Enterprise Architecting: Critical Problems

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Abstract

An enterprise architecture (EA) identifies the main components of the organization, its information systems, the ways in which these components work together in order to achieve defined business objectives, and the way in which the information systems support the business processes of the organization. The components include staff, business processes, technology, information, financial and other resources, etc. Enterprise architecting is the set of processes, tools, and structures necessary to implement an enterprise-wide coherent and consistent IT architecture for supporting the enterprise's business operations. It takes a holistic view of the enterprise's IT resources rather than an application-by-application view. Given the size and still immature nature of many enterprise architecture efforts, a number of critical challenges and problem continue to exist. This paper surveys a number of these challenges and problems in an attempt to provide a platform for a discussion on enterprise architecture problems and possible solutions.

1. Introduction

In previous papers (Armour 1999a, Armour 1999b, Armour 2001), we described a framework and a methodology for enterprise architecting based on work we performed for the Department of the Treasury. In (Armour 2003, Kaisler 2003 and Valivullah 2003) we described how this methodology was applied to a small organization – the U.S. Capitol Police (USCP). It has also been applied to the Architect of the Capitol (AOC) and the U.S. Senate.

The Office of Management and Budget (OMB), in Circular A-130, asserts: 'An enterprise architecture is the explicit description and documentation of the current and desired relationships among business and management processes and information technology'. We see enterprise architecting as the scaling of system architecting to the enterprise - to a system of systems.

The benefits of enterprise architecting have begun to prove themselves: faster, better, and cheaper. But, these benefits come at a price. The organizational, cultural, and technical infrastructure require investment to support the architecting processes. Based on our experience, and discussions with other enterprise system architects, we have identified a set of challenges that every system architect and organization developing an enterprise architecture is likely to face. These challenges are rarely technical, but arise from political, project management, and organizational issues and weaknesses.

Note on convention: The use of the term 'enterprise architecture' has been taken to mean both the descriptive documents and the actual implementation. In order to minimize confusion, we will use the term 'enterprise architecture' to refer to the documentation and the word 'architecture' to refer to its implementation.

2. Motivation

There are three areas where critical problems arise in the process of enterprise architecting: modeling, managing, and maintaining EAs.

Modeling is essential to describing and understanding an EA. There are three reasons to model: (1) to visualize the EA, its evolution, and its generational impact on the existing architecture; (2) to depict to stakeholders the control and data flow through the architecture; and (3) to conduct end-to-end performance analyses. We found that selecting an appropriate framework and choosing a model to be the most difficult, but critical, tasks. It required significant time and effort to choose a suitable model. Because an enterprise architecture is strategic in nature, once a model has been chosen and developed, it will be a difficult to change it in the middle of implementation.

Management is essential to developing and deploying an EA. Typically, large organizations will have multiple ongoing projects that are remediating, renovation, or replacing information systems as well as developing new systems. Many of these projects are conducted on varying schedules. The challenge to the system architect is multifold: (1) coordinating schedules to ensure interdependencies mesh; (2) ensuring intersystem constraints at the interfaces are resolved; and (3) ensuring interoperability at the syntactic and semantic interactions between information systems.

Maintenance is essential to an EA because operational consistency must be preserved while the organization continues to evolve the architecture. Deploying enhanced or new systems should not impact day-to-day operations, so careful scheduling and integration of changes to the architecture is required.

The next three sections of this paper identify some of the critical issues in enterprise architecting that must be addressed through both research and practice.

3. Modeling Enterprise Architectures

EAs need to be modeled at two levels. First, they must be described in a way that provides a clear, coherent, concise picture of what the EA *is* and *is to be*, e.g., both the baseline and the target need to be modeled. Second, at the enterprise level, stakeholders need to understand the data and control flow issues and the decisions that will impact end-to-end performance.

Arguments regarding over "which model is right", "which notation is right", and "which paradigm is right" are relatively meaningless if the model cannot be understood by the stakeholders. A system architect can create a perfect EA model but it doesn't matter if project teams can't or won't take advantage of it. The EA must be good enough, but does not need to be perfect. During project development, it is likely incremental changes to the EA will occur as the project teams design, develop, and implement systems and applications.

3.1 Business View Representation and Alignment

The business view of an EA is a non-IT description of the business operations, processes, and data required to operate the business. Business modeling requires two elements: business events and business processes.

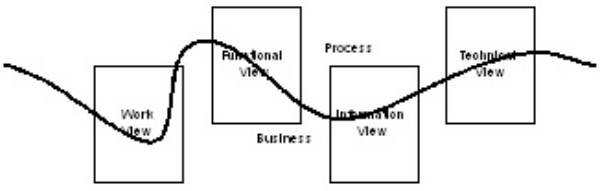

Figure 1. Business Process Thread

Business processes must be modeled and aligned across functions, data and information systems that will implement the processes. And, ultimately, must be mapped to the underlying infrastructure where "the rubber meets the road". Alignment

- Encompasses the organization's mission, vision, business drivers, strategic goals, strategic business
- Objectives, information needs, IT vision, IT mission, IT objectives, and guiding architectural principles.
- Ensures that the mission, business processes and priorities drive system development.
- Maps IT development to stakeholder needs and target business processes.
- Ensures the business vision provides the basis/foundation for the entire enterprise architecture.
- Requires the business view, which used as a guidance tool, remains relatively stable over time.

Business events act as triggers to initiate business processes. Business processes must be modeled across the organization. Depending on the degree of modeling desired, the following are some of the key questions that need to be answered by the business model:

- What are the key business operations for the organization?
- What organizational units are responsible for those business operations?
- Who (role or organizational unit) performs a business process?
- What business processes comprise a business operation?
- Where, geographically, are organizational units located?

We refer to this activity as "architecting at the boundaries". The interface between the end user and the enterprise's information systems is just as important as the network protocols that transfer the data from location to location. The environment presented to the end user, whether static or dynamically modifiable, is critical to the end user's performance of tasks in support of the business operations.

3.2 Limited Modeling Tools

The ability to model and align business operations and processes is lacking. Business processes drive architectural decisions and weave a thread through the architectural views. Business process owners need to

see how their requirements are met across multiple information systems.

Figure 2 below highlights some of the critical entities that need to be aligned throughout the enterprise architecture development. Currently, there is minimum tool support to track and maintain this diverse collection of entities.

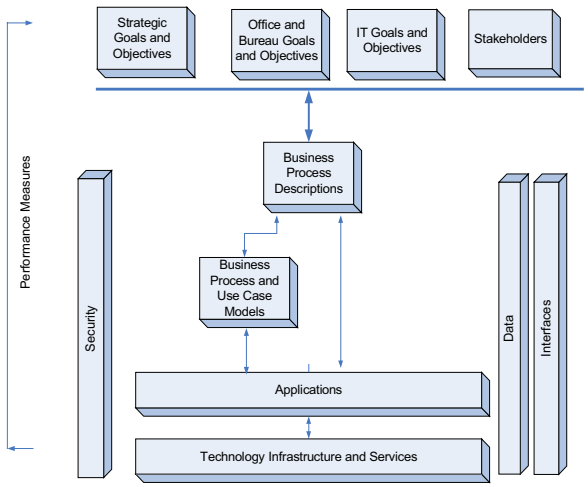

Figure 2: EA Alignment Map

When defining the alignment map, care should be taken to:

- Define the entities to align
- Define the attributes of entities
- Define the alignment links
- Reference the appropriate documents that contain the specific entities

Many current modeling tools, such as Rational Rose, are oriented to modeling software architectures. In Armour et al (Armour 2003), we showed how to begin to adapt UML to model EAs. Because EAs are systems of systems, there is an emphasis on a higher level of conceptual modeling. Additionally, business operations and processes must be integrated into the model. While there are a number of tools such as Metis, Popkins SA, Troux, Orbus, and Casewise Corporate Modeler, etc. that are beginning to address these issues, a well-integrated solution is not available at this time.

3.3 Stakeholders Perspectives

Different stakeholders require different perspectives through the EA views. A database administrator, for example, may focus on the structure and location of specific databases, while a sales executive may be focused on the location and movement of data through multiple information systems. Business executives are often more interested in seeing how information flows through the organization and which high-level information systems and applications support the business operations.

An EA needs to be simple enough for everybody to understand and get the gist of which system connects to which system, where applications reside, and how data and control flow through the system. Complex diagrams should be relegated to individual projects. Simple diagrams are easier to change. During the enterprise architecting process, changes and updates are likely to occur quickly until the EA is stabilized for a particular iteration. If decisions about components and their interrelationships are uncoordinated, ad hoc or localized, the result is likely to be duplication of effort and resources, poor coordination and control, problems with management and business performance, inability to share important resources such as information, and inefficiencies in operation.

Stakeholders may be other Federal agencies as well. The Office of Management and Budget (OMB) has developed the Federal Enterprise Architecture (FEA) as a business-based framework for the federal government. The FEA goal is to facilitate interagency analysis, identify duplicate investments, gaps and provide opportunities for collaboration within and across federal agencies. The FEA models enterprise architecture as 1. Performance Reference Model, 2. Business Reference Model, 3. Service Component Reference Model, 4. Data and Information Reference Model and 5. Technical Reference Model.

3.4 Representing Dynamics

A major weakness of many current modeling tools is representing system dynamics. Yet, this is essential for estimating the end-to-end performance of an architecture for different business processes. At the EA level, such estimates must necessarily be coarse, but system architects need to know the order of magnitude of the processing time for different business processes to both establish and verify performance requirements, but also to assess how architectural changes affect the EA. A mechanism is needed for calculating and/or associating performance data with EA elements.

Major research questions include:

- What is the best mechanism for representing system dynamics in an enterprise architecture-modeling tool?
- What constructs or artifacts should be modeled in evaluating the dynamics of an enterprise architecture?

4. Managing Enterprise Architectures

Implementing an EA requires strong program and project management expertise along with an IT portfolio management process, while maintaining the architecture requires a robust change management process and procedures. Additionally, EA management requires emphasis on the "ilities" of system engineering.

4.1 Managing the Integrated Enterprise Life Cycle

Most enterprise architectures are built on top of legacy systems, e.g., there are no "green fields". Once the enterprise architecture is specified by the system architect, individual components of the EA that are to be remediated, renovated, or replaced, or developed anew are often turned over to one or more project managers. Typically, these project managers do not report to the system architect. Two key issues arise: (1) what oversight authority does the system architect have over system development projects, and (2) how are project management decisions assessed against the enterprise architecture. Enterprise architecture is closely linked to other major disciplines in what we refer to as the enterprise management lifecycle, as depicted in figure 3.

Let's address issue 2 first. Decisions regarding the ownership of enterprise IT resources and the responsibility for managing and integrating new resources into the enterprise architecture are an issue of IT Governance. IT Governance must have the support and authority of the organization's executive management if it is to succeed. Most organizations will create a cross-organization architecture board, representative of all stakeholders, whose purpose is to oversee the implementation of the EA according to the established architectural principles.

Issue 1 derives from issue 2. In many organizations, the system architect reports to the architecture board and may be an ex officio member. The system architect operates with the authority of the architecture board in most day-to-day decision-making. He must possess the political and business acumen necessary to know when to promote issues for the architecture board's consideration.

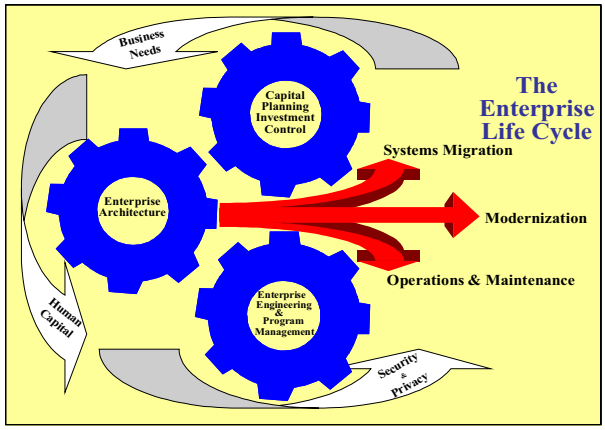

Figure 3: The Integrated Enterprise Life Cycle

Together, the architecture board and the system architect establish the architecture compliance process. The system architect analyzes, designs, reviews, assesses, and proposes EA changes to the architecture board, which must approve them. Architecture compliance involves having the authority to ensure that individual projects hew to the EA and the established architectural principles.

4.2 Assess Technical Architecture Maturity

The foundation for an enterprise architecture is its technical infrastructure. During the architecture transition planning phase, the system architect must assess the maturity of the technical infrastructure to determine whether it can support the proposed enhancements to the enterprise architecture. Several models have been proposed for assessing technical architecture maturity. Gartner's (James 2002) model proposes five levels of maturity: chaotic, reactive, proactive, service, and value with associated descriptions.

Some key questions that need to be answered here include:

- What elements should a canonical maturity model encompass?
- What figure of merit should be used for assessing overall technical maturity as a composite of the maturity of individual elements of the technical architecture?

- How can/will the technical architecture maturity model be used in evaluating the EA maturity model?

4.3 Assessing Infrastructure Stress

Every modification to an enterprise architecture introduces change to the underlying technical infrastructure, whether new hardware, software, or telecommunications platforms, or just parametric changes. Individual project managers may understand the impact of such changes on local platforms, but often do not understand the impact of changes on other platforms. Change induces stress in an architecture. Some key questions that need to be answered here include:

- What is the measure of stress on the technical infrastructure?
- How do we measure and assess stress on the infrastructure?
- How do we determine if specific changes will 'break' the architecture?
- How does the system architect use this measure (and others) to predict when something will break as a result of changing the technical architecture?

4.4 The System Architect's Value Proposition

Many executives continue to see the system architect as a non-revenue producing expense. Developing the value proposition for a system architecture group is difficult in an organization that is used to making reactive, rather proactive decisions.

The Federal Government mandated the need for enterprise architectures in OMB-97-16, IT Architecture Guidelines. They asserted that large IT investments would be evaluated against enterprise-wide IT architectures. The Clinger-Cohen Act (Information Technology Management Reform Act of 1996) mandated the appointed of a Chief Information Officer (CIO) who will develop an IT strategic plan, develop measures for assessing performance against that strategic plan, and report regularly to Congress on IT performance. The CIO is responsible for the EA. These documents mandate, but do not justify the role of the system architect.

Two challenge here are:

- How does the system architect contribute to the bottom line?
- How does the system architect's activity reflect itself in improved productivity, better end-to-end performance, better IT investment & portfolio management, faster time to market of news services and products, etc.

4.5 Virtual Enterprises

Virtual enterprises are dynamic entities that seek to create transparency of services' location and often involve multiple organizations. Typically, a virtual enterprise arises from B2B collaboration. Several issues arise from virtual enterprises that require the system architect to proactively plan for their implementation:

- Developing semantic standards for interpreting exchanged information
- Establishing security in a multiparticipant environment
- Lack of centralized control

Because virtual enterprises are very dynamic, they are not easily represented in existing tools. We need to determine canonical methods and mechanisms for representing virtual enterprises.

4.6 Evaluating EA Maturity

A continuing problem is how to assess an enterprise architecture: (1) what are the characteristics of a good EA and (2) how does an organization's EA match those characteristics. Based on our experience, we suggest the following:

- The EA's boundaries are well-defined
- EA elements have clearly assigned responsibilities
- Interfaces, formats, and protocols between EA elements are well-defined; alternatively, every interface supports only approved formats and protocols
- An external auditor adequately documents the EA to permit compliance review and assessment.

The U.S. Government Accounting Office (GAO 2004) has released a framework for assessing and evaluating enterprise architectures. A high-level view is depicted in figure 4.

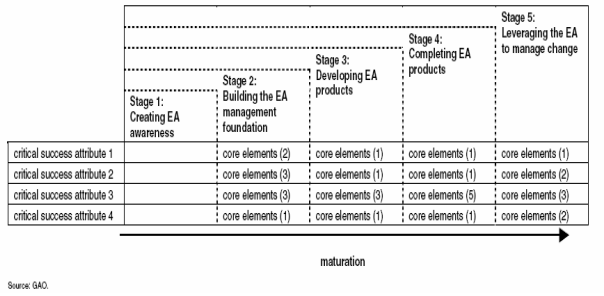

Figure 4. High-Level of GAO's EAMMF.

The EAMMF provides five levels of EA maturity:

1. Creating EA Awareness: An organization has no documented EA, no plans to develop one, and no commitment to the EA process.
2. Building the EA Management Foundation: The organization has designed a Chief Architect, selected a framework, set up a staff and steering committee, and selected a process.
3. Developing EA Products: The organization has committed to the EA process and begun developing baseline and target architectural documents and a transition plan.
4. Completing EA Products: EA products, include the baseline and target architectures are complete and being used to decide IT investments.
5. Leveraging the EA To Manage Change: The EA continually evolves and is used across the enterprise for IT decision-making. Metrics are established to assess its effectiveness

While the EAMMF provides some guidance on how to assess an EA methodology and framework, we feel that more detailed procedures must be defined and that these must be correlated to the domain.

4.7 Assessing the Enterprise Architecture

The previous section identified the stages of EA process maturity, e.g., how well an organization is evolving in its pursuit of creating, managing, and maintaining an EA. The Open Group has developed a six-level model for assessing how an architecture conforms to its EA. (Open Group 1999) Table 1 depicts the six levels.

Table 1. Open Group EA Conformance Model

Level	Description
Irrelevant	The architecture shares no features in common with the EA, so assessment is not possible or feasible
Consistent	Some features of the architecture conform to the EA; some are not implemented (yet), and the architecture may have features not specified by the EA (legacy features, for example).
Compliant	Some features are not yet implemented, but all features are specified by the EA.
Conformant	All features specified in the EA are implemented, but additional features are present not specified in the EA.
Fully Conformant	There is full correspondence between the architecture and the EA. No features are implemented that are not specified by the EA.
NonConformant	Any of the above in which some features specified in the EA are not implemented.

4.8 Scalability

We consider a system to be scalable if there is a straightforward way to upgrade the system to handle an increase in interactions while maintaining a consistently acceptable level of performance. By straightforward we mean that no architectural changes are required to scale the system. A naïve application of this concept to an EA would suggest that we just increase the capabilities of individual systems in the architecture or increase the number of some types of systems. For example, to handle more front-end transaction in a stock-trading system, we should be able to increase the number of front-end servers servicing end users.

From parallel processing applications and benchmarking studies, we know that throwing more iron at a problem only works so well. Ultimately, the complexity of the number of interactions engendered

by the increased platforms obviates most performance gains.

4.9 Enterprise Architecture Metrics

Currently, there is very little guidance on metrics that can be captured to help assess the EA. A possible set of metrics, includes, but is not limited to:

- Annual update to Enterprise Architecture (completed/not completed)
- Percent of systems compliant with Enterprise Architecture
- Number of exceptions and variations to Enterprise Architecture
- Number of concepts and business cases reviewed for EA compliance (including pass, update and fail discussion)
- Number and outcome of EA reviews on ongoing efforts
- Number of changes proposed to EA
- Number of changes accepted

4.10 Best Practices

There are many 'bets practices' that have been enumerated in the technical literature. We need a method to validate and verify – qualitatively, if not quantitatively – that these are best practices.

Some best practices that we find useful, but which we feel need substantive verification rather than just 'word of mouth' acclamation include:

- Start small and grow the EA slowly.
- Train employees or hire contractors to transfer knowledge.
- Provide encouragement and resources.
- Have a good change or configuration management plan in place.
- A good capital and investment management plan and an Investment Review Board (IRB) that requires compliance with EA are prerequisites for good EA management practice.
- Use appropriate tools to maintain the EA. The most expensive is not necessarily the best tool.
- Each EA is unique. They all have common processes and principles. Include entities that make sense to your business environment.
- There is no cookie cutter approach.
- Scan the EA of similar organizations like yours.
- Reuse principles, process and artifacts. Modify to suit your enterprise.
- Do it if it makes sense.
- Fancy artifacts (pictures, graphs, documents, etc.) do not necessarily equate to better EA.

We need to extend our collection of best practices with good examples of where they did/didn't work and why, and process/procedure descriptions that underlie the best practices so that they can be reused effectively.

5. Maintaining Enterprise Architectures

Once an enterprise architecture is described and implemented, the organization faces several problems in maintaining it. Because most EAs evolve from existing architectures, these exists a tension between the continuing operations and the introduction of enhanced or new systems. Three key principles that can mitigate some of the risk and difficulty associated with architecture maintenance are:

- Design and build the architecture to change, not to last.
- Using the 80/20 principle, build only what you need to.
- Be prepared to rapidly change what you have built in response to changing business requirements.

Maintaining an EA has been given little attention in the technical literature. As more EA efforts become fully engaged, we need to identify best practices in support of maintaining an deploying EAs.

5.1 Continuing Technical Innovation

Technology continues to evolve at a rapid pace. A key question for the system architect and for IT operations is how fast should the organization refresh its hardware and software platforms. This question cannot be answered on purely technological grounds as we have found out in building the Senate's Alternate Computing Facility. Successive generations of servers have steadily increased their power requirements. This necessitated redesigning and upgrading the power backup capabilities of the facility to accommodate the increased power requirements of new servers.

Technology refreshment is often a resource issue. How often you refresh may depend on:

- The available funds to purchase new machines and software versions
- The time required to update applications to make use of new features,
- The installation/deinstallation costs,

So, some questions to be answered include:

- How often should the technical infrastructure be refreshed (as a best practice)?
- Should technical infrastructure refreshment be treated as a project within the EA?

5.2 Evolving Business Models

Business models continue to evolve rapidly even as the dotcom era has come and stabilized. Organizations continue to develop and deploy web-based portals for doing business, only smarter. However, the richness of the Web has yet to be fully exploited and this is leading to new business models, including virtual enterprises. These business models have an impact on EAs because they may require rapid deployment (or redeployment) of new platforms and services.

The Internet changed the way we communicate, the way we do business (but, not as much as we originally thought), and the way we locate and access information. In many cases, it has effectively washed away the boundaries of what's inside and outside of a business. One of the continuing challenges facing business executives is the movement towards an eBusiness model while continuing to maintain a brick-and-mortar local presence. Successful firms will balance these two business models. Few companies will be as successful as Amazon in establishing an eBusiness presence.

Time to consumer is a critical metric. eBusinesses must ensure that they can provide the information to their customer base, but also deliver the goods when orders are placed. This end-to-end model – order to picking to delivery to billing to receivables – is a primary performance metric for assessing an enterprise system architecture. Many organizations will form strategic alliances with new eBusiness service providers as opposed to building their own eBusiness IT services. Coordinating multiple e-business initiatives is extremely complex. The infrastructure must now support multiple tiers and multiple points of integration. This requires integrating Internet applications into an enterprise's infrastructure and implementing advanced functionality into its applications. As a result, the enterprise system architecture for eBusiness is much different from that of five years ago, and must be developed and deployed while maintaining the existing IT infrastructure.

5.3 Mobility

Mobility represents a particular challenge to system architects. As Hayward (Hayward 2002) notes, "Mobility is not an add-on to existing architectures; it is a profound disruption". As computers (PDAs, laptops) become more powerful, services become more mobile. At a minimum, network connectivity is broken and re-established, especially if it is based on cellular technology.

5.4 Integrity

The integrity of an EA is a measure of compliance with the EA as information systems are remediated, renovated, or replaced. Measuring integrity is a difficult problem. We need to define whether the measure is discrete or continuous. The integrity of the architecture fails for a number of reasons, including:

- Project teams don't know the EA exists or don't understand it
- Project teams, deliberately or not, don't follow the EA
- Project teams don't coordinate and collaborate with the system architect
- Although EA processes are followed, too many waivers are granted.

A different type of integrity challenge arises from the ubiquity of the Web. To many users, their business environment includes direct access to the Internet. However, this causes significant problems for system architects and security personnel alike.

At many organizations, a standard desktop image is provide each user upon delivery of a new workstation. This image contains all of the tools and utilities the organizations feels the user needs to be productive within the corporate community, to communicate with others, and to accomplish their jobs. Internet accessibility poses a direct challenge to the user's environment, including:

1. a user may download programs from the Internet that have not been approved by the central IT organization

2. a user may download and install updates that have not been approved
3. a user may establish links to other organizations that provide backchannels and conduits that enable security attacks

The user may become dependent upon individually acquired programs and tools that do not have central or even contracted support. When mission-critical functions become dependent upon such tools, the organization risks serious impact to operation and performance if the tool fails, the vendor goes out of business, or the user leaves without training another user. Enterprise system architects must recognize these challenges, must develop a strategy to accommodate them (or not), and must ensure throughout that the integrity of the architecture is maintained.

5.5 Security

Security is a major concern in building an EA. The system architects need to take into consideration the Confidentiality, Integrity and Availability (CIA) of the systems and infrastructure. Information security architecture is an integral part of EA, providing security from the perimeter to the core. A 'defense in depth' strategy works well based on the CIA analysis of individual systems and general support systems. For federal agencies, Federal Information Security and Management Act (FISMA, 2002) mandates information security. NIST Publications 800 series (NIST-PUB 800-XX) provides guidelines on assessing and implementing information security guidelines. Based on CIA analysis, systems are classified at three levels namely high, medium and low security systems. This classification dictates the minimum required protection needed for that particular system.

6. Conclusions

We have described a set of problems that affect the enterprise architecting process based on the lessons we have learned over the past five years. We feel that these problems as well as others will need to be identified, discussed, debated and resolved by both the academic and practitioner communities in order for the enterprise architecture discipline to continue to grow and evolve. This paper is a start in the effort to systematically identify these issues.

Organizations need to have clear, but concise, strategic plans for business and IT. The business strategic plan becomes the driver for the EA. The EA becomes the 'DNA' or the 'Rosetta Stone' for the organization's stakeholders and leads to the development of the IT strategic plan.

Developing an EA should not be done just to meet government mandates or requirements. Enterprise architecting should be a part of the enterprise capital planning process. Enterprise architects need organizational and executive support and funding to successfully perform their mission. The executives should not expect an immediate reward and should recognize that EA is not an operational initiative, but a strategic concept.

The challenges we have identified here are largely non-technical. In part, this is because enterprise architecting is not overly technical, but conceptual. As a result, it is much harder to both qualitatively and quantitatively describe and measure the benefits of enterprise architecting. We hope that some of the issues raised in this paper will begin to generate interest in developing methods and metrics for qualitative and quantitative measurement.

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