Association for Information Systems
AIS Electronic Library (AISeL)

ACIS 2002 Proceedings | Australasian (ACIS)

December 2002

Architecture Practice: a fundamental discipline for information systems

Pin Chen
Department of Defence, Canberra, Australia

Angela Pozgay
Department of Defence, Canberra, Australia

Architecture Practice: a fundamental discipline for information systems

Pin Chen and Angela Pozgay

DSTO C3 Research Centre, Fernhill Park
Department of Defence
Canberra, ACT, Australia
pin.chen@dsto.defence.gov.au

Abstract

Through analysing relations and dependency of architecture concepts, activities and frameworks, this paper presents an understanding of current architecture practice and points out its relevance and importance to large Information Systems (IS) development. The improvement of architecture practice in various architecture-related activities requires a re-definition of architecture roles and establishment of linkage and dependency of architecture products and activities to produce and use them. Architecture practice is growing and should be developed towards a fundamental engineering discipline for IS development and management such that it can be systematically taught at universities.

Keywords

Architecture views, system architecture, architecture frameworks, architectural methodology and enterprise frameworks and architecture practice

INTRODUCTION

People use the concept of architecture when they build or communicate about complex systems. Nowadays, the use of architecture is far beyond only for the purpose of design (Bass *et al.,* 1998; CAWG, 1997; IAWG, 1998; Horowitz, 1996; Lockheed, 1996; Zachman, 1996; Meta Group, 1999). Increasing complexity in architecture development and use has led to unprecedented development and use of various architecture frameworks and methodologies that have great impacts on large Information Systems (IS) development and management. It is time for IS communities including stakeholders, researchers, and developers to develop the architecture practice towards a discipline and make it be an organisation's capability for its future development.

By exploring the complexity of development and use of architecture and inter-dependency among different architectures and architecture-related activities, this paper discusses an emerging discipline, Architecture Practice, which can bring those separate or isolated architectures and activities into an engineering context such that outcomes from the individual activities can be developed towards a sustainable and integrated architecture-based knowledge capability for future organisation development.

CONCEPTS AND PROBLEMS

Due to the active development of various concepts and methods, architecture-related research and development has become one of rapidly developing areas in IT/ IS. It is attracting great attention from both research and development communities. Without changing much of its features, being mainly based on experience, the values of many architecture works reported have been limited. Comparing with other more matured sciences, architecture for information systems is still at its early stage of development. This is evident when examining a variety of definitions of the same terminology, like "architecture", and confusing use of some terms, such as "architecture framework" or "enterprise architectures", in various scenarios. A consistent understanding and use of concepts and terminology in architecture is fundamental for its success.

Architecture

Despite a diversity of architecture definitions, the most well known is architecture is the structure of components, their relationships, and the principles and guidelines governing their design and evolution over time (IAWG, 1998).

Architecture view

A view of architecture is a specific aspect in which an architecture presents a system. An architecture can have a set of views. An architecture view is also called a type of architecture, such as organisation architecture, business and functional architecture, software architecture, technical architecture and so on.

Architecture framework

A framework for architecture is an approach to constructing architecture in a particular style in terms its structure or organisation. An architecture framework can be either *ad hoc*, which is based on successful or useful experience and can be considered as a reference when people address similar problems, or *methodology-oriented*, which is developed on a basis of both experience and some disciplines such that people can use it as a ***method*** in a similar and applicable domain, such as the frameworks for business-to-business E-commerce (Shin, 2000) and enterprise frameworks (Zachman, 1996; Meta, 1999).

Architecture methodology

An architecture methodology is well developed on a basis of development disciplines in terms of definition, structures, notation and processes. It can guide developers to achieve a high quality of architecture through following the specially designed processes or steps. An architecture framework can be seen as a methodology when adequate disciplined processes are introduced with it. Comparing with frameworks, the methodology tells not only "what to do" but also "how to do it correctly".

Architecture tools

Architecture tools developed for various purposes, such as quality, efficiency, publication, documentation and storage, include languages, notation standards, drawing and designing facilities, and repositories.

Architecture capability

The value of architecture is proved by its applications and capability. Architecture capability can be realised in different manners with different degrees of support and success, from guiding development, planning systems, supporting general knowledge communication and sharing, improved designing and architecting, to more advanced capabilities such as architecture-based modelling and simulation. Individual architecture activities produce a variety of architecture capabilities but often in separate or isolated fashions in current practice. As a result, the value of architecture is limited.

The development and use of architecture is related to a number of disciplines, including Software Engineering, System Engineering, computer networks, programming languages and methodologies, and information system planning and development methodologies; and required in many different development scenarios, such as systems analysis and design, strategic planning, legacy systems evolution, re-development, integration and simulation and modelling. This implies, therefore, that the architecture for a large organisation is the outcome of multi-discipline-based community practice. Its success cannot be guaranteed by any single effort and must be based on all architecture-related activities that jointly form the community practice, called as ***Architecture Practice***.

In other disciplines such as civil engineering and mechanical engineering, the concept of architecture is well defined, well established with its development and use environments and systematically taught at universities or in professional training. Being a product of the combination of arts, architect's understanding and vision, and applications of fundamental sciences, architecture is conceived and produced by an architect who received systematic education for the qualification and used in communications on the design of a building with other stakeholders. In information systems development, unfortunately, architecture is still in its infant stage and based mainly on experience and technology solutions. Architecture issues are touched independently in a number of subjects in IS or computer science departments. People working on different aspects of architecture have different titles, including data architect, system architect, network architect, system integrator and

enterprise architect. Architecture professionalism is presented and delivered separately by a number of IT professionals with different responsibilities.

In the information age, an organisation operates in a structured information space through information systems developed since it not only puts its data, information and knowledge into systems but also implement its business processes through systems. In future, it will have to evolve based on the existing systems. IS development and management is now part of business planing and management of the organisation. What can the organisation rely on to plan, develop and manage its systems and enable its evolution including its systems evolution? How can an organisation develop a kind of capability that can ensure a sustained, sustainable and controlled evolution of its systems and respond quickly and cost-effectively to future changes?

Features, promises and problems from architecture frameworks

A framework of architecture is introduced to better handle the complexity of architecture development. In order to meet different requirements of architecture development, there have been a variety of architecture frameworks. Consequently, choosing a suitable framework and using it correctly is becoming an issue. An investigation into the experience of using architecture frameworks shows that the degree of success largely depends on:

- Whether people can identify the right context to use the framework at the right time to generate the right products.
- How well it can be used in combination or jointly with efforts that address different issues in the architecture practice.

Note that any framework or approach is usually presented with claims only on what it can deliver but without telling where it may not be suitable. In practice, it should not be ignored that any architecture framework has its applicability to certain domains or development scenarios. As a mandated approach, for example, the C4ISR Architecture Framework is a military-operation-oriented approach for the C4ISR domain, in particular for a military mission context. Whether it is a good methodology for developing enterprise architectures, software architecture or an infrastructure architecture, is questionable. Various problems have been observed in improper use of some architecture frameworks or approaches. Vendor's preference or interests in a particular framework could mislead use of some architecture frameworks and consequently could result failures of the investments of large organisations in architecture.

There are some questions regarding architecture frameworks that are not addressed by the frameworks themselves. For instance, whether an organisation should only use a single framework or approach or more than one. Why is the selected one better than others? Whether and how they can be used together if multiple frameworks are adopted.

Architecture practice exists when various architecture products are generated in engineering and development activities. The problems experienced in current IT practice have indicated a need of improvements in architecture practice in order to:

- Bring together related disciplines and addressing systematically principles of development, management and use of architecture.
- Address the issues that are not usually covered by individual frameworks or approaches.
- Achieve an integrated architecture capability for improvement of future development capability.

Without such a discipline, an organisation can develop various individual architectures but it is hard to continuously and cost-effectively develop and maintain a successful and integrated architecture capability.

ARCHITECTURE IN PRACTICE

The complexity of architecture issues increases noticeably when development scenarios change from single stand-alone system to evolutionary development of Systems-of-Systems

(SOS) as shown in Figure 1. The architecture issues needed to support the development of SOS cover the architecture issues of the previous two scenarios and additional architecture issues such as enterprise data management, risk management, interoperability, standards/ guidelines, technical architecture, future planning, etc. The increased number and complexity of architecture issues is evident when SOS is required to achieve a high level of interoperability among their component systems and with external systems.

Instead of inventing a new definition of architecture for such a changing context of using architecture, we are more interested in exploring and investigating three distinct features/ roles of architecture: being a *blueprint* – a basis for acquiring a new system; being a *current picture* – a basis for understanding an existing system; and being a *roadmap* – a basis for supporting realisation of the first two features. Different architecture products play different roles, yet on a systematic level they are inter-related. Activities of designing, proposing and applying an architecture solution are carried out in context of existing systems or organisation environments. For example, using a newly proposed software architecture (such as Object-Oriented based middleware) in a legacy system environment requires architecture knowledge of the systems and technology standards adopted and changes to the existing (such as wrapping existing application interfaces).

The complexity of architecture issues is not only observed by the increasing number and types of architectures but also by the changing context of each architecture including its role, relations to others, accessibility and usage. In order to let system architects work effectively and efficiently with fewer mistakes, it is necessary to create a better and well-organised practice environment for carrying out architecture-related activities.

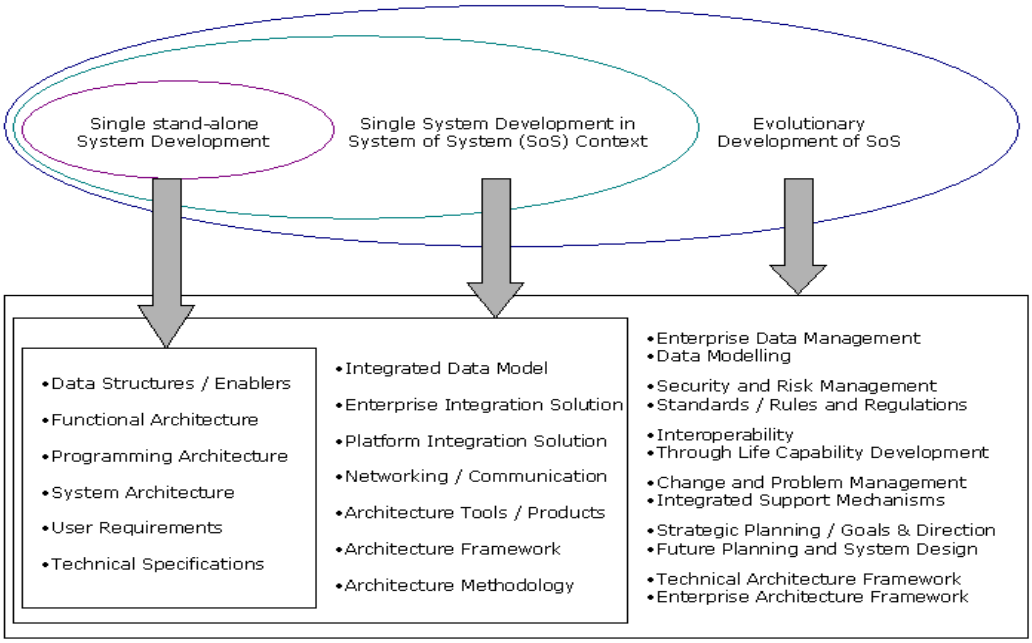

Figure 1: Increasing Complexity in Architecture Issues

Architecture practice is an emerging and fundamental discipline, which has the potential to improve the IT development capability of large organisations by addressing systematically the principles of development, management and use of architecture. Through such a practice, various organisational knowledge and systems knowledge can be engineered in an architectural fashion for a diversity of purposes.

Since architecture practice for most large organisations is currently not systematically planned and managed, the potential of architecture claimed by using many architectural approaches has not been achievable. This situation arises due to three common problems appearing in most architecture activities, that is, *incompleteness*, *inconsistency* and *confusion*. It is not surprising that some large organisations or certain business domains, like the defence organisation, may even face more chaotic situations due to the increasing complexity of architecture issues.

It is important to distinguish architecture practice from most architecture frameworks or approaches such as Zachman Framework (1996), Microsoft Solution Framework, TOGAF, and the C4ISR Architecture Framework (CAWG, 1997). An architecture framework or an architectural approach usually suggests a set of principles from specific viewpoints for certain architecture-related activities that are indeed part of architecture practice. Architecture practice operates in an enterprise-wide context where multiple architecture frameworks or approaches can be used for different aspects of IT practice. It can help the organisation coordinate, integrate and manage all architecture-related activities.

We see architecture practice as an engineering discipline supporting IT applications and future business development, which has relevance to many other disciplines including computing, information systems, systems engineering, knowledge engineering and organisation studies. Therefore, studies of architecture require a methodology to systematically address the following main issues:

- What is the rationale behind architecture practice?
- How is it related to the IT development capability required by an organisation?
- How can architecture practice be planned, coordinated and managed in order to achieve the potential of the architecture concept?
- What kind of architecture practice supporting environments should be developed for a particular organisation?
- What are the roles and responsibilities that architecture practice should be expected by the present organisation, and how will these qualities be reflected in future capability development?
- How is architecture practice related to other relevant disciplines?

In developing a common understanding of architecture issues it can be shown that shifting focus from architecture to architecture practice results in the disappearance of some of the confusion related to the definition of architecture and also provides a context framework for relating different architecture products and processes. It is likely that the architecture practice study can help establish an architecture-based foundation for the integration of those relevant disciplines.

Architecture involves different levels of complexity when it is applied to different disciplines. For example, in the construction industry, the high complexity of architecture is handled well in the disciplined practice, and the resultant building complex is a stable physical structure and would unlikely face continuous changes in term of architecture. However, in the rapid, dynamic and continuous changing IT industry, the levels of architecture complexity are increasingly high and diverse, and in order for architecture to evolve with change requirements in a sustainable fashion, it will require the establishment of the linkage between architecture issues and responsibilities of management and other key stakeholders in the systems lifecycle.

The interests in architecture of all primary groups are illustrated in Figure 2. Central to this process is the role of the Chief Information Architect (CIA) or Chief Information Officer (CIO)), whose main responsibility includes planning, designing, organising and managing the architecture practice. It is through architecture practice that a CIA/ CIO can communicate effectively with stakeholders on different issues of architecture and manage complexity of systems or organisation evolution.

ARCHITECTURE PRACTICE RECOMMENDED TO LARGE ORGANISATIONS

Developing architecture practice as a discipline does not start from scratch, since lots of issues have been addressed by various efforts made in developing architecture-related concepts and technologies. Nevertheless, the reason why today's practice cannot be seen as a discipline is because there is still a missing foundation to bring all of them together. The architecture practice shown in Figure 3 has four main considerations:

- To present a context to examine and relate architecture activities and frameworks.
- To distinguish enterprise architecture from system architecture.
- To distinguish “to-be” architecture, that could be from multiple choices, from “as-is” one that is unique.
- To achieve a framework to integrate and manage IT practice disciplines.
- To conduct the practice with clear strategic directions in defining, developing and managing architecture products, architecture processes and supporting environments.

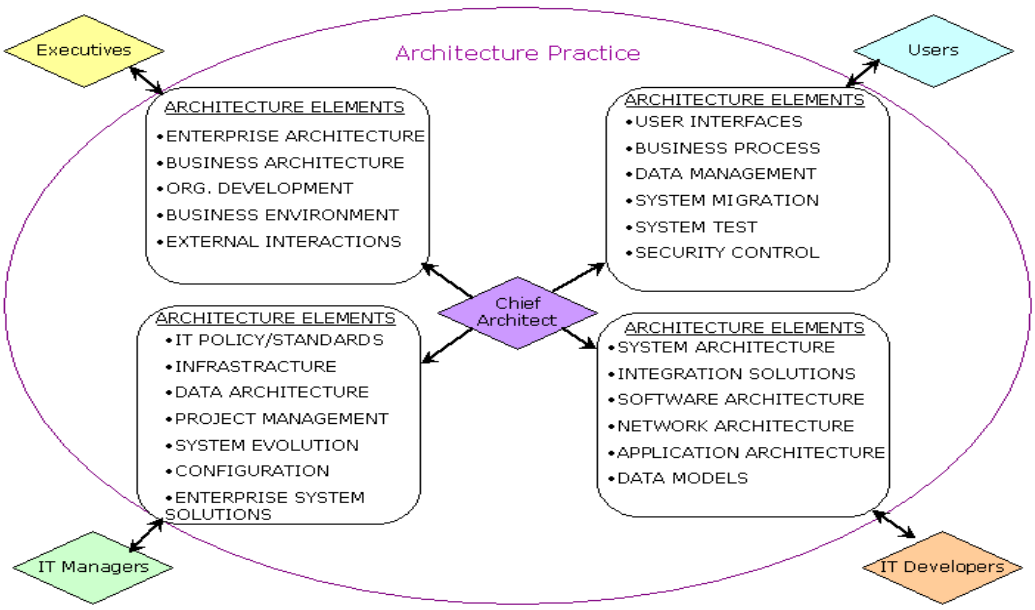

Figure 2: Stakeholders’ communications on architecture

The main differences between the recommended practice and architectural approaches (or architecture frameworks) are:

- Each architectural approach is developed and used to guide architecture-related activities focusing on only certain aspects of architecture practice.
- Architecture practice as a discipline focuses on the principles of context management for all architecture-related products, approaches, issues and activities. It can provide rational suggestions and guidance on how to choose architecture frameworks and how to develop the elements for the supporting environment and systems architectures. It helps identify weakness of limitations of frameworks or methodologies, and to explore opportunities for practice improvement.

One of the main features of the architecture practice is provision of a well-defined context for developers to plan and conduct their work so that they can make best use of the resources generated by others. The practice can facilitate coordination among different frameworks as far as they can be tailored to fit into the context.

The system architecture acquisition process (SAAP) helps achieve organisational knowledge preservation. This process defines the formal architecture management of developed systems. Unfortunately, it is not explicitly defined by the traditional software engineering disciplines, which basically guide developers in developing a specific system. The reality of the evolutionary development of large and complex systems is challenging this kind of practice since it fails to distinguish between the organisation’s long-term interests in acquiring IT capability and vendor’s or project-based interests. Introducing SAAP can help

preserve systems architectures as organisation knowledge assets and maximise the return of the investments in architecture.

The roles of enterprise architecture elements are to guide and to provide references and knowledge resources supporting the development of architecture for new systems and changes of the existing. For example, a standard-based technical architecture tells architects what technologies can or should be used in developing new systems and what cannot be used. A product developed by the U.S. Department of Defense, called LISI (CAWG, 1998), can be used to assess interoperability between systems from a layered architecture viewpoint.

The Architecture Practice Supporting Environment (APSE) is at the centre of architecture practice. Supporting elements (or called the enterprise architecture elements) and the repository can be integrated to provide accessibility and functions for architecture planning and analysis across elements or resources.

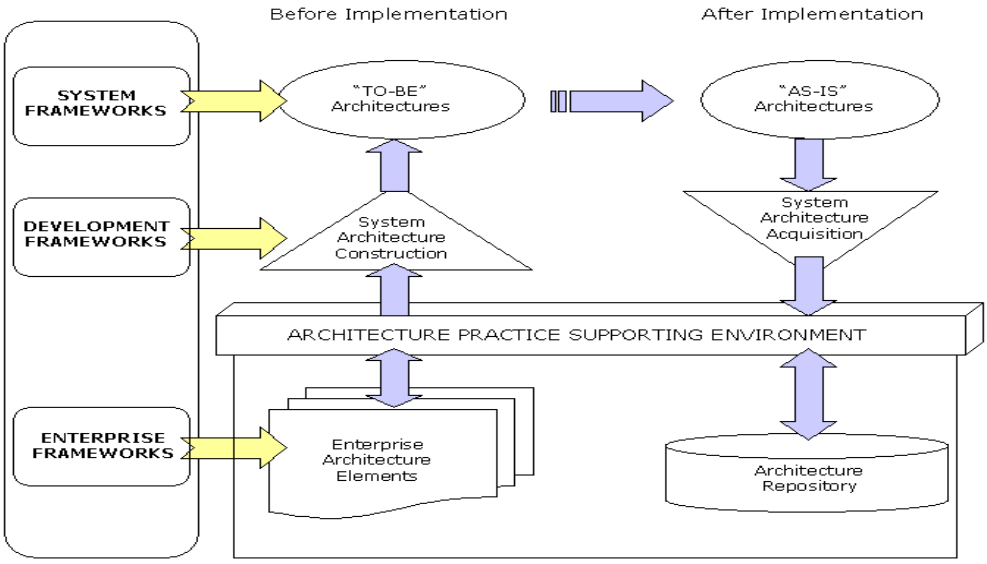

Figure 3. Frameworks supporting recommended Architecture Practice

The Enterprise (systems) Architecture Repository (EAR) is a store of the information that is generated by the SAAP. It should always be a valid picture of existing systems. This information differs from the system architecture (blueprint) generated using different methods or representations before implementation. It is represented in a synchronised format by using a consistent notation. The notation is used to capture only the necessary information and to reference other associated resources including the blueprint if it is not kept as part of EAR. The EAR development is a key element of architecture practice data management solutions.

FEATURES AND LIMITATION ANALYSIS OF ARCHITECTURE FRAMEWORKS

Generally speaking, an architecture methodology or framework provides guidance in architecture development for a particular *sub-area* of the whole practice by defining a set of viewpoints and/ or supporting elements and certain processes for producing certain types of architecture products.

How big such a *sub-area* is depends on each framework or methodology – supporting the range from only programming, or a single system development, to enterprise-wide development. Whether a methodology that claims to support enterprise-wide development is sufficient to address all needs of the organisation in architecture practice is an interesting question. The answer from the developer of the methodology might be “yes”. From our architecture practice study point of view, however, the answer is that depending on the nature of the organisation it may not be enough and there is also a need to examine its

applicability. Since the size and nature of organisations vary, their architecture practice requirements are quite different. A methodology that can successfully support or guide architecture practice for a small organisation in its specific development settings may have difficulty or sometime even be improper when it is applied to a large organisation in a quite different development setting.

As mentioned earlier, the enterprise supporting elements (ESE, or the enterprise architecture elements shown in Figure 3) are defined or recommended differently in many architecture frameworks or approaches due to their different focuses or objectives. The need to use multiple architecture frameworks are observed when an organisation finds there is no such framework that can provide a complete set of ESE required by its practice and guidance to develop architecture products of interest to the organisation.

The principles of the architecture practice discussed in Chen (2000) are *partially* shared by those architecture frameworks or approaches since they can, to a certain extent, support the implementation of some principles, such as planning and selecting some elements of ESE for their specific purposes and realising the value of architecture products generated through using the frameworks.

Combining the analysis above with the framework review, we now establish a common basis to examine and compare different architecture frameworks or approaches. The examination starts with the following questions:

- What main architecture issues does a framework or approach address?
- How does it deal with the concept of ESE?
- How does it deal with the architectures of existing systems or systems architecture acquisition at the enterprise level?
- How are the architecture issues addressed by the framework related to architecture issues and products, which are *not* covered by the same framework?
- What are architecture capabilities (a single product, a set of both descriptive and supporting products, management solutions, tools or practice supporting environments) that can be delivered by the framework?

However, the examination of a framework is a form of subjective evaluation depending on personal interests and understanding. Instead of evaluating in detail all those frameworks or approaches, we suggest that organisation with interests in those methodologies perform their own evaluation through combining these questions with their specific interests.

ARCHITECTURE PRACTICE MANAGEMENT

In order to achieve the disciplined architecture practice, management solutions are necessary for a large organisation and should be made in the following aspects:

- Solutions on planning and coordination of architecture activities.
- Solutions on selection of frameworks/ methodologies.
- Solutions for handling complexity and evaluating architecture.
- Solutions for architecture product management.
- Solutions for APSE development.

More fundamental and theoretical studies on architecture practice can help reach better and rationalised solutions. For instances, an ontology or taxonomy on architecture can help categorise different architectures and frameworks; a survey of developed architectures could help better understand current situations of architecture practice, identify problems and suggest improvements.

Architecture practice management can starts with assessing the current practice of an organisation against the recommended architecture practice. The definition of architecture practice requirements for an organisation can then help identify the needs of solutions in those aspects. An important goal of the architecture practice management is to achieve

high-level architecture professionalism to deliver architecture capability. The architecture professionalism is built on a basis of a well-organised team structure involving not only system architects but also people working in organisation planning, technology policy and standards, and knowledge asset management. More importantly, these teams must work jointly to realise the value of architecture.

ARCHITECTURE PRACTICE MATURITY (APM)

Architecture practice maturity, generally speaking, is jointly determined by two factors: coverage and maturity of individual elements and activities in the practice. Architecture practice maturity is related to its complexity. A high-level of maturity of architecture practice involves a high-level of complexity. A high-level of complexity in architecture practice, however, cannot guarantee a high-level of maturity since the maturity levels of individual efforts, products, management and coordination are all important factors. No sufficient and systematic study has been undertaken to address the concept of APM. An effort in classifying architecture practice maturity levels made by the Meta Group (1999) through using SEI's (1999) model is interesting but only covers certain aspects, mainly the enterprise-wide technical architecture (EWTA) and a product called "a repository".

The philosophies used to improve architecture practice could be different from one organisation to another. In order to reach the main goal of architecture practice, however, it should be noted that certain issues and challenges are common to most large organisations.

- Strategic planning and management decisions.
- Defining the context of practice.
- Choosing or developing suitable frameworks and approaches.
- Defining and developing the APSE including the supporting elements.

The rapid growth of architecture practice in large organisations will be a noticeable trend in the first decade of the next century (Meta Group, 1999). This is challenging both researchers and practitioners in terms of achieving better practice. Questions like why and how architecture practice should grow need to be addressed from many different viewpoints including science, engineering, technology and management. In order to develop architecture practice as an engineering discipline as suggested by Zachman (1996), researchers and practitioners are required to first reach a common understanding of the context of the whole of architecture practice, to learn how to relate their own work to others, to refine a common set of definitions of concepts involved in the architecture practice.

Planning and rationalising architecture practice is not an easy task. Architecture practice maturity is a challenging issue for large both organisations and industry. If the opportunities to achieve better architecture practice are realised by both organisations and industry, it will lead to a significant change in the culture and process of IT practice and a more manageable development environment based on the established architecture capabilities and practice.

TEACHING ARCHITECTURE PRACTICE AS A DISCIPLINE

Architecture has been practiced and treated mainly as arts of design and development by IS communities rather than an engineering discipline. Some aspects or fields of architecture practice, such as software architecture, network architecture and system architecture, have attracted more attention than others from researchers and academics. These topics have been taught independently in relevant courses at universities. Industry training course cover a much broader areas but often focus on specific technology-related issues of architecture. Such unsystematic education on architecture results in the limited and incomplete understanding of students and professionals on architecture roles and issues in systems development and management and makes the task to establish and develop architecture professionalism even more difficult.

Systematically teaching architecture as a discipline in IS departments is required and important since nowadays large organisations are continuously facing evolution challenges of their SoS. It is hard, however, to do because of the following reasons: 1) lacking of

academics who have broad knowledge and experience in architecture; 2) no available and well-developed textbook on architecture practice as a whole; 3) architecture issues related to multiple disciplines and subjects; and 4) architecture practice itself yet to become mature and be established on a basis of information architecture theory.

Thinking architecture beyond architecting and design is necessary in order to develop architecture practice towards a development and management discipline. A textbook on this discipline needs at least to cover:

- Architecture practice context and principles.
- Architecture as technology solutions.
- Architecture as system design solutions.
- Architecture as information and technology management solutions.
- Architectural frameworks/ methodologies.
- Architecture processes.
- Architectural tools.
- Architecture data management.
- Architecture practice planning and management.
- Case studies.

CONCLUSIONS

Future systems and organisation development requires large enterprises to pay more attention to their architecture practice rather than only individual architecture. Without a sophisticated understanding and effective management of architecture practice, it is hard for an organisation to achieve a high level of IT development capability. Re-defining the role of architecture for large information systems development and management is absolutely important and necessary in order to make architecture practice be an engineering capability. In order to teach the architecture as a fundamental discipline of information systems at universities, academics and researchers must study architecture activities and outcomes as a whole and address architecture issues jointly. Unlike any single architecture concept, the architecture practice aims to establish a full set of architecture professionalism, processes, data and supporting environments that are required for not only development but also management and evolution of an organisation and its SoS.

REFERENCES

Bass, L., Clements, P. and Kazman, R. (1998) *Software Architecture in Practice*, Addison-Wesley Longman.

Chen, P. and El-Sakka, A. (2000) *Context Analysis and Principles Study of Architecture Practice*, DSTO Technical Report, DSTO-CR-0151.

Horowitz, B. M. (1996) *The Importance of Architecture in DoD Software, Guidelines for Successful Acquisition and Management of Software-Intensive Systems*, June.

IEEE Architecture Working Group (AWG) (IAWG) (1998) *IEEE Recommended Practice for Architectural Description, IEEE Std 1471, Draft Version 3.0*, 3 July

Lockheed, M. (1996) Tactical Defence Systems, *Organization Domain Modelling (ODM) Guidebook (Version 2.0)*

Meta Group (1999) *Enterprise Architecture Strategies (EAS)*, Meta Delta, 31 March

Shin, S. S. Y., Pendyala, V., Sundaram, M. and Gao, J. Z. (2000) Business-to-Business E-commerce Frameworks, IEEE *Computer,* pp40-47, October

Software Engineering Institute (SEI) (1999) *Definitions on Architecture*, http://www.sei.cmu.edu/ architecture/definitions.html

The C4ISR Architecture Working Group (AWG) (CAWG) (1997) *C4ISR Architecture Framework (Version 2.0)*, December

The C4ISR Architecture Working Group (AWG) (CAWG) (1998) *Levels of Information Systems Interoperability (LISI)*, March

Zachman, J. (1996) *Enterprise Architecture*: *The Issue of the Century*, http://www.zifa.com/zifajz01.htm

COPYRIGHT