ENTERPRISE-WIDE INFORMATION TECHNOLOGY PROJECT METHODOLOGY ASSOCIATED WITH ENTERPRISE ARCHITECTURE AND INFORMATION ARCHITECTURE, EXAMPLE OF THE ENTERPRISE PORTAL

by

JUN GI HA

(Under the Direction of RICHARD THOMAS WATSON)

ABSTRACT

According to the Standish Group in 2004, estimates of failures of information technology projects in the United State were $55 billion of total project spending, or $255 billion. Even though information technology quality has become more reliable, many projects have still not succeeded as the survey results show.

To reduce failure risks of information technology projects, the integration of enterprise architecture and information architecture into software engineering and project management practices will be an important issue for organizations. These four fields, project management, software engineering, information architecture, and enterprise architecture, will become tremendously interdependent and their

collaboration will become extremely important.

The purpose of this thesis is to present an integrated framework and a methodology, based on the four fields, which are adapted for implementing enterprise-wide information systems, such as enterprise portals. This framework and methodology is based on the practical and theoretical ideas presented by *A Guide to the Project Management Body of Knowledge* (PMBOK) from the Project Management Institute (2004), *Software Engineering Methodology* from Pressman (2000), *Information Architecture Development Process* from Peter Moville and Louis Rosenfeld (2007), and *The Open Group Architecture Framework* (TOGAF) from The Open Group (2003).

INDEX WORDS: Project Management, Software Engineering, Enterprise Architecture, Information Architecture, Enterprise Portal, Framework, Methodology

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JUN GI HA

B.E., Kyungil University, Republic of Korea, 1999

M.S., Yonsei University, Republic of Korea, 2001

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JUN GI HA

Major Professor: Richard Thomas Watson

Committee: Craig Allan Piercy
Dale Louis Goodhue

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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To my lovely wife,

Young Ah Kim,

whose endless love and encouragement made my life happy

To my affectionate parents,

Yeong Mun Ha and Jeong Su Gu,

whose devotion for me made my life blessed

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Jun Gi Ha

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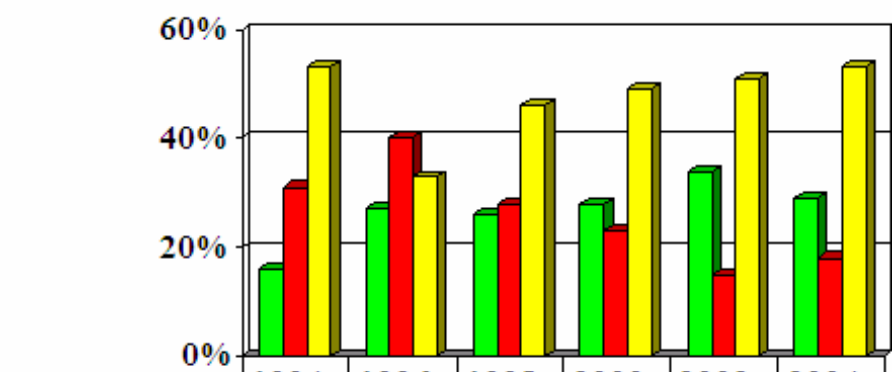
CHAPTER 1 – INTRODUCTION

Even though information technology (IT) quality has become more reliable, the risks and costs of IT projects have increased. The Standish Group, a market research and advisory firm, in 1994 surveyed that IT projects in the United States wasted $140 billion of a total project spending, $250 billion. The CHAOS Chronicles, in their 2004 report, estimated that of a total project spending of $255 billion in 2004 projects in the United States there was $55 billion wasted., (Standish Group 2004).

The Standish Group found that a 16% of projects in 1994 were successful and a 29% of projects in 2004 were regarded as a success. The success rate of IT projects doubled in 10 years, but on the other hand, the challenge rate remained consistently above 50 percent (Standish Group 2004). The detailed results of the study are shown in Figure 1.1, 1.2, and 1.3.



	1994	1996	1998	2000	2002	2004
Succeeded	16%	27%	26%	28%	34%	29%
Failed	31%	40%	28%	23%	15%	18%
Challenged	53%	33%	46%	49%	51%	53%

Figure 1.1: Summary of the CHAOS Study Results (Standish Group 2004)

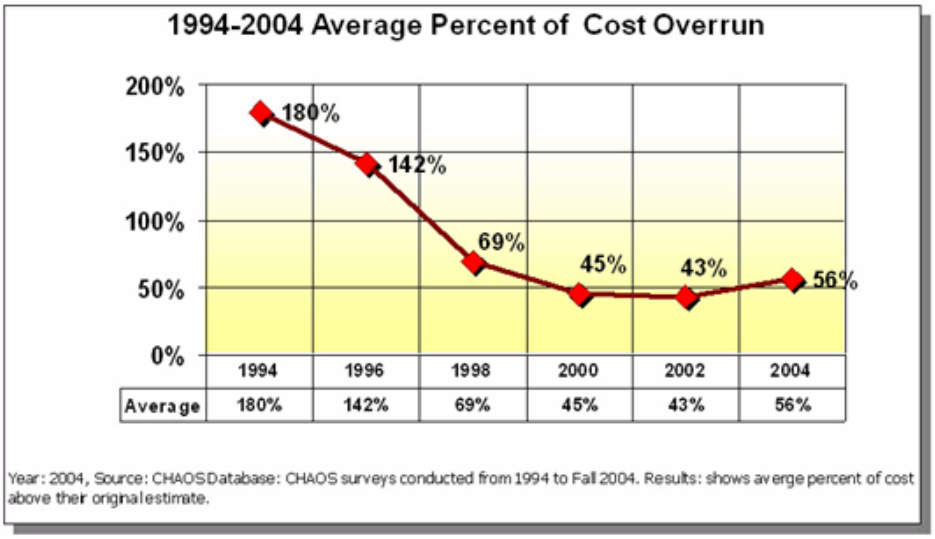


Figure 1.2: 1994-2004 Average Percent of Cost Overrun (Standish Group 2004)

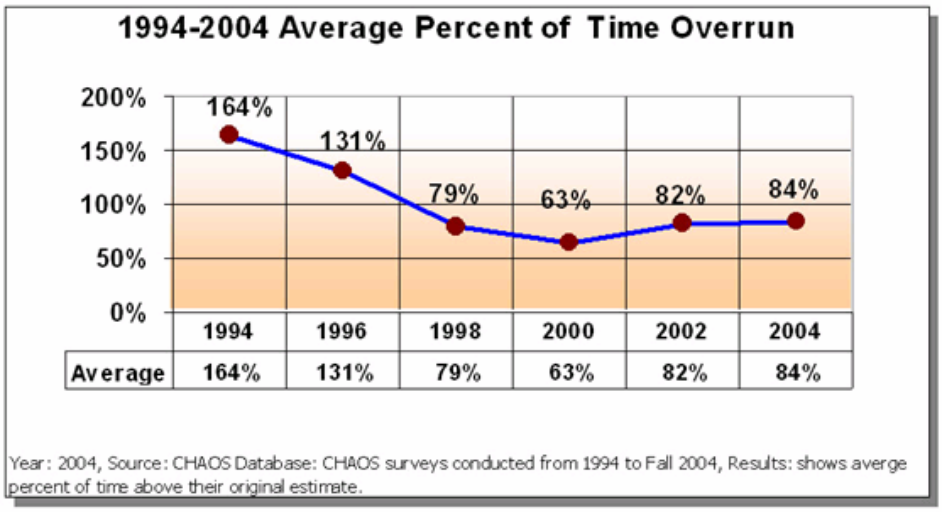


Figure 1.3: 1994-2004 Average Percent of Time Overrun (Standish Group 2004)

The Standish Report presented additional views as to why some projects were successful while others failed. According to the 2006 Report, user involvement, executive management support, and clear business objectives ranked at the top three factors for IT project success. Table 1.1 shows the order of important facts that lead to successful projects.

Table 1.1: Top Ten Reasons for Success (Standish Group 2006)

Rank	Reason
1.	User Involvement
2.	Executive Management Support
3.	Clear Business Objectives
4.	Optimizing Scope
5.	Agile Process
6.	Project Manager Expertise
7.	Financial Management
8.	Skilled Resources
9.	Formal Methodology
10.	Standard Tools and Infrastructure

Based on the top ten reasons provided in the study, we are able to infer the importance of the project management. Project management must be accepted and supported by all levels within the enterprise, such as users, executive managements, and project managers. Moreover, the project management methodology must have a systematic scheme that can define clear business objectives and scopes. Peter F. Drucker, a business thinker, defined "*efficiency is doing things right; effectiveness is doing the right things*". A focus on good project management and methodologies will allow enterprises to do things right and do the right things.

1.1 Risks Associated with Enterprise-Wide IT Projects

What are the reasons IT projects have such a high failure rate? Why are they frequently beset with time and cost overruns? To find the answers, we need to know the risks that enterprises face with IT projects. Wiegers (1998) offered the definition: "*a risk is a problem that could cause some loss or threaten the success of our project, but which has not happened yet*" (Wiegers 1998). Many researches have studied various risks in IT projects and have tried to classify the risks in diverse ways.

An enterprise is typically a widely distributed and a large organization. It faces many changes both inside and outside of the enterprise. As the organization and its technologies change, its system requirements and design must also change. In fast, highly changeable environments, attempts have been made in overcoming the limitations of traditional organizational structures. For example, numerous business process re-engineering (BPR) projects have been undertaken. However, many such projects have been discarded because of the great and unexpected expense in both time and cost. In addition, with many information systems, thee various systems have been built in a non-architected and a non-integrated way for over 20 or 30 years. Many different information systems work within the same enterprise without interacting each other.

Jack Welch, a former CEO of General Electric, created the term "*the Boundaryless Organization*". It means that the organization has to be made permeable. It is a critical condition that the right person has the right information at the right time and the right place. The organization must have “*a boundaryless information flow*” in order to achieve this critical condition (The Open Group 2003).

However, many current information systems have the difficulty in supporting the required information flow for supporting “*the boundaryless organization*”. When organizations consider new information systems projects, they should keep in mind “*the boundaryless organization*” and “*the boundaryless information flow*”. Moreover, their methodologies used with projects should support this way of thinking.

There are several topics that are frequently related to IT project failures, particularly in large systems. Most of these problems have their origins in the topics related to the project lifecycle (Sage 1999). Table 1.2 summarizes some of the risks in enterprise-wide projects.

Table 1.2: Summary of Risk Factors in Enterprise-Wide Projects (Sumner 2000)

Organizational fit	Failure to re-design business processes Failure to follow an enterprise-wide design which supports data integration Lack of data integration and lack of data standardization
Skill mix	Insufficient training and re-skilling Insufficient internal expertise Lack of business analysts with business and technology knowledge Failure to effectively mix internal and external expertise Lack of ability to recruit and retain qualified ERP systems developers
Management structure and strategy	Lack of senior management support Lack of proper management control structure Lack of a champion and Ineffective communications Lack of a change management strategy
Software systems design	Failure to adhere to standardized specifications which the software supports Failure to effectively integrate "add-on" modules Failure to recognize the importance of application-specific knowledge
User involvement and training	Insufficient training of end-users and Ineffective communications Lack of full-time commitment of customers to project management and project activities and Lack of sensitivity to user resistance Failure to emphasize reporting
Technology planning	Inability to avoid technological bottlenecks Lack of an integrated technology strategy to support client-server implementation and attempting to build bridges to legacy applications
Project management	Lack of disciplined, flexible project management Failure to recognize the risk of scope expansion (time and cost)

1.2 Necessity and Purpose of Thesis

When the enterprise environment and the enterprise itself changes, information systems must have the agility to change. To achieve agility, information systems have to be aligned with the enterprise's vision and strategies. These systems must provide “*the boundaryless information flow*”. Non-architected and non-integrated systems cannot accomplish “*the boundaryless information flow*” and cannot survive in globalize and competitive environments.

As we can infer from the survey result of the Standish Group and section 1.1 entitled “Risks Associated with Enterprise-Wide IT Projects”, the major problem of IT projects lies with project management and the relationship between the enterprise goals and software development aspects. For effective management of large enterprise-level projects, the project management requires centralized control and the extensive monitoring. Due to the scope of large enterprises understanding the relationship between business processes, organizational structures, and extensive data integration is a critical factor. This critical factor can be resolve by introducing enterprise architecture and information architecture.

Figure 1.4 illustrates the relationship of the thesis framework components. To launch the rocket (software and information systems), the rocket launcher (project management) controls and monitors the rocket in order to launch right. Two fuel tanks (information architecture and enterprise architecture) support the rocket in order to reach the right destination.

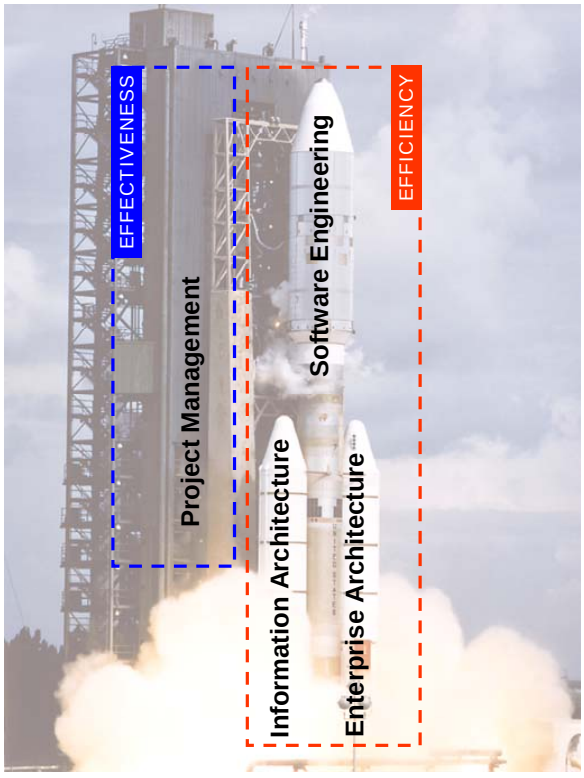


Figure 1.4: Relationship of the Thesis Framework Components (Photo from NASA)

Each methodology of the components provides distinguished optimization for the thesis framework, as depicted in Figure 1.5. The project management methodology (PMM) manages the project itself. The software engineering methodology (SEM) develops the information system itself. The information architecture methodology (IAM) describes information structure itself. The enterprise architecture methodology (EAM) expresses enterprise structure itself. The SEM becomes the connecting portion among them.

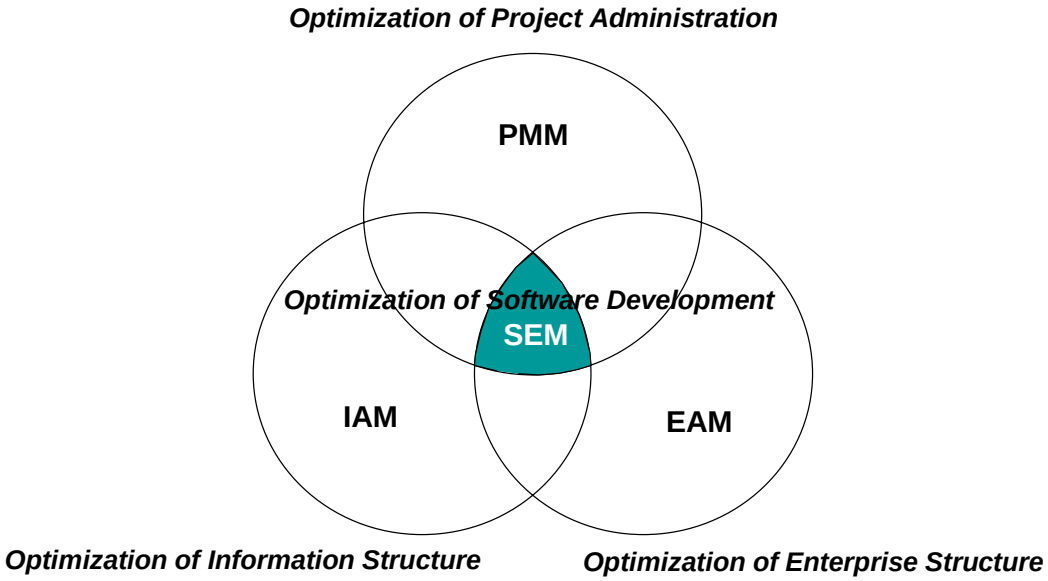


Figure 1.5: Four Optimizations of the Thesis Framework Components

The purpose of this thesis is to present an integrated framework and a methodology, based on project management, software engineering, enterprise architecture, and information architecture. The framework and methodology in this thesis can be adapted for implementing enterprise information systems, such as enterprise portals. Enterprise portals provide a good example for applying the framework and methodology presented in the thesis because enterprise portals need to have the integrated access to information from many different legacy systems. In addition, they need content integration, interface design, and search engine configuration.

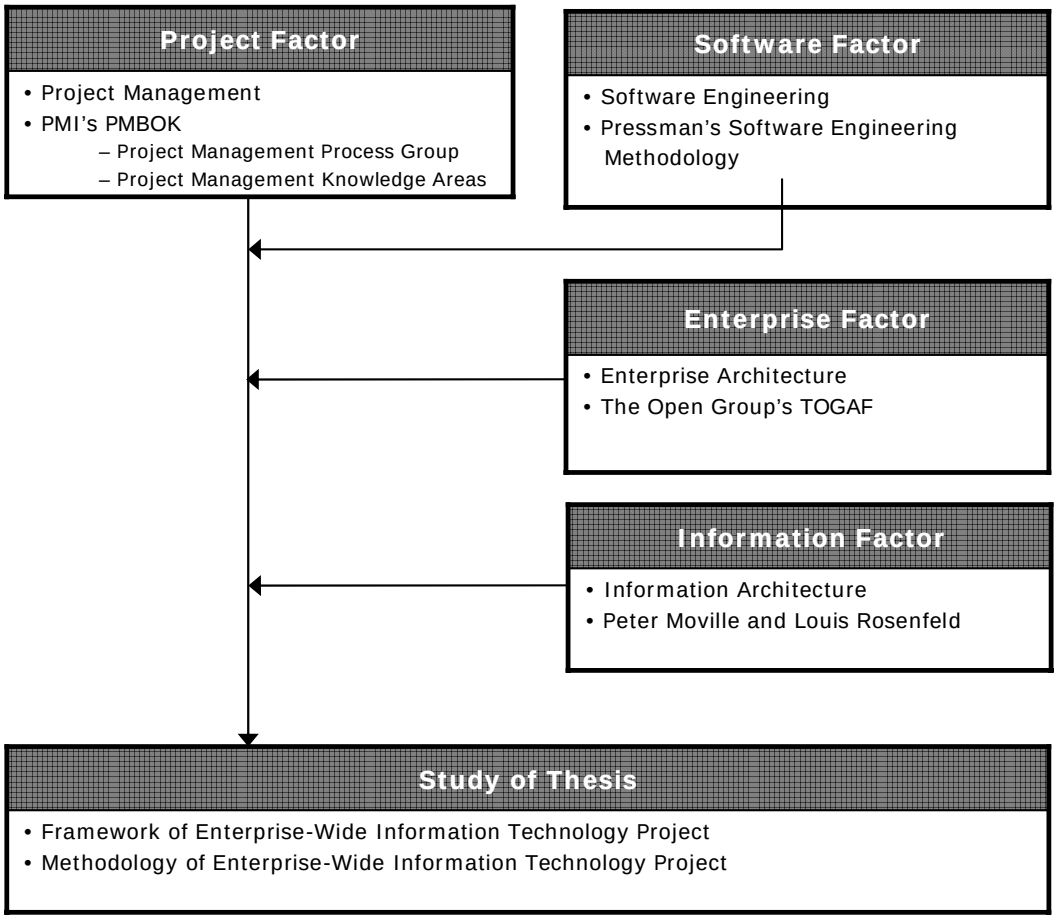


Figure 1.6: Framework of Thesis Study

The first step of this study is the construction of a conceptual framework regarding four factors: project, software, enterprise, and information factors, as illustrated in Figure 1.6. This framework establishes a theoretical foundation of a development framework and methodology.

Based on this framework, a suggested methodology accompanied with processes, inputs, outputs, and tools that can be applied to implement in enterprise-level systems development cases will be presented. Ideally, results could be practically applied to real projects and we could measure the efficiency and the effectiveness of the framework and the methodology, but this is beyond the scope and time constrains of the thesis and remains for future work.

1.3 Outline of Thesis

This thesis has four chapters and two appendixes structured as follows:

- Chapter 1 introduces the survey results and risks related to IT projects. It also presents the necessity and the purpose of the study.
- Chapter 2 reviews the related literature to provide the conceptual foundation for the thesis.
- Chapter 3 presents a framework and the methodology for enterprise-wide IT projects that can be applied to implementing enterprise information systems development.
- Chapter 4 contains the overall conclusions of the thesis with suggested future study.
- Appendix A details the lifecycle processes of PMBOK from Project Management Institute, such as inputs, outputs, and tools & techniques.
- Appendix B describes the Architecture Development Method of TOGAF from The Open Group.

CHAPTER 2 – LITERATURE REVIEW

This chapter reviews the related literature. Definitions of the major terms are reviewed and conceptual foundations of four fields (project management, software engineering, enterprise architecture, and information architecture) are studied.

2.1 Enterprise and Enterprise Portal

2.1.1 Enterprise

The Open Group (2006) defines "*an enterprise is any collection of organizations that has a common set of goals and/or a single bottom line*". A government agency, an entire corporation, or a division of a corporation can be an enterprise (The Open Group 2006).

Nowadays the scope of an enterprise is often extended to include their partners, suppliers, and customers. The enterprise environment and structure has shifted because of many elements, as depicted in Table 2.1.

Table 2.1: The Shifting Paradigm of Enterprise Structure (Targowski 2003)

Element	From	To	Permanency
World Power	Cold War Pax Americana	Single superpower and terrorists Pax Globosus	Dynamic
Enterprise Type	Isolated	Virtual	Temporary
Products Program	Economy of Scale	Economy of Scope	Long-term
Relationship with Suppliers	Disposal	Alliance	Long-term
Market	Domestic	Global/Regional	Long-term
Culture	National	National/Global	Long-term

Targowski (2003) classified the enterprise organization by two criteria: the geographic criterion and the IT criterion. The enterprise organization classified by geographic criterion is summarized in Table 2.2, and that classified by IT criterion is presented in Table 2.3.

Table 2.2: Enterprise Organization Classified by Geographic Criterion (Targowski 2003)

Local Enterprise	Whose area of sales is limited to a given city or region
National Enterprise	Whose area of sales is within national borders, such as Kroger Food
International Enterprise	Having an international division, which manages its operation in selected countries, such as Steelcase
Multidomestic Enterprise (Multinational enterprise)	Allowing each of its foreign country operations to act with some autonomy. For example, by designing and producing in Italy for the Italian market and in South Korea for the South Korean market
Global Enterprise (Multinational enterprise)	Integrating operations that are located in different countries. The development of capabilities and the decisions to disperse them globally are essentially made in the enterprise's home country, such as General Electric and Ford Motor

Table 2.3: Enterprise Organization Classified by IT Criterion (Revised from (Targowski 2003))

Off-line Enterprise	In which data processing operates in a batch mode, not on-line and not in real-time
On-line Enterprise	Which processes information on-line through computer networks
Integrated Enterprise	Which applies a common, enterprise database for the majority of applications
Agile Enterprise	Having capability of rapid adaptation in response to unexpected changes and environment
Informated Enterprise	Which applies knowledge management systems in decision-making
Mobile Enterprise	business applications supported by mobile broadband, such as cellular networks
Virtual Enterprise	Which applies communication technology in connecting different worker locations, when the workers very often operate from their own home, a hotel, a car, or a customer's location.

Organizations worked with stand-alone systems in the past because the structures of the organizations were simple and the technologies used to support their businesses had limitations. As the complexity in business and IT has increased, organizations have needed more advanced systems using improved technologies. This trend has made it difficult for organizations to integrate their information systems.

2.1.2 Enterprise Portal

The term of "*a portal*" has been used to describe the well-known Internet search engines sites that provide users a gateway to access information and data on the Internet. The purpose of a portal is to gather information from different resources and make a single-starting point of access to information. Enterprise portals have developed over time based on business needs and IT capabilities as depicted in Table 2.4.

Enterprise portals enable organizations to access a wide-range of services and content. Through the enterprise portals, organizations are able to integrate their business intelligence, collaboration and communities, content management, and learning considerations (Collins 2003).

Table 2.4: Generations of Enterprise Portals (Brosche 2002)

Generation	Category	Enterprise Portals
First	Referential	Search engine with a hierarchical catalog of Web content. Each catalog entry contains a description of the content object and a link to it.
Second	Personalized	Users create personalized views of the portal contents. Their views show just the categories and applications they are interested in viewing. They can publish documents to the corporate repository for viewing by others as well as subscribe to those documents
Third	Interactive	The portal embeds applications to enhance personal and workgroup productivity. These include e-mail, calendars, workflow, project management, expense reports, travel, monitors of productivity indicators, etc.
Fourth	Specialized	Role-based portals for managing specific corporate functions. This involves integrated enterprise applications with the portal so that users can read/wirte/update corporate data.

Ovum, an analyst and consulting company, has researched the taxonomy of portals with its hierarchy, as illustrated in Figure 2.1.

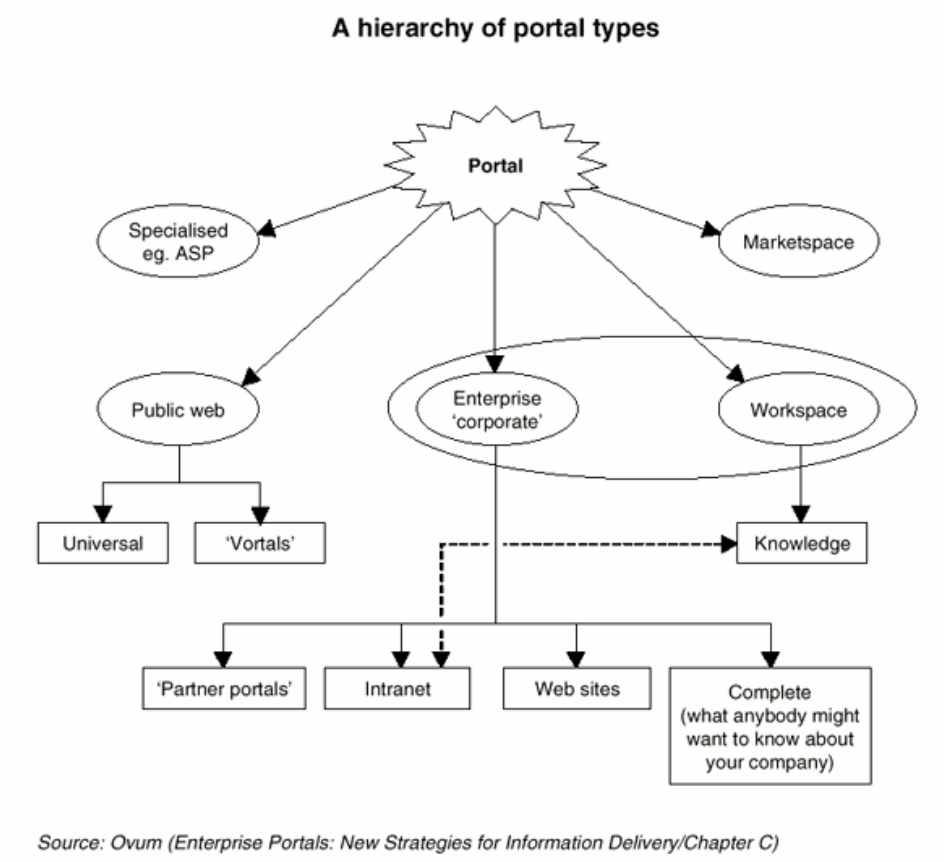


Figure 2.1: Taxonomy of Portals by Ovum

2.2 Project Management and Software Engineering

2.2.1 Project Management

The Project Management Institute (PMI), an international-nonprofit-professional organization, provides well-known definitions of a project and project management. A project is "*a temporary endeavor undertaken to create a unique product, service, or result*". Project management is "*the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations form a project*" (PMI 2004).

Successful project management has to meet the triple constraints (scope, time, and cost) and satisfy the project's sponsors. Balancing these three constraints is the duty of the project manager.

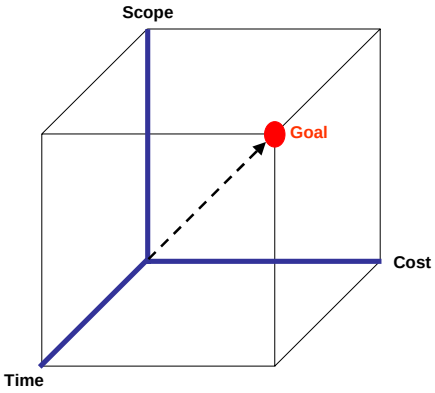


Figure 2.2: Triple Constraints of Project Management

The PMI has provided *The Guide to the Project Management Body of Knowledge* (PMBOK) since 1987. The document has five Project Management Process Groups and nine Project Management Knowledge Areas. The five Process Groups have 44 processes, and each process is connected with each Knowledge Area.

The Project Management Process groups provide logical phases that map out the project lifecycle in order to plan, execute, and control projects, and deliver the project's final product, such as information systems. At each phase, deliverables, such as a project scope statement, project management plan, and final product, are generated, and these deliverables may become inputs for other phases. Figure 2.3 shows the interaction of the five Project Management Process Groups.

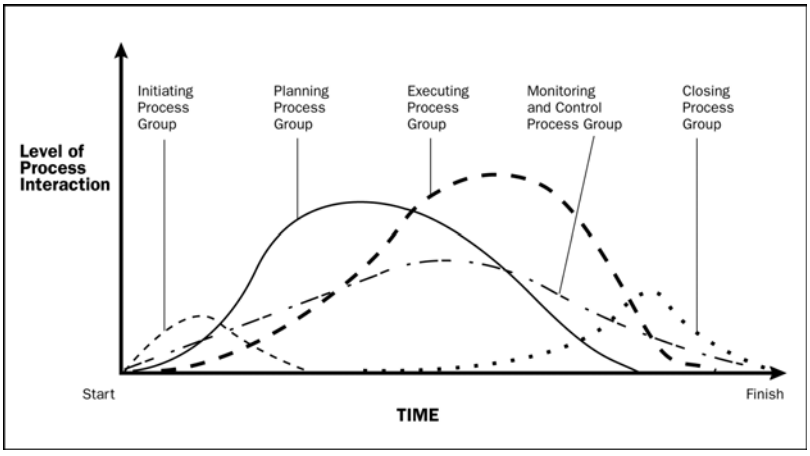


Figure 2.3: Process Groups Interact in a Project (PMI 2004)

The Project Management Knowledge Areas explain the core competencies that project managers must develop. Four core Knowledge Areas (project scope, project time, project cost, and project quality management) lead to specific project objectives. Four facilitating Knowledge Areas (project human resources, project communications, project risk, and project procurement management) are the ways through which the project objectives are reached. One Knowledge Area (project integration management) effects and is effected by other knowledge areas (Schwalbe 2006). Figure 2.4 illustrates the project management framework with the Project Management Knowledge Areas.

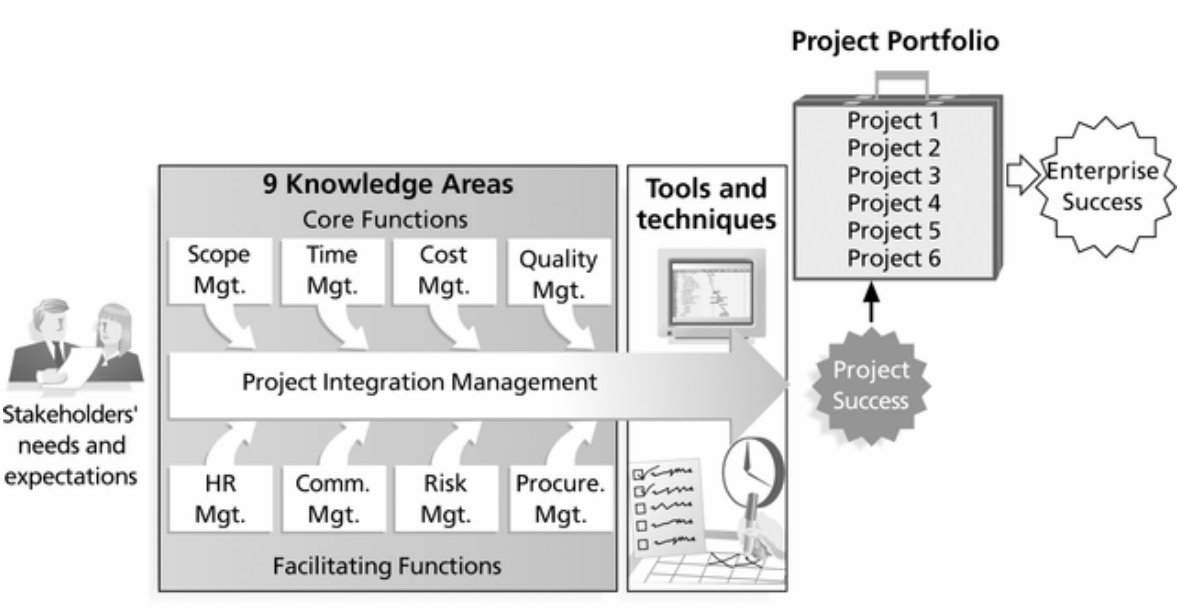


Figure 2.4: Project Management Framework (Schwalbe 2006)

Project management tools and techniques help project managers and project team members in various aspects of project management. For example, project charters, scope statements, and work breakdown structures are used for project scope management. In the case of project time management, Gantt charts, network diagrams, and critical path analyses are provided. Cost estimates and earned value management are suggested for project cost management.

2.2.2 Software Engineering

IT projects follow a project lifecycle that is based in project management practices. Information systems development follows a product lifecycle that is based in software engineering. When organizations introduce their methodologies, they have to consider both the project lifecycle aspect and the product lifecycle aspect.

Software engineering is defined as "*the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software*" (IEEE 1990). Designers of information systems have conventionally adapted software engineering methodologies to develop information systems.

To reduce project cost and risk from the constraint of project time, agile software engineering methodology was developed in the mid 1990s. This methodology emphasizes keeping code clear, testing it frequently, and delivering the software rapidly.

The most popular methodology of agile software engineering methodologies is the *Extreme Programming* (XP), as shown in Figure 2.5. This methodology is based on the consequences of simplicity, feedback, iteration, and communication.

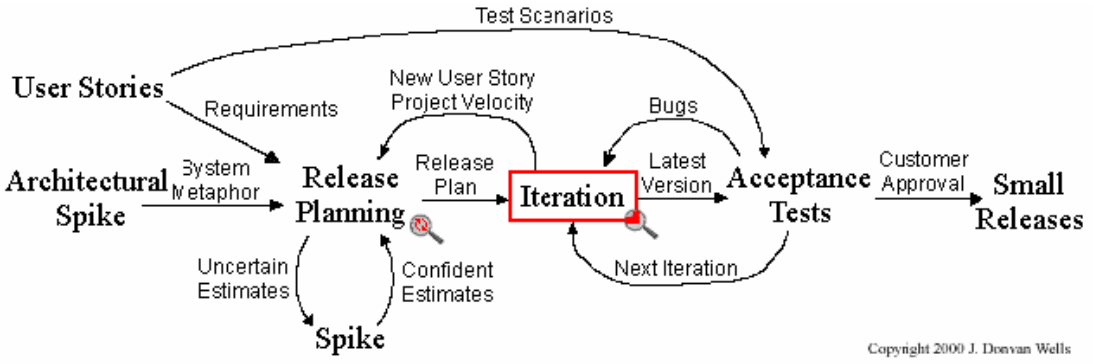


Figure 2.5: Extreme Programming (http://www.extremeprogramming.org/ 2000)

Because many methodologies have been developed, a project team faces the difficult decision of choosing an appropriate methodology. Selecting a methodology is complex since there are many factors to consider, such as time, cost, and requirements of user. Table 2.5 summarizes the selection criteria of a development methodology.

Table 2.5: Criteria for Selecting a Methodology (Alan Dennis, Barbara Haley Wixom et al. 2005)

	Structured Methodologies		RAD Methodologies			Agile Methodology
Ability to Develop Systems	Waterfall	Parallel	Phased	Prototyping	Throwaway Prototyping	XP
with Unclear User Requirements	Poor	Poor	Good	Excellent	Excellent	Excellent
with Unfamiliar Technology	Poor	Poor	Good	Poor	Excellent	Poor
that are Complex	Good	Good	Good	Poor	Excellent	Poor
that are Reliable	Good	Good	Good	Poor	Excellent	Good
with a Short Time Schedule	Poor	Good	Excellent	Excellent	Good	Excellent
with Schedule Visibility	Poor	Poor	Excellent	Excellent	Good	Good

2.2.3 Methodology

Many definitions for “*a methodology*” have been proposed and a methodology is defined by (Wikipedia 2007) as the following: "*the analysis of the principles of methods, rules, and postulates employed by a discipline" or "the development of methods, to be applied within a discipline" or "a particular procedure or set of procedures*" (Wikipedia 2007).

It is important to choose a methodology that is flexible, and a methodology that is able to be updated as needed, integrates into the current standard tools, and can be tailored to specific projects (Reiners 2003).

According to Ray (2003), the purpose of a methodology is to present a guideline for the qualified systems development within cost constraints of a complex business. Many methodologies for the development of information systems have been proposed by consulting companies, such as Accenture, Gartner Group, and PriceWaterhouse Coopers (Ray 2003).

Methodologies are composed of model, process, techniques and notations, and tools.

Model: A model represents a conceptual framework that depicts the relationships between varieties of conceptual elements in a system. A model can be described in verbal, mathematical, and graphical formats.

Process: A process is a set of sequential steps to perform a business, economic, or social task. In case of information systems development, the steps of the Standard Development Life Cycle (SDLC), the waterfall, the spiral, the Rapid Application Development (RAD), and the Rational Unified Process (RUP) are processes.

Techniques and Notations: Techniques and notations assist in clarifying requirements and facilitating inputs from stakeholders. They are typically described in graphic or verbal formats.

Tools: Tools assist in automating the usages of the techniques. These tools are very important in supporting the design and documentation of information systems.

2.3 Enterprise Architecture

Organizations have adopted enterprise architecture (EA) as a method to align their business strategies and processes with their IT strategies and information systems.

The field of EA has been developing continuously and many definitions of EA are presented. The popular definition of "*enterprise architecture*" is:

"*Enterprise architecture is the process of translating business vision and strategy into effective enterprise change by creating, communicating and improving the key principles and models that describe the enterprise's future state and enable its evolution. The scope of the enterprise architecture includes the people, processes, information and technology of the enterprise, and their relationships to one another and to the external environment. Enterprise architects compose holistic solutions that address the business challenges of the enterprise, and support the governance needed to implement them*" (Gartner 2006).

Enterprise architectures have been developed by non-profit, commercial, and Federal organizations. The Open Group Architecture Framework (TOGAF) used in this study is one of many architectures and architecture frameworks. Major developments of EA are shown in Figure 2.6.

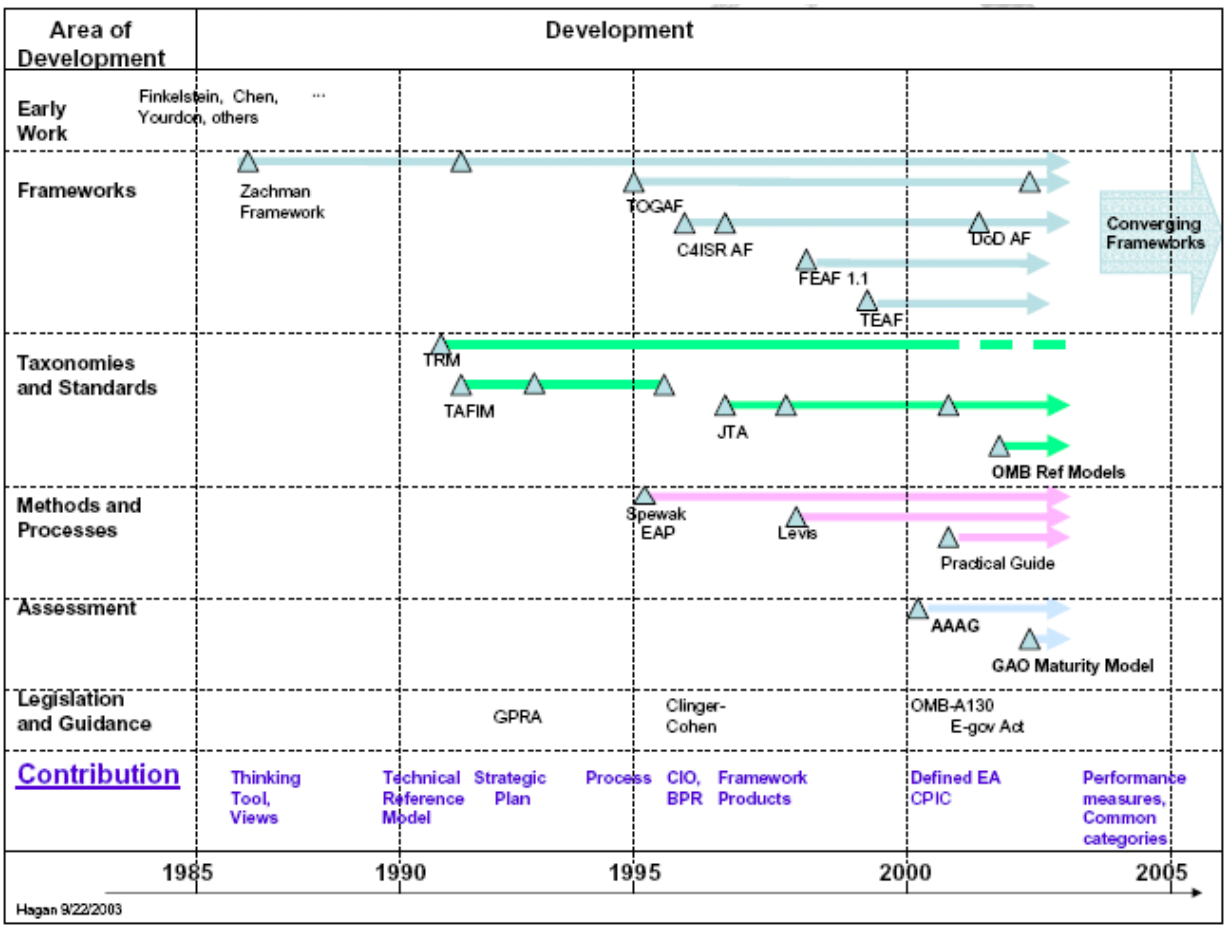


Figure 2.6: Major Developments in the History of EA (MITRE 2004)

In 1987, John A. Zachman presented his EA framework as a pioneer. His framework is depicted in Figure 2.7. The six columns of the framework arrange architecture information into Data, Function, Network, People, Time, and Motivation categories. The five rows of the framework arrange architecture information into Scope, Enterprise Model, System Model, Technology Constrained Model, and Detailed Representations categories.

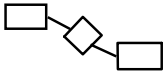
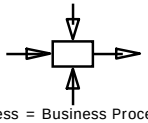
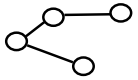
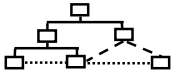
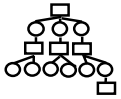
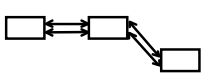
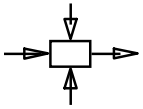
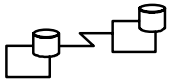
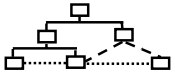
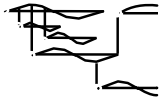
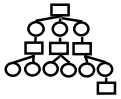
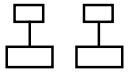
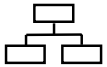
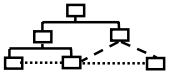
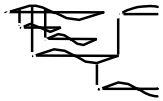
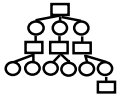
Perspectives \ Abstractions	DATA *What*	FUNCTION *How*	NETWORK *Where*	PEOPLE *Who*	TIME *When*	MOTIVATION *Why*
SCOPE ***Planner*** contextual	List of Things - *Important to the Business*  Entity = Class of Business Thing	List of Processes - *the Business Performs*  Function = Class of Business Process	List of Locations - *in which the Business Operates*  Node = Major Business Location	List of Organizations - *Important to the Business*  People = Class of People and Major Organizations	List of Events - *Significant to the Business*  Time = Major Business Event	List of Business Goals and Strategies  Ends/Means=Major Business Goal/Critical Success Factor
BUSINESS MODEL ***Owner*** conceptual	e.g., Semantic Model  Entity = Business Entity Rel. = Business Relationship	e.g., Business Process Model  Process = Business Process I/O = Business Resources	e.g., Logistics Network  Node = Business Location Link = Business Linkage	e.g., Work Flow Model  People = Organization Unit Work = Work Product	e.g., Master Schedule  Time = Business Event Cycle = Business Cycle	e.g., Business Plan  End = Business Objective Means = Business Strategy
SYSTEM MODEL ***Designer*** logical	e.g., Logical Data Model  Entity = Data Entity Rel. = Data Relationship	e.g., Application Architecture  Process.= Application Function I/O = User Views	e.g., Distributed System Architecture  Node = IS Function Link = Line Characteristics	e.g., Human Interface Architecture  People = Role Work = Deliverable	e.g., Processing Structure  Time = System Event Cycle = Processing Cycle	e.g., Business Rule Model  End = Structural Assertion Means =Action Assertion
TECHNOLOGY MODEL ***Builder*** physical	e.g., Physical Data Model  Entity = Tables/Segments/etc. Rel. = Key/Pointer/etc.	e.g., System Design  Process= Computer Function I/O =Data Elements/Sets	e.g., Technical Architecture  Node = Hardware/System Software Link = Line Specifications	e.g., Presentation Architecture  People = User Work = Screen/Device Format	e.g., Control Structure  Time = Execute Cycle = Component Cycle	e.g., Rule Design  End = Condition Means = Action
DETAILED REPRESEN-TATIONS ***Subcontractor*** out-of-context	e.g. Data Definition  Entity = Field Rel. = Address	e.g. Program  Process= Language Statement I/O = Control Block	e.g. Network Architecture  Node = Addresses Link = Protocols	e.g. Security Architecture  People = Identity Work = Job	e.g. Timing Definition  Time = Interrupt Cycle = Machine Cycle	e.g. Rule Specification  End = Sub-condition Means = Step
FUNCTIONING ENTERPRISE	**DATA**	**FUNCTION**	**NETWORK**	**ORGANIZATION**	**SCHEDULE**	**STRATEGY**

Figure 2.7: Zachman Framework for Enterprise Architecture (Zachman 2003)

2.4 Information Architecture

Definitions of "*Information Architecture*" (IA) are various from the general meaning to the mixed meaning with other areas. Morville and Rosenfeld (2007) defined various definitions as the following:

- "*The structural design of shared information environments*"
- "*The combination of organization, labeling, search, and navigation systems within web sites and intranets*"
- "*The art and science of shaping information products and experiences to support usability and findability*"
- "*An emerging discipline and community of practice focused on bringing principles of design and architecture to the digital landscape*" (Peter Morville and Rosenfeld 2007).

The scope and definition of IA becomes ambiguous among the web design communities because of the necessity of finding a way of accessing digital information (Andrew Dillon and Turnbull 2005). Figure 2.8 illustrates the correlation of IA among the web design fields.

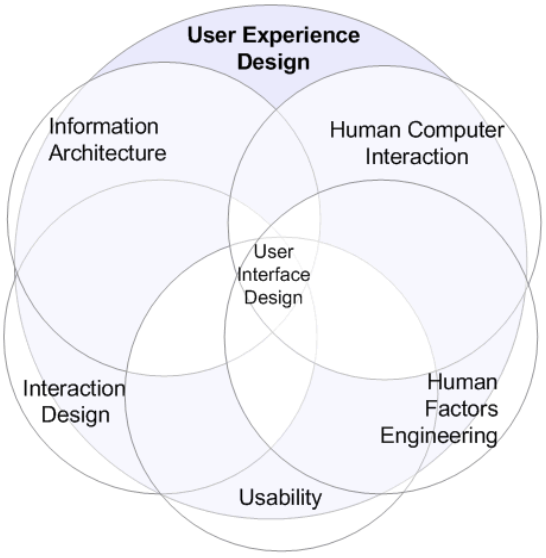


Figure 2.8: Correlation of Information Architecture among the Web Design Fields (Paluch 2006)

Morville and Rosenfeld (2007) suggest context, content, and users as the foundation of information architecture design. Figure 2.9 shows the interdependent characteristic and the relationship of users, content, and context. To design effective information architecture, information architects have to understand these three areas.

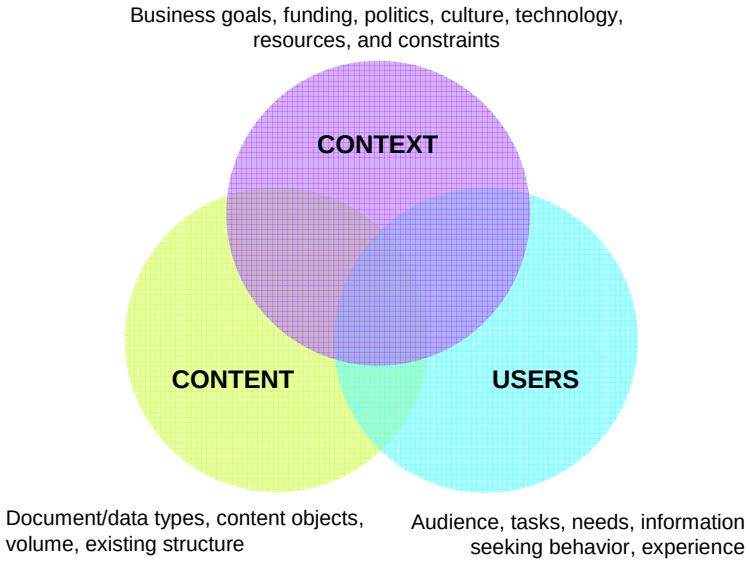


Figure 2.9: The Three Circles of Information Architecture (Peter Morville and Rosenfeld 2007)

Some basic terms of the information architecture field can be described as follows:

Context: A web site and an intranet of an enterprise are located within a business context. An enterprise has visions, objectives, and strategies. Understanding these elements of business is an essential to design effectively.

Content: Content is data and information that users of the web sites and the intranets need to use. Metadata, services, and documents are the content.

Users: Information architects have to understand the demographics, the preference, and the behavior of users. User research and analysis should be completed during the analysis phase of projects.

It is important to visualize information architecture because that gives stakeholders a conceptual understanding. Morville and Rosenfeld (2007) describe four categories as the bases of visualizing information architecture.

Organization systems: Methods to categorize information on the web sites and the intranets, such as by subject or chronology

Navigation systems: Approaches to browse through the content, such as clicking through a hierarchy and A to Z Directory (see Figure 2.10)

Search systems: Ways to find information, such as executing a search query (see Figure 2.11)

Labeling systems: Methods to represent information and describing categories and links in words for user

Figure 2.12 provides a visualization of these architectural components for the Graduate School web site in The University of Georgia.

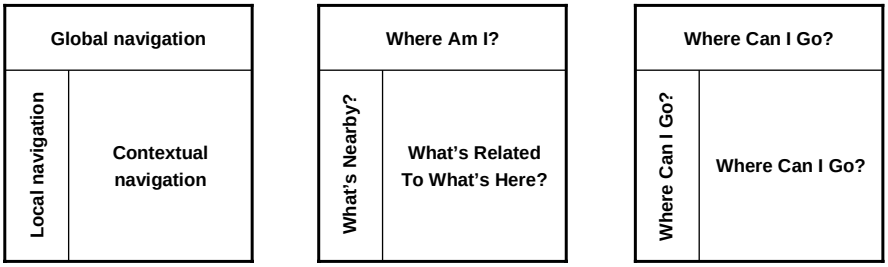


Figure 2.10: Global, Local, and Contextual Embedded Navigation Systems (Peter Morville and Rosenfeld 2007)

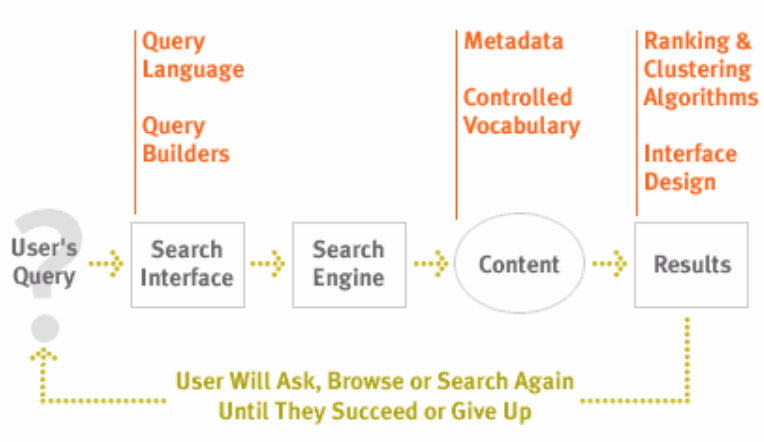


Figure 2.11: The Basic Anatomy of a Search System (Morville 2001)

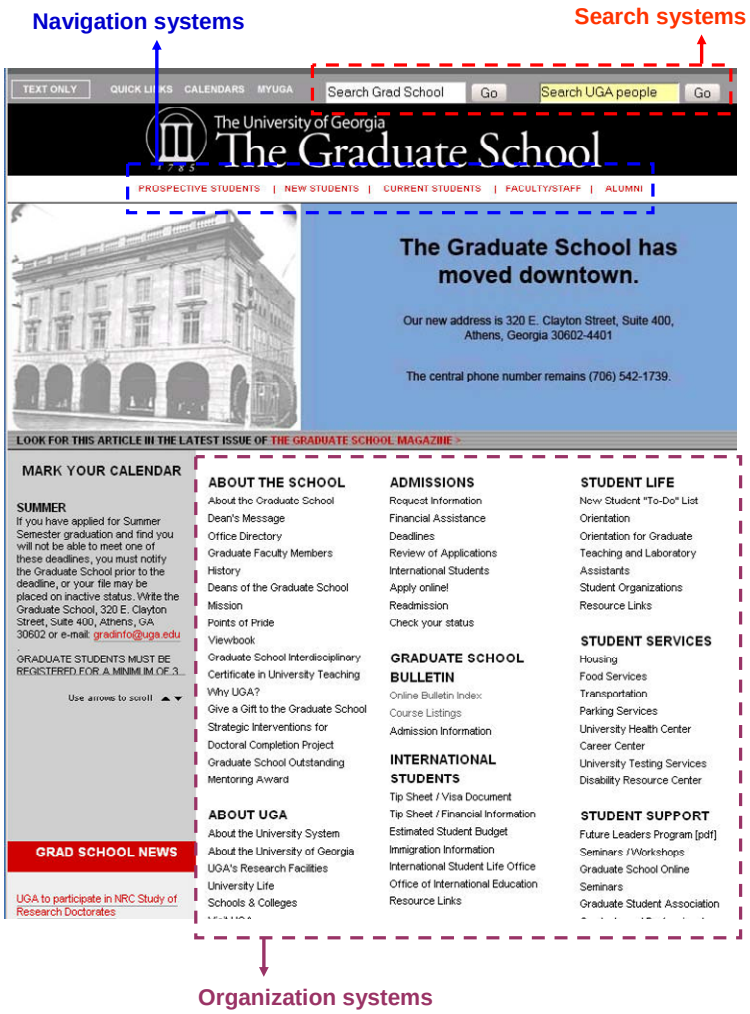


Figure 2.12: UGA Graduate School Website with Architectural Components

CHAPTER 3 – ENTERPRISE-WIDE INFORMATION TECHNOLOGY PROJECT FRAMEWORK AND METHODOLOGY

This chapter describes the framework and the methodology for IT projects on the enterprise-level. Lots of IT development methodologies have been suggested so far, but most of them focus on developing products themselves. When organizations introduce the existing IT methodologies, they have to consider whether the methodologies fit within a project management methodology. If the projects' scopes cover an entire enterprise, enterprise architecture and information architecture will be essential parts for the projects. Through these two architectures (enterprise architecture and information architecture), organizations will have more opportunities for competitive advantage as the efficiency and the effectiveness increase of information systems.

The primary objective of this study is to advocate the integration of enterprise architecture (EA) and information architecture (IA) into software engineering (SE) with project management (PM). The integration of these four fields is the most important component that distinguishes this thesis from other types of IT project methodologies.

3.1 Framework of Methodology

The framework in this thesis presents a big picture for the project teams that implement the project. The methodologies of the framework provide detailed steps for information systems implementation. Each methodology has its inputs and outputs. Outputs of one methodology become inputs of other methodologies.

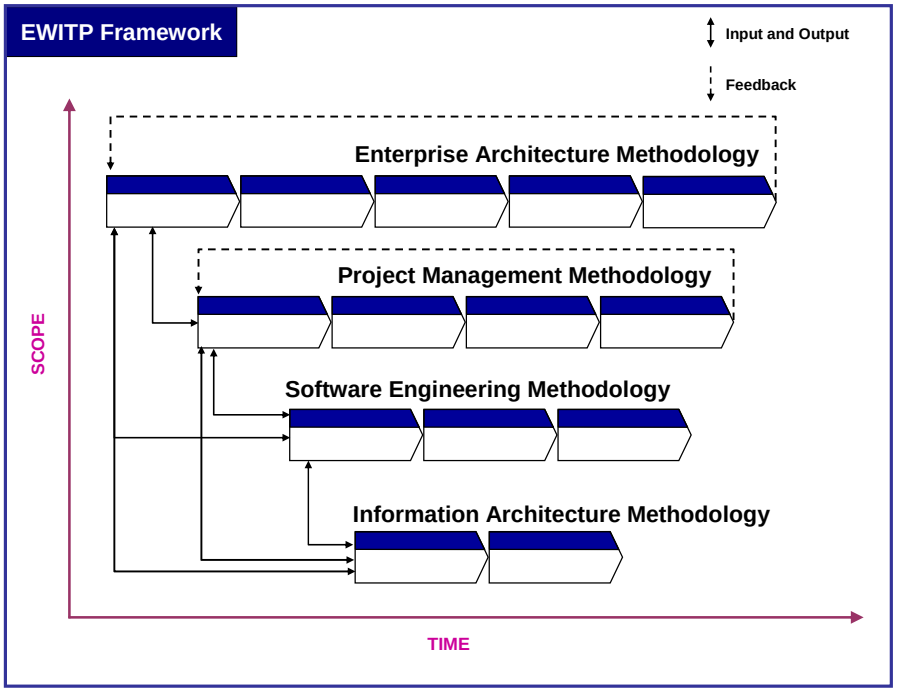


Figure 3.1: Relationship between the Framework and the Methodology

As illustrated in Figure 3.1, the four methodologies (enterprise architecture methodology, project management methodology, software engineering methodology, and information architecture methodology) are tremendously interdependent and their relationships are important extremely. To reduce risks of the information technology project on the enterprise-level, an organization should keep these four methodologies together.

As depicted in Figure 3.2, the SE methodology is a part of the PM methodology because most of the activities for building the information systems happen at the planning, executing, and monitoring & controlling processes of the PM methodology. The first and last processes of the PM methodology (initiating and closing processes) take place before and after the information systems development. The IA methodology is a part of the SE methodology. The activities of the IA methodology occur during the analysis and architecting phase on the SE methodology. The outputs of the EA methodology become inputs of the SE methodology and the PM methodology.

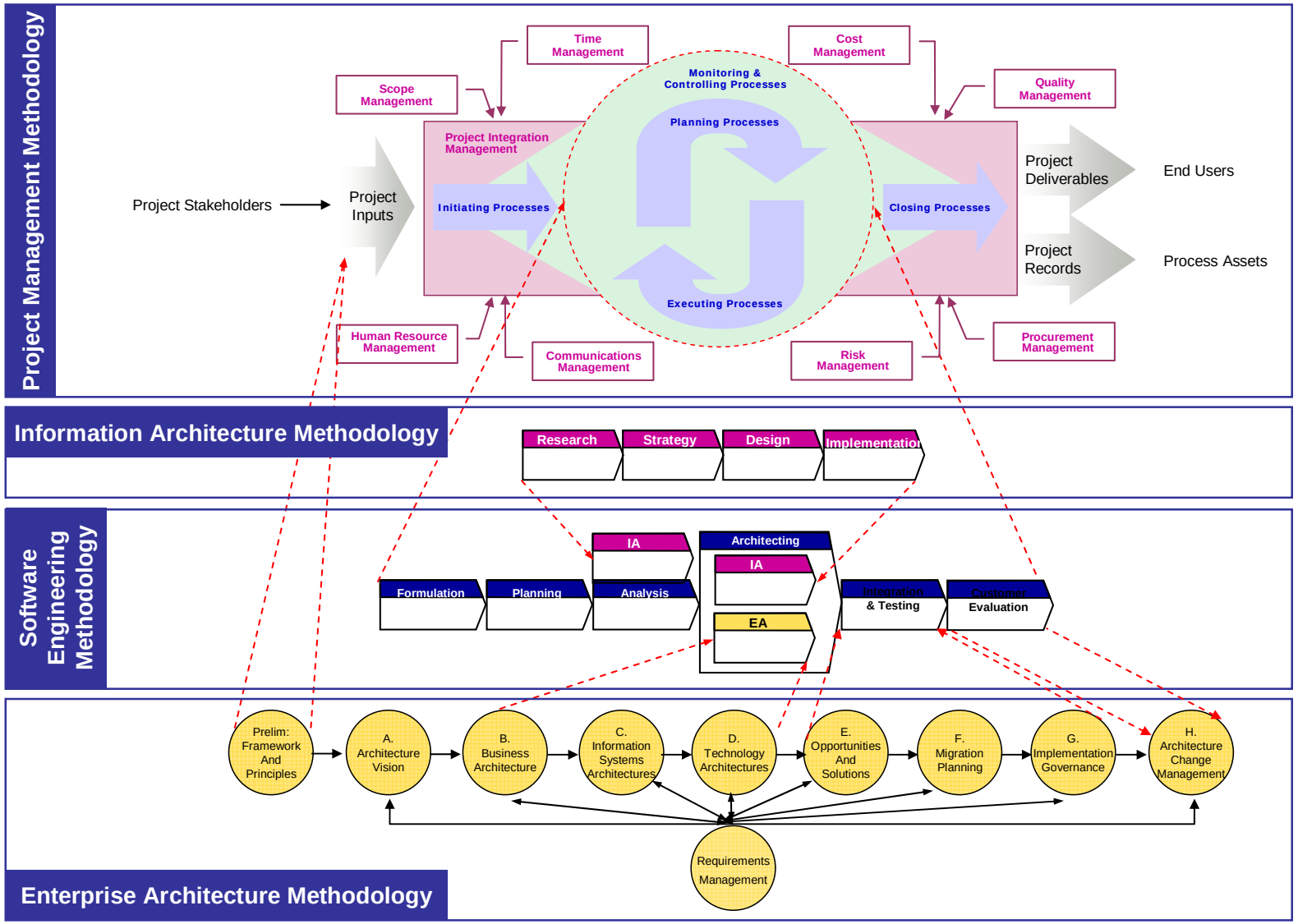


Figure 3.2: Detailed Relationship between the Framework and the Methodology

Project stakeholders are individuals and organizations involved in or affected by the project. Project sponsors, project managers, project teams, support staffs, users, and opponents of the project are the stakeholders. These stakeholders have their own roles at same or different processes on the project. Figure 3.3 and 3.4 show the list of stakeholders and their participation and role on project processes.

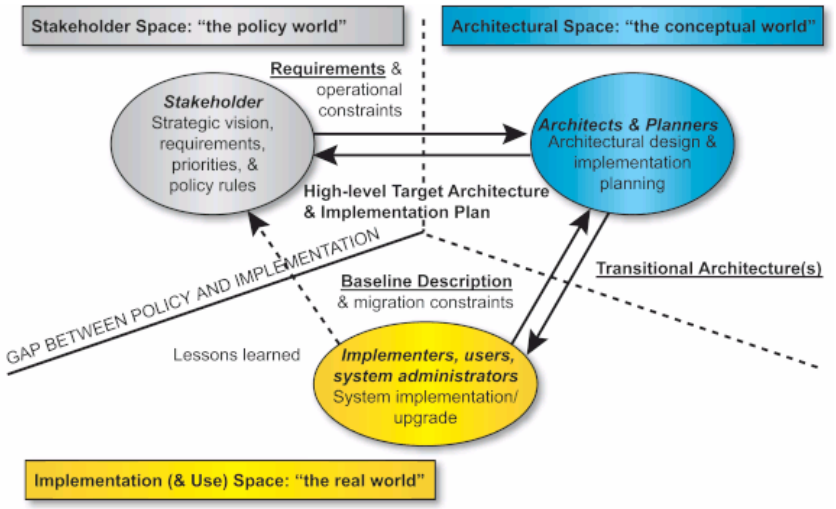


Figure 3.3: Role of Architects vis-à-vis the Stakeholders and Implementers on Enterprise Architecture Methodology (The Open Group 2003)

	Initiating	Planning	Executing	Monitoring & Controlling	Closing
Project Manager					
Enterprise Architect					
Information Architect					
Business Owner / Project Sponsor					
End User					
Business Analyst					
Software Engineers and Programmers					
Database Designer and Administrator, System Engineers					
User Interface Designer and developer					
Graphic designer, content manager, usability engineer					

Figure 3.4: Stakeholders and their Participation on the Methodology

3.2 Elements of Framework

3.2.1 Project Management Methodology

The project management methodology in this thesis is based on the five Project Management Process Groups and the nine Project Management Knowledge Areas of *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* from the Project Management Institute (PMI), an organization of project management professionalism.

The PMBOK Guide is generally accepted as describing the best practices on a wide-range of projects, from building construction to software development. Therefore, not all of the processes will apply in the same way on each and every project. Project managers and their team members have to decide which processes from the Process Groups will be applied to reach their project goals.

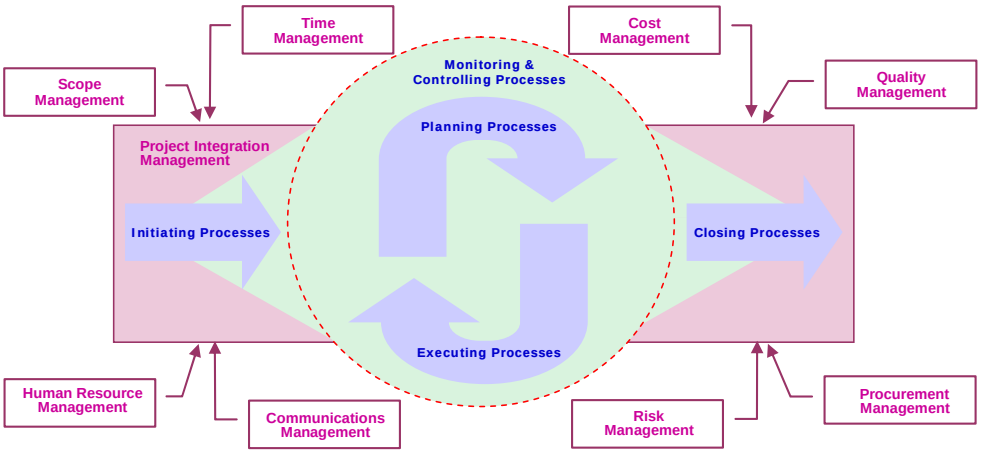


Figure 3.5: Project Management Process Groups and Knowledge Areas

Project Management Process Groups

The Project Management Process Group is composed of five groups: initiating process group, planning process group, executing process group, monitoring and controlling process group, and closing process group. These processes cooperate with each other throughout a project. Inputs (documents, plans, and designs), tools and techniques (mechanisms applied to inputs), and outputs (documents and products) illustrate these processes.

Phase 1 - Initiating Process Group:

The Initiating Process Group is composed of the processes that assist the definition and the authorization of starting a new project. Before beginning the Initiation Process Group activities, business needs and requirements of the organization are documented from the enterprise architecture. In the case of an enterprise portal, before developing an enterprise portal, understanding all business and technical issues are critical because of its inherent complexity.

Phase 2 - Planning Process Group:

The Planning Process Group is used to identify, define, and refine the objectives and plans of the project. This Process Group collects information from various sources and develops the project management plan. Moreover, this group defines the project scope, project cost, and project schedule. If important changes happen throughout the project, the project management team has to revisit this planning process group.

Phase 3 - Executing Process Group:

The Executing Process Group is composed of the processes in order to integrate people and other resources to perform the project management plan. The project team must decide which processes are involved for the team’s detailed project. Moreover, this group addresses the scope described in the project scope statement and executes consented changes.

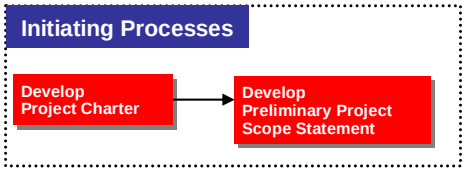


Figure 3.6: Initiating Process Group (PMI 2004)

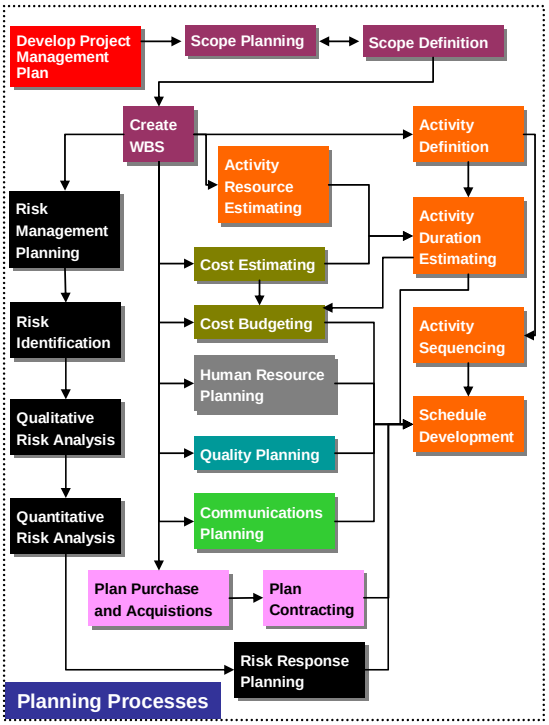


Figure 3.7: Planning Process Group (PMI 2004)

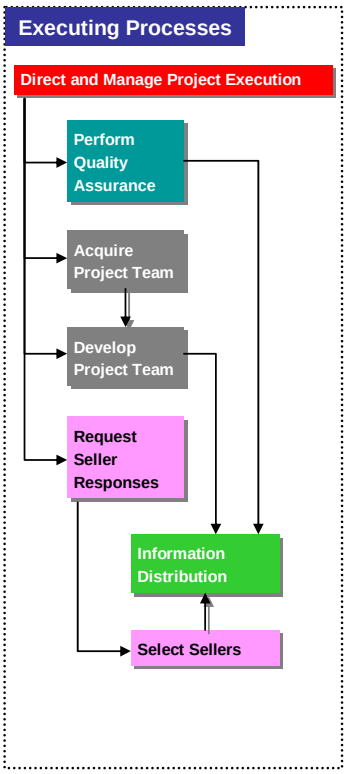


Figure 3.8: Executing Process Group (PMI 2004)

Phase 4 - Monitoring and Controlling Process Group:

The Monitoring and Controlling Process Group is composed of processes that measure and monitor the performance of the project management plan in order to identify present and potential problems. The project team has to decide which processes are involved for the team's detailed project.

Phase 5 - Closing Process Group:

The Closing Process Group consists of the processes that officially finish all activities of the project and deliver the completed product to a project sponsor. This group confirms that all defined processes are finished within all the Project Management Process Groups in order to complete the project.

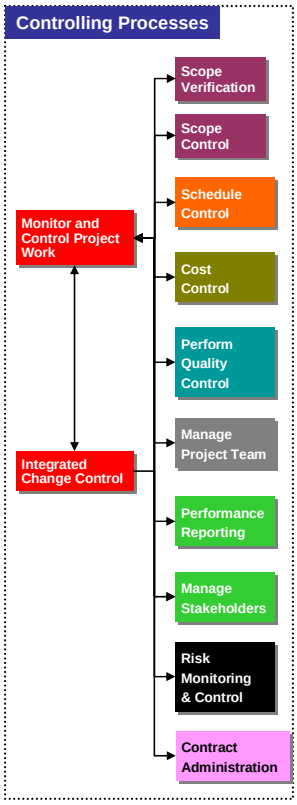


Figure 3.9: Monitoring and Controlling Process Group (PMI 2004)

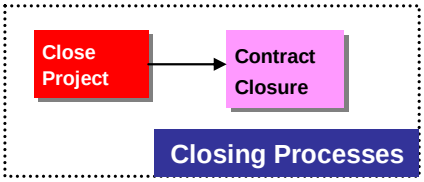


Figure 3.10: Closing Process Group (PMI 2004)

Figure 3.11 illustrates the general summary of the interactions among the five Project Management Process Groups. Each Process Group describes and constrains how its inputs are used to generate its outputs for that Process Group.

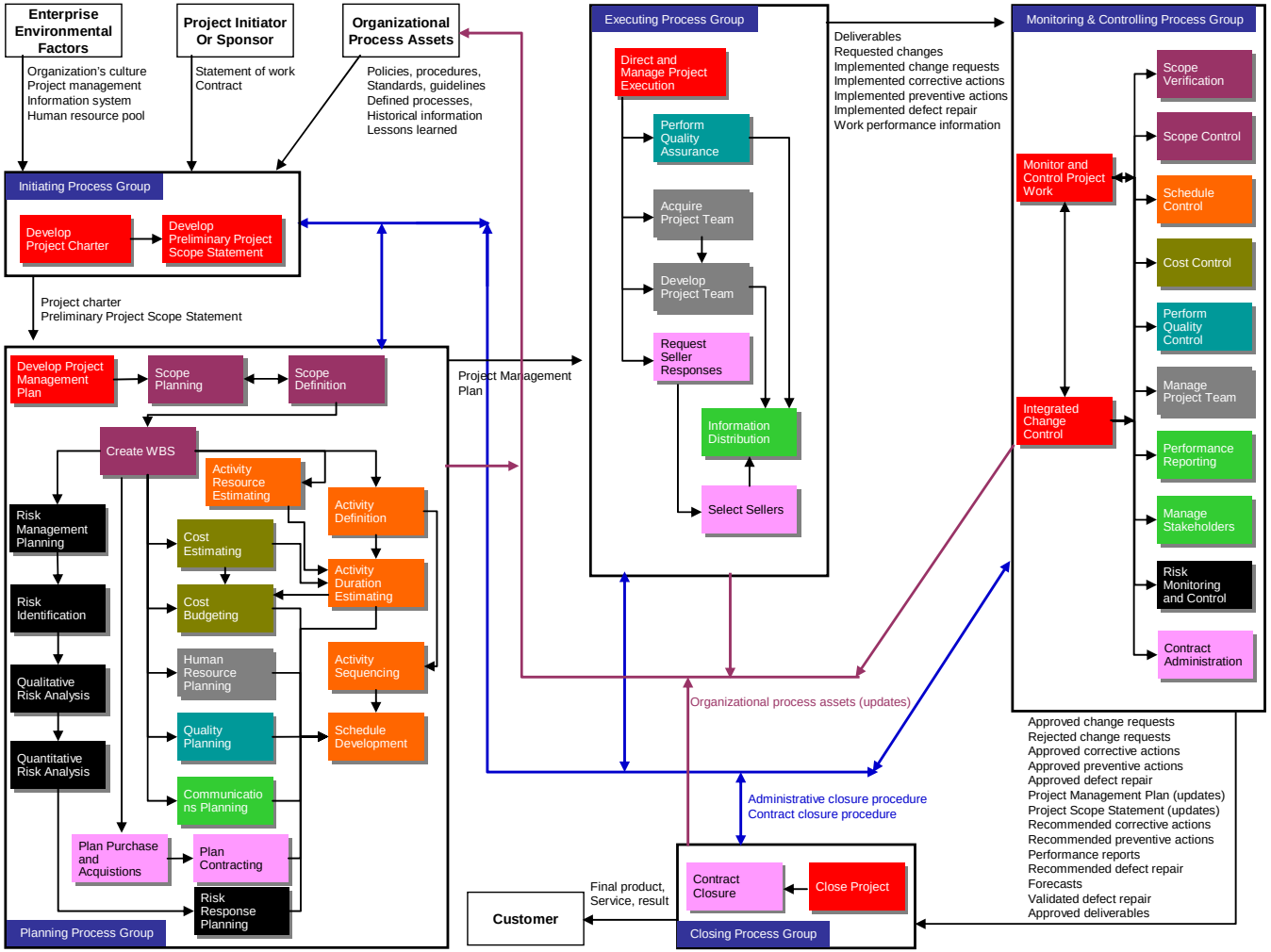


Figure 3.11: High Level Summary of Process Groups' Interactions (Revised from (PMI 2004))

Project Management Knowledge Areas

A Guide to the Project Management Body of Knowledge describes nine knowledge areas that organize the 44 project management processes from the Project Management Process Groups for supporting the project management. The nine knowledge areas are described as the following:

- *Project Integration Management*: depicting the processes and activities that combine the diverse factors of the project management, such as defining, uniting and coordinating activities within the Process Groups (Figure 3.12)
- *Project Scope Management*: supporting the processes and activities concerning the scope that contains all required work (Figure 3.13)
- *Project Time Management*: illustrating the processes and activities involved in the project completion on time (Figure 3.14)
- *Project Cost Management*: describing the processes and activities concerning the cost activities in order to finish the project within the authorized budget (Figure 3.15)
- *Project Quality Management*: explaining the processes and activities concerning the guarantee that is satisfied the project's objectives (Figure 3.16)
- *Project Human Resource Management*: depicting the processes and activities involved in managing and organizing the project team (Figure 3.17)
- *Project Communication Management*: supporting the processes and activities involved in production and distribution of project information (Figure 3.18)
- *Project Risk Management*: illustrating the processes and activities managing risk on the project (Figure 3.19)
- *Project Procurement Management*: describing the processes and activities involved in the acquisition of products and results on the project (Figure 3.20)

These nine knowledge areas are illustrated in Figure 3.12 to Figure 3.20.

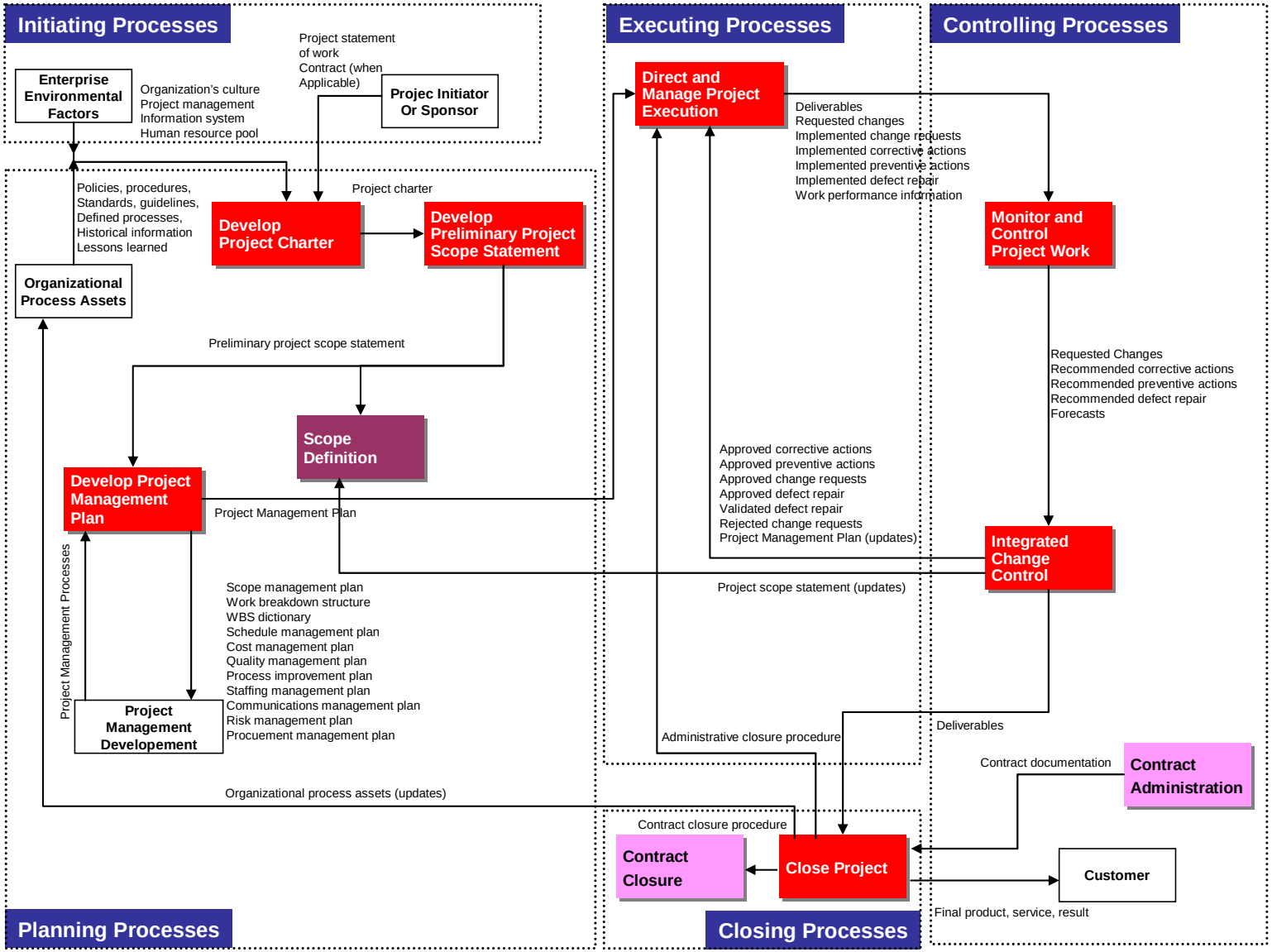


Figure 3.12: Project Integration Management Processes Flow Diagram (Revised from (PMI 2004))

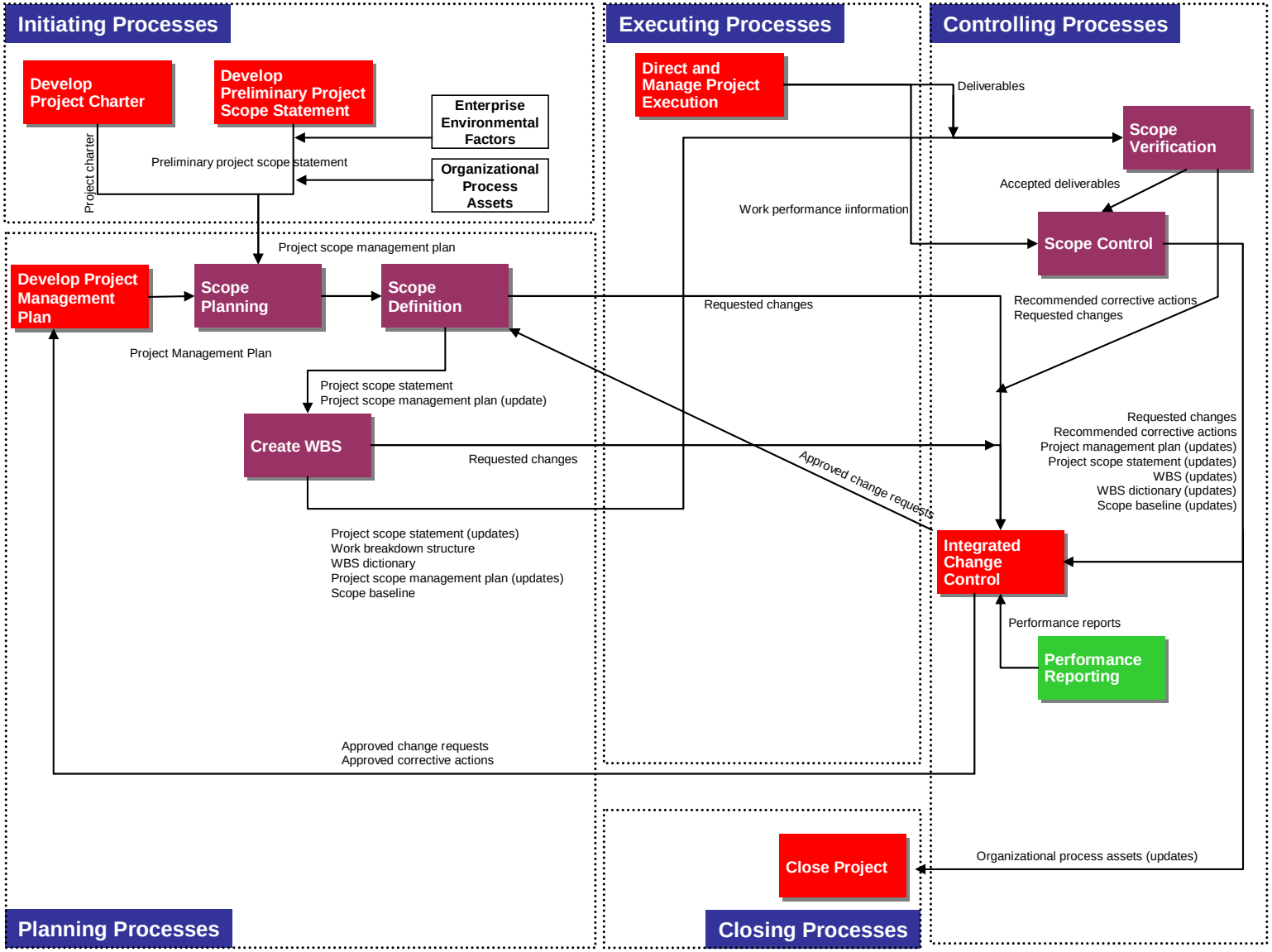


Figure 3.13: Project Scope Management Process Flow Diagram (Revised from (PMI 2004))

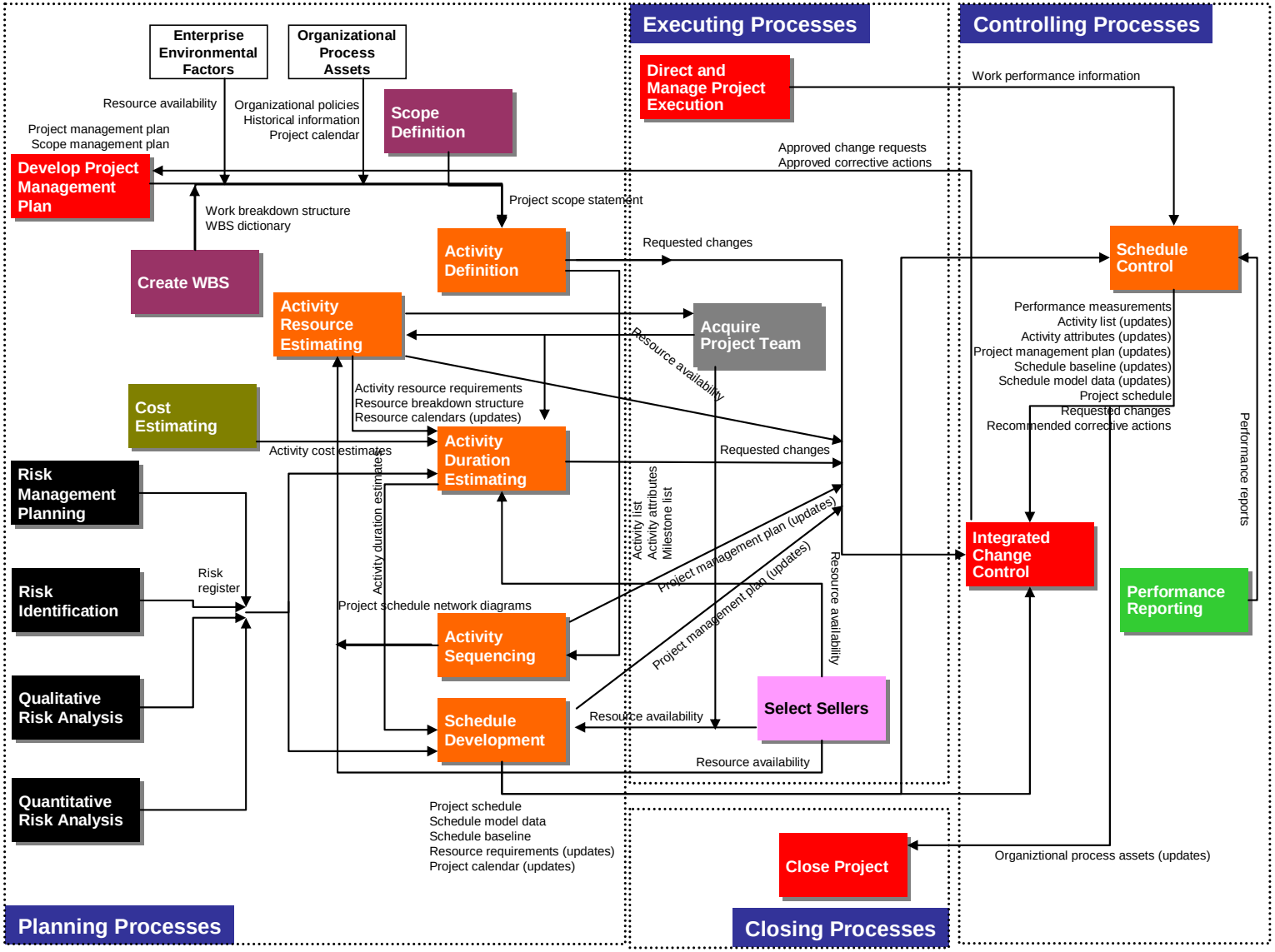


Figure 3.14: Project Time Management Process Flow Diagram (Revised from (PMI 2004))

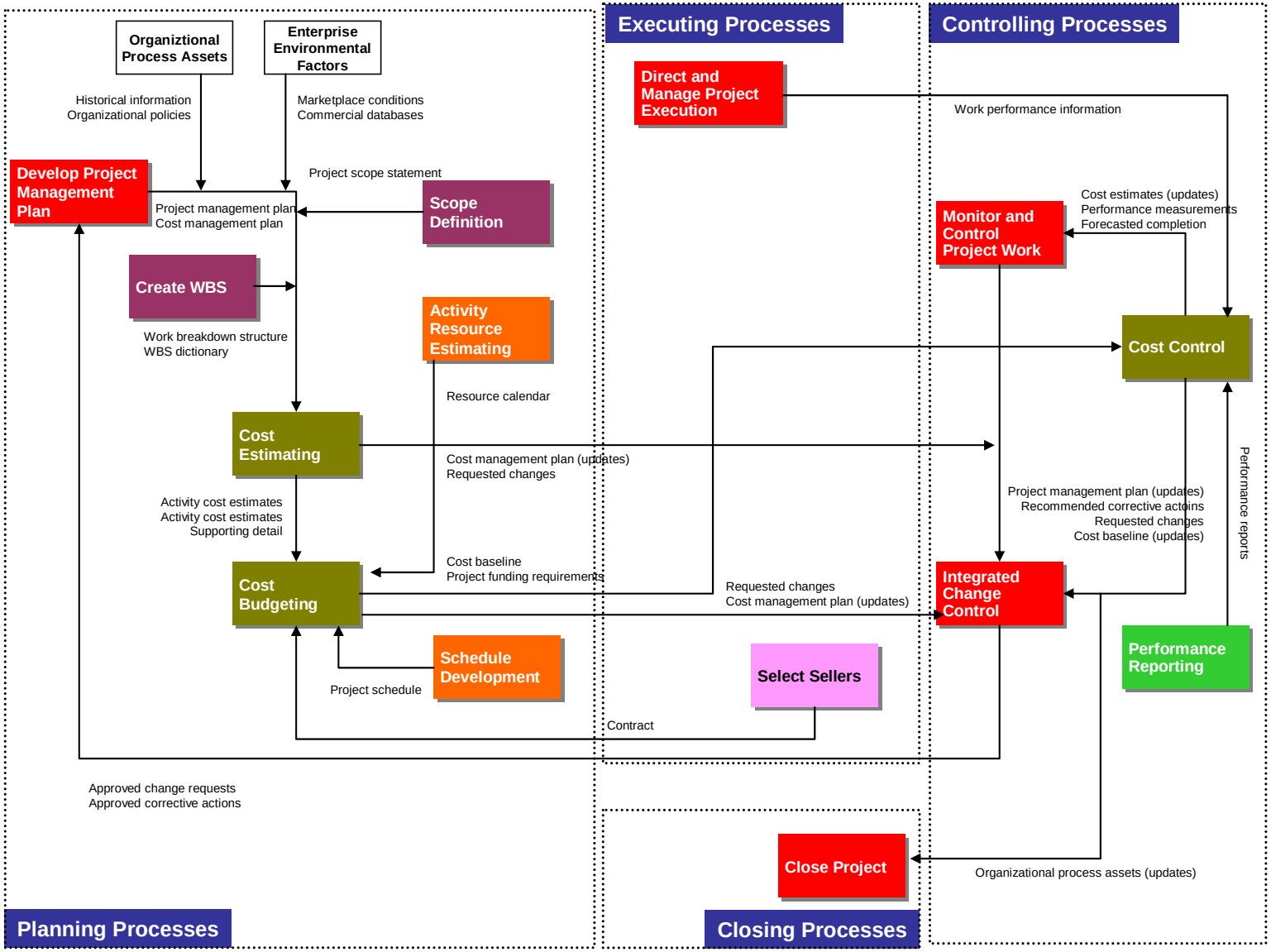


Figure 3.15: Project Cost Management Process Flow Diagram (Revised from (PMI 2004))

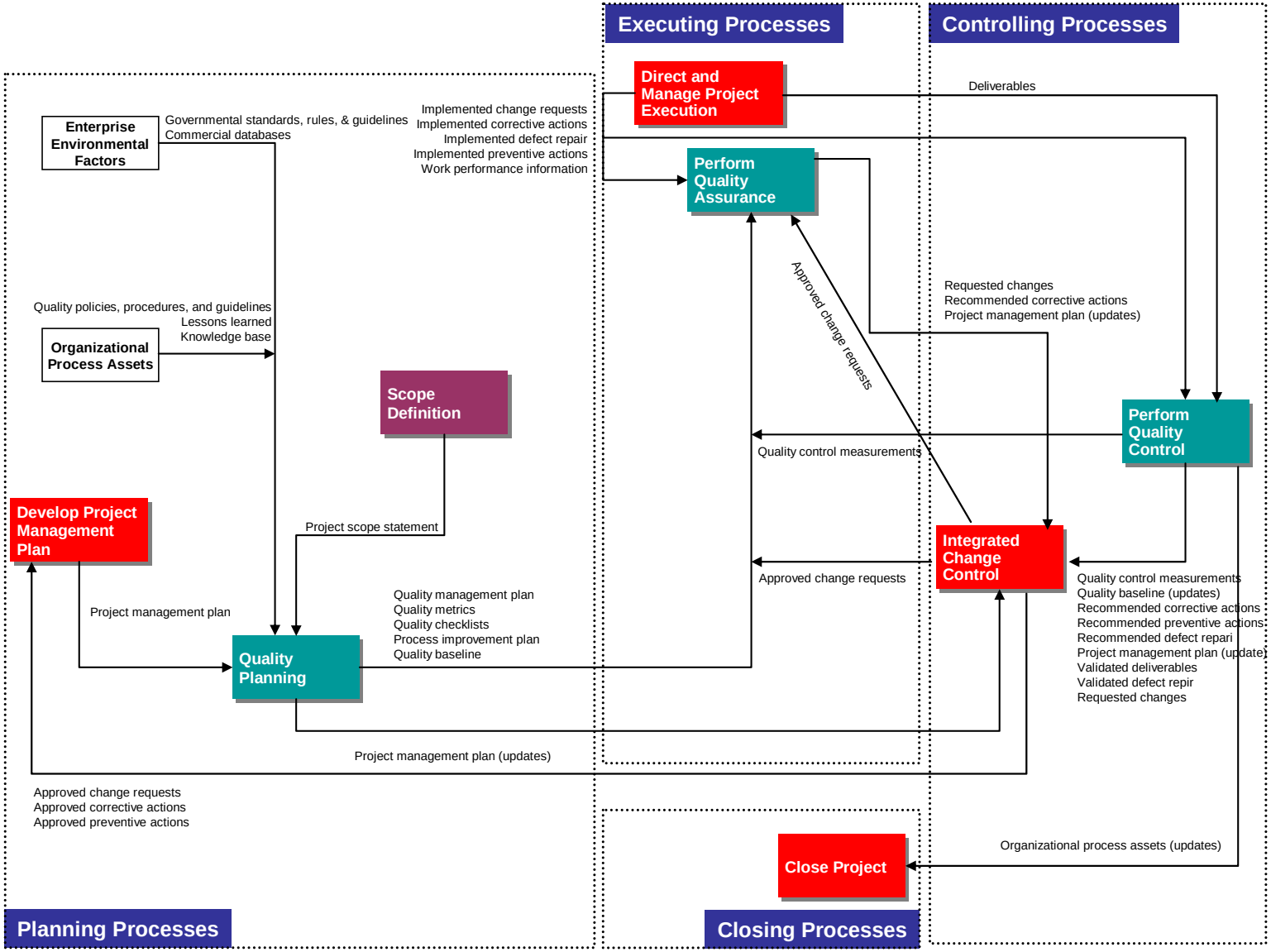


Figure 3.16: Project Quality Management Overview (Revised from (PMI 2004))

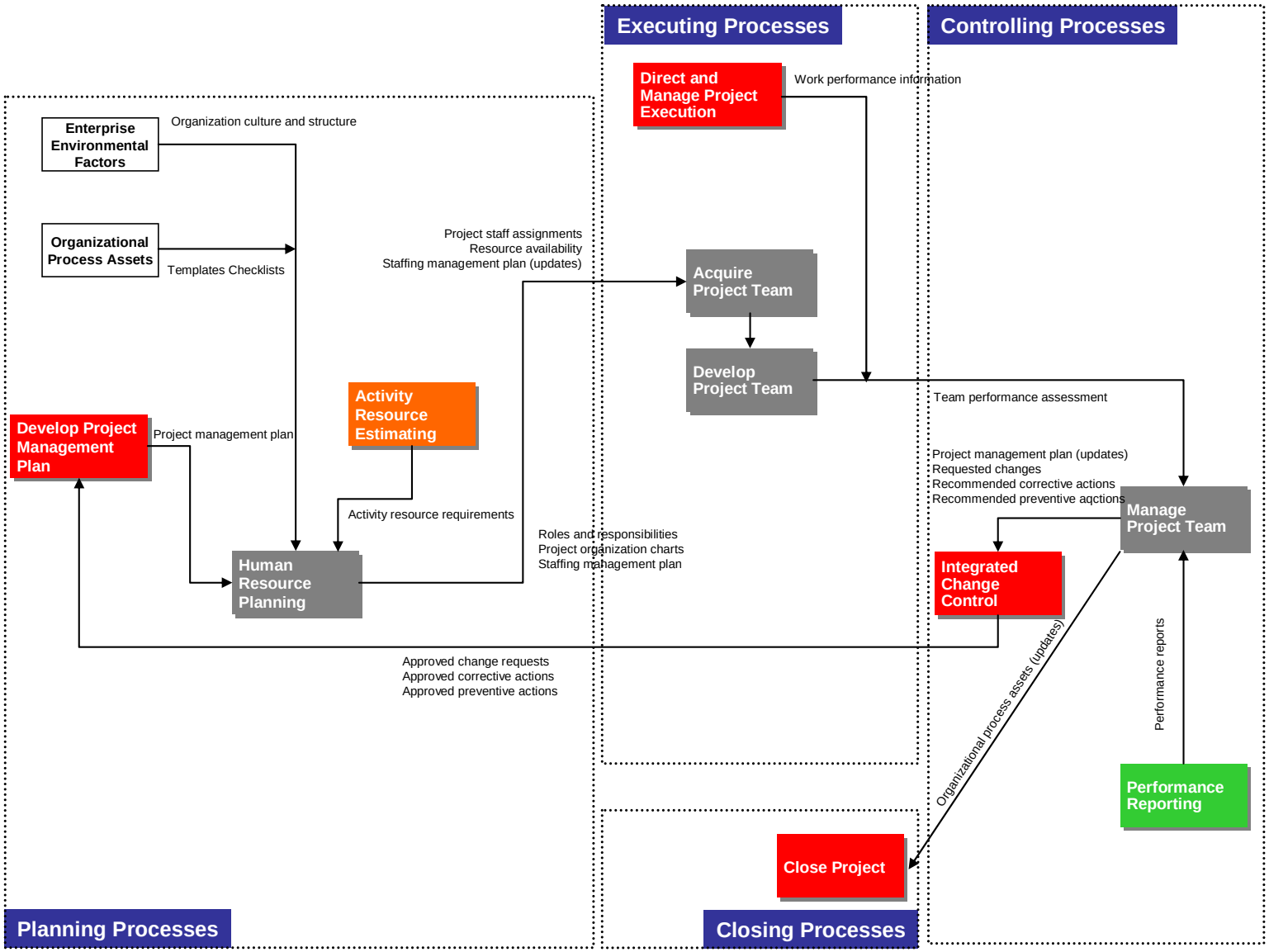


Figure 3.17: Project Human Resource Management Process Flow Diagram (Revised from (PMI 2004))

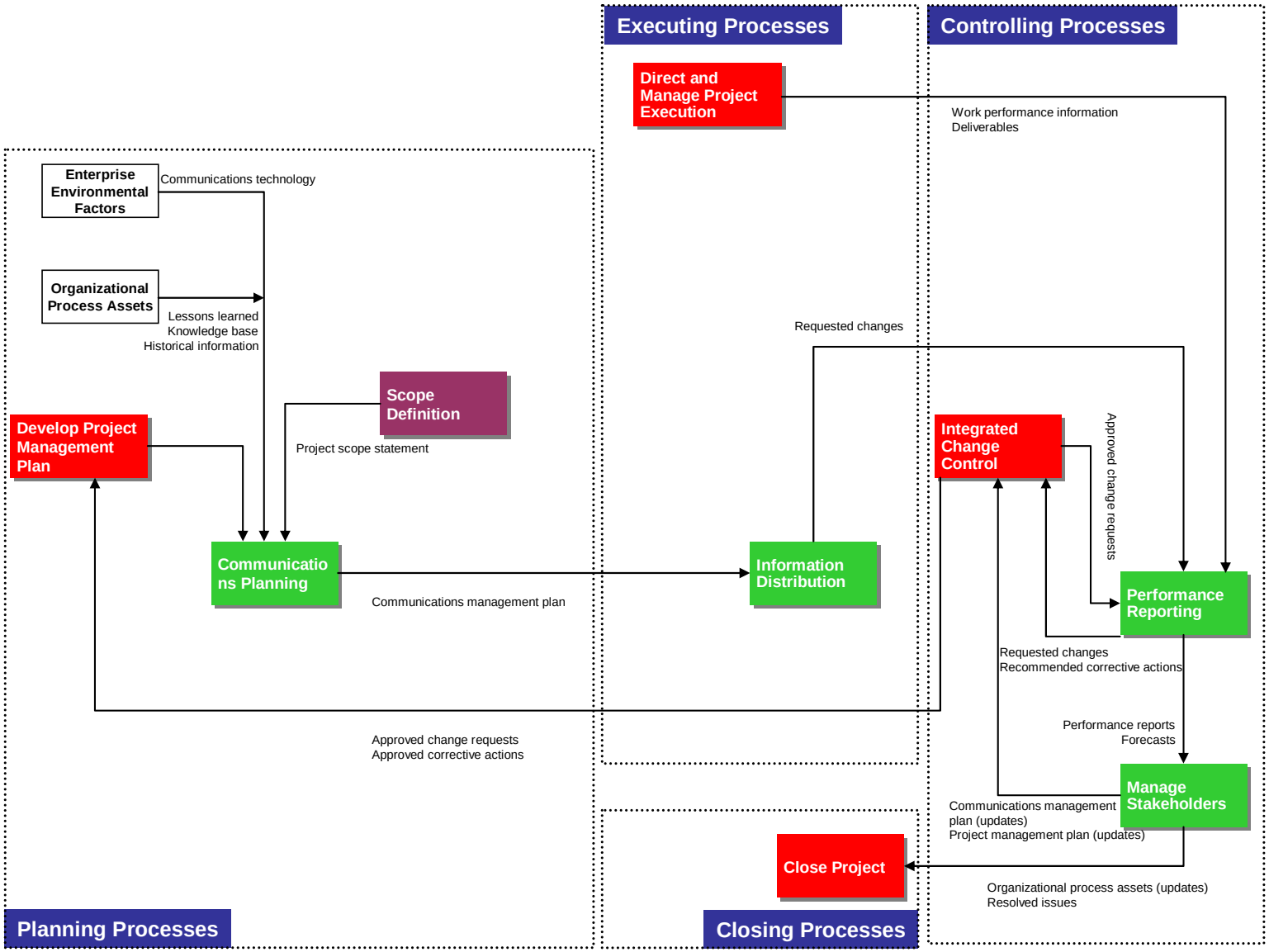


Figure 3.18: Project Communications Management Process Flow Diagram (Revised from (PMI 2004))

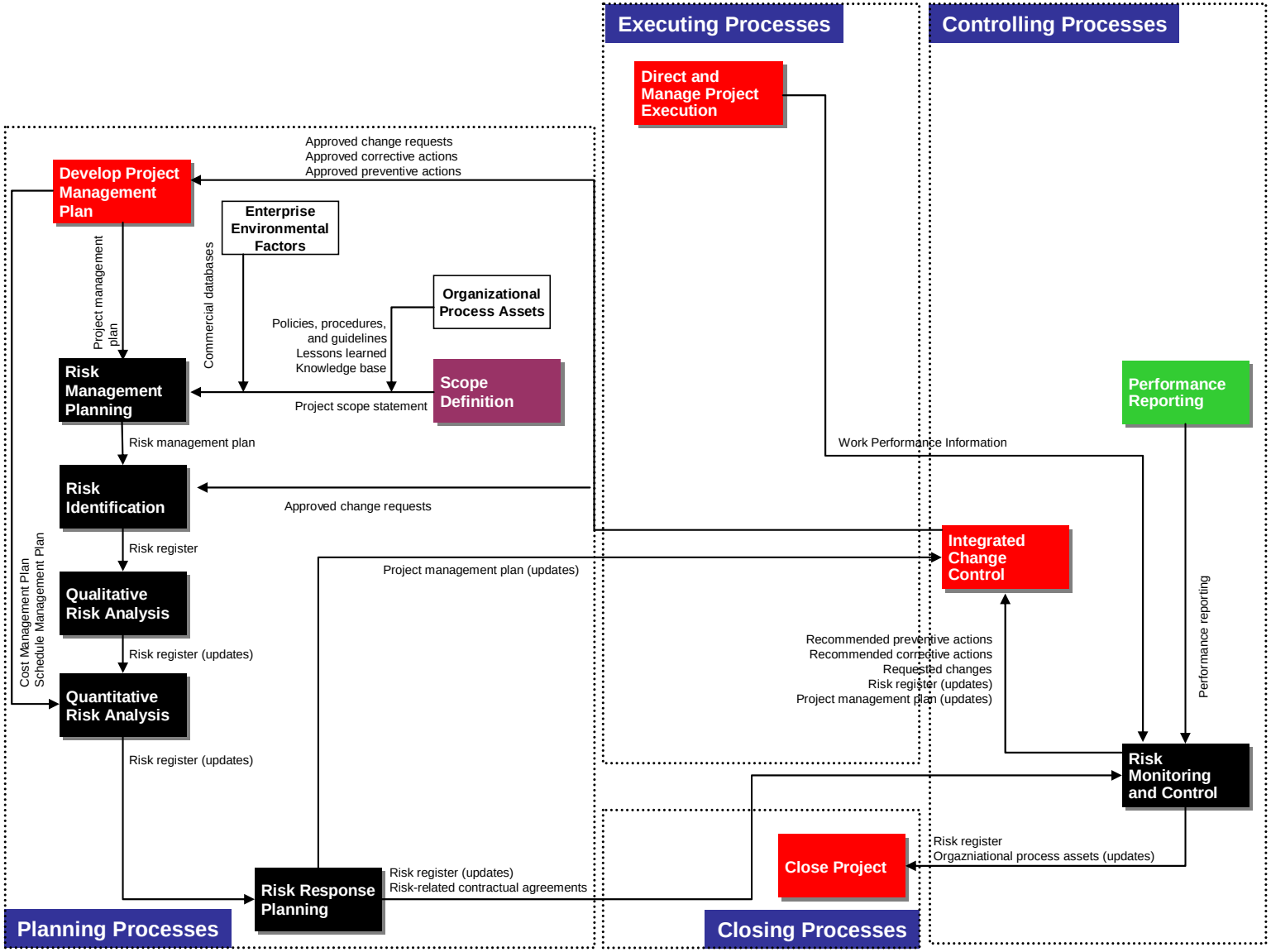


Figure 3.19: Project Risk Management Process Flow Diagram (Revised from (PMI 2004))

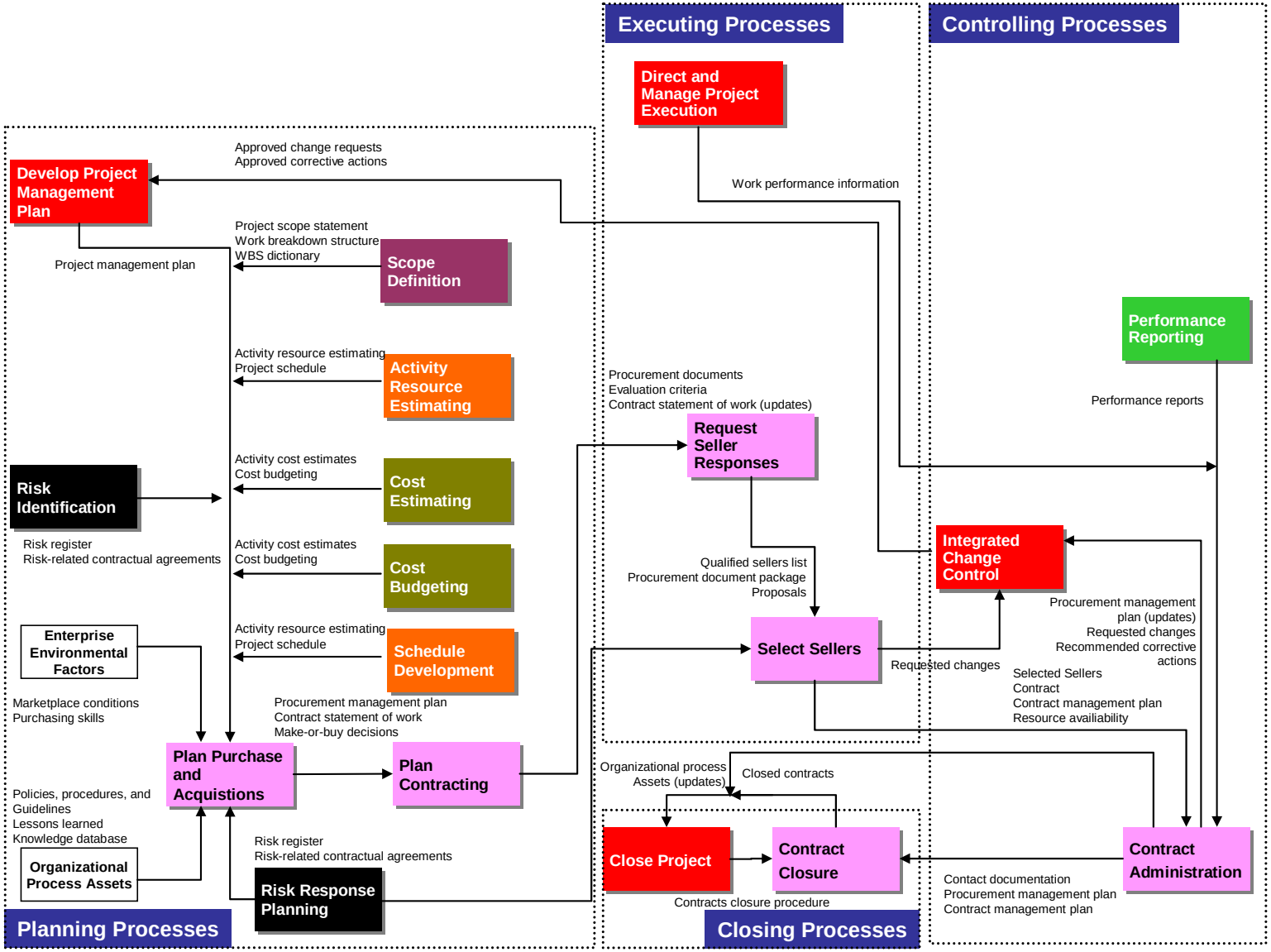


Figure 3.20: Project Procurement Management Process Flow Diagram (Revised from (PMI 2004))

Relationship between Project Management Methodology and Software Engineering Methodology

The project management methodology focuses on managing the project itself; on the other hand, the software engineering methodology focuses on developing the information systems. In the development of information systems, many organizations use the software engineering methodology as a part of the project management methodology.

The project scope statement and the project management plan of the PM methodology provide the development scope and plan to be performed in the SE methodology.

The Monitoring and Controlling Process Group of the PM methodology monitors the ongoing developing project of the SE methodology against the project management plan and the project performance baseline of the PM methodology. This process group controls changes and corrective actions for potential problems.

Completed information systems of the SE methodology become the input of the Closing Process Group on the PM methodology in order to finish all activities of the SE methodology.

3.2.2 Software Engineering Methodology and Information Architecture Methodology

The software engineering methodology in this thesis is based on Pressman's web software engineering methods (2000). Figure 3.22 illustrates an overall summary of the methodology and the interactions among the phases. Each phase defines and constrains how its inputs are used to produce its outputs for other phases. Parts of the analysis phase and the architecting phase are connected with the information architecture methodology and the enterprise architecture methodology. The software engineering methodology becomes the connecting portion between the information architecture methodology and the enterprise architecture methodology. Next is provided a brief description of each phase.

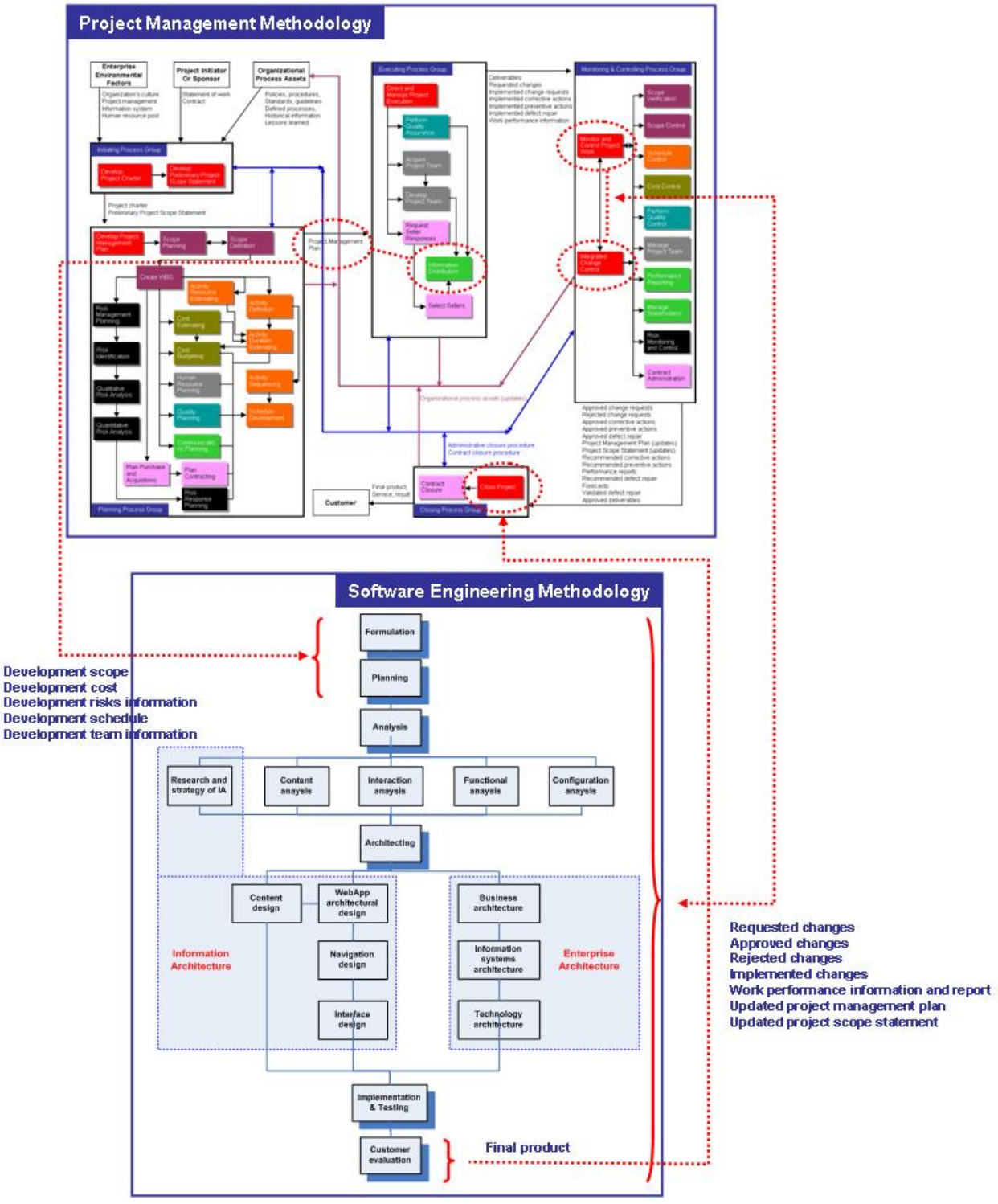


Figure 3.21: Relationship between the Project Management Methodology and the Software Engineering Methodology

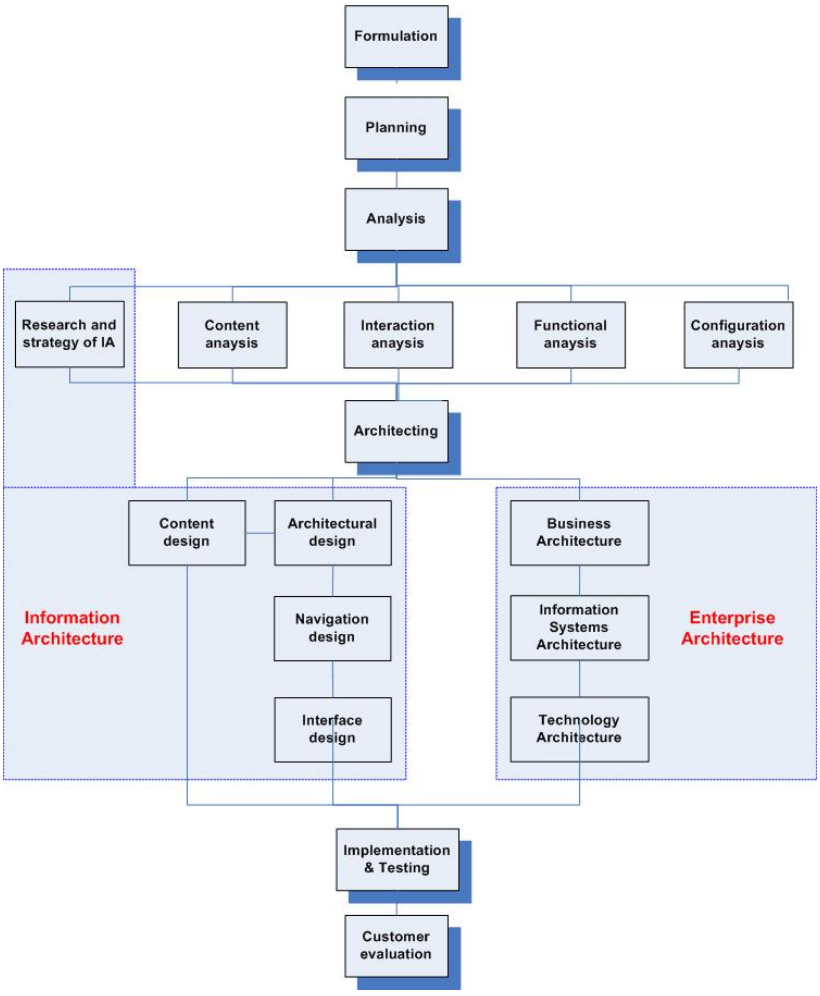


Figure 3.22: Software Engineering Methodology Incorporated with Information Architecture Methodology and Enterprise Architecture Methodology

Phase 1 - Formulation

The formulation phase facilitates the user and the developer in order to create a common set of goals and objectives for the system building. Moreover, it identifies the development scope from the project management methodology and offers a way for determining a successful product.

Phase 2 - Planning

The planning phase defines the overall project cost, risks related with the development and development schedule from the project management methodology.

Phase 3 - Analysis

The analysis phase identifies the requirements of the contents, function, behavior, infrastructure, and information architecture for the system. The developing scope, defined at the formulation phase, is elaborated to make a complete analysis model for the system. Five different types of analyses are performed during this phase.

Content analysis: The content offered by the system is identified at this phase. The content consists of text, images, audio, and video data. The data modeling technique is used to define and describe the data objects that are used within the systems.

Interaction analysis: The user-interaction method for the system is fully described. Use case techniques are used to present descriptions of the interaction in detail.

Functional analysis: The use cases descriptions created during the interaction analysis describe the operations that are applied to systems content. These use cases indicate other processing functions. All operations and functions of the systems are fully described during this analysis.

Configuration analysis: The environment and infrastructure of the systems are fully defined. The infrastructure, such as the component infrastructure and databases, for the systems should be identified as part of this analysis.

Research and Strategy of IA: The purpose of this stage is to have an understanding of business context and content, the presented information architecture, and the users. Review of presented background information and the meeting of IA strategy team are performed at the beginning of this stage.

The research of IA presents a contextual understanding that serves as a foundation for developing an IA strategy. This strategy establishes the process and the scope of the project from the IA viewpoint. Peter Morville and Rosenfeld (2007) suggest the main components of context, content, and users as the primary framework of IA. Figure 3.23 provides the research tools and methods of information architecture at this stage.

Context	Background research	Presentations and meetings	Stakeholder interviews	Technology assessment
Content	Heuristic evaluation	Metadata and content analysis	Content mapping	Benchmaking
Users	Search log and clickstream analysis	Use cases and personas	Contextual inquiry	User interviews and user testing

Figure 3.23: Tools and Methods for Information Architecture Research
(Peter Morville and Rosenfeld 2007)

Figure 3.24 illustrates the development outline of the information architecture strategy and its resulting deliverables. This outline includes extremely iterative and interactive processes.

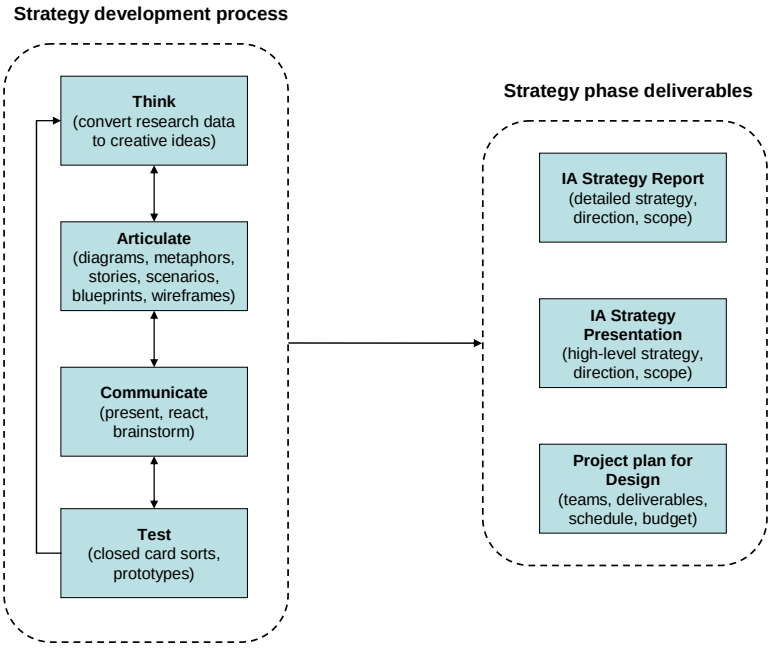


Figure 3.24: Developing the Information Architecture Strategy
(Peter Morville and Rosenfeld 2007)

Phase 4 - Architecting

Architecting Information Architecture (Relationship between Information Architecture Methodology and Software Engineering Methodology)

When organizations develop information systems, they have keep in mind the value of information architecture. How much does it cost to find information? If they failed to find appropriate information or they get incorrect information, how much do they suffer a loss? It could be tremendous. In other words, organizations will have a chance to save cost and time through the development of a good information architecture.

During the architecting stage information architects form a high-level strategy for the information architecture. They make detailed IA blueprints, wire-frames, and metadata schema. Graphic designers and programmers will use these outputs.

At this stage information architects develop 4 main types of design:

Architectural design: This design focuses on describing the overall hypermedia structure of the system and its applications.

Navigation design: After the system architecture has been established and the components, such as pages, applets, and other processing functions, have been confirmed, the information architects have to define navigation paths that allow a user to access system contents and services. The information architects have to define the navigation semantics for diverse users of the systems and identify the syntax of the navigation achievement (Pressman 2000). An Enterprise-wide system has different user roles, so the system analyst makes a *semantic navigator unit* (SNU) for each objective related with each user role.

Interface design: The user interface gives the user the first impression. Regardless of the values of its content and services, if a potential user is inconvenienced they may leave the system due to a weakly designed user interface.

Content design: At this stage, the entire structure and specified layout of the information contents will be generated by non-technical members of the project team.

Architecting Enterprise Architecture (Relationship between Enterprise Architecture Methodology and Software Engineering Methodology)

The enterprise architecture methodology provides blueprints that give a broad view on the architectural building blocks across an organization and the scheme of interacting with architectures (see the Figure 3.27 on the page 54). The blueprints illustrate an architecture design integrating business, information systems, and technology architectures.

All the enterprise architecture domains (business, information system, and technology architectures), their main subjects, and their dependencies are depicted in the Figure 3.25. The information systems and technology architecture domains are regarded as “technologies”. Their scope contains applications, data, and technology. The business architecture domain is regarded as “business reference”. Its scope contains business process and information, business performance, and organization.

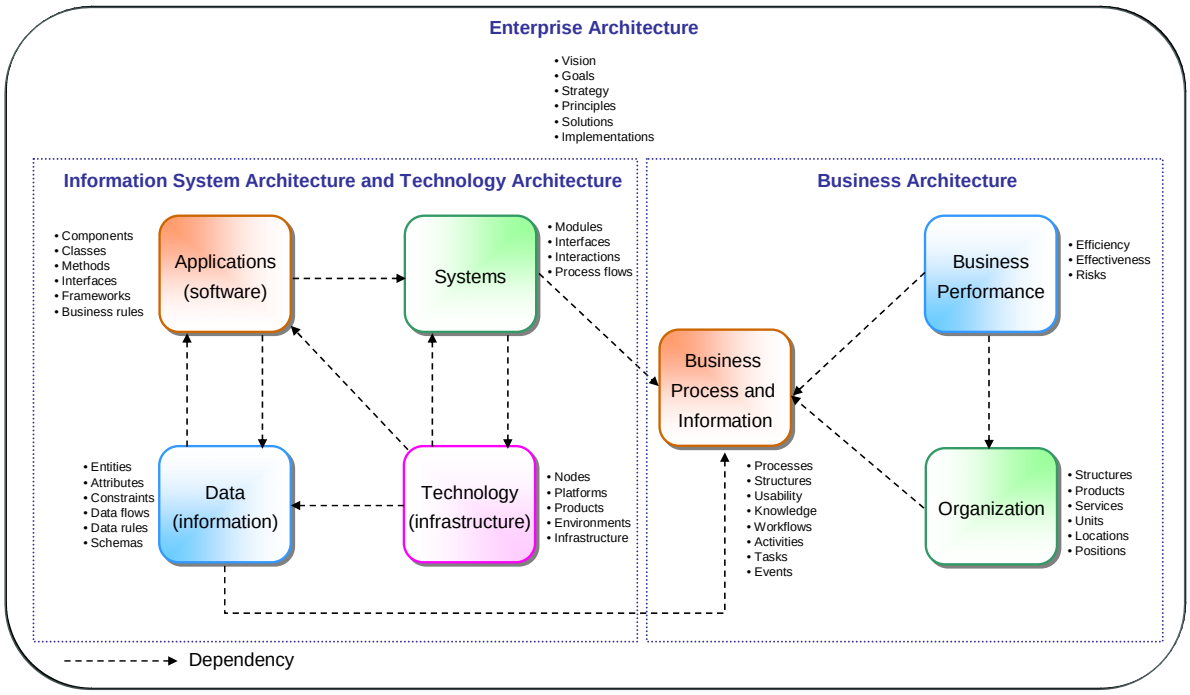


Figure 3.25: Components and subjects of the enterprise architecture discipline (Revised from (Temnenco 2007))

Phase 5- Implementation and Testing

The implementation phase includes construction processes to build an information system. The content identified at the content design stage in the architecting phase is combined with the architectural, navigation, and interface designs to make information systems pages or Web pages on enterprise portals. This combination is integrated with the enterprise architecture (business, information systems, and technology architectures).

The testing phase is the process of testing the system in order to find and correct errors. Pressman (2000) suggests the following steps to test the system, especially object-oriented systems:

Step 1: The content model of the systems is assessed to find out errors.

Step 2: The design model of the systems is assessed to reveal navigation.

Step 3: The processing components and Web pages are assessed by unit test.

Step 4: The architecture is built and integration tests are performed.

Step 5: The integrated system is assessed for entire functionality and content deliverance.

Step 6: The system is employed in different environmental configurations and is assessed for compatibility with each configuration.

Step 7: End-users control and monitor the system to assess (Pressman 2000).

Phase 6 - Customer Evaluation

Customers perform the customer evaluation phase. They continually evaluate and monitor the system usage in order to provide user feedback. Requested changes, such as scope extension, are reflected in the next project iteration. Completed information systems become the input of the Closing Process Group on the project management methodology.

3.2.3 Enterprise Architecture Methodology and Software Engineering Methodology

The enterprise architecture methodology in this thesis is based on the Architecture Development Method (ADM) of The Open Group Architecture Framework (TOGAF) Version 8.1, the Enterprise Edition. TOGAF was initially designed as a method to develop the technology architecture of an organization. TOGAF has been evolved by the Open Group into a methodology for developing the overall business architecture. The ADM is the core of TOGAF and a way to develop an enterprise architecture. The ADM has the following phases:

Preliminary Phase: Framework and Principles: Adopt framework and define principles

Phase A: Architecture Vision: Define scope, develop vision, map an overall strategy, and obtain approvals

Phase B: Business Architecture: Develop current and target business architectures and establish the gap between the two architectures

Phase C: Information System Architectures: Describe target architectures as data and applications architectures

Phase D: Technology Architecture: Develop target technology architecture that an organization will be implemented

Phase E: Opportunities and Solutions: Check suitability for implementing the three architectures described in phase B, C, and D

Phase F: Migration Planning: Prioritize works and create the migration plan

Phase G: Implementation Governance: Provide oversight to implement

Phase H: Architecture Change Management: Monitor the system working to manage changes and loop back to the preliminary phase for new architecture

Architecture Requirements Management: Manage architecture requirements at all phases of the ADM

Figure 3.26 shows these phases of the Architecture Development Method.

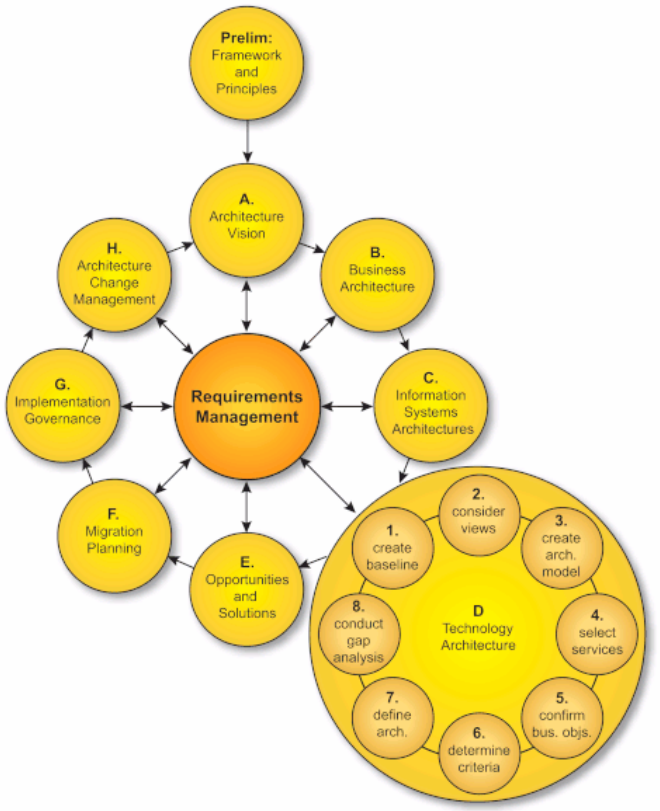


Figure 3.26: TOGAF Architecture Development Method (The Open Group 2003)

Blueprints for Enterprise Architecture

Blueprints give a broad view on the architecture building blocks across an organization and the scheme of interacting with architectures. They describe the effects of architecture design between business, information systems, and technology architecture. The Figure 3.27 demonstrates the derivation of the EA blueprints from the organization and the business process.

Table 3.1: Enterprise Architecture Framework (Revised from (Rohloff 2005)

Business Architecture	Business models, Organization, Processes, Information
Information Systems Architecture	Enterprise Applications, Portal & Information Management Platform, Data Repositories, EAI Services
Technology Architecture	Basic Services, Workplace Services, Server Systems & Storage, Network

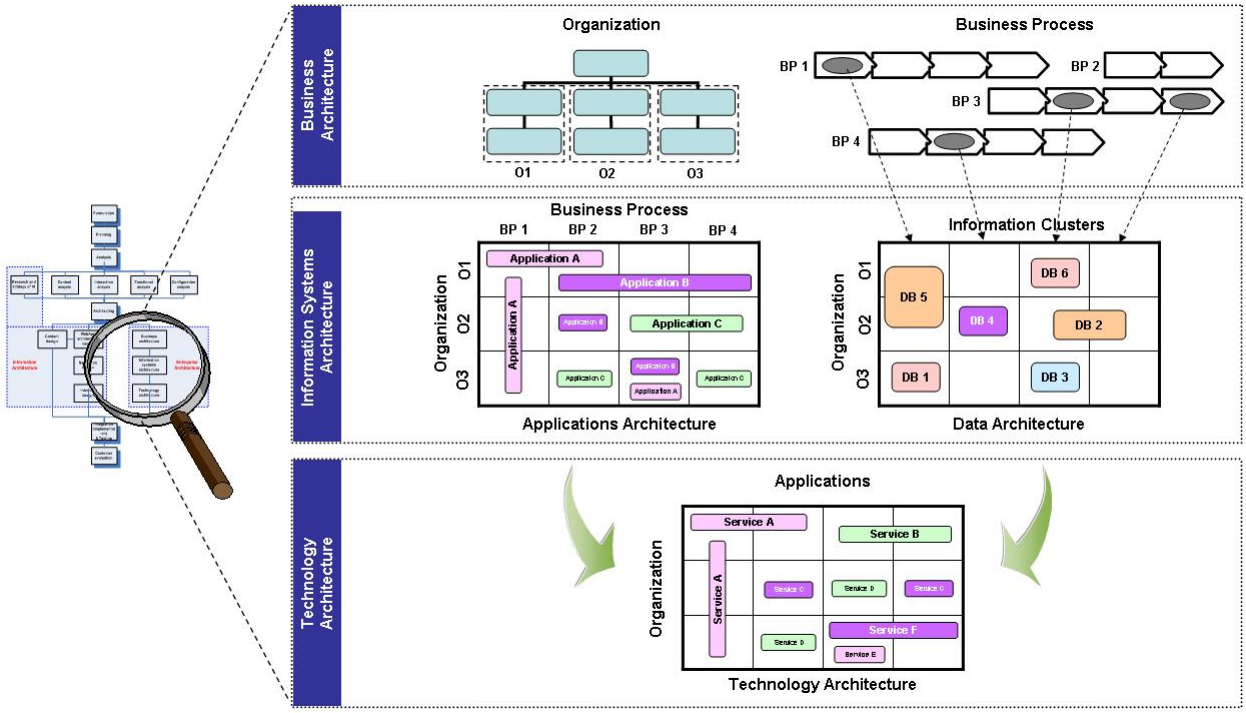


Figure 3.27: Blueprints of Business Architecture, Information Systems Architecture, and Technology Architecture (Revised from (Rohloff 2005).

Integrating the EA blueprints into the software engineering methodology gives an organization the alignment of business and information technology on the enterprise-wide level. The business architecture describes the essential organization and business requirements based on business strategies and objectives of organizations. It also decides the frame for the design of the information systems and technology architecture that must support organization's business.

The applications architecture illustrates how business processes are supported by applications. The data architecture shows how the database deployments are supported by information clusters. The technology architecture describes how the infrastructure-services deployments are supported by applications. The steps involved in the development of the three architectures (business, information systems, and technology architecture) are illustrated in Figure 3.28 to 3.31 below.

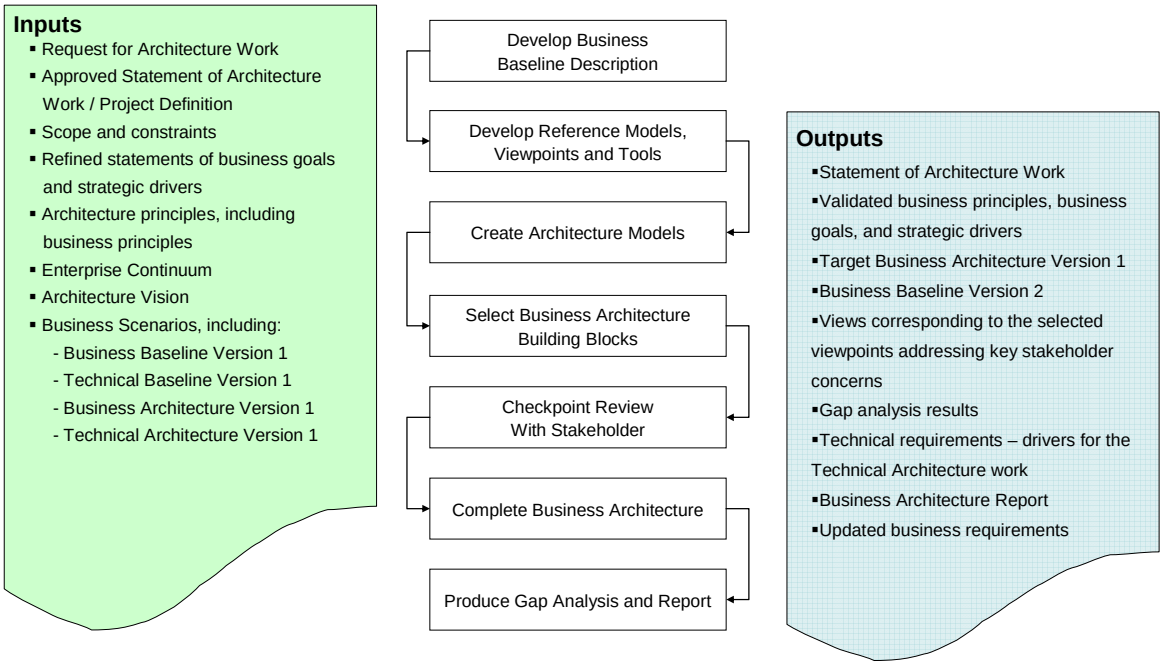


Figure 3.28: The ADM: Business Architecture (Revised from (The Open Group 2003))

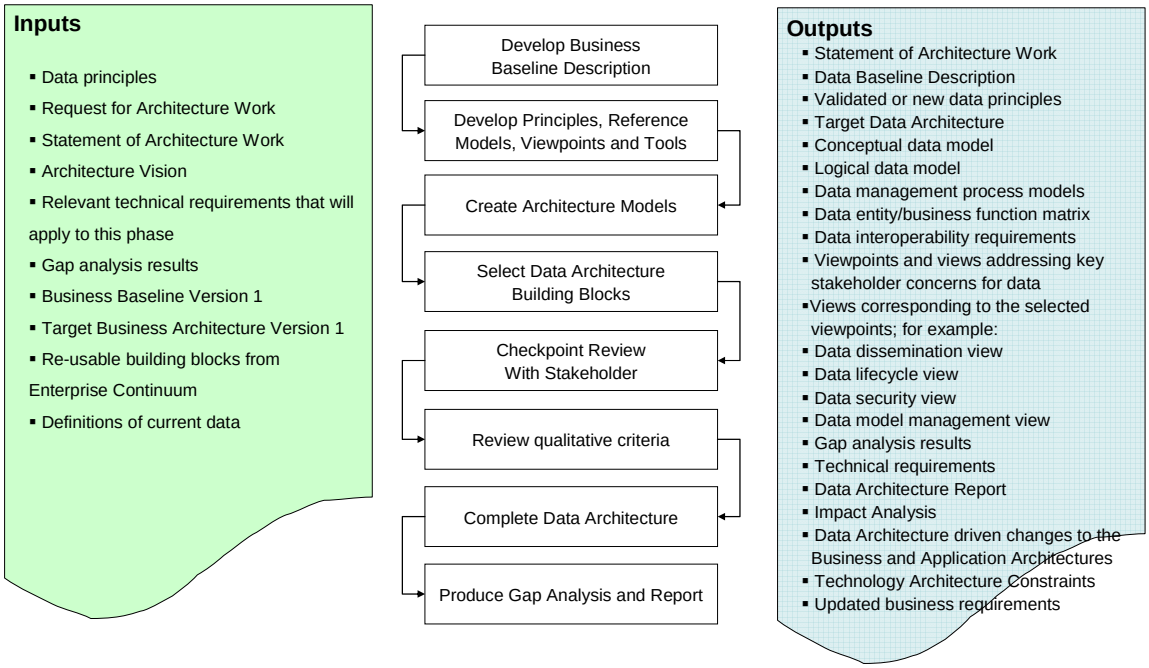


Figure 3.29: The ADM: Data Architecture (Revised from (The Open Group 2003))

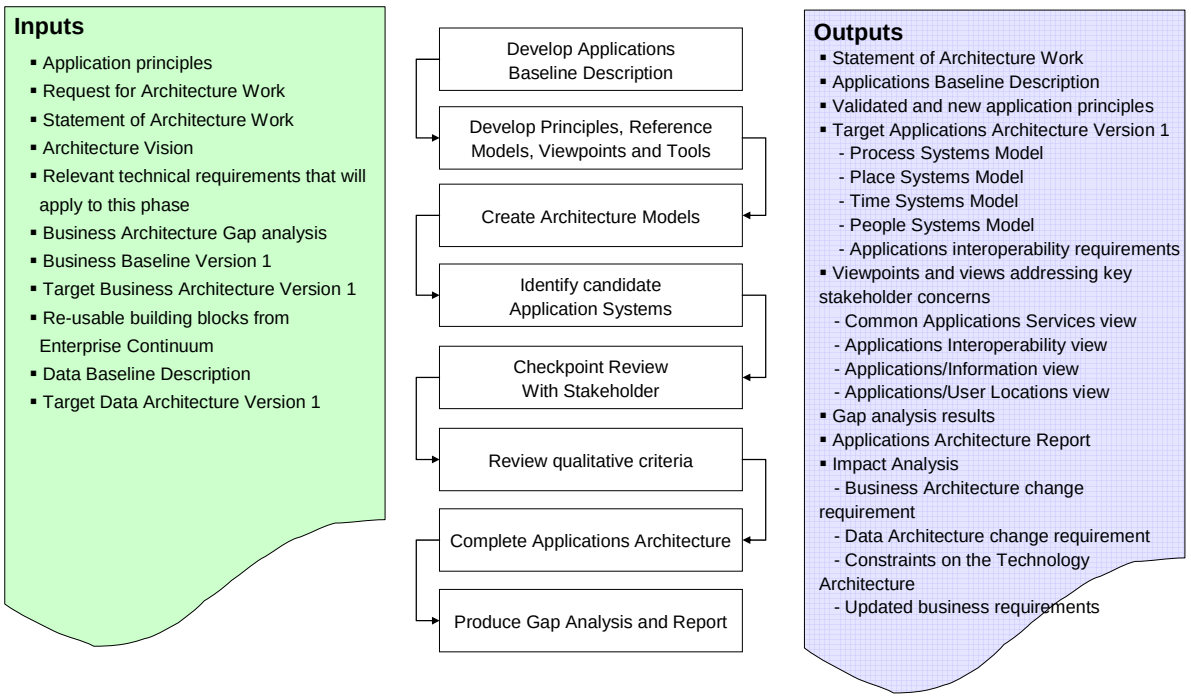


Figure 3.30: The ADM: Application Architecture (Revised from (The Open Group 2003))

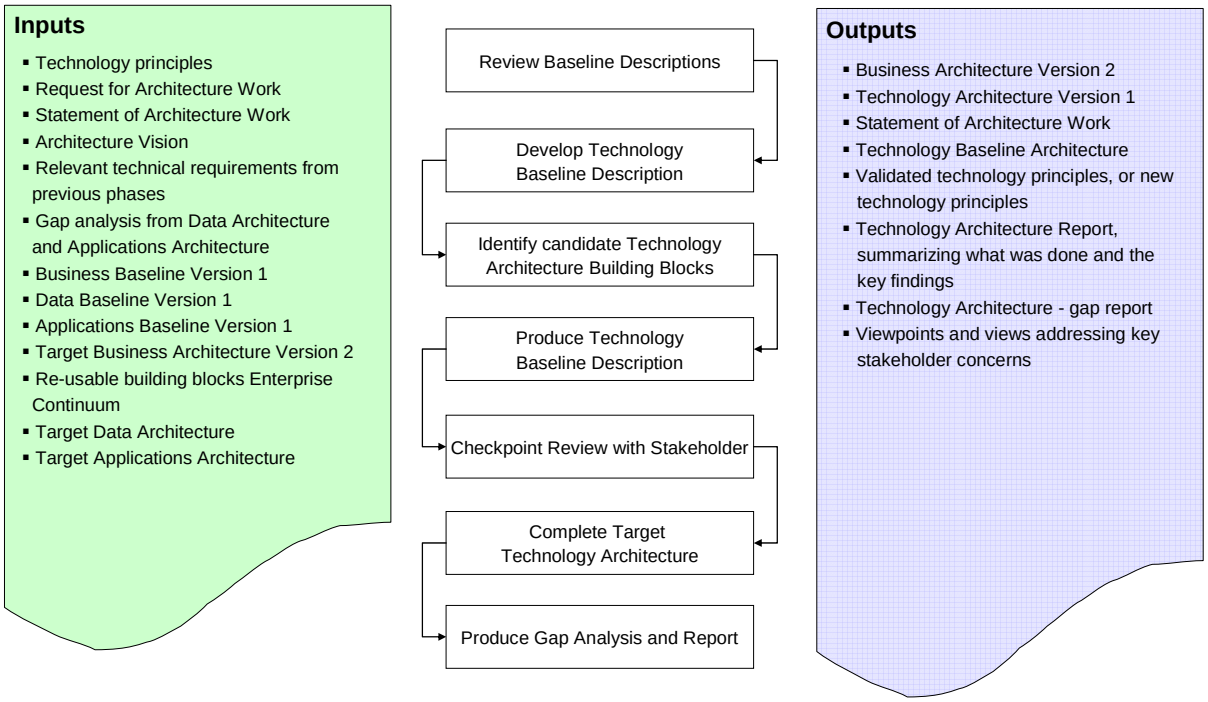


Figure 3.31: The ADM: Technology Architecture (Revised from (The Open Group 2003))

An Example of Application Architecture

An architectural blueprint of the application architecture is important to demonstrate an information systems support for business processes. Figures 3.32 and 3.33 provide examples of an as-is (existing) and to-be (target) application architectures. The existing applications and the target applications are mapped to organizations and business processes. These blueprints provide overviews of the existing application architecture as well as the target application architecture.

The blueprint of the target application architecture explains the deployment plan to execute an information technology strategy. The deployment plan is derived from a gap analysis between the existing architecture and the target architecture. After the gap analysis, the project team prioritizes tasks to implement the target application architecture.

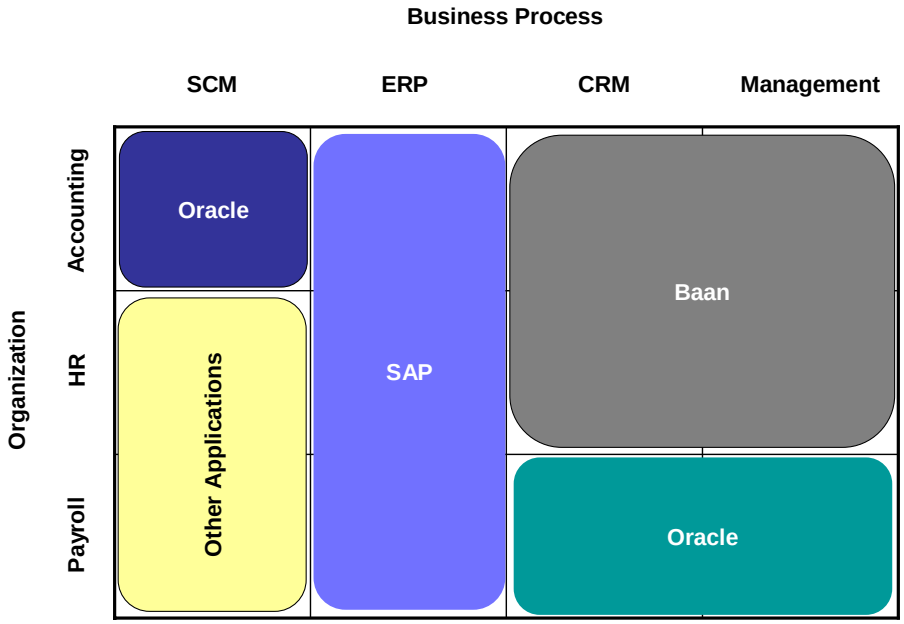


Figure 3.32: As-Is/existing Application Architecture

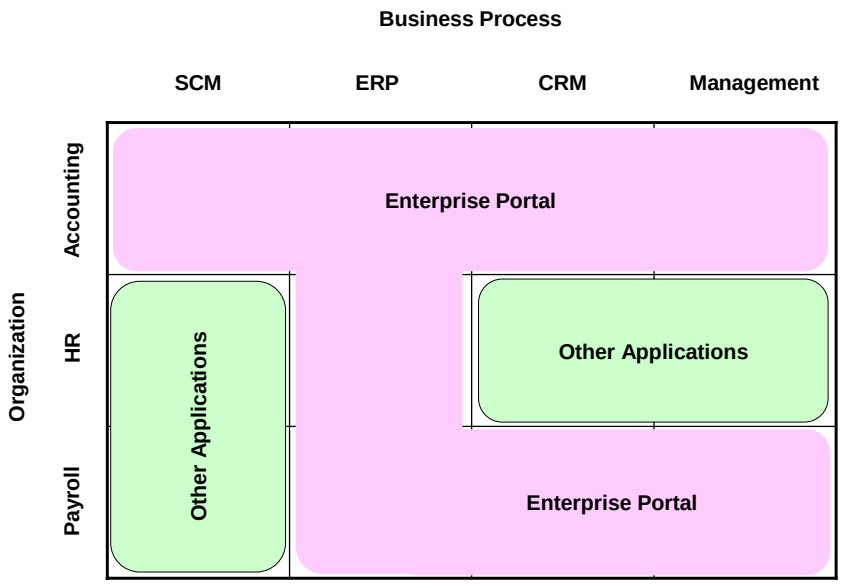


Figure 3.33: To-Be/target Application Architecture

Application Architecture Reference Model for Enterprise Portals

One of the main challenges for the information systems in the enterprise is to access integrated information in and out of the organization. TOGAF has a Technical Reference Model (TRM) for an Integrated Information Infrastructure. This Reference Model focuses on the application-level components and services, as illustrated in Figure 3.34.

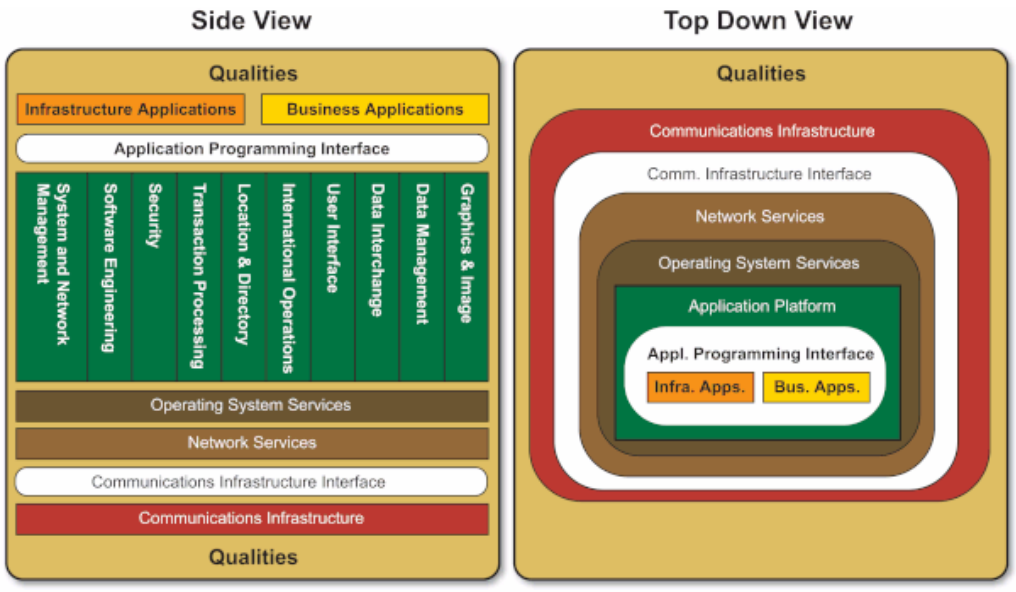


Figure 3.34: TOGAF Technical Reference Model (The Open Group 2003)

The Integrated Information Infrastructure Reference Model (III-RM) presents insights related to the "*Boundaryless Information Flow*" in enterprise portal environments. III-RM is the subset of the TRM, and the scope of III-RM on the TRM is highlighted in grey in Figure 3.35.

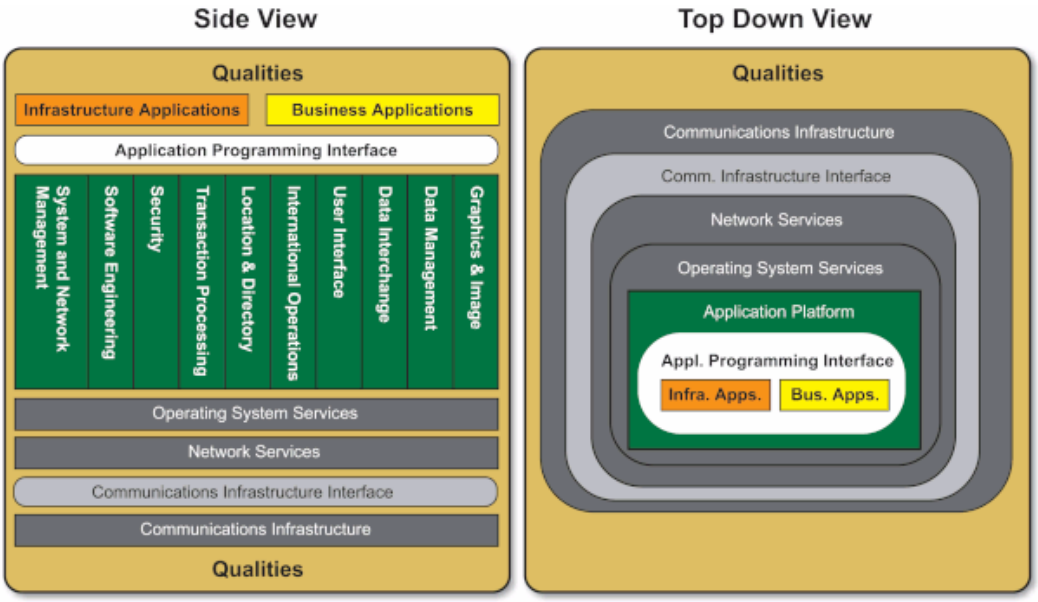


Figure 3.35: Focus on the Integrated Information Infrastructure Model (The Open Group 2003)

Figure 3.36 shows the detailed III-RM that supports the "*Boundaryless Information Flow*".

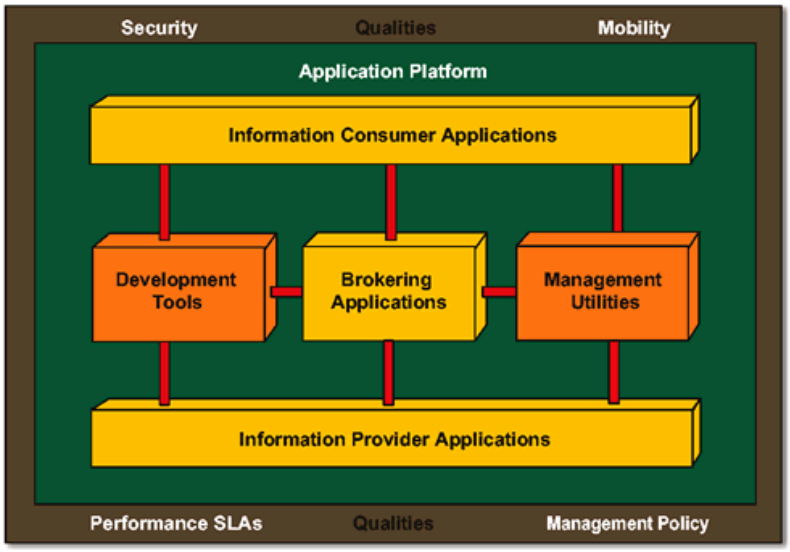


Figure 3.36: Integrated Information Infrastructure Reference Model (III-RM) (The Open Group 2003)

In this example there are three types of Applications in the III-RM.

Information Provider Applications that provide responses to user requests from Brokerage Applications and basic access to data stored by enterprise servers, such as ERP, CRM, SCM;

Brokerage Applications that control the requests from Information Consumer Applications and across Information Provider Applications; and

Information Consumer Applications that transport information to the system's users and offer services to access information in the system

The overall set of these three applications constructs an environment to access heterogeneous systems and databases.

The processes of an enterprise are broadly divided into three general categories: buy, internal, and sell spaces. Figure 3.37 illustrates the Open Group's approach to the "*Boundaryless Information Flow*" for Enterprise Portals. These spaces need access to information in order for their tasks to be completed. Access to integrated information extensively improves the execution of all these spaces (The Open Group 2003).

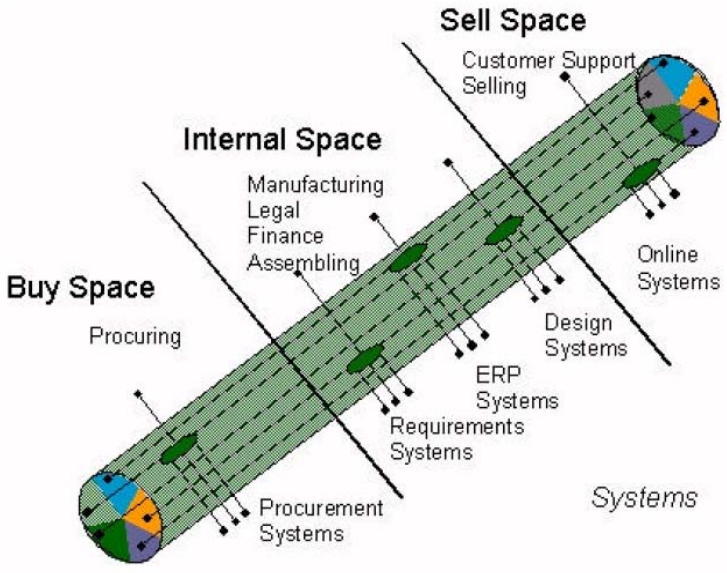


Figure 3.37: An approach to Boundaryless Information Flow for Enterprise Portals (The Open Group 2003)

Table 3.2: Three high-level processes of Enterprise Portals (The Open Group 2003)

Process Categories	Process Description and Output
Buy space processes	Include processes such as ordering, procurement, and accounts payable and receivable.
Internal space processes	Include processes such as logistics, manufacturing, competitive intelligence, production, assembling, delivery, and product lifecycle.
Sell space processes	Include processes such as sales, customer support, and customer relationship management.

Figures 3.38, 3.39, 3.40, and 3.41 show how III-RM provides enterprises integrated access to integrated information as in case of an enterprise portal.

Information Provider Applications of III-RM

Information within organizations is kept within data silos, as depicted in Figure 3.38. Information Provider Applications of III-RM liberate data from their silos. To achieve this Information Provider Applications of III-RM provide an open interface to a potentially proprietary silo interface, as illustrated in Figure 3.39.

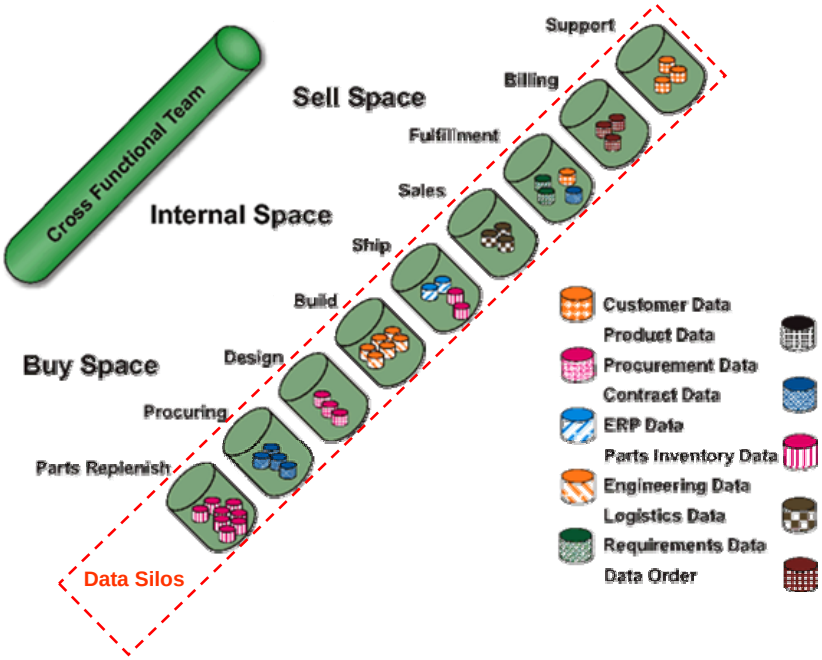


Figure 3.38: Liberate Data Silos to Meet Information Needs of Cross-Functional Enterprise Teams (Revised from (The Open Group 2003))

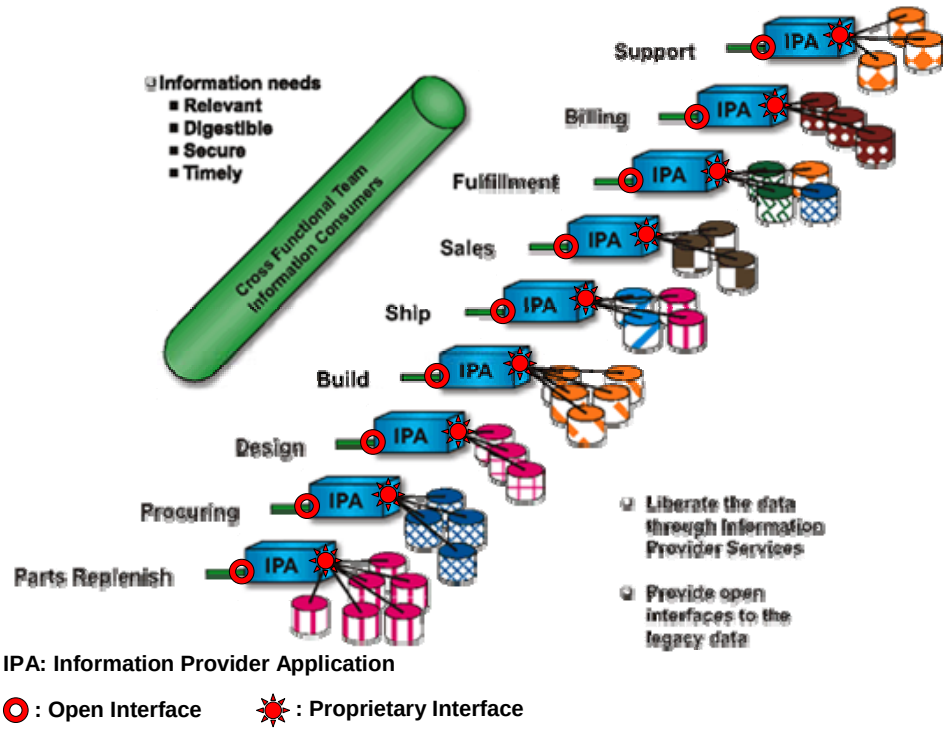


Figure 3.39: Information Provider Applications Liberate Data by Providing Open Interfaces to Data Silos (Revised from (The Open Group 2003))

Brokerage Applications of III-RM

Brokerage Applications of III-RM have single requests from Information Consumer Applications. These single requests need access to multiple Data Silos. Brokerage Applications allocate the single requests to multiple Data Silos, gather the responses from Information Provider Applications, and then send the single responses back to the Information Consumer Applications.

Brokerage Applications contact Information Provider Applications through the open interfaces of Information Provider Applications. Brokerage Applications integrate information that comes from multiple Information Provider Applications and transfer the integrated information to Information Consumer Applications through the open interfaces of Brokerage Applications.

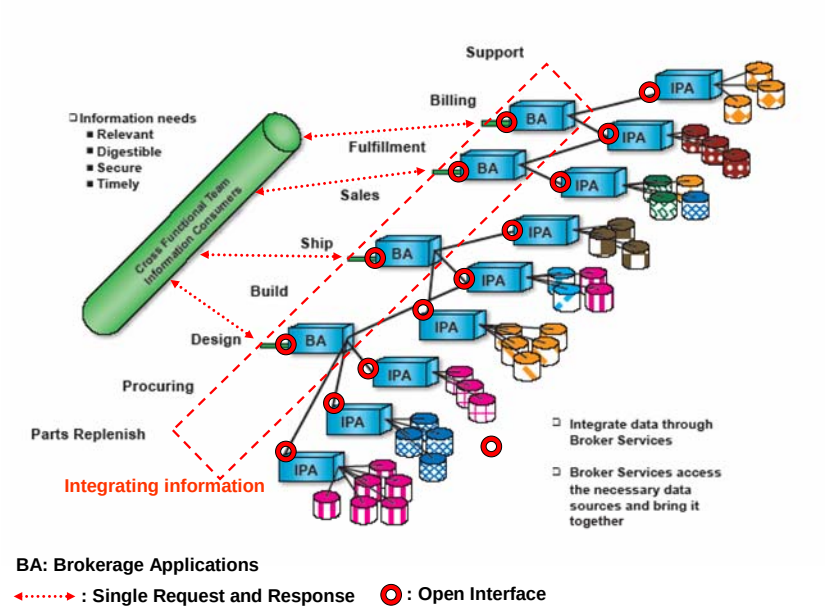


Figure 3.40: Brokerage Applications Integrate Information from Information Provider Applications (Revised from (The Open Group 2003))

Information Consumer Applications of III-RM

Information Consumer Applications supply data to end users of the system and connect with Brokerage Applications through the open interfaces of the Brokerage Applications. Firewalls and security services are used for security, as illustrated in Figure 3.41.

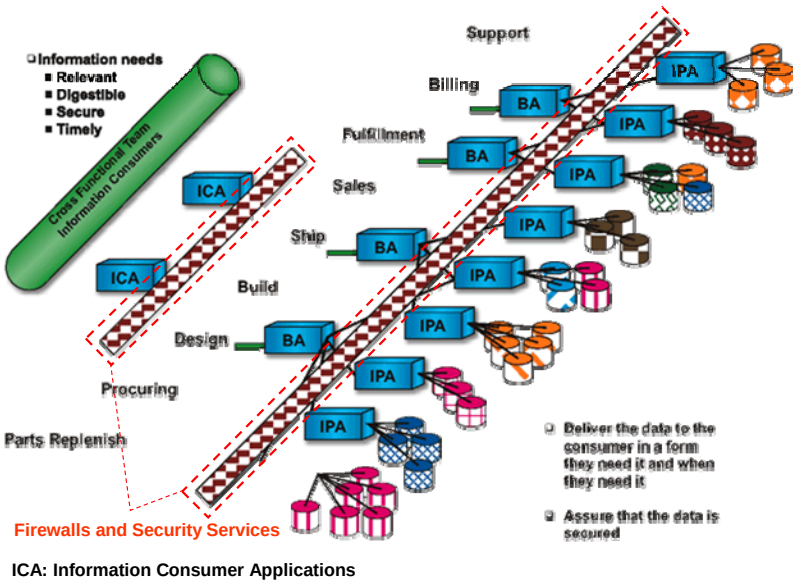


Figure 3.41: Information Consumer Applications Communicate using Open Interfaces (Revised from (The Open Group 2003))

Relationship between Enterprise Architecture Methodology and Project Management Methodology and Software Engineering Methodology

The EA methodology is "*business architecture-driven*" in order to "*realize a business vision*"; on the other hand, the SE methodology is "*technology architecture-driven*" in order to "*design and deliver a software-based system*" (Temnenco 2007).

The interrelationship and integration of the three architectures (business architecture, information system architecture, and technology architecture) are essential to the enterprise architecture, as discussed in the section entitled "Blueprints for Enterprise Architecture" on page 54. The outputs (business architecture, information system architecture, and technology architecture) of Phase C (Information System Architecture) and D (Technology Architecture) of the EA methodology become the inputs of the Architecting Phase of the SE methodology.

Phase E (Opportunities and Solutions), F (Migration Planning), and G (Implementation Governance) of the EA methodology represent the implementation processes of the enterprise architecture; thereupon, these Phases interact with the Implementation Phase of the SE methodology.

The outputs of the Customer Evaluation Phase of the SE methodology become the inputs of Phase H (Architecture Change Management) of the EA methodology. Requested changes, such as scope extension, on the Customer Evaluation Phase are reflected in the new architecture of the EA methodology.

Business Data (business goals, business strategy, business drivers, and business principles) of Preliminary Phase of the EA methodology is related with the inputs (Enterprise Environmental Factors and Organizational Process Assets) of the Initiating Process Group of the PM methodology.

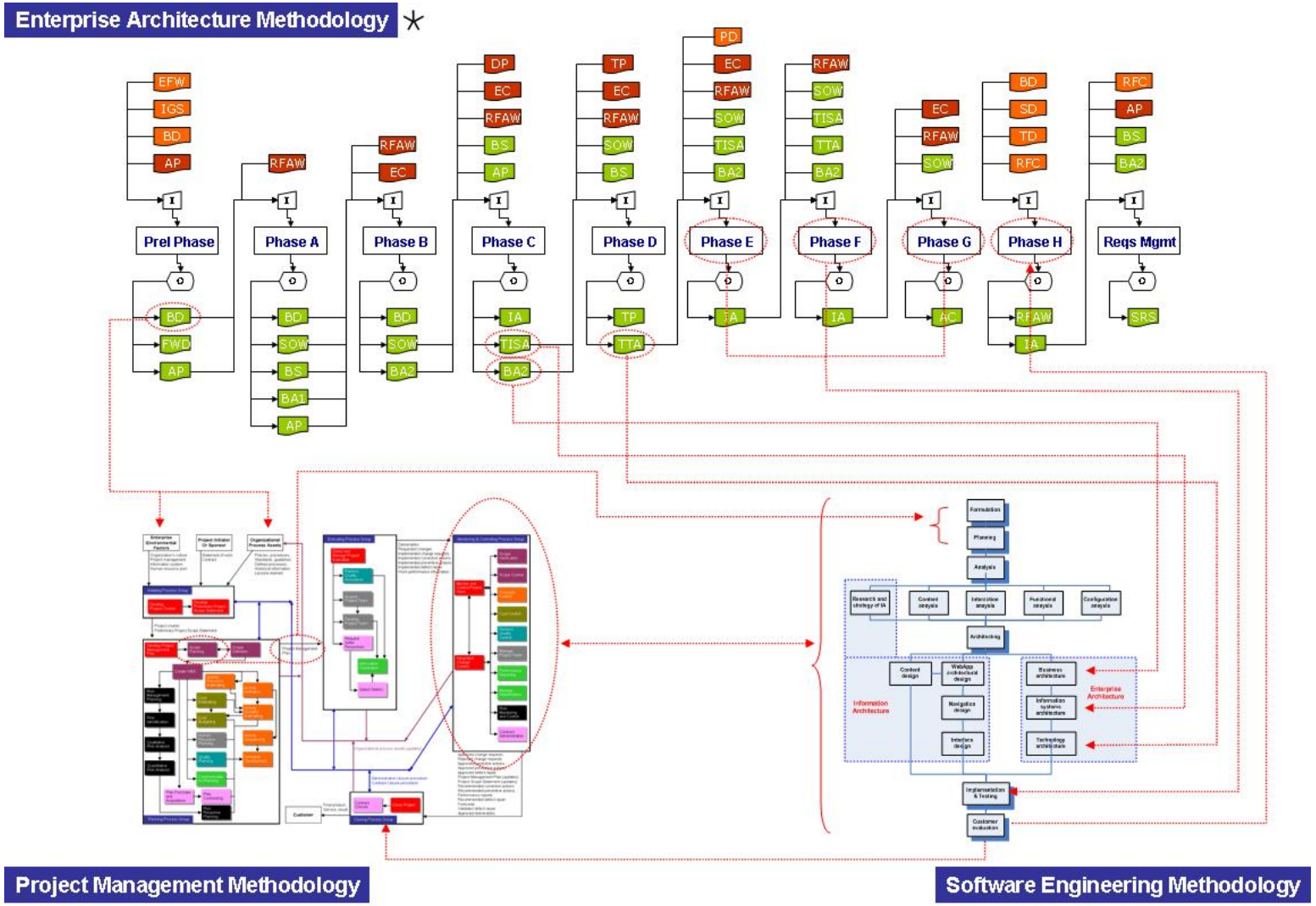


Figure 3.42: Relationship between Enterprise Architecture Methodology and Software Engineering Methodology and Project Management Methodology
* The Enterprise Architecture Methodology map was revised from (Estrem 2004)

CHAPTER 4 - CONCLUSIONS

This chapter describes the overall conclusions with contributions and suggested future study.

4.1 Conclusions

As an enterprise is a distributed organization and is complex in itself, it faces many changes both internal and external to the enterprise. When the enterprise environment and enterprise itself changes, information systems must have agility to change. In the case of information systems, many have been built in a non-architected and a non-integrated manner over the past 20 or 30 years. Many different information systems work within same enterprise without interacting each other.

It is a critical condition that the right person has the right information at the right time and the right place. The organization must have "*the boundaryless information flow*" in order to achieve this critical condition. Information systems need to be aligned with the enterprise's visions and strategies. Non-architected and non-integrated systems cannot accomplish "*the boundaryless information flow*" and cannot survive in global and competitive environment.

Even though IT quality has become more reliable, the risks and costs of IT projects have increased. According to the Standish Report and the literature review, the importance of project management and the relationship between the enterprise and software aspects are suggested for successful IT projects, particularly in large systems.

To have effective management of huge enterprise-level projects, project management requires centralized control and extensive monitoring. It also must be accepted and supported by all levels within the enterprise. Due to the enterprise scope, understanding the business processes, organization structures, and extensive data integration is a critical factor. It is

possible to resolve by introducing enterprise architecture and information architecture.

In order to achieve these requirements, I studied the conceptual integration of four methodologies (project management, software engineering, enterprise architecture, and information architecture). The result of this thesis can be used as the reference for information systems development methodology in enterprise-level heterogeneous environment.

4.2 Contributions

To reduce risks inherent with the development of information systems on the enterprise-level, this thesis is presents a newly integrated framework and methodology, based on project management, software engineering, enterprise architecture, and information architecture.

This thesis reports the study of a framework and methodology that overcomes deficits of existing methodologies. Moreover, it is hypothesized that the framework and methodology can be adapted for implementing enterprise-wide information systems, particularly enterprise portals.

4.3 Limitations and Future Research

4.3.1 Limitations

The framework and methodology were presented at a conceptual level. In order to be practically applied into real projects, specific inputs, outputs, and tools & techniques have to be developed. These requirements are beyond the thesis scope due to research time constraints.

4.3.2 Future Research

Developing Framework and Methodology by Organization Scale and Industrial Classifications: The framework and methodology in the thesis will not fit all information systems projects. The framework and methodology should be customized based on diverse business

environments. According to organization scale (large, medium, and small-sized enterprises) and industrial classifications (manufacturing, distribution, and retail industries), the framework and methodology should apply differently.

Developing a Framework and Methodology for Introducing Packaged Systems: The thesis has studied the framework and methodology as a development approach for information systems. Many organizations have built their information systems by introducing package software (SAP and Oracle products). In case of the introduction of packaged software, the framework and methodology should be modified.

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APPENDICES

Appendix A – PMI's Project Management Process Groups (PMI 2004)

Appendix A details the lifecycle processes of PMBOK from Project Management Institute. This lifecycle processes were used as the foundation of the project management methodology in the thesis. Processes, inputs, outputs, and tools and techniques of the five Project Management Process Groups are tabled in Table A.1 to Table A.5.

Table A.1: Initiating Process Group: Processes, Inputs, Outputs, and Tools & Techniques

Processes	Inputs	Outputs	Tools & Techniques
Develop Project Charter	Contract Project statement of work Enterprise environmental factors Organizational process assets	Project charter	Project Selection Methods Project Management Methodology Project Management Information System Expert Judgment
Develop Preliminary Project Scope Statement	Project charter Project statement of work Enterprise environmental factors Organizational process assets	Preliminary project scope statement	Project Management Methodology Project Management Information System Expert Judgment

Table A.2: Planning Process Group: Processes, Inputs, Outputs, and Tools & Techniques

Processes	Inputs	Outputs	Tools & Techniques
Develop Project Management Plan	Preliminary project scope statement Project management processes Enterprise environmental factors Organizational process assets	Project management plan	Project Management Methodology Project Management Information System Expert Judgment
Scope Planning	Enterprise environmental factors Organizational process assets Project charter Preliminary project scope statement Project management plan	Project scope management plan	Expert Judgment Templates, Forms, Standards
Scope Definition	Organizational process assets Project charter Preliminary project scope statement Project scope management plan Approved change requests	Project scope statement Requested changes Project scope management plan (updates)	Product Analysis Alternatives Identification Expert Judgment Stakeholder Analysis
Create WBS	Organizational process assets Project scope statement Project scope management plan Approved change requests	Project state statement (updates) Work breakdown structure WBS dictionary Scope baseline Project scope management plan (updates) Requested changes	Work Breakdown Structure Templates Decomposition

Activity Definition	Enterprise environmental factors Organizational process assets Project scope statement Work breakdown structure WBS dictionary Project management plan	Activity list Activity attributes Milestone list Requested changes	Decomposition Templates Rolling Wave Planning Expert Judgment Planning Component
Activity Sequencing	Project scope statement Activity list Activity attributes Milestone list Approved change requests	Project schedule network diagrams Activity list (updates) Activity attributes (updates) Requested changes	Precedence Diagramming Method (PDM) Arrow Diagramming Method (ADM) Schedule Network Templates Dependency Determination Applying Leads and Lags
Activity Resource Estimating	Enterprise environmental factors Organizational process assets Activity list Activity attributes Resource availability Project management plan	Activity resource requirements Activity attributes (updates) Resource breakdown structure Resource calendar (updates) Requested changes	Expert Judgment Alternatives Analysis Published Estimating Data Project Management Software Bottom-up Estimating

Activity Duration Estimating	Enterprise environmental factors Organizational process assets Project scope statement Activity list Activity attributes Activity resource requirements Resource calendar Project management plan - Risk register - Activity cost estimates	Activity duration estimates Activity attributes (updates)	Expert Judgment Analogous Estimating Parametric Estimating Three-Point Estimates Reserve Analysis
Schedule Development	Organizational process assets Project scope statement Activity list Activity attributes Project schedule network diagrams Activity resource requirements Resource calendar Activity duration estimates Project management plan - Risk register	Project schedule Schedule model data Schedule baseline Resource requirements (updates) Activity attributes (updates) Project calendar (updates) Requested changes Project management plan (updates) -Schedule management plan (updates)	Schedule Network Analysis Critical Path Method Schedule Compression What-If Scenario Analysis Resource Leveling Critical Chain Method Project Management Software Applying Calendars Adjusting Leads and Lags Schedule Model

Cost Estimating	Enterprise environmental factors Organizational process assets Project scope statement Work breakdown structure WBS dictionary Project management plan -Schedule management plan -Staffing management plan -Risk register	Activity cost estimates Activity cost estimate supporting detail Requested changes Cost management plan (updates)	Analogous Estimating Determine Resource Cost Rates Bottom-up Estimating Parametric Estimating Project Management Software Vendor Bid Analysis Reserve Analysis Cost of Quality
Cost Budgeting	Project scope statement Work breakdown structure WBS dictionary Activity cost estimates Activity cost estimate supporting detail Project schedule Resource calendars Contract Cost management plan	Cost baseline Project funding requirements Cost management plan (updates) Requested changes	Cost Aggregation Reserve Analysis Parametric Estimating Funding Limit Reconciliation
Quality Planning	Enterprise environmental factors Organizational process assets Project scope statement Project management plan	Quality management plan Quality metrics Quality checklists Process improvement plan Quality baseline Project management plan (updates)	Cost-Benefit Analysis Benchmarking Design of Experiments Cost of Quality (COQ) Additional Quality Planning Tools

Human Resource Planning	Enterprise environmental factors Organizational process assets Project management plan -Activity resource requirements	Roles and responsibilities Project organization charts Staffing management plan	Organization Charts and Position Descriptions Networking Organizational Theory
Communications Planning	Enterprise environmental factors Organizational process assets Project scope statement Project management plan -Constraints -Assumptions	Communications management plan	Communications Requirements Analysis Communications Technology
Risk Management Planning	Enterprise environmental factors Organizational process assets Project scope statement Project management plan	Risk management plan	Planning Meetings and Analysis
Risk Identification	Enterprise environmental factors Organizational process assets Project scope statement Risk management plan Project management plan	Risk register	Documentation Reviews Information Gathering Techniques Checklist Analysis Assumptions Analysis Diagramming Techniques
Qualitative Risk Analysis	Organizational process assets Project scope statement Risk management plan Risk register	Risk register (updates)	Risk Probability and Impact Assessment Probability and Impact Matrix Risk Data Quality Assessment Risk Categorization Risk Urgency Assessment

Quantitative Risk Analysis	Organizational process assets Project scope statement Risk management plan Risk register Project management plan -Project schedule management plan -Project cost management plan	Risk register (updates)	Data Gathering and Representation Techniques Quantitative Risk Analysis and Modeling Techniques
Risk Response Planning	Risk management plan Risk register	Risk register (updates) Project management plan (updates) Risk-related contractual agreements	Strategies for Negative Risks or Threats Strategies for Positive Risks or Opportunities Strategy for Both Threats and Opportunities Contingent Response Strategy
Plan Purchase and Acquisitions	Enterprise environmental factors Organizational process assets Project scope statement Work breakdown structure WBS dictionary Project management plan -Risk register -Risk-related contractual agreements -Resource requirements -Project schedule	Procurement management plan Contract statement of work Make-or-buy decisions Requested changes	Make-or-Buy Analysis Expert Judgment Contract Types

	-Activity cost estimates -Cost baseline		
Plan Contracting	Procurement management plan Contract statement of work Make-or-buy decisions Project management plan -Risk register -Risk-related contractual agreements -Resource requirements -Project schedule -Activity cost estimates -Cost baseline	Procurement documents Evaluation criteria Contract statement of work (updates)	Standard Forms Expert Judgment

Table A.3: Executing Process Group: Processes, Inputs, Outputs, and Tools & Techniques

Processes	Inputs	Outputs	Tools & Techniques
Direct and Manage Project Execution	Project management plan Approved corrective actions Approved preventive actions Approved change requests Approved defect repair Validated defect repair Administrative closure procedure	Deliverables Requested changes Implemented change requests Implemented corrective actions Implemented preventive actions Implemented defect repair Work performance information	Project Management Methodology Project Management Information System
Perform Quality Assurance	Quality management plan Quality metrics Process improvement plan Work performance information Approved change requests Quality control measurements Implemented change requests Implemented corrective actions Implemented defect repair Implemented preventive actions	Requested changes Recommended corrective actions Organizational process assets (updates) Project management plan (updates)	Quality Planning Tools and Techniques Quality Audits Process Analysis Quality Control Tools and Techniques
Acquire Project Team	Enterprise environmental factors Organizational process assets Roles and responsibilities Project organization charts Staffing management plan	Project staff assignments Resource availability Staffing management plan (updates)	Pre-Assignment Negotiation Acquisition Virtual Teams

Develop Project Team	Project staff assignments Staffing management plan Resource availability	Team performance assessment	General Management Skills Training Team-Building Activities Ground Rules Co-Location Recognition and Rewards
Information Distribution	Communications management plan	Organizational process assets (updates) Requested changes	Communications Skills Information Gathering and Retrieval Systems Information Distribution Methods Lessons Learned Process
Request Seller Responses	Organizational process assets Procurement management plan Procurement documents	Qualified sellers list Procurement document package Proposals	Bidder Conferences Advertising Develop Qualified Sellers List
Select Sellers	Organizational process assets Procurement management plan Evaluation criteria Procurement document package Proposals Qualified sellers list Project management plan -Risk register -Risk-related contractual agreements	Selected sellers Contract Contract management plan Resource availability Procurement management plan (updates) Requested changes	Weighting System Independent Estimates Screening System Contract Negotiation Seller Rating Systems Expert Judgment Proposal Evaluation Techniques

Table A.4: Monitoring and Controlling Process Group: Processes, Inputs, Outputs, and Tools & Techniques

Processes	Inputs	Outputs	Tools & Techniques
Monitor and Control Project Work	Project management plan Work performance information Rejected change requests	Recommended corrective actions Recommended preventive actions Forecasts Recommended defect repair Requested changes	Project Management Methodology Project Management Information System Earned Value Technique Expert Judgment
Integrated Change Control	Project management plan Requested changes Work performance information Recommended preventive actions Recommended corrective actions Recommended defect repair Deliverables	Approved change requests Rejected change requests Project management plan (updates) Project scope statement (updates) Approved corrective actions Approved preventive actions Approved defect repair Validated defect repair Deliverables	Project Management Methodology Project Management Information System Expert Judgment
Scope Verification	Project scope statement WBS dictionary Project scope management plan Deliverables	Accepted deliverables Requested changes Recommended corrective actions	Inspection

Scope Control	Project scope statement Work breakdown structure WBS dictionary Project scope management plan Performance reports Approved change requests Work performance information	Project scope statement (updates) Work breakdown structure (updates) WBS dictionary (updates) Scope baseline (updates) Requested changes Recommended corrective actions Organizational process assets (updates) Project management plan (updates)	Change Control System Variance Analysis Replanning Configuration Management System
Schedule Control	Schedule management plan Schedule baseline Performance reports Approved change requests	Schedule model data (updates) Schedule baseline (updates) Performance measurements Requested changes Recommended corrective actions Organizational process assets (updates) Activity list (updates) Activity attributes (updates) Project management plan (updates)	Progress Reporting Schedule Change Control System Performance Measurement Project Management Software Variance Analysis Schedule Comparison Bar Charts

Cost Control	Cost baseline Project funding requirements Performance reports Work performance information Approved change requests Project management plan	Cost estimates (updates) Cost baseline (updates) Performance measurements Forecasted completion Requested changes Recommended corrective actions Organizational process assets (updates) Project management plan (updates)	Cost Change Control System Performance Measurement Analysis Forecasting Project Performance Reviews Project Management Software Variance Management
Perform Quality Control	Quality management plan Quality metrics Quality checklists Organizational process assets Work performance information Approved change requests Deliverables	Quality control measurements Validated defect repair Quality baseline (updates) Recommended corrective actions Recommended preventive actions Requested changes Recommended defect repair Organizational process assets (updates) Validated deliverables Project management plan (updates)	Cause and Effect Diagram Control Charts Flowcharting Histogram Pareto Chart Run Chart Scatter Diagram Statistical Sampling Inspection Defect Repair Review

Manage Project Team	Organizational process assets Project staff assignments Roles and responsibilities Project organization charts Staffing management plan Team performance assessment Work performance information Performance reports	Requested changes Recommended corrective actions Recommended preventive actions Organizational process assets (updates) Project management plan (updates)	Observation and Conversation Project Performance Appraisals Conflict Management Issue Log
Performance Reporting	Work performance information Performance measurements Forecasted completion Quality control measurements Project management plan -Performance measurement baseline Approved change requests Deliverables	Performance reports Forecasts Requested changes Recommended corrective actions Organizational process assets (updates)	Information Presentation Tools Performance Information Gathering and Compilation Status Review Meetings Time Reporting Systems Cost Reporting Systems
Manage Stakeholders	Communications management plan Organizational process assets	Resolved issues Approved change requests Approved corrective actions Organizational process assets (updates) Project management plan (updates)	Communications Methods Issue Logs

Risk Monitoring and Control	Risk management plan Risk register Approved change requests Work performance information Performance reports	Risk register (updates) Requested changes Recommended corrective actions Recommended preventive actions Organizational process assets (updates) Project management plan (updates)	Risk Reassessment Risk Audits Variance and Trend Analysis Technical Performance Measurement Reserve Analysis Status Meetings
Contract Administration	Contract Contract management plan Selected sellers Performance reports Approved change requests Work performance information	Contract documentation Requested changes Recommended corrective actions Organizational process assets (updates) Project management plan (updates) -Procurement management plan -Contract management plan	Contract Change Control System Buyer-Conducted Performance Review Inspections and Audits Performance Reporting Payment System Claims Administration Records Management System Information Technology

Table A.5: Closing Process Group: Processes, Inputs, Outputs, and Tools & Techniques

Processes	Inputs	Outputs	Tools & Techniques
Close Project	Project management plan Contract documentation Enterprise environmental factors Organizational process assets Work performance information Deliverables	Administrative closure procedure Contract closure procedure Final product, service or result Organizational process assets (updates)	Project Management Methodology Project Management Information System Expert Judgment
Contract Closure	Procurement management plan Contract management plan Contract documentation Contract closure procedure	Closed contracts Organizational process assets (updates)	Procurement Audits Records Management System

Appendix B – TOGAF's (The Open Group Architecture Framework) Architecture Development Method (The Open Group 2003)

Appendix B describes the Architecture Development Method of TOGAF from The Open Group. This method was used as the foundation of the enterprise architecture methodology in the thesis. Steps, inputs, and outputs of each phase are tabled in Table B.1 and Table B.2.

Table B.1: Architecture Development Method's Phase, Steps, Inputs, and Outputs

Phase	Steps	Inputs	Outputs
Preliminary Phase: Framework and Principles	Conjunction with a wide variety of other architecture frameworks, if required	TOGAF Architecture Development Method (ADM) Other architecture framework(s), if required Business strategy, business principles, business goals, and business drivers, when pre-existing IT governance strategy, when pre-existing Architecture principles, when pre-existing Principles that are being subscribed to, arising from other, federated architectures	Framework definition Architecture principles Restatement of, or reference to, business principles, business goals, and business drivers
Phase A: Architecture Vision	1. Establish the Project 2. Identify Business Goals and Business Drivers 3. Review Architecture Principles, including Business Principles 4. Define Scope	Request for Architecture Work Business strategy, business goals, and business drivers Architecture principles, including business principles, when pre-existing Enterprise Continuum - existing architectural	Approved Statement of Architecture Work, including in particular: Scope and constraints Plan for the architectural work Refined statements of business goals and strategic drivers

	5. Define Constraints 6. Identify Stakeholders and Concerns, Business Requirements, and Architecture Vision 7. Develop Statement of Architecture Work and Secure Approval	documentation (framework description, architectural descriptions, existing baseline descriptions, etc.)	Architecture principles, including business principles Architecture Vision, including: Baseline Business Architecture, Version 0.1 Baseline Technology Architecture, Version 0.1 Baseline Data Architecture, Version 0.1 Baseline Applications Architecture, Version 0.1 Target Business Architecture, Version 0.1 Target Technology Architecture, Version 0.1 Target Data Architecture, Version 0.1 Target Applications Architecture, Version 0.1
Phase B: Business Architecture	1. Develop Baseline Business Architecture Description 2. Identify Reference Models, Viewpoints, and Tools 3. Create Architecture Model(s) 4. Select Business Architecture Building Blocks (e.g., business services) 5. Conduct Formal Checkpoint Review of Architecture Model and Building Blocks with	Request for Architecture Work Approved Statement of Architecture Work Refined statements of business goals and strategic drivers Architecture principles, including business principles, when pre-existing Enterprise Continuum Architecture Vision, including: Baseline Business Architecture, Version 0.1	Statement of Architecture Work, updated if necessary Validated business principles, business goals, and strategic drivers Target Business Architecture, Version 1.0 (detailed), including: Organization structure - identifying business locations and relating them to organizational units

	Stakeholders 6. Review Non-Functional (Qualitative) Criteria (e.g., performance, costs, volumes) 7. Complete Business Architecture 8. Perform Gap Analysis (see Approach) and Create Report	Baseline Technology Architecture, Version 0.1 Baseline Data Architecture, Version 0.1 Baseline Applications Architecture, Version 0.1 Target Business Architecture, Version 0.1 Target Technology Architecture, Version 0.1 Target Data Architecture, Version 0.1 Target Applications Architecture, Version 0.1	Business goals and objectives - for the enterprise and each organizational unit Business functions - a detailed, recursive step involving successive decomposition of major functional areas into sub-functions Business services - the services that the enterprise and each enterprise unit provides to its customers, both internally and externally Business processes, including measures and deliverables Business roles, including development and modification of skills requirements Business data model Correlation of organization and functions - relate business functions to organizational units in the form of a matrix report Baseline Business Architecture, Version 1.0 (detailed), if appropriate Views corresponding to the selected viewpoints addressing key stakeholder concerns Gap analysis results Technical requirements - identifying,

			categorizing, and prioritizing the implications for work in the remaining architecture domains; for example, by a dependency/priority matrix. (For example, guiding trade-off between speed of transaction processing and security.) List the specific models that are expected to be produced (for example, expressed as primitives of the Zachman Framework). Business Architecture Report Updated business requirements
Phase C: Information Systems Architectures	Detailed steps for Phase C are given separately for each architecture domain: - Data Architecture (Phase C: Information Systems Architectures - Data Architecture) - Applications Architecture (Phase C: Information Systems Architectures - Applications Architecture)	Application principles, if existing Data principles, if existing Request for Architecture Work Statement of Architecture Work Architecture Vision Enterprise Continuum Baseline Business Architecture, Version 1.0 (detailed), if appropriate Target Business Architecture, Version 1.0 (detailed) Baseline Data Architecture, Version 0.1 Target Data Architecture, Version 0.1 Baseline Applications Architecture, Version 0.1	Statement of Architecture Work, updated if necessary Baseline Data Architecture, Version 1.0 Target Data Architecture, Version 1.0 Baseline Applications Architecture, Version 1.0 Target Applications Architecture, Version 1.0 Data Architecture views corresponding to the selected viewpoints addressing key stakeholder concerns Applications Architecture views corresponding to the selected viewpoints addressing key stakeholder concerns

		Target Applications Architecture, Version 0.1 Relevant technical requirements that will apply to Phase C Gap analysis results (from Business Architecture) Re-usable building blocks (from organization's Architecture Continuum, if available)	Data Architecture Report, summarizing what was done and the key findings Applications Architecture Report, summarizing what was done and the key findings Gap analysis results: Areas where the Business Architecture may need to change to cater for changes in the Data and/or Applications Architecture Constraints on the Technology Architecture about to be designed Impact Analysis Updated business requirements (if appropriate)
Phase C: Information Systems Architectures - Data Architecture	1. Develop Baseline Data Architecture Description 2. Review and Validate Principles, Reference Models, Viewpoints, and Tools 3. Create Architecture Model(s) 4. Select Data Architecture Building Blocks 5. Conduct Formal Checkpoint Review of Architecture Model and Building Blocks with Stakeholders 6. Review Qualitative Criteria (e.g.,	Data principles, if existing Request for Architecture Work Statement of Architecture Work Architecture Vision Relevant technical requirements that will apply to this phase Gap analysis results (from Business Architecture) Baseline Business Architecture, Version 1.0 (detailed), if appropriate	Statement of Architecture Work, updated if necessary Baseline Data Architecture, Version 1.0, if appropriate Validated data principles, or new data principles (if generated here) Target Data Architecture, Version 1.0 Business data model Logical data model Data management process models

	performance, reliability, security, integrity) 7. Complete Data Architecture 8. Conduct Checkpoint/Impact Analysis 9. Perform Gap Analysis and Create Report	Target Business Architecture, Version 1.0 (detailed) Baseline Data Architecture, Version 0.1, if available Target Data Architecture, Version 0.1, if available Re-usable building blocks, from organization's Enterprise Continuum, if available (in particular, definitions of current data)	Data entity/business function matrix Data interoperability requirements Viewpoints addressing key stakeholder concerns Views corresponding to the selected viewpoints; for example: Data dissemination view Data lifecycle view Data security view Data model management view Gap analysis results Relevant technical requirements that will apply to this evolution of the architecture development cycle Data Architecture Report, summarizing what was done and the key findings Impact Analysis Areas where the Business Architecture may need to change to cater for changes in the Data Architecture Identify any areas where the Applications Architecture (if generated at this point) may need to change to cater for changes in the Data Architecture Constraints on the Technology

			Architecture about to be designed Updated business requirements, if appropriate
Phase C: Information Systems Architectures - Applications Architecture	1. Develop Baseline Applications Architecture Description 2. Review and Validate Principles, Reference Models, Viewpoints, and Tools 3. Create Architecture Model(s) 4. Identify Candidate Application Systems 5. Conduct Formal Checkpoint Review of Architecture Model and Building Blocks with Stakeholders 6. Review Qualitative Criteria (e.g., security, availability, performance, costs) 7. Complete Applications Architecture 8. Perform Gap Analysis (see Approach) and Create Report	Application principles, if existing Request for Architecture Work Statement of Architecture Work Architecture Vision Relevant technical requirements that will apply to this phase Gap analysis results (from Business Architecture) Baseline Business Architecture, Version 1.0 (detailed), if appropriate Target Business Architecture, Version 1.0 (detailed) Re-usable building blocks, from organization's Enterprise Continuum, if available Baseline Applications Architecture, Version 0.1, if appropriate and if available Target Applications Architecture, Version 0.1, if available	Statement of Architecture Work (updated if necessary) Baseline Applications Architecture, Version 1.0, if appropriate Validated application principles, or new application principles (if generated here) Target Applications Architecture, Version 1.0 Process Systems Model Place Systems Model Time Systems Model People Systems Model Applications interoperability requirements Viewpoints addressing key stakeholder concerns Views corresponding to the selected viewpoints; for example: Common Applications Services view Applications Interoperability view Applications/Information view Applications/User Locations view Gap analysis results

			Applications Architecture Report, summarizing what was done and the key findings Impact Analysis Areas where the Business Architecture may need to change to cater for changes in the Applications Architecture Identify any areas where the Data Architecture (if generated at this point) may need to change to cater for changes in the Applications Architecture Constraints on the Technology Architecture about to be designed Updated business requirements, if appropriate
Phase D: Technology Architecture	1. Develop Baseline Technology Architecture Description 2. Develop Target Technology Architecture; see detailed steps Step 1 is to create a Baseline Description in the TOGAF format. Step 2 is to consider different architecture reference models, viewpoints, and tools. Step 3 is to create an architectural model of building blocks.	Technology principles, if existing Request for Architecture Work Statement of Architecture Work Architecture Vision Baseline Technology Architecture, Version 0.1 (from Phase A) Target Technology Architecture, Version 0.1 (from Phase A) Relevant technical requirements from previous phases	Statement of Architecture Work, updated if necessary Baseline Technology Architecture, Version 1.0, if appropriate Validated technology principles, or new technology principles (if generated here) Technology Architecture Report, summarizing what was done and the key findings Target Technology Architecture, Version

	Step 4 is to select the services portfolio required per building block. Step 5 is to confirm that the business goals and objectives are met. Step 6 is to determine criteria for specification selection. Step 7 is to complete the architecture definition. Step 8 is to conduct a gap analysis.	Gap analysis results (from Data Architecture) Gap analysis results (from Applications Architecture) Baseline Business Architecture, Version 1.0 (detailed), if appropriate Baseline Data Architecture, Version 1.0, if appropriate Baseline Applications Architecture, Version 1.0, if appropriate Target Business Architecture, Version 1.0 (detailed) Re-usable building blocks, from organization's Enterprise Continuum, if available Target Data Architecture, Version 1.0 Target Applications Architecture, Version 1.0	1.0 Technology Architecture, gap report Viewpoints addressing key stakeholder concerns Views corresponding to the selected viewpoints
Phase E: Opportunities and Solutions	1. Identify Key Business Drivers Constraining Sequence of Implementation 2. Review Gap Analysis from Phase D 3. Brainstorm Technical Requirements from Functional Perspective 4. Brainstorm Co-existence and Interoperability Requirements	Request for Architecture Work Statement of Architecture Work Target Business Architecture, Version 1.0 Target Technology Architecture, Version 1.0 Target Data Architecture, Version 1.0 Target Applications Architecture, Version 1.0	Implementation and migration strategy High-level Implementation Plan Impact Analysis - project list

	5. Perform Architecture Assessment and Gap Analysis 6. Identify Major Work Packages or Projects	Re-usable Architecture Building Blocks (from organization's Enterprise Continuum, if available) Product information	
Phase F: Migration Planning	1. Prioritize projects 2. Estimate resource requirements and availability 3. Perform cost/benefit assessment of the various migration projects 4. Perform risk assessment 5. Generate implementation roadmap (timelined) 6. Document the Migration Plan	Request for Architecture Work Statement of Architecture Work Target Business Architecture, Version 1.0 Target Technology Architecture, Version 1.0 Target Data Architecture, Version 1.0 Target Applications Architecture, Version 1.0 Impact Analysis - project list	Impact Analysis - detailed Implementation Plan and Migration Plan (including Architecture Implementation Contract, if appropriate)
Phase G: Implementa-tion Governance	1. Formulate Project Recommendation 2. Document Architecture Contract 3. Review Ongoing Implementation Governance and Architecture Compliance	Request for Architecture Work Statement of Architecture Work Re-usable Solution Building Blocks (from organization's Solutions Continuum, if available) Impact Analysis - detailed Implementation Plan and Migration Plan (including Architecture Implementation Contract, if appropriate)	Impact Analysis - implementation recommendations Architecture Contract The architecture-compliant implemented system
Phase H: Architecture Change	1. Monitor Technology Changes 2. Monitor Business Changes 3. Assess Changes and Development of	Request for Architecture Change - technology changes: New technology reports	Architecture updates Changes to architecture framework and principles

Management	Position to Act 4. Arrange Meeting of Architecture Board (or other governing council)	Asset management cost reduction initiatives Technology withdrawal reports Standards initiatives Request for Architecture Change - business changes: Business developments Business exceptions Business innovations Business technology innovations Strategic change developments	New Request for Architecture Work, to move to another cycle

Phase: ADM Architecture Requirements Management

Inputs

▪ The requirements-related outputs from each ADM phase.

▪ The first high-level requirements are articulated as part of the Architecture Vision, generated by means of the business scenario or analogous technique.

▪ Each architecture domain then generates detailed design requirements specific to that domain, and potentially to other domains

▪ Deliverables in later ADM phases that contain mappings to the design requirements and generate new types of requirements (for example, conformance requirements, time windows for implementation)

Steps

Table B.2: Architecture Requirements Management Steps and ADM Steps

	Requirements Management Steps	ADM Phase Steps
1.		Identify/document requirements - use business scenarios, or an analogous technique.
2.	Baseline requirements: Determine priorities arising from current phase of ADM. Confirm stakeholder buy-in to resultant priorities. Record requirements priorities and place in requirements repository.	
3.	Monitor baseline requirements.	
4.		Identify changed requirement: Remove or re-assess priorities. Add requirements and re-assess priorities. Modify existing requirements.
5.	Identify changed requirement and record priorities: Identify changed requirements and ensure the	

	requirements are prioritized by the architect(s) responsible for the current phase, and by the relevant stakeholders. Record new priorities. Ensure that any conflicts are identified and managed through the phases to a successful conclusion and prioritization. Generate Requirements Impact Statement for steering the architecture team. Notes Changed requirements can come in through any route. To ensure that the requirements are properly assessed and prioritized, this process needs to direct the ADM phases and record the decisions related to the requirements. The requirements management phase needs to determine stakeholder satisfaction with the decisions. Where there is dissatisfaction, the phase remains accountable to ensure the resolution of the issues and determine next steps	
6.		Assess impact of changed requirements on current (active) phase. Assess impact of changed requirements on previous phases. Determine whether to implement change, or defer to later ADM cycle. If decision is to implement, assess timescale for change management implementation. Issue Requirements Impact Statement, Version n+1.
7.		Implement requirements arising from Phase H. The architecture can be changed through its lifecycle by the architecture change management phase (Phase H). The

		requirements management process ensures that new or changing requirements that are derived from Phase H are managed accordingly.
8.	Update the requirements repository with information relating to the changes requested, including stakeholder views affected.	
9.		Implement change in the current phase.
10.		Assess and revise gap analysis for past phases. The gap analysis in the ADM Phases B through D identifies the gaps between Baseline and Target Architectures. Certain types of gap can give rise to gap requirements. The ADM describes two kinds of gap: Something that is present in the baseline, but not in the target (i.e., eliminated - by accident or design) Something not in the baseline, but present in the target (i.e., new) A "gap requirement" is anything that has been eliminated by accident, and therefore requires a change to the Target Architecture. If the gap analysis generates gap requirements, then this step will ensure that they are addressed, documented, and recorded in the requirements repository, and that the Target Architecture is revised accordingly.

Outputs

- A structured requirements statement, including:
- Changed requirements
- Requirements Impact Statement