Towards Data Supply Chains in Enterprise Architecture Management

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Abstract: This paper discusses the idea of transferring the concept of supply chains and value creation from material flows to data flows. The paper has a focus on enterprise architecture management (EAM) and the data required for EAM. Our proposal is to transfer the idea of supply chains from manufacturing to EAM by combining three different approaches (a) information demand patterns as means to express the information demand of organizational roles in EAM, (b) information logistics value chains as conceptual foundation for establishing the value creation steps required from the data supply chain, and (c) knowledge services as core elements of an architecture for EAM data supply chain. The paper presents work-in-progress which so far primarily stays on a conceptual level. The research method used primarily is argumentative-deductive.

1 Introduction

Since Porter's seminal work on value creation and value chains [Po08], it is common practice in many industrial areas to base organization structures and activity planning on value creation principles. In more complex industry areas, like automotive or telecommunication industries, even the supplier structure and the chain of supply is oriented towards value creation principles [Gu01]. This paper discusses the idea of transferring the concept of supply chains and value creation from material flows to data flows. The paper has a focus on enterprise architecture management (EAM) and the data required for EAM. The idea as such is inspired by work from information logistics, a research area focusing on demand-oriented information supply.

In the context of big data scenarios, demand-orientation is expected to contribute to solve or bypass some of the problems attached to big data. Big data challenges are commonly attributed to the three dimensions volume, variety and velocity [Zi12], i.e. large quantities of data have to be processed or analyzed nearly in real-time from data sources with varying structure. If the exact information demand and the value of the information for EAM are known, the volume of data to be analyzed probably is only

affected if data sources can be ruled out due to the demand, but the volume of data to be stored for later use definitively can be reduced.

Our proposal is to transfer the idea of supply chains from manufacturing to EAM by combining three different approaches:

- Information demand patterns as means to express the information demand of organizational roles in EAM
- Information logistics value chains as conceptual foundation for establishing the value creation steps required from the data supply chain
- Knowledge services as core elements of an architecture for EAM data supply chain

The paper presents work-in-progress which so far primarily stays on a conceptual level. We explore the transferability of value chain and information demand concepts from information logistics to data supply in enterprise architecture management. The research method used primarily is argumentative-deductive, i.e. we investigate existing theories and concepts regarding their applicability for the problem at hand and argue for the possibility to use them. Future work will have to include more design-oriented work, like, e.g., development of a prototype showing the feasibility and usefulness of the approach.

The remainder of this paper is structured as follows: section 2 summarizes the background for this paper. Section 3 presents our conceptual approach for data supply chain in EAM. Section 4 shows first elements of implementing the approach by using a typical EAM role as example. Section 5 summarizes the findings and gives an outlook.

2 Background

The background for this work stems from three different areas briefly discussed in this section: enterprise architecture management (2.1), supply chains and value creation (2.2) and information logistics (2.3).

2.1 Enterprise Architecture Management

Enterprises are complex, highly integrated systems comprised of processes, organizational units, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries [Ah12]. Enterprise Architecture Management (EAM) aims at providing an integrated view on all aspects of the organization under consideration with all dependencies of artifacts and information objects necessary for business performance. In this context, architecture is defined as a fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principle guiding the organization's design and evolution [La09]. Enterprise Architecture (EA) is the formal declaration of the basic structures of an organization, its components and relations, as well as the processes used for development.

In this context, EAM provides an approach for a systematical development of the organization in accordance with its strategic vision [Ra11], yet its value depends on the organizational capabilities to perform EAM effectively. EAM consists of three major functions such as transforming, monitoring and planning. Transforming is the alignment of an enterprise architecture towards the target state of the respective enterprise architecture domains. Monitoring is the controlling that needs to be applied to ensure the intended progress and planning is the analysis of the current-state enterprise architecture that provides on-going information for specific questions that facilitate decision-making.

The need for efficient data supply in EAM was confirmed in a study regarding EAM challenges commonly perceived in industry [Wi13]. In particular the challenges that "*EAM is not just a task for enterprise architects […] but also for the whole enterprise*" and the "*lack of ability to express information demands*" confirm that there is a variety of information sources in enterprises providing important information for planning, monitoring and transformation tasks. Furthermore, many different organizational roles involved in EAM exist, each of them with distinct and different information demands.

2.2 Value Chains and Supply Chains

Supply chain and supply chain management (SCM) are terms frequently used in economics and production which have been thoroughly researched during the last decades. A multitude of textbooks and different approaches for structuring and describing supply chains and their management is available, like, e.g. [Cho04], [Cha07] and [Iva10]. Among the many definitions, the Council of SCM Professionals defines SCM as follows[1]: "*Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. […]*".

A supply chain as such consists according to [cho04] of all parties involved in fulfilling a customer request. The supply chain includes the manufacturer and suppliers, transporters, warehouses, retailers, and customers themselves. Within each organization, such as a supplier, the supply chain includes all functions involved in receiving and filling a customer request, like, e.g., new product development, marketing, operations, distribution, and customer service. Supply chains build upon the concept and paradigm of value chains. According to Porter [Po08] "*A value chain is a chain of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market.*" The idea of value chains is based on the process view of organizations, i.e. an organization is considered as a system, made up of subsystems each with inputs, transformation processes and outputs, all of them consuming resources, like money, labor, materials, equipment, administration and management.

Development of a value chain for data supply in EAM requires to not only consider data supply as chain of transformation processes but to also understand the value creation

[1] See http://cscmp.org/sites/default/files/user_uploads/resources/downloads/glossary-2013.pdf

connected to the different transformations. Transformation processes in this context are not necessarily data transformation processes, but also include transformation processes performed (manually) by organizational roles or by stakeholders outside the organization.

2.3 Information Logistics

The research field information logistics was established in the late 1990s and defined in [Sa07]. The main objective is optimized information provision and information flow, based on information content, time of delivery, location, presentation and quality. The information logistics field focuses on improving the information flow by applying logistic principles to information supply. Identifying and providing the right content is a core challenge of information logistics. During the last decade, many IT applications have been developed implementing the objective of information logistics. Some of the applications are services providing bad weather warnings, traffic information or personalized news, and solutions for businesses in different domains like WIND service (weather information on demand), Smart-Wear (location-based information supply for mobile users) [Sa07]. The concept of information demand is defined by [Lu07] as "…the constantly changing need for current, accurate, reliable, and integrated information to support (business) activities, whenever and where ever it is needed."

This definition implies a number of aspects that must be considered while analyzing information demand. Information demand should change as the task, roles and responsibilities, to which information demand is connected, change. The information should be relevant, current, accurate and reliable; otherwise it will contribute to information overflow. The information demand should be integrated with the business activities, as it is necessary to have a solid knowledge about the context in order to be aware of any changes of information demand that might happen. Whenever and where ever emphasize the importance of time and location while analyzing the information demand [Lu07]. A specific method for information demand analysis was developed and evaluated in a number of industrial projects [Lu11].

3 Approach for Data Supply Chain in EAM

This section introduces the proposed approach for establishing data supply chains in EAM. The basic idea behind our approach is to start from the information demand of the roles in enterprise architecture management and to focus on the value creation required for providing the information demanded by these roles. Traditional information system development approaches or software engineering approaches start from requirements and derive functional and non-functional requirements to be met by the IT-system which is supposed to provide required information. We argue that flexibility and adaptability in a data supply chain would benefit from first understanding the required value creation and in a second step investigating the required functionality and means to implement them. The value creation perspective allows for explicitly taking into account organizational and technical means to fulfill the information demand. This demand-

driven procedure is not focused on implementation issues and puts the need of the EAM roles in focus.

More concrete, our approach at this early stage of our work consists of two elements: (a) a defined process for eliciting the information demand and the value creation connected to this demand which has to be met by the data supply chain, and (b) an architecture for implementing the technical, IT-related part of the data supply. These two elements will be introduced in the next two sections.

3.1 Process for determining information demand and required value creation

The proposed process for defining a data supply chain in EAM starts from the roles in EAM and their tasks and responsibilities. We propose to start by either performing an information demand analysis according to the method published in [Lu11] or to use an information demand pattern for the role, if this already exists (step 1). Starting from the role's information demand description or information demand pattern, the information supply actions can be derived, which include the required value creation (step 2). The information supply actions can be used in order to determine IT-based services categories to be included in the supply chain (step 3). The binding of the IT-based services categories to concrete IT-components and processing sequences would be the final step (step 4). All steps are reflected by the architecture presented in section 3.1. Steps 1 to 3 will be described in more detail in the following.

Step 1: Information Demand Patterns
The general idea of information demand patterns is similar to most pattern developments in computer science [Sa11]: to capture knowledge about proven solutions in order to facilitate reuse of this knowledge. *In the context of data supply for EAM, information demand patterns should be developed for the typical roles in EAM (see section 4 for an example).* An information demand pattern can be defined as follows: *An information demand pattern addresses a recurring information demand problem that arises for specific roles and work situations in an enterprise, and presents a conceptual solution to it.*

Such a pattern consists of a number of essential parts describing the pattern:

- A statement about the *organisational context* where the pattern is useful. This statement usually identifies the application domain or the specific departments or functions in an organisation forming the context for pattern definition.
- *Problems* of a role that the pattern addresses. The tasks and responsibilities a certain role has are described in order to identify and discuss the challenges and problems, which this role usually faces in the defined organisational context.
- The *conceptual solution* that resolves the problem, which for information demand patterns includes three parts:
    - *Information demand* of the role, which is related to the tasks and responsibilities, is described as part of the pattern, i.e. the different parts of the information demand are identified

- *Quality criteria* for the different parts of the information demand include the general importance of the information demand part, the importance of receiving the part completely and with high accuracy, and the importance of timely or real-time information supply
- a *timeline* indicating the points in time when the different information parts should be available at the latest

- The *effects* that play in forming a solution. If the needed information part should not be available or arrive too late this might affect the possibility of the role to complete its task and responsibilities. The effects described in the pattern include
  - Potential economic consequences
  - Time/efficiency effects, i.e. whether the role will need more time for completing the task or will be less efficient
  - Effects on improving or reducing the quality of the work results
  - Effects with respect to the motivation of the role responsible
  - Learning and experience effects
  - Effects from a customer perspective

An example of an information demand pattern with the above structure is presented in section 4, table 1.

Step 2: Information Supply actions
The information supply actions define the value creation linked to the question: how to decide on the right way to provide the demanded information? Should the information be "pushed" to the person or "pulled" by the role? At what point in time is the value of the information optimal from the role's perspective? Should the information be aggregated with other related information?

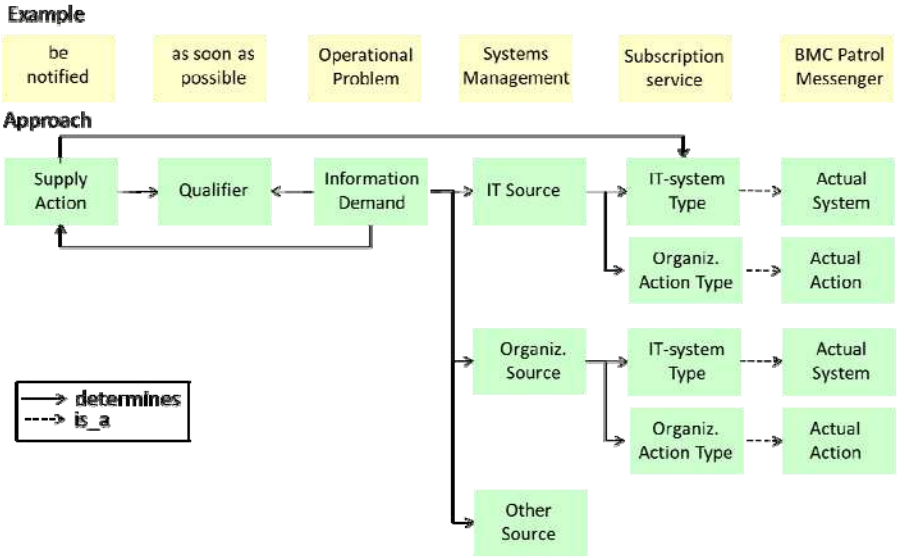

Figure 1. *Supply action and related concepts*

Figure 1 illustrates the main concepts in the area of information demand and information supply actions and their relations. The figure consists of an example (upper part, coloured yellow) and the actual approach (below the example, coloured green). The central concept of the approach obviously is the information demand, for example the "operational problems" of the role "application responsible". This information demand is characterized by a qualifier, which reflects the quality criteria contained in the information demand pattern. The example in figure 1 is "as soon as possible". The activity required to satisfy the information demand with the given qualifier we will call supply action. In figure 1 the supply action is to "be notified", i.e. in order to receive the information about an operational problem as early as possible, the role "application responsible" should be notified if new operational problems emerge.

Satisfying the information demand also requires to identify the source of information. This can be an IT based source (labelled "IT source" in figure 1), like a web site or an information system, or an organisational source (labelled "organiz. source"), like another role or organization in an enterprise, or another kind of source, like the personal network of the individual having the role or a community of practice. The example given in figure 1 shows the "systems management " as IT source for the operational problem information. For all supply actions, we potentially have both, technologies or organizational activities, which can be used to realize these actions, applied both on IT sources, organizational sources or other sources.

As a starting point, we propose to use the supply actions identified in several information logistics projects and summarized in [Kh10]. For brevity reasons, we will only include the IT-based supply actions, not the organizational ones:

- Receive: this supply action should be used if the most appropriate way to supply the information to a certain role is that this role "receives" this information, i.e. from the IT source or the organizational source the information is pushed to the role. This supply action typically is used with qualifiers indicating the timing of the supply, like to receive the information in real-time or receive it in case of a certain event. In comparison to the "be notified" action, the complete information is provided to the role.
- Be notified: this supply action means that the role receives a notification about how to get the demanded information. i.e. not the complete information is provided, but changes, updates or new information are indicated.
- Retrieve: this supply action should be used if the information required is not time-critical and not very dynamic. The user pulls this information when it is convenient for her or him.
- Monitor: this supply action should be used if changes in a specific information or information source are part of the information demand of a role. Monitoring can in practice be very similar to "be notified", but should be used for changes, not for new information.
- Look up: this supply action should be used if accuracy of an information is very important and the information is not used very often by a certain role. To "look up" the information at the place of origin on-demand is supposed to contribute to avoiding mistakes.

- Verify: this supply action is appropriate if the correctness and up-to-date-ness of an information has to be verified, i.e. the information basically is available. The source and way to retrieve it should be provided.
- Aggregate: in addition to receiving a certain information, some information demands even consist of aggregating related information into one "delivery". This supply action should be used if many small and related information items appear in a relatively short time frame and can be aggregated into a larger information package.

Step 3: Determine IT-services
The portfolio of IT-services applicable for implementing the supply actions can roughly be divided into tools for "pushing" information to the role having a certain information demand, and in tools requiring the role to "pull" this information. In general, there are usually standard off-the-shelf tools and solutions specifically developed for a certain application area. Examples for "pull" tools are: search engines, information retrieval systems, retrieval functionality in document management system, mediator based information systems, meta-information systems. Examples for "push" tools are news service, RSS feeds, e-mailing systems supporting mail lists, event-condition-action systems and subscription services based on information systems.

In EAM these IT-services will have to provide information from sources relevant for EAM, like EAM tools, systems management solutions, business activity monitors, incident managements systems or ERP-systems.

The example in figure 1 shows "subscription service" as IT-system type for implementing the supply action "be notified" and "BMC Patrol Messenger" as the actual system providing the information about "operational problems" from "systems management".

3.2 Architecture for Data Supply Solutions

The architecture for data supply solutions has to reflect the integration various information sources and the flexible, adaptive provision of information to organizational roles based on processing operations. Many different types of architectures have been proposed in research which would in principle be suitable for this purpose. Examples are context-based systems, publish/subscribe architectures or event-condition-action systems.

Our proposal is to base the data supply architecture on knowledge management architectures and, more specific, on knowledge services. Maier proposed an architecture with five layers depicted in figure 2. These layers are:

- Access services: authentication and authorization of the user via different access channels
- Personalization services: adaptation of user interface and content provided to the user's individual demands

- Knowledge services: core layer of the architecture including the four basic knowledge services search, publishing, collaboration and learning
- Integration services: integration of different information and knowledge sources including format and semantic integration, e.g. by using ontologies of structured vocabularies
- Infrastructure services: transparent provision of access to different information sources, which includes wrappers for the sources, homogenous access services, etc.

Maier's architecture needs adaptation for our purposes mainly in the architecture layers II and III, i.e. personalization and knowledge services. For personalization, we will use the results of the information demand analysis or information demand patterns. The information demand is uses to personalize the services to the role's specific information demands. Regarding the knowledge service, the supply actions will be integrated as specific additional services, which in turn will be implemented using the integration service layer. Most of the supply actions can be considered as contributions to the knowledge services "search" and "publishing": retrieve and lookup are based on search, be notified and receive are based on publishing, monitor and verify require a combination of search and publishing.

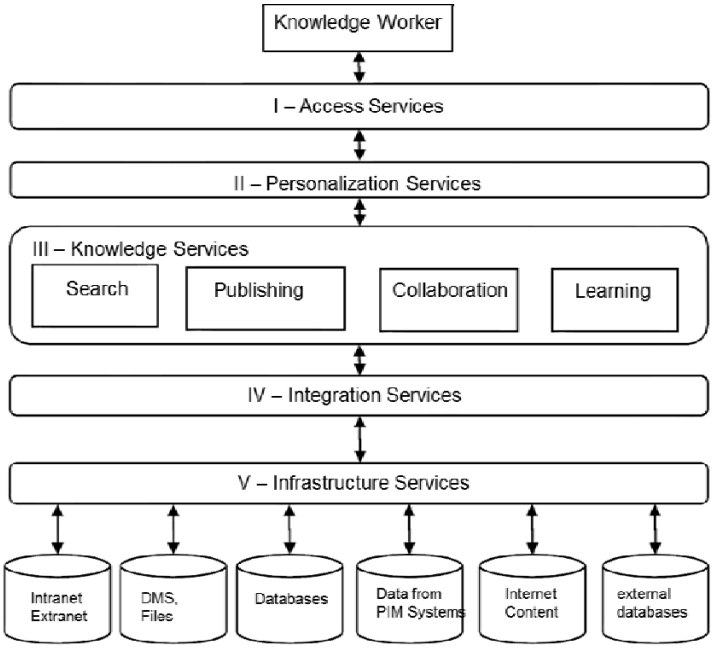

Figure 2. Adaptation of Maier's knowledge service architecture

4 Example: Data Supply for Application Owner

In order to illustrate our proposal and as an initial step of validation, we developed an information demand pattern for a typical role in EAM. Based on this pattern, we will perform the three steps introduced in section 3.1.

Step 1: As introduced in section 3.1, an information demand pattern consists of a number of essential parts used for describing the pattern: pattern name, organizational context, problems addressed, conceptual solution (consisting of information demand, quality criteria and timeline), and effects. For brevity reasons, we will limit the presentation of the information demand pattern on context, problem and the information demand element of the conceptual solution. The example considered is the role of an Application Owner. Table 1 shows an excerpt from the information demand pattern for this role.

Table 1: Excerpt from information demand pattern for Application Owner

Role: Application Owner in EAM
Context: the application owner role is considered in the context of EAM. The problems associated to the application owner role is: many different information sources in the organization potentially provide relevant information about the application, technical or organizational components relevant for the application, or business, technical and legal requirements important for the application from different organizational actors and at different not a-priori known points in time. To keep track of all information in time and act accordingly requires availability of all information to the application owner, which often is not implemented.
Tasks and Responsibility: An application owner is responsible for a defined IT-application in an organization during the application's complete lifetime and that the application meets the organizational requirements from an operational, functional and quality perspective. Among the tasks of the role are • Continuously capture business requirements and take them into account for further development of the application and during release planning • Make sure that the IT-infrastructure underlying the application meets the requirements of the application • Supervise quality and conformance with service level agreements of the application delivery • Responsibility for the application to be compliant to relevant policies and laws • Responsibility for the application to deliver the expected business value, which includes appropriate integration into business services
The information demand of the role consists of*:* • Changes in organization-internal and external policies, laws and regulations affecting the application • Severe operational problems which are recurring and not solved by first level and second level operational support • Planned changes in the IT-infrastructure possibly affecting the application, like

changes in the releases of operating systems, databases, server components or underlying services
- Strategic and tactical plans of the organization leading to new business requirements to the application
- Complaints and emerging new requirements from the users of the application
- Changes in the cost structures related to the application
- Changes in business process execution related to the application

Step 2: From the information demand, supply actions can be derived. Again, we present only an excerpt of the supply actions for the application owner's information demand pattern. The excerpt in table 2 focuses on severe operational problems and changes in business process execution.

Table 2: Supply actions for the information demand pattern in table 1 (excerpt)

Supply Action	**Qualifier**	**Information Source**	**Comment**
Information Demand: Severe operational Problems			
Be notified	As soon as problem occurs repeatedly	Incident management or trouble ticketing platform of the systems and application management responsible for operations of the application	It is essential to receive the information about recurring problems as soon as possible; the detailed problem description as such can be retrieved after assessing the severity. It is not always possible to subscribe "severe and recurring problems"
Information demand: change in business process execution			
Receive	In case the number of cases exceeds a given percentage of the overall process throughput	Business activity monitoring of the workflow platform underlying the application	If the business process usually is executed automatically, the number of cases to be handled manually is interesting for the role. If this number of "manual" cases grows, this indicates that potentially the business process has to be adjusted.

Step 3: Based on the supply actions, we have to determine the IT-services and how the value creation desired in the supply actions can be achieved. Table 2 already indicates which "information sources" are relevant for the information demand considered in the example, which in this example directly correspond to IT-services. In the following, we will focus on the different activities to be performed in order to achieve the value creation using the identified IT-services.

The example in table 2 identifies incident management and business activity monitoring as relevant sources. From both sources, information has to be used under certain conditions ("qualifier"). Thus, the implementation of the supply actions has to include to "subscribe" to certain information. However, the further processing steps are different. Regarding the supply action "be notified" from incident management, the processing could look as follows: subscribe to incident management information – adapt format of this information to standard – filter information according to qualifier – evaluate information with regards to relevance – send notification to role. For "receive" from business activity monitoring, the processing could be as follows: subscribe to business activity monitoring information – adapt format of this information to standard – store information to track record file – query track record for relevant set of records – create report according to qualifier – send report to role.

Both processing sequences contain similar and partly even identical steps, but also different steps. The similar / identical steps can be an indicator that the same (parameterizable) IT-service can be used which avoids multiple implementation of the same functionality. For the above example, this would, e.g., be "adapt format to standard". When analyzing the supply actions and required IT-services for all roles in EAM, we expect to find a large number of overlaps between the supply actions and high potential to reuse the same kind of IT-service. Thus, the design of a data supply chain consisting of a limited number of processing steps (IT-services) which are used many times would be possible, which is an advantage as compared to constructing information supply independently for different roles or separately for different information sources.

5 Summary and Future Work

The work presented in this paper has many limitations which have to be subject of future work. Only one example was considered to explain the approach and show the conceptual feasibility. The approach has not been fully elaborated; possibly, further adjustments in the reference architecture are required. An implementation of at least a prototypical solution is required in order to confirm feasibility. In particular for big data volumes we need adjustments on the integration and persistence service layers in the architecture discussed in section 3.2.

The most important future work, however, is in moving from the one example and single role focused view of the supply chain to a supply chain design for EAM in an organization in general. The real value of the supply chain idea is to consider data supply as management task and to manage the whole data supply chain in a holistic way. Principles and core processes from supply chain management in manufacturing

industries are important sources of inspiration for this future work. The supply chain management institute distinguishes eight different processes in SCM, all of them should be transferred to data supply chain management also: Customer Relationship Management Process, Supplier Relationship Management Process, Customer Service Management Process, Demand Management Process, Order Fulfillment Process, Manufacturing Flow Management Process, Product Development and Commercialization Process, and Returns Management Process.

Demand management, to take one example, is the SCM process that balances the customers' demand with the capabilities of the supply chain. With the right process in place, management can include forecasting, increase flexibility and reduce variability. In data supply chains, demand management would have to include the different role's demand, a view on potential demand changes triggered by organizational changes and a forecast on adaptation required in the data supply chain.

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