

Understanding Challenges of Applying Enterprise Architecture in Public Sectors: A Technology Acceptance Perspective

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Abstract—Enterprise Architecture (EA) as a popular approach, has been used in city governments and public sectors to improve consistency among their business goals and ICT implementations. Despite theoretical benefits that have been widely agreed on, challenges have also been met in practice reflecting on issues about techniques, businesses, organizations, processes, and etc. It is not easy to understand the challenges from different perspectives and come up with an integrated solution. In this research, we reviewed nine scientific papers in which projects of applying EA in governments or public sectors in real scenario have been presented. We collected challenges reported in these projects and proposed to observe them by using Technology Acceptance Model (TAM) as a lens. Through this technology acceptance perspective, more than seventy challenges can be understood and organized in a consistent way. The results are expected to bring some in-depth insights and to help practitioners to apply EA in public sectors.

Keywords—Enterprise Architecture, government, public sector, technology acceptance model (TAM).

I. INTRODUCTION

Enterprise Architecture (EA) [1] is an approach to improve the alignment between an organization's business goals and their Information Technologies (IT). It attempts to capture the status of the organization's business architecture, information resources, information systems, and technologies so that the gaps and weaknesses in their processes and infrastructures can be identified, and development directions can be planned. EA has become a popular approach to increase the efficiency of IT utilization. EA has also been used in city governments and public sectors where common business goals are shared among multiple branches in a similar way in organizations.

Despite of theoretical and proven benefits EA has brought to organizations and businesses, challenges have also been met when applying EA in real scenario. These challenges cover different aspects of the application and are raised from different perspectives. The diversity of the challenges makes it difficult for stakeholders to understand them in a consistent way, and to come up with effective solutions to solve them.

In this research, we tried to understand and summarize the challenges of applying EA in public sectors from the perspective of EA users. To achieve this, we reviewed nine scientific papers in which real projects of applying EA in

governments or public sectors have been reported. We collected challenges reported there and organized them by utilizing TAM. Tam is used widely in information system domains and suitable for proof of concept. As a result, more than seventy challenges are organized in a consistent way. We further explore and propose possible solutions to solve these challenges.

The paper is organized as follows, Section 2 introduces some background information such as Enterprise Architecture (EA) and its applications in governments and public sectors. Technology Acceptance Model (TAM) is also introduced as it was used to observe the review findings. Then we introduce the research methods in Section 3 and summarize information of case studies presented in the chose papers in Section 4. In Section 5, we present how to utilize TAM to explain and organize the challenges. Discussion about the results and some related work are presented in Section 6 and Section 7. At last, we talk about limitations of our research, possible future work, and conclude the paper in Section 8.

II. BACKGROUND

A. Enterprise Architecture (EA) and EA frameworks

EA is a well-defined practice which uses a holistic approach in order to develop and execute strategies consistently. EA has become a key tool across IT industry because many organizations have not executed their business strategies successfully due to ineffective execution of strategies instead of strategies themselves [2]. The field of EA has evolved rapidly to address the challenge of executing business strategies.

EA applies architectural principles and practices to perform enterprise analysis, design, planning, and implementation. These practices leverage all aspects of the business in order to identify, motivate, and implement the organizations' information, technology, processes, and businesses changes that are required when executing its strategy [3].

EA practices provide business value by generating multiple outcomes, including but not limited to the strategic requirements, models of the future state, a roadmap to achieve the future state, and guidelines [3]. EA can be used to improve business effectiveness, efficiency, and flexibility. EA is also of help to improve innovation and change capabilities. In

addition, EA is helpful to clarify business rules and coordinate IT and business goals [4].

EA often consists of an enterprise architecture framework and an implementation methodology [5]. Several dedicated frameworks have been created such as the Zachman framework [6] in the earlier stage and The Open Group Architecture Framework (TOGAF) which has gathered the most attention for its contributions. According to [7], EA framework research, as one of the three main research streams of EA, has played a central role within EA research field (the other two streams are design & operations of EA management and EA conception & modeling).

B. Applications of EA in Governments or Public Sectors

EA is applied in many governments also. Most notably, in the United States, a country office has been established to promote a Federal Enterprise Architecture Framework (FEAF) in all its jurisdictions. The Australian federal government adopted FEAF to develop the Australian Government Architecture (AGA). The Australian Government Information Management Office is the office responsible for AGA's financial and deregulation department and EA is implemented in federal agencies and state governments [8].

C. Technology Acceptance Model

The Technology Acceptance Model (TAM) [9] is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use the technology, notably:

- Perceived usefulness (PU), was defined as "the degree to which a person believes that using a particular system would enhance his or her job performance";
- Perceived ease-of-use (PEOU), was defined as "the degree to which a person believes that using a particular system would be free from effort".

Similar to the Theory of Reasoned Action (TRA) [10], another widely studied model of social psychology that focuses on the determinants of conscious behavior, TAM assumes that the actual use behavior is determined by the Intention of Behavior (BI), and BI is considered to be determined by the person's Attitude toward the use of the system (A) and Perceived usefulness (PU) [11]. The overall model of TAM is presented in Figure 1.

- Attitude towards using (A) – is determined by PU and PEOU.
- Behavioral intention (BI) – is jointly determined by the person's Attitude and PU.
- Actual system Use (AU) – is determined by his or her BI to perform the behavior.

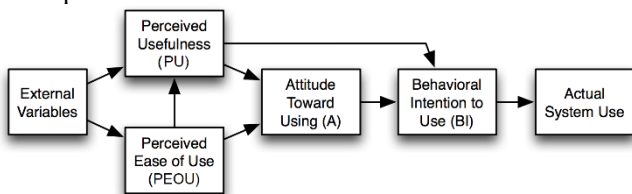


Fig. 1. Technology Acceptance Model (TAM).

TAM has been continuously studied and expanded. The two major upgrades are the TAM2 [12] and the Unified

Theory of Acceptance and Use of Technology (or UTAUT, [13]). TAM3 has also been proposed in the context of e-commerce with an inclusion of the effects of trust and perceived risk on systems [14].

III. METHODS

The intention of our study is to explore the challenges of applying EA from users' perspective. This study is not intended to be a comprehensive literature review. It is our first attempt to identify the challenge for a later more complete and in-depth investigation. To identify the papers which present the challenges of applying EA, we focused on scientific databases which cover interests and also have high impacts. We mainly executed automated searches in the Compendex EI and the Web of Science (ISI). The search string is as presented in Figure 2. We run trial searches to verify the relevance firstly, then revised the search terms and formalized the final search string.

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STA= (city OR government OR {public sector})
AND STA= ({enterprise architecture} OR {TOGAF} OR
{Zachman}) OR {FEA} OR {Gartner}
AND STA= {case OR perspective}
  
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Fig. 2. Search Terms.

After defining the searching string, we performed filtering. We *first* removed duplicated papers, papers that were not written in English, and papers that full-text was not available. *Second*, we read titles, keywords and abstracts of the papers and excluded irrelevant studies. *Third*, we further excluded papers by reading the introduction, conclusion, and full paper.

We finally identified nine papers as the primary studies. In these papers, one or several practical projects of applying EA in governments or public sectors have been reported. Concrete evidences regarding challenges of applying EA were presented. In each research, the word "challenge" or its synonyms such as "hindering factors"[15] or "obstacles"[16] were explicitly mentioned.

After that, we tried to organize and understand these challenges. We started by extracting challenges that are relevant to EA frameworks due to its dominant role in relevant researches [7]. However, we only identified few such challenges in this step. In addition, we found that these challenges seemed to be more relevant to users' uncertain feeling of using EA. Sometimes it was difficult to judge if a challenge is about EA, or is about users' perception of EA.

Through reading these papers, we found many clues indicating that lacking EA understanding was a big challenge at the first place of applying EA. Further, we noticed that among all the challenges that have been reported, in addition to those relevant to the perception of EA, some are relevant to the usage of EA.

This inspired us to introduce TAM as a lens to observe and organize these challenges. By doing so, we hope to be able to gain some insights about the causal relationship among the challenges. According to the TAM model presented in Figure 1, we revisited all the reported challenges in the primary studies one more time, and classified them into three groups: those about users' perception to EA, those about users' intention to use EA, and those about users' behavior of using EA. The detailed results are presented in Section 5.

IV. INFORMATION OF THE CASES

The 9 primary studies were published during 2007 to 2018. In these studies, 17 real cases of applying EA in governments or public sectors were reported. In the cases, EA has been applied in 8 countries including Egypt, Syria, Denmark, Netherlands, Norway, Finland, Malaysia, and Iran. The application domains include governments or public sectors such as hospitals, education sectors, road administrations, and etc. More detailed information of the cases is presented in Table 1.

In most papers we have collected, interpretive case study has been utilized as the main research method. Open and semi-structure interviews have been performed to obtain opinions and evidences from stakeholders of applying EA. In [8], documents have also been studied. In some cases, like [17], comparative study was performed to compare more than one cases.

TABLE 1. CASE INFORMATION

	Country	Governments /Public Sectors
[8]	Egypt	The Ministry of State for Administrative Development
	Syria	The Ministry of Communication and Technology
[17]	Denmark	The Ministry of Science, Technology and Innovation
	Netherlands	The Ministry of Government Modernization and Innovation
[18]	Norway	The Hospital Sector
		The Higher Education Sector
		The Norwegian Labor and Welfare Administration
		The Norwegian Higher Education Sector
[15]	Finland	Finnish Road Administration
		State Treasury
		Finnish Ministry of Finance
[21, 22]	Malaysia	Three cases (About health, financial and economic, national development plans) Ministry of Health
[16]	Iran	Nine large governmental organizations in Iran

V. A TECHNOLOGY ACCEPTANCE PERSPECTIVE TO UNDERSTAND CHALLENGES OF EA APPLICATIONS

More than seventy challenges have been reported in the 9 primary studies. They are related to different stakeholders (e.g., leaders, managers, EA experts, and general engineers) and different aspects (e.g., technical, managerial, and financial) of EA application. They were not presented from a single perspective. Therefore, it is difficult for scientists or practitioners to understand as a whole and solve them systematically. In this section, we present our proposals about how to understand and organize such diverse challenges.

A. Challenges Relevant to the Perception of EA

Among all the challenges, few are directly related to EA technologies. Challenges related to perception of EA are enumerated in Table 2. The challenges fall into five sub groups:

- 1) Evaluability. It is difficult to visualize (C2) or evaluate the value of EA (C14, C19);
- 2) Practicality. EA and its tools are complex (C17, C20), lack of agility (C1), do not embrace changes (C10, C22) and might not be quite practical (C3);
- 3) Effectiveness. Business driven is the only approach (C11). EA governance needs to be established (C9).
- 4) Accuracy. Some important things including holistic views (C8, C12, C21), processes (C7, C13, C16), tasks (C4), responsibilities (C5, C18), and costs (C6) have not been defined in a standardized and accurate way (C15, C23, C24);

These challenges show that users might not think EA is useful or easy to use in a desired way. However, one possible reason might be that users do not have full knowledge or a good understanding of EA.

TABLE 2. CHALLENGES RELEVANT TO THE PERCEPTION OF EA

	Challenges Relevant to User's Perception to EA	Group
[18]	C1. Lack of agility	2
	C2. Visualization of the value of EA	1
	C3. Transform visions into practice	2
[19]	C4. Lack of agreement about what should be done	4
	C5. Lack of agreement about where the responsibility for the AE work should be placed,	4
	C6. Lack of agreement about how EA costs should be allocated	4
	C7. Lacks a holistic effort to define processes	4
[15]	C8. Lack of an agreement on a vision and the extent of the EA initiative	4
	C9. Lack of establishing proper EA governance	3
[20]	C10. The change is going faster than the adoption of Government EA as a coherency management tool	2
[21]/[22]	C11. Unique business driven approach	3
	C12. Limited planning, scope and coverage	4
[8]	C13. Non-standardized business rules and process	4
	C14. No assessment mechanism	1
	C15. Lack of EA acculturation	4
	C16. No mandated EA rules and processes	4
	C17. Complicated EA tools	2
[8]	C18. Unclear ownership	4
	C19. Lack of evaluation tools	1
	C20. EA implementation is a complex process	2
[16]	C21. Unclear organizational strategies	4
	C22. Lack of change management tools	2
[17]	C23. Rigorous EA frameworks	4
	C24. Vague definitions	4

B. Challenges Relevant to the Understanding of EA

Table 3 lists clues (challenges) indicating users might lack necessary understanding of EA. Among these challenges, words such as "Unclear" (C25, C29), "Lack of Understanding" (C26, C27, C28, C30, C36, C39), "Confusion" (C38) have been frequently mentioned. In addition, it was indicated that skilled, experienced and other qualified persons (C31, C33, C34, C35, C37, C40, C41), and trainings (C32, C42) are of shortage. This might also suggest that various stakeholders could not understand EA frameworks well as what is expected by the initiators.

TABLE 3. CHALLENGES RELEVANT TO THE UNDERSTANDING OF EA

Literature	Challenges Relevant to Understanding EA
[18]	C25. Unclear/Competing EA approach/approaches C26. Understanding of EA
[19]	C27. Lack of EA understanding in the top management
[20]	C28. Could not change the way of thinking required for coherency management and holistic considerations.
[21]/[22]	C29. Unclear communication C30. Lack of understanding of internal process C31. Lack of skilled architects C32. Limited EA training and certification available C33. Retention of expertise C34. Centralized EA expert team
[8]	C35. Lack of e-Government experience C36. Awareness among project teams C37. Lack of skills
[16]	C38. Confusion in government C39. Unable to set common understanding C40. Lack of professional EA consultant C41. Lack of innovation in consultant's team C42. High costs of training the personnel

C. Challenges Relevant to the Behaviour Intention and Actual Use of EA

In addition to the first group of challenges (about users' perception to EA) as presented in Table 2, we succeeded to group the majority of other reported challenges into two categories as shown in Table 4 (about users' intention to use EA) and Table 5 (about the actual behavior of using EA) according to the structure of TAM.

From Table 4, we can see that all participants might not intent to participate, support or tolerant the application of EA. They might not recognize (C46) or trust (C43) EA. They might not believe EA is useful (C49). Therefore, they might be resistant to changes (C44, C45, C48), and fluctuated motivations could be sensed (C47).

TABLE 4. CHALLENGES RELEVANT TO THE USE INTENTION OF EA

Literature	Challenges Relevant to Use Intentions to EA
[18]	C43. Trust in the EA process
[8]	C44. Culture of change resistance
[20]	C45. Traditional EA viewpoints
[21]/[22]	C46. EA is under recognition
[16]	C47. Fluctuation in personnel's motivation C48. Personnel change resistance C49. Lack of management knowledge (difficult to convince them about the usefulness of developing EA)

TABLE 5. CHALLENGES RELEVANT TO THE USE BEHAVIOR OF EA

Literature	Challenges Relevant to Use Behavior to EA
[19]	C50. Lack of EA commitment in the top management C51. Lack of incentives to carry EA through C52. Lack of an overarching governing body to coordinate and to mandate principles
[15]	C53. Insufficient support for the EA development C54. Insufficient resources (financial, time, and human capital)
[21]/[22]	C55. Weak governance C56. Documentation completed but not in used or partially completed C57. Lack of continuous support C58. Undesirable political influence C59. Adverse stakeholder participation C60. Insufficient financial resources allocated C61. Economic pressure C62. Insufficient supply of other resources
[8]	C63. Weak support of top management C64. Lack of sufficient funding
[16]	C65. Constant change of management C66. Outdated organizational statutes C67. Lack of communication and collaboration C68. Lack of management support
[17]	C69. Organizational adoption C70. Major restructuring of responsibilities across levels of government C71. Cooperation between independent agencies C72. Keep up with the many initiatives and improve their systems to reduce red tape

Accordingly, as presented in Table 5, challenges reflecting various uncooperative or inefficient support and adoption of using EA are also presented in the primary studies. For instance, lack of commitment might happen to the top management (C50). While lack of resources (C54, C60, C61, C62, C64), coordinates (C52), supports (C53, C57, C63, C68) or incentives (C51), and constant changes (C65) might happen to all levels of management teams. Undesirable political influence (C58) or adverse stakeholder participation might happen also (C59). As a result, weak governance (C55) and unused documents (C56) were observed. General participants

felt reluctant to communicate and cooperate (C67, C71), or perform challenging tasks (C66, C70, C72).

D. Results

Based on the challenges from the primary studies, we tried to divide the first group of challenges (about the user perception of EA) as shown in Table 2 into three parts according to TAM: Perceived Usefulness, Perceived Ease of Use, or mixed. The integrated final clusters of challenges using TAM are presented in Table 6.

TABLE 6. GROUPED CHALLENGES ACCORDING TO TAM

Under standing	Perceived Usefulness	Perceived Ease of Use	Behavioral Intention to Use	Actual System Use
C25-C42	C2, C3, C14, C19	C1, C10, C17, C20	C43-C49	C50-C72
	C4, C5, C6, C7, C8, C9, C11, C12, C13, C15, C16, C18, C21, C22, C23, C24			

VI. DISCUSSION

In this section, we present our interpretation about the challenges reported in the primary studies, and propose possible solutions to solve the challenges.

A. A Hypothesis of the Whole Story

According to the challenges organized using TAM, an overall story seems to be clear. Various types of stakeholders (e.g., top managers, general managers, and other participants) have not perceived enough usefulness or ease of use of EA due to internal or external factors. They do not intent to use, and correspondingly, they are reluctant to use, and do not devote themselves entirely. As a result, leaders and managers do not provide necessary commitment or resources that are needed, while general participants do not follow up on EA tasks in an expected way.

This result looks reasonable as numerous evidences can be found from the informants. EA is thought to be complex, costly and not quite practical. "Effective EA requires investments not only on technical, but also organizational and cultural infrastructures" [15]. The result of using EA is unpredictable. As said in [19], since "architecture principles that have been proposed are only advisory", "architecture charts and goal statements are made without a significant force behind it", using EA "is based on a voluntary principle", and "a lot boils down to voluntary work and ideology".

This also explains why all informants "agreed that it is not really about a lack of competence" (It might be about a lack of willingness instead). This leads to the incomplete and unqualified fulfillment of AE tasks from a group of reluctant stakeholders except several architects or initiators. As the result, it is inevitable that numerous challenges have been met and unsatisfactory result was received. "the informants expect a number of significant benefits. A number of challenging issues significantly impeded the process".

B. Possible Solutions

According to the organized challenges, solutions to overcome the challenges could be identified in two areas. One is about how to improve the EA itself, and another is about how to improve the perception of EA of various stakeholders. Both usefulness and ease of use should be considered in each area.

For how to improve EA itself when applying it in public sectors, we must investigate whether and to what extent EA is useful, and if some major revisions are needed to achieve a more cost-efficient solution. Several questions might be worthy studying such as: 1) What are the most valuable parts of EA to specific scenario? 2) Which important requirements have not been supported by present EA? and 3) Is it possible to remove less used EA parts to decrease the complexity, lower the required expertise, and improve the value for cost of EA?

For how to improve users' perception of EA, practical solutions can be explored such as providing more case studies, demonstrations, and trainings to leaders, managers and general participants, especially those who have little experiences of using EA. As reported in [4], although such trainings are very important, IT persons instead of all stakeholders have attended such trainings. Additionally, surveys or interviews might also be necessary to gain insights on whether all stakeholders recognize, understand, are willing and ready to adopt EA in their work, with a good understanding on the costs and gains. Responses must be taken when necessary. To gain the best results, such measures might need to be done throughout the overall project.

C. Towards a More Customized Model

In this study, we have described our initial attempt to utilize a novel perspective to organize and understand more than seventy challenges that have been reported in EA application cases. We borrowed the well-known model of TAM in the information system domain for this effort. There are several other models that are relevant to the mechanisms of how users accept and use techniques like UTAUT [23]. The main reason that we chose TAM in this research is that, TAM contains fewer variables and is therefore very suitable for presenting a complex phenomenon cleanly. The organized and consistent result presented in Section 5 proves the value of utilizing TAM. However, we are aware that more customized models could be needed in order to better characterize the rationale and nature of the challenges, as well as to propose concrete solutions accordingly.

VII. RELATED WORKS

There are some related works to our research. For example, [24] collected and analyzed articles about applying EA in public sectors which have been published over the past 15 years until 2017. The analysis showed that development perspectives, case studies in developed countries and the local environment seemed to constitute the mainstream study of using EA in public sectors. Public sector EA seems to be fragmented and there is no strong single research stream. Instead, researchers conducted local case studies. This means that the knowledge, challenges, and best practices of EA development, implementation, or adaptation will not accumulate. Therefore, more research is needed to be conducted in specific areas.

[25] reviewed literature that were published in Chinese journals about EA application in government departments during six years until 2013. This paper attempted to systematically study the current status and progress of Chinese e-government EA research. The paper provides a quantitative and qualitative analysis of research papers. For each paper, the study examined the author's institutional associations and departments, journal titles and questions,

paper length, research topics, research methods, analytical levels, and geographic focus to take a multifaceted perspective. The research results showed that with the continuous development of China's e-government, EA has attracted more and more attention from Chinese scholars over time. However, the research topics were unbalanced and unfocused, and most of the research on Chinese EA focused on architectural frameworks and methodologies, and EA and multi-theme advocates. In terms of research methods, [25] concludes that papers in the research field generally lacked academic rigor.

These two papers have intensively reviewed studies on applying AE in governments or public sectors. However, they are not focus on practical cases. In addition, they intended to provide an overall view on the research streams. They did not focus on the challenges and presented clues to organize them. In our research, we focused on real scenario, trying to find clues and evidences to understand the practical challenges when applying EA in public sectors.

VIII. CONCLUSIONS AND FUTURE WORKS

In this article, we reviewed nine scientific papers about practical experiences of applying EA in governments or public sectors. More than seventy challenges have been reported from different observation perspectives in these papers. To ease scientists or practitioners to understand and solve these challenges, we introduced TAM as a lens to better organize them. The results showed that these challenges are to a large extend relevant to unsatisfied users' perception of EA (whether it is useful, and whether it is easy to use), corresponding reluctant use intention and undevoted user behavior. Therefore, we propose that, in order to achieve better application of EA in this area, improving users' perception of applying EA is pivotal.

There are some limitations of present research. *First*, some literature that are less relevant to our predefined scope may be missed. The study is not a comprehensive systematic literature review. Thus, thoughts and proposals discussed in this paper might not be very complete or objective. Therefore, we plan to perform a more systematic review to further prove our findings. *Second*, although we have grouped the majority of the reported challenges using TAM, there are still few challenges falling out of current model such as "old infrastructure [16]". Further investigation on such challenges might be a useful complementation or enrichment to current model. *Third*, we have proposed that improving users' perception of EA is the key to solve challenges of applying EA in public sectors. This proposal requires empirical evaluation, and we have planned it as one of our future work.

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