizational culture, as well as the characteristics of the external competitive ecosystem in which the organization operates [8-9]. In practice, though, EA initiatives often focus simply on improving alignment between business and IT strategies [9].

The EA process involves analyzing an organization's current architecture, identifying its weaknesses, and formulating and implementing an improved target architecture. To facilitate this, the current architecture is captured in a detailed set of documents describing structures, processes, and systems [10] from various perspectives. Study of these documents allows the identification of areas of redundancy, inefficiency, or lack of resources that can be addressed by an improved target architecture [2]. EA frameworks for such work include TOGAF, GERAM, E2AF, and FEAF [2, 9].

3 When Conventional EA Is Impossible: Technologized Megacorps and the "Unmanageable" Organization

While a considerable industry has grown up around EA – including numerous professional associations, training programs, certifying bodies, and journals – the potential benefits of EA remain debatable, the results generated by the use of different EA frameworks vary between organizations in unpredictable ways, the critical success factors for EA are unclear, and the failure rate for EA initiatives remains significant [9, 11-15]. It is not uncommon, for example, for a costly and time-consuming EA initiative to generate vast quantities of documentation that few organizational personnel will ever read or utilize [16-17] or for a conventional EA approach to model an organization in such

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elaborate (and irrelevant) detail that it renders management of the organization *more* rather than *less* complex for its members [16, 18]. An especially challenging dynamic arises from the fact that the same organizational characteristics that lead an organization's decision-makers to conclude that launching an EA initiative is necessary may simultaneously make it difficult for such an EA effort to succeed.

Here we consider especially three such organizational traits that increase the perceived utility of a properly executed EA initiative while simultaneously rendering it difficult or impossible to effectively design and implement a new target architecture. These factors are extreme (1) organizational size, (2) organizational speed, (3) and organizational complexity. By itself, each of these poses a challenge for the successful execution of an EA initiative; when all three traits reach "unmanageable" levels within a single organization, conventional EA approaches can be rendered unworkable.

3.1 The Theoretical Concept of the "Megacorp"

The theoretical basis for focusing on these three characteristics in particular derives from reconsideration of the idea of the *megacorp* in light of its newly emerging "technologized" form. As conceptualized by economist Alfred Eichner in the 1960s and 1970s, the "megacorp" is not simply a "very large corporation"; rather, it represents a qualitatively distinct type of company. Namely, a megacorp is one of the leaders within an oligopolistic industry; the limited price competition that the megacorp encounters allows it to "increase the margin above costs in order to obtain more internally generated investment funds, that is, a larger corporate levy" [19-20], which it uses to enable a state of perpetual growth [20-21]. Because the megacorp is expected to endure permanently, sacrificing its short-term profits for investment in long-term profit growth is not risky but highly reasonable [20]. Moreover, because its shareholders (who come and go) are distanced from any involvement in the running of the company, the megacorp's professional managers are free to focus on long-term profit *growth* and the development of the company, rather than maximization of short-term profits and immediate financial gains for shareholders. Such a megacorp possesses a coherence, purpose, and even "life" [22] of its own; it is essentially an autonomous and "enduring organization with survival and growth as key objectives" [20]. However, growth and survival do not depend simply on securing enough funds; they also require a firm to successfully shape or navigate a complex array of political, social, technological, and environmental factors. Thus rather than adopting typical metrics that track a company's health solely in terms of financial performance, over time such a firm – through its managerial class – may develop a complex set of (non-financial) geopolitical, social, cultural, technological, or ecosystemic strategies and objectives – which are *its own* goals and not those of its shareholders.

One might imagine that such a megacorp is ideally suited to serve as a venue for the practice of conventional enterprise architecture. After all, it is a large and stable organization, and because it formulates strategies based on a goal of long-term multidimensional growth and development (and not maximization of short-term financial profits), its strategic objectives do not lurch from one direction to the next at a rate that makes it difficult for its personnel structures, IT systems, and other elements to keep pace.

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While that is true, the higher margins and resources for investment in growth enjoyed by a megacorp allow it to methodically grow larger than would otherwise be possible for companies, pushing the limits of the organizational size manageable for human personnel. Moreover, the ongoing "technologization" (and, increasingly, "technological posthumanization") [23] of megacorps resulting from their deepening and expanding incorporation of autonomous AI, social robotics, human-robot interaction, VR systems, brain-computer interfaces, ubiquitous computing, the Internet of Things, cyber-physical systems, and other Industry 4.0 [24-25] phenomena both enables and drives further growth in organizational size and complexity, as artificial agency (or augmented human agency) makes it possible for a company to perform more work, more types of work, and work of greater speed and complexity than could be performed by natural biological human beings alone. Such dynamics may easily allow near-future technologized megacorps to "outgrow" the capacity of conventional EA to be employed in managing them. Below we consider such dynamics in more detail.

3.2 Organizational Size as an Obstacle for EA

Metrics like market capitalization, annual revenue, or number of employees are sometimes used in an attempt to capture a company's size in a single figure, but in reality the concept of an organization's "size" is much more complex and multidimensional. Here an organization's "size" can be understood as its *spatial extension;* however, this is not reducible simply to its number of physical facilities or the geographical span of its operations. An organization's structures, processes, and systems not only occupy a certain amount of three-dimensional physical space; they also occupy (or create) several other overlapping types of space, including temporal, informational, cognitive, social, political, and ecosystemic space [26-27]. A given organization possesses a unique extension in each of these spaces. Such extension generates a multifaceted workspace within which the organization can form structures and operate, but it also creates corresponding types of *distance* that tend to undermine organizational alignment.

By its very nature, a large organization's internal distances work against the possibility of achieving and maintaining alignment. For example, the physical distance between employees and facilities makes it impossible for one employee to directly observe what others are doing; instead of existing within a single self-adjusting cybernetic feedback loop, an organization's activity thus becomes divided into thousands of disjointed operations. Similarly, it takes time for information about events occurring in one part of the organization to reach another part; in this way, spatial distance gives rise to temporal distance, making it difficult to effectively synchronize activities throughout the organization. Moreover, an employee's lack of knowledge about or causal interaction with events in other parts of the organization can lead to a lack of psychological investment; this "emotional distance" between employees can also negatively impact workplace culture, making it more difficult to create a culture that is aligned with and actively supports the other organizational elements.

To some extent, distance in informational and social space can be reduced through interpersonal contact among employees; physical and temporal distance can be compressed through technological means like email, instant messaging, social media, or

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videoconferencing. Indeed, the recent rise of *ad hoc* "virtual organizations" [28-29] reflects the role that new forms of ICT can play in overcoming distance and establishing connections through organizational space, thereby allowing the creation of organizations whose employees, facilities, and informational resources are so spatially distant from one another that they would not be able to form a viable organization in the absence of such technology. On the other hand, it is possible for an organization to grow so massive in size that it is no longer simply "large" but literally becomes *unmanageably* large. Researchers have discussed such "unmanageably large" organizations in a number of contexts [30-34]. The extension of such entities within their multifaceted organizational space may become so great and the distances between their elements so vast that conventional EA approaches can no longer successfully grasp them.

3.3 Organizational Speed as an Obstacle for Conventional EA

An organization's "speed" has at least two aspects: (1) the organization's speed of regular internal operations and (2) the speed of evolution of the organization and its external ecosystem. For example, a hedge fund whose primary business activity consists of high-frequency trading may rely on its automated systems to make decisions and execute transactions within a matter of microseconds; however, the basic structure of the organization might remain little changed from year to year. An online social media company may have a high speed of internal operations *and* evolution, while an airplane manufacturer's work of designing and producing a given model of airliner might span decades [35]. A high speed of regular internal operations is relatively easy for EA frameworks to deal with. A high speed of ecosystemic evolution poses a greater challenge: by the time an organization's current architecture has been analyzed, a new architecture designed, stakeholder buy-in obtained, and necessary changes in organizational structures, processes, systems, and culture implemented, the market ecosystem will already have transformed and the organization's strategy will be out-of-date. While new strategies might be rapidly adopted, reconfiguring the organization's architecture to maintain alignment with those strategies requires time. In such circumstances, an organization's architecture may trail several steps behind its strategies.

As with the case of organizational size, it is possible for an organization's speed of internal operations or speed of organizational and ecosystemic evolution to be so great that such dynamics are no longer simply "fast" but literally become *unmanageably* fast. Organizations' struggles with "unmanageably fast" dynamics have been noted in various contexts [36-37]. Such dynamics can easily exceed the boundaries of what the typically deliberate processes of conventional EA are capable of handling. It is precisely in a case of rapid ecosystemic change that an organization needs to develop the type of flexibility that EA promises to deliver – but it is also in such cases that the techniques of conventional EA reveal their limitations: their exhaustive, detailed-oriented approach is not well-suited to quickly developing an architecture, and they do not yield architectures that can continuously and automatically update themselves to match the evolving realities of the competitive ecosystem.

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3.4 Organizational Complexity as an Obstacle for Conventional EA

An organization's *complexity* can be understood in various ways. If an organization's size is reflected in the degree of extension of the organizational space that comprises overlapping component spaces of physical, temporal, informational, cognitive, social, political, and ecosystemic space, then its degree of complexity is reflected in the "convolutedness" of that space. Such complexity can be analyzed from a philosophical perspective (e.g., in terms of the Deleuzean "foldedness" of the space [38] or the topology of its underlying "possibility space" [39]), or it may even be mathematically quantified (e.g., in terms of its fractal dimension D [40]). Such complexity is manifested in phenomena like the degree of recursiveness within organizational structures, processes, and systems; the degrees of interdependency between organizational elements; and the scope and depth of specialized expert knowledge needed to successfully recognize, interpret, and manipulate various aspects of the organization's functioning.

In today's world, such convolutedness is often largely a matter of the *technological* complexity of an organization and its work. Such complexity is growing hand in hand with the emergence of the types of rich, intricate ecosystems of cyber-physical systems and organizations [25] conceptualized in the "Industry 4.0" paradigm [24] – a world in which all devices (and even human workers) are networked and become capable of directly communicating with and influencing one another, thereby exponentially increasing the topological complexity of the architectures within which they are connected.[1]

It is possible for an organization's complexity to be so great that the organization becomes *unmanageably* complex. The traits of organizations confronted by such "unmanageable complexity" have been discussed in a range of contexts [42-46]. One of the key aims of enterprise architecture is to reduce organizational complexity – or at least, to create a streamlined set of interfaces by which personnel can understand and manage their organization's remaining irreducible complexity [1-3]. However, in the case of an unmanageably complex organization, the nature and degree of complexity may be so overwhelming that enterprise architects are not able to identify, conceptually disassemble, and understand the organization's components – which is a prerequisite for formulating an improved target architecture. Figure 1 reflects the manner in which some emerging types of technologized oligopolistic megacorps reflecting the Industry 4.0 paradigm may combine unmanageable size, speed, and complexity.

[1] Drawing on the philosophical notion of human culture as a "rhizome" (i.e., an array of mutual influences that lacks a central origin or genesis and that is horizontally spreading, non-hierarchical, and maximally interconnected; possesses self-healing internal links; assimilates heterogeneous elements to form symbioses or hybrids; and grows naturally without a centrally planned architecture) developed by Deleuze and Guattari [41] and the concept of the technologized oligopolistic "megacorp" discussed earlier in this text [19-20], the dynamics that establish such immeasurably complex interconnections between constituent elements of an organization – which, aided by decentralized networking technologies, often develop in a quasi-organic, biomimetic pattern – could be understood as contributing to the emergence of a "rhizocorp."

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4 Enterprise Meta-Architecture: A Means of Managing the Unmanageable?

Efforts to apply the techniques of conventional EA can encounter insurmountable obstacles in organizations that are unmanageably large, fast, or complex. The question thus arises whether it might be possible to develop some variant form of EA which – while perhaps delivering substandard results for organizations of "normal" size, speed, or complexity – would nevertheless possess the advantage that it could be utilized in organizations that would be considered "unmanageable" from the perspective of conventional EA. This would appear to require reconceptualizing the relationship of organizational personnel to the EA process, the level of abstraction at which EA is "managed," and the extent to which EA activities must be automated. Ongoing developments in the fields of Big Data and parametric design suggest how this might be accomplished.

Fig. 1. Organizations of unmanageable size, speed, and complexity may face insurmountable obstacles when attempting to employ conventional EA approaches to generate alignment.

4.1 Big Data, Parametric Design, and Meta-Management

Many contemporary organizations are accumulating large amounts of data that possesses great business value, insofar as it could potentially be used to identify previously unrecognized trends, personalize product offerings for individual customers, or predict the behavior of consumers or competitors; however, the datasets are so vast in size, diverse in type, complex in structure, and rapid in their growth that they cannot be effectively managed, understood, or exploited with traditional data-analysis tools like two-dimensional spreadsheets. Moreover, such rich streams of data are often generated in real time, and an organization must process, interpret, and act upon them almost instantaneously to build a competitive advantage or maintain parity with rivals.

In recent years, a range of "Big Data" approaches (e.g., involving semi-automated data mining) have been developed to allow knowledge to be extracted from such vast datasets. In comparison to earlier data-processing approaches, many automated Big Data techniques minimize the role of the human end user in manually performing steps like data selection, cleansing, or analysis: the end user may have no direct access to individual data points but is instead presented with meaningful visualizations of particular types of entities, trends, or other phenomena uncovered within the dataset by automated algorithmic processes. Such approaches remove the user from the fine-grained

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detail of the dataset by one step, "elevating" the user's plane of engagement into the higher-order realm of: (1) determining the types of insights that would be useful for business purposes, if they could be obtained; (2) configuring the operating parameters for data-mining software and allowing it to autonomously extract such knowledge; and then (3) determining how the organization should act on the insights that result [47-49].

In effect, such Big Data approaches offer organizational personnel a means of effectively managing datasets that would previously have proven unmanageably large, unmanageably complex, or changing in a way that is unmanageably fast – but with the constraint that such personnel are acting at one degree of remove from the data itself. Human personnel are still managing the process, but at a higher level – by establishing the broad parameters within which the automated systems will operate. In effect, automated Big Data approaches shift the role of human workers from *directly managing data* to *managing the systems that manage data;* in this way, the management of data is replaced with a higher-order "meta-management."

Similar dynamics are found in emerging approaches to parametric design and AI-facilitated form-finding used in the design of buildings: such morphogenetic techniques (e.g., based on evolutionary computing) can yield startling biomimetic designs with exceptional performance characteristics that could not have been devised by a human architect. In such an approach, the human architect serves as a "meta-designer" who (1) decides what broad criteria a building should fulfill and (2) bears legal and ethical responsibility for choosing from among the resulting designs proposed by the algorithmic system; however, the details of the design are developed by the architectural AI [38].

4.2 Distinguishing Enterprise Meta-Architecture (EMA) from Conventional EA

Drawing on Big Data and parametric design, it is possible to conceptualize a new form of EA that would be capable of developing and implementing an improved target architecture for an organization whose size, speed, and complexity place it beyond the grasp of conventional EA techniques. This proposed approach can be referred to as "enterprise meta-architecture" (or EMA),[2] insofar as the key feature distinguishing it from conventional EA is the fact that in EMA, human enterprise architects do not directly design a target architecture; rather, they establish the basic goals and parameters for an automated system that generates, implements, and continuously adjusts the target

[2] The phrase "enterprise meta-architecture" has been previously employed in other contexts, e.g., by Covvey et al. [50], who use it to describe a three-level EA incorporating the levels of "Meta-Applications," "Enterprise Middleware," and "Departmental Applications Systems," and by Ota and Gerz [51], who explain that "the development of architectures requires an enterprise (meta) architecture on how to define architectures." Similarly, Van de Wetering and Bos [52] formulate a noteworthy "meta-framework for Efficacious Adaptive EA" grounded in cybernetics and Complex Adaptive Systems theory; however, it still relies on the utilization of conventional EA frameworks by human enterprise architects.

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architecture.[3] EMA relies on the fact that phenomena that are "unmanageable" for a human worker of a particular physiological nature and cognitive capacities may not be unmanageable for an artificially intelligent system of sufficient sophistication [23]. Differences between EMA and conventional EA are summarized in Table 1.

Table 1. A comparison of conventional anthropocentric EA suitable for use in "normal" organizations with a form of enterprise meta-architecture (EMA) that can be employed in organizations of otherwise unmanageable size, speed, and complexity.

Conventional enterprise architecture (EA)	Enterprise meta-architecture (EMA)
Human architects directly engage with the fine-grained details of architecture analysis, design, and implementation.	Human architects set goals and parameters for the creation and maintenance of architectures by an automated system.
Architectural software is a passive tool.	Architectural software is a proactive agent.
Architecture is interpreted through a handful of discrete "views" and "landscapes" comprehensible to human architects.	Architecture may be captured and analyzed directly as a holistic and continuous object of endless and irreducible complexity.
The range and variety of possible target architectures are limited by human experience and imagination.	Processes involving, e.g., evolutionary computation may generate unexpected and counterintuitive yet effective architectures.
While data-gathering may be bottom-up, architectural design and implementation is centralized and top-down.	Architectural creation and implementation may be distributed among autonomous EMA agents embedded throughout an organization.
An organization's actual architecture may be analyzed just once every few years.	An organization's actual architecture is continuously analyzed.
A new target architecture may be designed and implemented just once every few years.	Adjustments to the actual architecture are ongoing and continuous.
Over time, the actual architecture diverges from the nominal, normative architecture in unrecognized ways.	Continuous analysis and adjustment maintain harmonization of the actual architecture with the target architecture.

4.3 Toward Development of the Technological Foundations for EMA

A fully automated EMA system would require AI possessing distinct capacities for (1) analyzing an organization's structures, processes, and systems, (2) designing an improved target architecture that advances the business objectives chosen by human personnel, and (3) implementing a target architecture within the organization. Given current technological limitations, creation of a fully automated EMA system is not yet feasible. However, pieces are in place that could be employed toward its development. Beyond general semi-automated approaches to data-mining and Big Data [47-49], researchers are making progress in developing semi-automated tools for strategic analysis

[3] The determination of which organizational elements should be parameterized within the EMA system could be informed by a robust "organizational phenomenology" grounded either in the phenomenology of architecture [26] or a systems-theoretical phenomenology [53].

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[54] and the gathering of data and generation of EA documentation (using tools like Nagios, Iteraplan, and SAP PI) [55-58]. Similarly, many forms of AI (including evolutionary computing) exist that could be harnessed for the automated creation of improved target architectures. Steps in that direction can be seen, for example, in algorithmic approaches to organizational design for artificial multi-agent systems [59-60].

Perhaps the greatest obstacle to the design of a fully automated EMA system that could operate in a continuous feedback loop of architectural adjustment is the limited capacity of AI systems to implement a new target architecture within an organization. For a contemporary organization that primarily includes human workers, implementing a new architecture would require an EMA agent to successfully teach, train, monitor, and coach such workers – to persuasively communicate the rationale for actions that they may not readily accept and to negotiate with them the most contentious points of organizational change. While AI is not yet capable of effectively filling such roles, ongoing developments in the field of social robotics (especially in workplace contexts) [23] suggest that it may eventually be possible. Moreover, the need for engagement with human workers may lessen over time, as artificial agents play increasingly important and widespread roles in organizations, placing more organizational structures and dynamics under the (potential) direct influence of an automated EMA system.

4.4 Distinguishing EMA from "Adaptive" and "Agile" EA

EMA differs from recently emerging forms of "adaptive" EA [61-65] or "agile" EA [66-68] that attempt to make the process of designing and implementing a target architecture more flexible, streamlined, interactive, responsive, and outcome-oriented. Such approaches frequently rely on the use of advanced types of EA software, but as tools rather than actors within the architectural process: they still generally require human enterprise architects to engage with the fine-grained details of analysis, design, and implementation. EMA and agile and adaptive EA approaches may be able to mutually enhance one another: EMA that uses agile or adaptive EA as its conceptual foundation may have fewer processes to automate than EMA based on more exhaustive conventional EA approaches, while new AI-based techniques developed in pursuit of an EMA framework could further enhance the speed and flexibility of agile or adaptive EA.

4.5 The Expected Value of Enterprise Meta-Architecture

EMA could provide a means for improving alignment in organizations that have gradually grown in size, speed, or complexity to the point that it is difficult to apply conventional EA methods. Moreover, even in organizations for which conventional EA is still a practical option, the automated nature of EMA might render it less expensive and more efficient. Perhaps of greater long-term interest, though, is the potential of EMA (alongside other new management technologies) to facilitate the creation of entirely new types of architecture that could not otherwise exist or survive. For example, consider (1) a hypothetical organization whose strategies, tactics, and business processes are continuously and automatically adjusted in real time in response to the millions of interactions with customers occurring every day, or (2) a hypothetical organization

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whose thousands of workers all provide immediate feedback on proposed strategies as they are being developed in real time at the C-Suite and board level, with an automated system eliciting and sifting through such input to instantaneously identify and synthesize the most insightful and useful feedback. Such visions do not portray theoretical impossibilities; they simply reflect architectures that (at the moment) are unfeasible from a practical perspective. To the extent that automated EMA technologies someday allow such architectures to function, they could open the door for new organizational forms to be conceptualized and developed.[4] That would represent a qualitative shift in architecture made possible by EMA, beyond the quantitative advance of allowing conventional organizations to grow larger or more complex than is feasible today.

4.6 Potential Disadvantages of Enterprise Meta-Architecture

At the same time, the use of EMA could create difficulties for organizations. Although it is meant to reduce or manage complexity, an EMA mechanism itself would be an immensely complex system subject to potential malfunctions, failures, hacking, viruses, and problems of interoperability with other systems. Moreover, if EMA allowed some large organizations to develop greater internal alignment, adaptability, and responsiveness to their markets, in the long run that might compel other organizations to adopt EMA systems for competitive reasons – despite the fact that novel and significant kinds of financial, legal, and ethical risks arise when a company delegates to automated systems higher-level functions of strategy development and implementation.

4.7 Areas for Future Research

The empirical study of EMA systems in production environments (i.e., real-world organizations) will need to wait for advances in the field of artificial intelligence that may require a considerable time to be realized. However, development of the theoretical underpinnings of EMA and its potential applications can already be pursued. As a stepping stone between theory and real-world application, simulations [39] can play a critical role; such simulations could build, for example, on existing algorithmic approaches to the development of organizations in artificial multi-agent systems [59-60].

5 Conclusion

While conventional EA has a range of potential benefits to offer organizations, its implementation can become difficult or impossible for organizations whose size, speed, and complexity are too great for human enterprise architects to directly grasp. This challenge becomes more pronounced as organizations' spatial extension grows larger (e.g., as facilitated by Industry 4.0 technologies), the speed of organizational, technological, sociopolitical, and market change accelerates, and the technological complexity

[4] The relative organizational stability of technologized oligopolistic megacorps, in particular, may provide a solid foundation for the development of such new architectural forms.

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of organizations and their competitive ecosystems grows ever more difficult to fathom. Through development of the types of enterprise meta-architecture approaches described in this text, it is hoped that the benefits of enterprise architecture can be more robustly enjoyed even by those organizations operating on the frontiers of unmanageability.

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