Leveraging Enterprise Architecture to Address Key Challenges of Web 3.0

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Abstract

The worldwide web and the internet have become a necessity for most, if not all, businesses. Additionally, with the increased demand for robustness, self-evolution, ubiquitous connectivity, decentralisation and a semantic web from the internet, Web 3.0 is sooner or later going to be a reality for organisations. And as with all implementations, careful analysis and study should be done to ensure the readiness and capabilities as well as risks and challenges of the endeavor. Are organisations prepared to rapidly adapt to this upcoming technology? How can they equip themselves with the necessary knowledge and information? This research paper has reviewed several sources of academic literature and identified possible key challenges that businesses might encounter in adapting to Web 3.0 and how leveraging enterprise architecture frameworks (EAF) to understand the modifications required within the organisation's structure can assist them. This research will use the 3 leading EAFs (TOGAF®, Zachman's Framework™, and Gartner's Pace layered application strategy) to address the identified challenges. A comparison table of the analysis will help to provide a clearer view of the result of the study. The outcome of the research identified that Zachman Framework™ has addressed the privacy, security, ICT infrastructure and staff skills challenges fully, whereas TOGAF® and Gartner's Pace Layer only made partial consideration. Nonetheless, both TOGAF® and Gartner's Pace layered application strategy fully addressed the issue of semantic interoperability, whereas Zachman Framework™ only did partially.

1. Introduction

The worldwide web is arguably one of the fastest-growing innovations in the 20th century. From the read-only characteristics of Web 1.0 primarily used to publish information, it quickly progressed into an interactive experience Web 2.0 that led to the explosive social media culture we have now. The next phase of evolution, Web 3.0, entails an integrated web experience where the machine will be able to understand and catalogue data in a manner similar to humans. It will undoubtedly bring forth opportunities and expected challenges for organisations that will use this technology as part of their innovation strategy (Rudman et.al, 2016).

Innovation is a key element for success in organisations. Product innovation, process innovation, and business innovation. How businesses adapt and innovate to create and maintain their core competency and continually support their competitive advantage is of crucial importance (Tohidi & Jabbari, 2012). Another key element is understanding how information communication technology (ICT) can be leveraged to enable growth within the organisation.

This research paper aims to explain how organisations can use Enterprise Architecture Frameworks (EAF) to address the challenges that adapting to Web 3.0 will present. Implementing novel technology poses several

complications that if not assessed properly can lead to misalignment and instability of the company. Thus, a careful analysis with a holistic view of the organisation alongside its stakeholders must be done to ensure the success of the strategy (Cooper, 2019). Addressing the challenges will then lead to the identification of opportunities on how companies can best leverage Web 3.0 to their advantage.

Through the lens of EAF, this research paper aims to serve the following objectives:

- Identify three main challenges that organisations will have to address if they are to adapt to the new Web 3.0 in their ICT strategy.
- Use the industry's most renowned frameworks: TOGAF®, Zachman Framework™, and Gartner's Pace-Layered Application Strategy to provide a baseline of how organisations can address the identified challenges
- Compare the findings from the three EAFs to arrive at a conclusion and general recommendation

The research paper introduces the method of research used for the identification of research literature. Following the research method, the key challenges that organisations will have to address if they were to adapt their processes to Web 3.0 are discussed. Further, three of the chosen EAFs addressing the identified challenges are discussed. The paper concludes by giving a comparison table and a recommendation based on the comparison.

2. Research Method

A systematic approach fit for evaluating emerging trends given by Ramdhani et al. (2014) has been adopted throughout this paper as the research methodology. The author identifies the following 5 steps (Table 1) that have guided the research.

No.	Step Identification	Mapping
1	Identification of the research question	To define the scope of the research the following question has been identified: "How can organisations leverage enterprise architecture to adapt to Web 3.0?"
2	Setting criteria for inclusion and exclusion	The following topics were identified as the broader areas of research: i. The challenges that Web 3.0 can pose for businesses ii. The key architectural frameworks: Gartner's Pace Layer Application Strategy, The Open Group Architecture Framework (TOGAF®) and the Zachman Framework™ The timeline for the research has been restricted to the literature published in the last 10 years, which means between 2012 and 2022.
3	Selecting and accessing the identified research papers	With the timeline's constraint, Google Scholar and The University of Melbourne Library have been leveraged to find the following number of articles: Topic i – 23 articles Topic ii – 52 articles

4	Evaluating literature quality	The abstract and the conclusion of each article were read to identify the following best-fit articles for the scope of this paper. Topic i – 8 articles Topic ii – 15 articles
5	Analysing and synthesising the findings	The following ideology was used- i. Understand the challenges that Web 3.0 presents ii. Understand the 3 identified frameworks iii. Map the framework to the discovered challenge iv. Compare the frameworks with each other

Table 1: Research Methods

3. Challenges

As Vojíř & Kučera (2021) stated, re-decentralization of the web is the core of Web 3.0. This paper further went on to outline the consequences which included accessibility of web content and monetisation of user data impacting privacy and interoperability. Further, we researched the relationships between privacy, interoperability and Web 3.0 to deep dive into the topic. Furthermore, from Kuleza et al (2018), we are able to interpret that the evolution from Web 1.0 to Web 4.0 involved an increase in the use of advanced architectures, styles, platforms and technologies to support running them. Thereby we interpreted that upskilling is a key requirement or challenge that organisations would need to face if they want to upgrade to Web 3.0.

Our research identified three main challenges of adapting to Web 3.0, which will be described in this section. Our research was limited to exploring literature around the selected ideas. Additionally, due to the narrative nature of the topic, the research has a more quantitative approach rather than a qualitative approach supported by measurable evidence. Lastly, the conclusions drawn were not tested in practice and give an opportunity for the readers to investigate in future studies.

3.1 Need for Privacy and Security

Web 3.0 is built on linking, integrating, and analyzing data from diverse data sources to create new information streams. The machine readability of data delivers the privacy risks of personal data exposure, the prospect of politicizing the Web and suppression of digital identities more effectively than with previous versions of the Web (Vojíř & Kučera, 2021). It is important to note that data standards for controlling metadata and data privacy are lacking which will lead to difficulties in monitoring and regulating Web 3.0 (Nath K et al., 2015).

As opposed to the old economy, establishing trust in potential transaction partners is a huge challenge for internet businesses (Busom et al., 2016).

Further, attackers may purposefully distort data and construct counterfeit services. Hence, a privacy or security breach can result in reputation damage and monetary loss for the organisation.

3.2 Issue for Semantic Interoperability

Web 3.0 is all about democratised analysis, semantic search, and answer extraction from substantial amounts of linked data (Sheth & Thirunarayan, 2012). Enterprise information systems require extracting, organising, and standardising data from a variety of different and heterogeneous content sources, such as structured, semi-structured, and unstructured sources and formats, that may be internal or external to the organisation (Sheth & Thirunarayan, 2012). For an enterprise to be interoperable its enterprise systems and applications need to communicate with one another across organisational boundaries in a seamless manner (Jiang et al., 2012). As a result, inferring implicit information from instances and available context is semantically difficult (Sheth & Thirunarayan, 2012).

From the above, we can infer that if the organisation is not semantically interoperable then the quality of results in Web 3.0 is low, and risk of miscommunication increases resulting in increased resource utilisation.

3.2 The Need to Update Infrastructure and Upskill Talent

Web 3.0 features Semantic Web, Artificial Intelligence, 3D graphics, Blockchain and Ubiquitous connectivity (Partrizio, 2022). Communication protocols, Microservices, browser-based frameworks, boilerplates client-side code, asynchronous programming, and integration with cloud computing infrastructures are all parts of the infrastructure requirements of Web 3.0 (Kulesza et al., 2018). Currently, most companies use legacy programmes that generate millions, if not billions, of dollars in revenue (Fogel, 2020). From the above, we can infer that the existing infrastructure might not have the capabilities to run Web 3.0 Further, the staff supporting the infrastructure might not have the required knowledge and capabilities. Furthermore, older websites will get obsolete, and businesses will lose the customers they had to date. As a result, they will be under pressure to upgrade their digital offerings and infrastructure so that they do not lose their captured market and provide better for their customers.

4. Enterprise Architecture Frameworks (EAF): Addressing Web 3.0 Challenges

4.1 TOGAF®

4.1.1 Introduction

Developing and sustaining an enterprise architecture is a complex process involving many stakeholders and decision processes. The Open Group Architecture Framework (TOGAF®) helps bridge this gap by providing a well-documented body of knowledge comprising a detailed methodology and a set of supporting tools to develop and sustain an effective enterprise architecture (The Open Group, 2018). By using TOGAF®, organisations can develop an enterprise architecture that reflects the needs of stakeholders, employs best practices and gives due consideration to current and perceived future needs. Primarily, TOGAF® consists of four architectural domains that allow for a holistic requirement gathering methodology across an enterprise's different domains comprising: business, data, applications, and infrastructure (The Open Group, 2018). Building on these key domains, this report will take into consideration the Architecture Development Method (ADM) specifically the Architecture Development Cycles (Figure 1), to effectively address the mentioned issues (The Open Group, 2018).

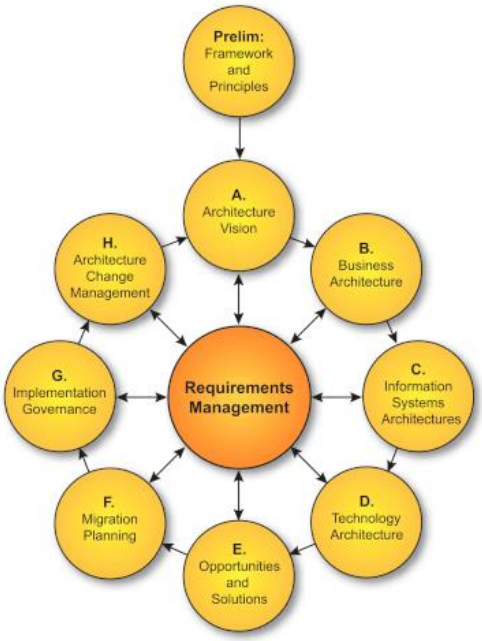

Figure 1: TOGAF® Architecture Development Cycle
Source: Structure of the TOGAF® Standard (The Open Group, 2018)

4.1.2 Addressing the Need for Privacy and Security

TOGAF® addresses and provides a conceptual overview of various security and risk concepts that are used in Information Security Management (ISM) and Enterprise Risk Management (ERM) across an enterprise (The Open Group, 2016). This Security Services Catalog provides a common terminology and reference framework for security management and to realise security goals (The Open Group, 2016). This conceptual catalogue is integrated across its four key domains and across the ADM Phases to ensure the correct embedding of relevant security and risk concepts and procedures across Web 3.0 applications (The Open Group, 2016). TOGAF® can also be tailored to use existing enterprise security architectures to appropriately address risk and security concerns and take into consideration each stakeholder's security aspect as such reflects both internal/external information security requirements (Al-Turkistani et al., 2021). With this in place, a conceptual and sound basis is provided for organisations to mitigate security and risk across Web 3.0 applications.

4.1.3 Addressing the Issue of Semantic Interoperability

Interoperability requirements are clearly defined and established under TOGAF® guidelines (The Open Group, 2018). Building on this, the Data Architecture Phase and Technology Architecture Phase are paramount in building a shared vocabulary, thereby mitigating semantic interoperability concerns across inter and intra-organisational processes (The Open Group, 2018). The Data Architecture phase details the type and source of data required to support organisations and makes it understandable to all stakeholders involved, whereas the Technology Architecture phase specifies the appropriate technical mechanisms to permit the information and service exchanges (The Open Group, 2018).

Notably, information models within TOGAF® can provide a referential guide for semantic support of processes within an organisation and external interactions with third parties. In addition, organisations can implement an interoperability requirements matrix to identify inter-stakeholder and inter-system interoperability requirements and detail the nature of information and systems being shared (The Open Group, 2018). With this clarity in thought and processes, organisations can leverage the aforementioned reference points and build on setting a data dictionary that comprises shared vocabulary and policies for meaningful exchange of information across Web 3.0.

4.1.4 Addressing the Prerequisite to Update Infrastructure and Talent to keep up with the gained market

A predominant threat when adopting Web 3.0 is the potential risk when engaging stakeholders in these technologies without proper training and guidance (Bruwer & Rudman, 2015). As such, to accelerate the implementation of Web 3.0 across an enterprise, consumers need to be educated on the various issues surrounding its application (Bruwer & Rudman, 2015). Reskilling and upskilling programs are essential in providing consumers with this technical understanding to leverage the technology to its potential and identify potential risks (Bruwer & Rudman, 2015).

The flexibility of the TOGAF® ADM phases enables technologies such as Web 3.0 to become a driver and a strategic resource instead of a recipient of change requests (The Open Group, 2018). Building on each phase, the Requirements Management Phase provides a holistic view of the architecture of a Web 3.0 application. With this clarity in thought and processes, organisations can provide relevant stakeholders with incentivised upskilling and reskilling programs to bridge this skill gap. In addition to upskilling programs, governments must also prioritise funding for emerging technologies to close the infrastructure and skill gap.

4.2 Pace-Layered

4.2.1 Introduction

The Pace-Layer Application Strategy Framework was introduced by Gartner Inc more than 10 years ago. This framework aims to fill the gaps in the different needs for change and flexibility between business and IT domains (Maoz, 2015). To enable leaders to address this issue, Gartner provides the Pace-Layered architecture (Figure 2) that

consists of three layers that represent the different velocities and complexity of integration of the systems within an organisation. These are:

Systems of Record: Usually standard or legacy systems across the industry that enable the main processes of an organisation that are the basis and support from which the company builds its differentiation and innovation capabilities. The pace of change for these systems is usually slow.

Systems of Differentiation: These are the systems and applications that are unique to the organisation and that allow it to gain a competitive advantage over the competitors. The pace of change here is faster.

Systems of Innovation: The systems from this layer embrace innovation and experimentation, hence this layer moves faster than the other two layers.

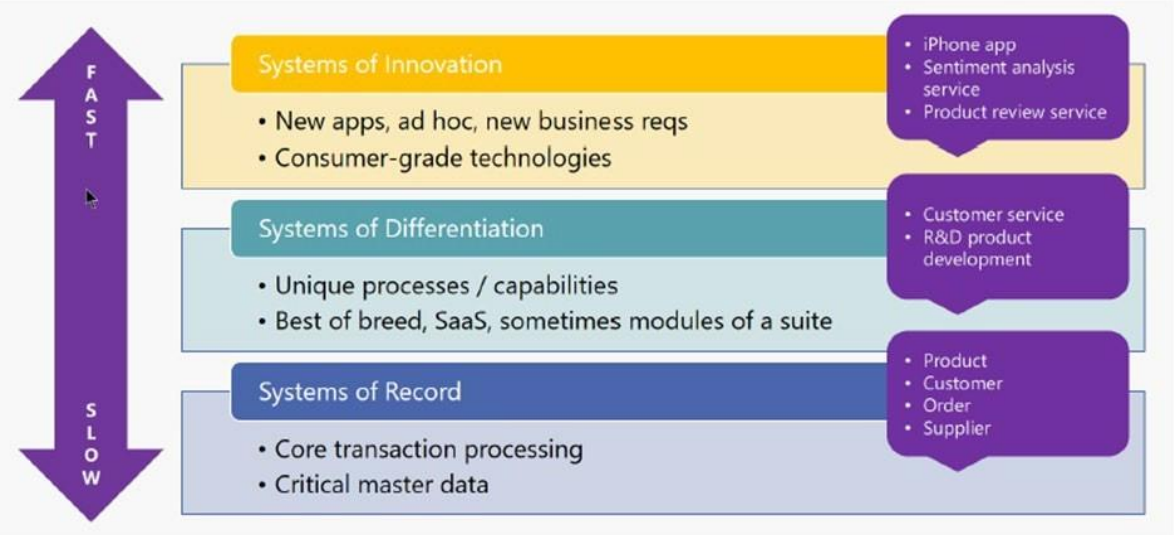

Figure 2: Gartner's Pace-Layered Framework Structure
Source: Maoz, 2015

4.2.2 Addressing the Need for Privacy and Security

Web 3.0 applications will probably be developed using cloud and blockchain services such as "Amazon Managed Blockchain" which provides specialised tools to manage blockchain networks (AWS). In terms of security and privacy, this PaaS could be treated as a system of differentiation where governance and the Pace-Layered architecture will play an important role by identifying, mapping and controlling the APIs and middleware systems that will provide the information to the Web 3.0 applications of the company by establishing and redesigning security and privacy protocols, establishing standards for connective tissue across the layers to ensure security since once the application runs through the blockchain network, all the data will be visible to everyone.

4.2.3 Addressing the Issue of Semantic Interoperability

The Pace-Layered framework recommends using service-oriented architecture (SOA) concepts as the connective tissue between the different layers. In this context, semantic interoperability could be achieved by using ontology languages and metadata which will improve the collaboration between business and IT because services will be defined in business terms (IBM Cloud Education, 2021). The benefits of this approach go from a reduced cost of IT infrastructure by eliminating redundant extraction processes to timesaving and supporting informed decision making (Rudman & Bruwer, 2016).

4.2.4 Addressing the Prerequisite to Update Infrastructure and Talent to keep up with the gained market

Since Web 3.0 is an emerging technology, its use will start as an innovation project, so this challenge could be addressed by using Pace-Layered mapping and categorizing all the systems of an organisation which will improve the understanding of the different needs of each layer allowing the company to analyse the infrastructure mainly the systems of record if they are robust enough to support the upper layers or if they will need some updates to enhance integration or creating new API's to connect with the new services that will deliver the Web 3.0 applications. After having the ICT infrastructure well-understood, defining the staff profiles and skills required to implement this technology becomes easier.

Furthermore, according to Gartner, the Pace-Layered framework leverages not only innovation but could also help to define a CRM strategy to enhance customer service (Maoz, 2015).

4.3 Zachman Framework™

4.3.1 Introduction

The Zachman Framework™ is one of the oldest architectural frameworks that provide a structured way to support the development and changes to the enterprise architecture within a business (Zachman, 2019). Essentially, the framework is a 6 by 6 matrix (Figure 3) where the rows represent views/perspectives, columns represent aspects and their intersection helps architects understand the different facets of the organisation (Gerber et al., 2020).

	DATA *What*	FUNCTION *How*	NETWORK *Where*	PEOPLE *Who*	TIME *When*	MOTIVATION *Why*
Objective/Scope (contextual) *Role: Planner*	List of things important in the business	List of Business Processes	List of Business Locations	List of important Organizations	List of Events	List of Business Goal & Strategies
Enterprise Model (conceptual) *Role: Owner*	Conceptual Data/ Object Model	Business Process Model	Business Logistics System	Work Flow Model	Master Schedule	Business Plan
System Model (logical) *Role:Designer*	Logical Data Model	System Architecture Model	Distributed Systems Architecture	Human Interface Architecture	Processing Structure	Business Rule Model
Technology Model (physical) *Role:Builder*	Physical Data/Class Model	Technology Design Model	Technology Architecture	Presentation Architecture	Control Structure	Rule Design
Detailed Reprentation (out of context) *Role: Programmer*	Data Definition	Program	Network Architecture	Security Architecture	Timing Definition	Rule Speculation
Functioning Enterprise *Role: User*	Usable Data	Working Function	Usable Network	Functioning Organization	Implemented Schedule	Working Strategy

Figure 3: Zachman Framework™ Structure
Source: Zachman Framework™ (Ertaul et al., 2012)

4.3.2 Addressing the Need for Privacy and Security

Instead of addressing data privacy and security through a different layer in the architecture, measures for the same can be defined at each step (Ertaul et al., 2012).

I. The first "WHAT" column can be used to define the levels of security, and the business needs for various categories of data (Ertaul et al., 2012).

II. The “HOW” or the second column addresses the security of processes, using various scenarios to develop permission controls (Ertaul et al., 2012).

III. “WHERE” is the third layer that caters to the storage requirements of the data. This includes defining areas of physical storage as well (Ertaul et al., 2012).

IV. Fourth layer, “WHO” defines the various levels of access that are required within the business (Ertaul et al., 2012).

V. The “WHEN” or the fifth layer helps businesses set up a calendar based on which data is available at the specified time (Ertaul et al., 2012).

VI. “WHY” is the final and the logical layer that explains the logic behind setting up the previous layers and is essential for future use (Ertaul et al., 2012).

4.3.3 Addressing the Issue of Semantic Interoperability

The 6 by 6 matrix of the Zachman Framework™ also answers the issue of data sharing and semantic interoperability associated with the decentralised nature of Web 3.0 for businesses. It might be difficult to update the existing system because of the missing links between blocks in the Zachman Framework™, however, it still can be leveraged to a certain extent (Sajid & Ahsan, 2016). Businesses need to understand different perspectives when looking at interoperability. Detailed representation, enterprise model, system model, technology constrained model and detailed representations can be used to define rules of interoperability (Bondar et al., 2017).

4.3.4 Addressing the Prerequisite to Update Infrastructure and Talent to keep up with the gained market

The Zachman Framework™ provides a comprehensive structure to solve the infrastructural issues and can be used to upgrade the infrastructure as well. By incorporating the Zachman Framework™, businesses can reengineer their infrastructure starting from the base layer to the conceptual layers. Since the Zachman Framework™ distinctively focuses on “WHO”, addressing the issue of training requirements also becomes simpler. The business initiatives are linked with the information system in the matrix which makes the framework easier and more effective to adopt. It is also useful for reusability and portability, which helps businesses examine the effect of the changes that they plan to bring along (Perkins, n.d.).

4.4 Comparison between the three Enterprise Architecture Frameworks

A comparison of the previously mentioned frameworks was made (Table 2) to address the main differences of them according to each challenge.

Web 3.0 Challenges in the business sector	Zachman Framework™	TOGAF®	Gartner’s Pace-Layered Application Strategy
Privacy and Security	Yes - It gives complete guidelines on how privacy and security can be answered using the columns of the 6 x 6 matrix.	Partial - It provides a conceptual overview of various security and risk concepts through the Security Services Catalog but does not provide specific guidance on ways to address security issues.	Partial - It gives general guidelines to address security and privacy and understands better the connection between systems, but it does not cover security and privacy specific solution practices.

Semantic Interoperability	Partial - It might be difficult to update the existing system due to missing links in different blocks of the framework.	Yes - It provides guidance on setting a shared vocabulary and policies via the Data and Technology Architecture phases.	Yes - It encourages utilising SOA concepts with the use of ontologies and metadata to connect systems more efficiently
ICT Infrastructure and staff skills	Yes - With clear guidelines and principles underlined, it supports infrastructural updates and answers staff training requirement questions as well.	Partial - It provides clarity on the requirements for accelerating technological change across an enterprise but does not have specific guidelines for specific technologies.	Partial - It helps understand the ICT infrastructure and the relationships between the systems of the organisation making it easy to analyse but does not give specific guidelines for this challenge.

Table 2: Comparative table between the three EA frameworks

5. Conclusion and Recommendations

The previous sections have demonstrated how enterprise architecture frameworks can be used to assess and address the several challenges that businesses must prepare for if they intend to adapt to Web 3.0. As explained in the summary table, it shows how effective and encompassing a chosen framework is concerning the challenge outlined and that one framework can be more useful in addressing a certain challenge than another. For example, Zachman Framework™ has shown how to fully address the two key challenges that were identified in this study, privacy and security and ICT infrastructure and staff skill, but it was only giving partial results in semantic interoperability. It is where both TOGAF® and Gartner's Pace Layers have demonstrated guidance and attention.

Thus, it is recommended for organisations to examine the issues through the lens of multiple frameworks and identify which will provide the most complete set of guidelines and baseline considerations in establishing a more holistic and comprehensive approach to implementation.

This research paper only identified three perceived challenges that the business sector might encounter if they decide to include in their strategy the adaptation to the next generation web, Web 3.0. This study is restricted with limitations to identifying all possible challenges that might present themselves in the design and implementation hence the key takeaway of this research is to show how EAF can be leveraged to increase the likelihood of success for business sectors should they wish to integrate this technology into their ICT strategic plans or technology roadmaps. It will provide ample guidance, but it does not create a foolproof solution to the challenges.

It should be well noted that frameworks used (TOGAF®, Zachman Framework™, Gartner's) and all EAF are used to formulate a baseline analysis with no quantitative measures to denote accuracy therefore should be interpreted as such with clear understanding and expectations.

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