A Model-based Approach to Managing Enterprise Information Systems

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Abstract. Organizations must evolve their information systems (IS) in order to adapt to changes in their environment or to maintain or enhance competitiveness. The use of modern application integration technologies (e.g., middleware) and advanced network technologies has resulted in IS that provide services at unprecedented levels, but at the price of becoming more complex and thus more difficult to evolve. By way of concrete examples, this paper focuses on the use of system models expressed in the Unified Modeling Language (UML) to effectively manage information systems assets. The system models capture critical information about an organization and are part of an overall framework called the Applic*ation Mapping Framework* or AMF. The AMF can be used by IT architects and planners to track applications, relate descriptions of system artifacts across different levels of abstraction and support redundancy, gap and impact analyses. The paper also identifies management roles needed to ensure that the AMF repository contains comprehensive and up-to-date models.

1 Introduction

The mission-critical role that Information Systems (IS) play in accomplishing business goals requires that they be managed and tracked as organizational assets. In this paper we describe a f*ramework* called the Application Mapping Framework (AMF), for organizing information about planned and deployed applications in an organization. The AMF is intended to support disciplined management and evolution of IS resources and enables business managers, information technology (IT) planners and architects, and application developers to (1) make decisions that minimize development risks and costs, (2) identify opportunities for cutting costs, and (3) identify new business opportunities. The AMF is more than just a static application portfolio. It provides services that can be used by IT planners and architects to support redundancy, gap and impact analyses. Proper use of the AMF will enhance the ability of an organization to maintain a corporate memory and utilize that memory to cost-effectively evolve its IS resources and business processes to meet business goals. The

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AMF is intended to provide a single, accurate, organized source of information about business processes, applications, data and other IT resources.

An overview of the AMF architecture is presented in Section 2 of this paper. Types of analyses supported by the AMF and management functions required to build, use and maintain the AMF, are presented in Section 3. Section 4 explains by way of an example how the AMF could be used to support IS planning and evolution. The paper concludes with our views on the merits of using a model-based approach to IS management and an outline of our planned work in this area.

2 An Overview of the AMF

The AMF provides a logical architecture for a repository of information on applications and data within an organization. Its development is based on experience gathered on industrial projects that focused on developing application portfolios for organizations with a large and diverse set of distributed applications. The AMF specifies an application that is flexible in terms of the physical form or location of information could be captured and integrated in the framework. To help organize its wide range of topics and content, the information in the AMF is structured into a number of core views. Information in a core view can be further organized into sub-views.

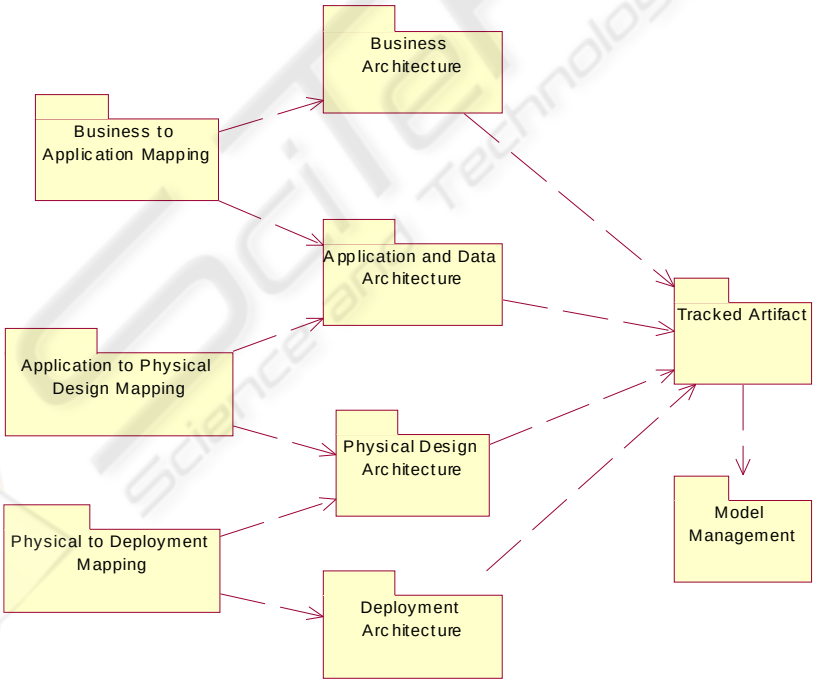

Fig. 1. Enterprise Application Map Structure

The UML (Unified Modeling Language) [1] is used to describe the structure of information in the AMF. An UML package is used to describe a view. UML Class Diagrams are used to describe the conceptual structure of information in a view, where a UML class represents a type of information item, a UML association represents a conceptual relationship between peer information item types, and an UML specialization relationship represents a further classification of an information item type. A view, represented as a package, contains a structure of packages (representing sub-views) and types (representing information item types).

At the top level, the AMF is organized into three views.

- The *IT Planning View* contains information pertaining to ongoing and planned IS projects, and includes information on tactical and strategic plans. The IT Planning View is intended to support the work of IT planners and project managers.
- The *Asset View* contains information about enterprise-wide and domain-specific reusable business artifacts. This view is intended to support systematic reuse of development experiences across an organization.
- The *Enterprise Application Map* is the central component of the AMF and contains information about the current and planned information system resources (e.g., applications, data, processes, roles) that are tracked within an organization. The previously mentioned views utilize information within this view (as indicated by the dependency relationships – the dashed arrows – between the packages).

This paper focuses on the Enterprise Application Map. The information in the Enterprise Application Map is organized into the following primary views (see Figure 1):

- *Business Architecture*: This view contains information about the business processes and entities that are tracked by an organization.
- *Application and Data Architecture*: This view contains information about the logical (i.e., technology-independent) aspects of applications and data. The information includes descriptions of the IS artifacts (applications and data) as they exist, as well as plans for evolving the artifacts. Descriptions include models and artifact metadata.
- *Physical Design Architecture*: This view contains information about the physical design of applications and data, that is, it presents a technology-specific view of applications. This view allows one to track the technologies that are used to implement applications and data.
- *Deployment Architecture*: This view contains information about the deployment and usage of applications within an organization. Information pertains to the "as is" deployment and usage of applications and data, as well as to planned deployments and usages.

Relationships between concepts across these views are described by the Mapping Packages:

- *Business to Application Mapping*: This package links elements in the Business Architecture view to the Application and Data Architecture view. The mappings provide traceability of business concepts to logical (platform independent) application concepts.

- *Application to Physical Design Mapping*: The mappings in this package provide traceability of logical application elements to physical (platform-specific) design elements.
- *Physical to Deployment Mapping*: The mappings in this package provide traceability of physical design elements to the artifacts to their deployed forms.

The other packages of information in the Enterprise Application Map contain information that is orthogonal to the packages described above.

- *Tracked Artifa*ct: This package contains information about properties that are common to artifacts that are tracked in the AMF. Currently, this includes only information pertaining to versioning of artifacts.
- *Model Management*: This package contains information about models, groupings of model elements used to present views of applications, the tools used to display models and the organizational roles responsible for maintaining the views.

3 Using the AMF

This section outlines the kinds of analyses that are supported and the management roles that are recommended for effective management and evolution of the AMF.

3.1 Management Roles

Effective use of the AMF by business analysts, architects and system developers is possible only when the contents of the AMF are relevant, properly packaged, easily retrieved, current and accurate. The following are recommended management roles that address issues related to the relevancy, accuracy, and usability of the AMF:

- *Content Manager*: Responsible for packaging, cataloging, and updating AMF contents.
- *Content Collector*: Responsible for collecting candidate contents.
- *Content Certifier/Evaluator*: Responsible for evaluating and certifying candidate AMF contents. The evaluation is carried out to determine, for example, the accuracy, relevance, and currency of candidate content.
- *Content Disseminator*: Responsible for promoting and facilitating the use of the AMF.
- *AMF Strategic Planner*: Responsible for developing and maintaining plans for evolving the AMF. This involves analyzing the usage of the AMF, analyzing repository contents (e.g., identifying content with diminishing returns), and identifying opportunities.

3.2 User Roles

Users of the AMF can be classified in terms of the roles they play in system and business process management and development. Below we list the roles and the types of interactions they can have with the AMF.

- *Business Analyst*: Responsible for defining, documenting and updating business processes.
- *IS Architect*: Responsible for planning and managing the integration and evolution of IT systems that support business processes.
- *System Architect*: Responsible for designing and managing the evolution of a particular system.
- *System Developer*: Responsible for implementing system designs and changes.

3.3 Model-based Analyses

A sample set of IT project planning activities supported by the AMF are listed below:

- *Impact Analyses*: During project planning one needs to determine, among other concerns, how the system to be developed impacts other systems, what resources are required and available for the project, what parts of the system functionality can be provided by existing system components and what parts need to be built or acquired. The AMF can be used to support impact analysis, determining the impact of change on the organization's ability to effectively meet business needs. The relationships among the artifacts in the AMF (for example, data/object create, read, update, and delete relationships between applications and data/objects) can be used to determine the impact of planned changes and new features on existing applications and data and on other current and planned IT projects.
- *Gap Analyses*: The AMF can also be used to support gap analyses. As new processes and system functionality are developed, gaps in the existing integrated system need to be identified and filled. Gap analysis is concerned with determining the missing functional and process elements that need to be present in order to implement new functionality of processes. The repository can be used to determine what parts of a system are under development or already exists, and what parts need to be obtained from outside vendors or be built in-house.
- *Redundancy analyses*: As an organization's pool of systems grows, the need to identify redundancies to reduce inefficiencies and avoid conflicts arising from multiple representations of a single concept across an organization becomes evident. Redundancy analysis is concerned with identifying systems that provide similar services. The repository can be used to determine whether proposals for new system features can already be met by existing systems and to determine wasteful overlaps in system functionality.
- *Reuse analyses*: Order-of-magnitude improve-ment in productivity and system quality can be accomplished if developers reuse product experiences. A well-managed integrated system can form the basis for identifying potentially reusable experiences across an organization. Reusability analysis is concerned with identifying potentially reusable artifacts. Commonality analyses can be carried out on the repository to identify organization-wide and domain-specific patterns that can be packaged for reuse (e.g., as product frameworks, components, reusable models).

4 An order fulfillment process scenario

The following scenario, though fictional, provides a realistic view of how the AMF can be used to support IT planning and system evolution within an organization. The Commercial Equipment (CE) Division of a fictitious organization has acquired a new distribution channel that is located overseas. The need to adhere to reporting regulations and other standards (e.g., customer addressing) in force within the foreign territory requires CE to reengineer its order fulfillment processes and systems.

In this scenario the AMF contains a web of artifacts ranging from business models of the processes to documents describing the deployment and usage of applications, and the computing infrastructure that currently support the processes. The AMF is accessed through interfaces that provide reporting functions and browsing starting points that are particular to the roles of the individuals accessing the repository. For example, the Business View interface of the AMF provides business analysts with a business-oriented view of the repository contents from which they can drill down to more system-specific views if required.

In the absence of an AMF, analysts, planners and developers have the challenge of locating, relating, and analyzing possibly poorly documented information about the current order fulfillment processes and supporting systems within CE. They may even have to revert to source code analysis. These activities are expensive, error-prone, and time-consuming. More importantly, such an environment is not conducive to the development of systems that fully exploit resources that can significantly reduce the cost of development without sacrificing system quality.

4.1 Business Analysis

The business analyst is responsible for defining an order fulfillment business process that will handle the orders of the new distribution channel. To carry out this task the analyst needs to (1) consider the impact of the proposed process solutions on existing processes and systems, and (2) identify possible opportunities for exploiting current system resources in the execution of the new processes, in order to define a cost-effective and realizable process.

As a starting point, the analyst uses the AMF to determine the location of documents that describe the current CE order fulfillment processes. Using the documentation reporting facility of the Business View interface, the analyst locates information on order fulfillment processes. A partial view of the table that is displayed as a result of the interaction with the AMF is shown below:

Table 1. Relationships between Processes and the Responsible Organizational Roles

Subject Area	Business Activity	Responsible Organization
Order	Order Fulfillment	Org1
	Order Entry	Org2
	Order Routing	Org2
	Order Management	Org3

The order fulfillment processes are contained in the Order subject area and consists of business sub-activities. Clicking on an activity name in column 2 takes the analyst to a page that contains model(s) of the activity. These models can be expressed as Activity Diagrams, Interaction Diagrams, and/or Use Cases. Using these links the analyst can not only access models that help in understanding the processes, but also use the information to identify models that are impacted by the change and that can be reused to describe the changed process. The analyst also needs to work with the owners of the process descriptions that will be impacted by the change. Clicking on the items in the third column of Table 1 results in a page that displays contact information for business process owners.

Table 2 is a partial view of the table that is displayed when Order Entry in column 2 of Table 1 is selected (in this case the process models are organized by the types of orders processed):

Table 2. Process Model Table for Order Entry

Business Activity	Order Entity Type	Essential Process Model	Process Realization Model
Order Entry	Domestic Dealer Order	Ess-.mdl	Real-OD.mdl
	Export Order Region 1	Ess-E1.mdl	Real-E1.mdl
	Export Order Region 2	Ess-E2.mdl	Real-E2.mdl

There are a number of variants of the Order Entry process, each determined by the type of order it processes. Selecting an order type in column 2 of Table 2 results in a page that describes the order type. Columns 3 and 4 contain pointers to models of the processes. An essential process model describes a process in terms of externally observable effects (i.e., effects that are observable by users of the business processes – the external view), and a process realization model describes a process in terms of how the activities are carried out (the internal view).

The analyst also needs to determine the business entities that are impacted by the change. To support this task the AMF can be used to produce the following table:

Table 3. Trace relationships between business activities and business entities

Business Activity		Business Entity	Access Type	Responsible Organization
Order Fulfillment				Org 1
	Order Entry	Order FDD …	Create Create …	Org2 Org2
	Order Routing	Supplier …	Update …	Supp
	Order Management	Customer Account …	Update …	Customer Dept

Selecting items in column 1 of Table 3 results in a page that shows the realization process models indicating which entities are created, accessed, updated and deleted by the business activity. Column 2 lists the business entities that are manipulated by the business activities, and column 3 specifies the type of access (Create, Read, Update, Delete).

The analyst also needs to have an idea of the order fulfillment systems and databases that would be impacted by the change in order to identify a cost-effective process solution. Another table (not shown), can show the relationship between the business activities and the systems and databases that support the activities. Selecting on the items in System and Database columns can link the analyst to a page that contains descriptions of the artifacts, contact information for the owners of the artifacts, and pointers to more detailed information about the systems and databases.

5 Related Work

Other frameworks for information systems architecture are being used today, most notably being the Zachman Framework (ZF), the Four+one framework and the RM-ODP. Each has its own merit providing developers of new systems architectural options for conceptualizing and designing. Zachman Framework is pre-object and reflects a structured approach to development. It consists of a thirty-six-cell matrix covering the perspectives of different stakeholders and aspects of the architecture. It is seen as the best way to conceptualize all the elements of a system but has been criticized as being process-heavy, requiring years to create. Ambler [3] suggests ways in which ZF can be used in an agile manner.

The RM-ODP [2] is rooted in object analysis, and covers five viewpoints enterprise, information, computational engineering and technology. Evitt [4] points out that the viewpoints are abstract and do not reflect the concerns of specific stakeholders as the ZF.

The AMF being proposed provides a lower level of detail than the ZF and RM-ODP. Whereas the frameworks mentioned above can be used for developing *new* systems, the AMF is intended for use as a lightweight means to document *existing* systems and the way they relate to each other. It is to be used as a management tool for identifying gaps, redundancies and reuse opportunities, and to be able to perform impact analysis. The AMF can be used within the context of both the ZF and the RM-ODP.

6 Further work

The AMF can provide a comprehensive representation of an enterprise's business and information systems and the means to conduct relevant queries and analyses. The proposed business architecture, application and data architecture etc. serve to define a workable structure for organizing, managing, analyzing and evolving enterprise information systems. Populating this framework with suitable, well placed and accurate business and information system design and implementation models

however, requires the involvement of skilled modelers, the formulation of and adherence to standards of operating that will guarantee capture of accurate information in a timely manner. The discipline required to make the use of the AMF a success will ultimately result in improved practices, processes and tools and to a more mature use of IT.

Our next step is to validate the AMF by using it to develop an IS repository for an industrial partner. We are currently evaluating different development environments for hosting, populating and querying an AMF repository. We will then develop and deploy a prototype repository infrastructure and evaluated its usage. The experience we gain will help refine the architecture and give insights into the types of mechanisms needed to seamlessly integrate AMF related activities and IS development and planning activities.

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