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Design Options for Service Directories in Business Networks

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Abstract

Web services and service oriented architectures (SOA) are spreading in many organizations to achieve business interoperability of their intra- and inter-organizational business processes. SOA is based on the idea that service providers develop and publish web services via standardized interfaces in directories (registries) where the services will be found and bound by service consumers. While these registry structures have emerged into a standard for local SOA implementations, the question remains how service directories should be organized in a business network, i.e. when multiple companies with individual SOA solutions interact. This research develops a framework for the analysis of service directories in business networks and provides design options for combining separate and distributed service directories. These design options are based on the range, reach, and richness of web service markets in the business network. The framework is applied to two business network cases.

Keywords: service repository, service oriented architecture, web services, business network.

1 INTRODUCTION

The ability to efficiently establish and change electronic relationships among business partners is key in many business concepts (Klein, 1996; Van Heck and Vervest, 2007). This ability is also known as the 'networkability' of an organization (Wigand, et al, 1997) and is influenced by several factors, including 'the products and services offered by (organizations in) the business network', 'the business processes involved', 'the organizational structure', 'the employees', 'the culture', and 'the information systems (IS)' (Österle et al., 2001; Alt and Smits, 2007). Successful adoption of IS has many non-technological prerequisites and calls for the alignment of processes, semantics and syntax (Rebstock, 2009).

Service-oriented architectures (SOA) have received strong attention in the past decade and, according to Gartner, have entered the 'slope of enlightenment' (ZDNet, 2009). This suggests that a technology has already 'survived' the phase of exceeded expectations ('trough of disillusionment') and is about to attain the 'plateau of productivity'. Underlying this (assumed) increased maturity in practice is the hope that SOA is an important enabler for business interoperability (Currie and Parikh, 2006). Based on the analysis of several SOA implementations Legner and Heutschi (2007) identify three objectives that business managers mention for the adoption of SOA: 'to realize a standardized integration infrastructure', 'to decouple application domains', and 'to create flexible user/business process integration'.

Linking the business-oriented notion of 'networkability' with the more technological notion of 'business interoperability' leads to the vision of modular business components that may be used electronically and that are independent of specific technological platforms as well as institutional arrangements (Österle et al., 2001). The combination of this potential for technological flexibility and the needs for organizational flexibility makes service architectures a powerful approach to implement networkability in a business network. However, while the basic SOA and the design of services have been discussed in many contributions already (Curry and Parikh, 2006; Legner and Heutschi, 2007), the question still remains how service consumers can find these services and how the directories should be organized in a business network, i.e. when multiple companies with individual SOA solutions interact.

This paper focuses on the basic design dimensions for the directories in a SOA and assesses some generic design options. The topic is relevant for business managers because it includes decisions on the (out-) sourcing of business services, the development and selection of (electronic) markets as well as intermediaries for obtaining the right services at the right time, and choices with respect to the degree of standardization within and among organizations. The topic is relevant from an IT perspective since it influences the design and development of repositories and registries for (web) services and is key in developing any technological architecture based on the SOA concept.

To identify design options and requirements for service directories in business networks the first part of this research includes a deductive review of existing literature on service science, web services, SOA and existing directory standards. It leads to the identification of two design dimensions which are used for discussing design options in a framework. The second part is inductive in nature and comprises two business network cases in which design options for service repositories are developed based on business requirements. Finally, the conclusions summarize the findings and suggest some directions for future research.

2 SERVICE DIRECTORIES IN THE LITERATURE

2.1 Networkability and intermediate structures in business networks

Networking among companies has wide rationalities. Organizations may engage in network relations in order to focus on internal resources and core competencies by outsourcing non-core activities to partners and service providers (Bakos, 1991). Partnering among (legally) independent organizational units promises advantages such as competitive products and services and efficient processes (Iacono and Wigand, 2005). However, success of a business network depends on (i) the overall network performance rather than the individual performances of the network participants (Kleijnen and Smits, 2003; Christiaanse, 2005), (ii) the competitive position of the business network rather than the competitive positions of the network participants (Provan et al., 2007), and (iii) the flexibility of the network to establish electronically enabled cross-functional and cross-organizational processes (Van Heck and Vervest, 2007).

Business flexibility and the coordination among the distributed activities are often based on 'bus-like' infrastructures. In analogy to the Ethernet bus in local area networks, these buses provide a communication network, standards and applications (Österle et al., 2001). Using a 'hub-like' topology, a 'business bus' follows the idea of middleware systems that are used to reduce the complexity when interfacing between a large number of applications. Enterprise application integration (EAI) systems have introduced intermediate layers that decouple individual applications (Lee et al., 2002). Complexity reduction and the potential cost savings may be calculated from n x (n-1) integration points with bilateral (two-way) integration compared to n x 2 for the intermediate structure. Remarkably, these advantages are not limited to the technical level. Kumar and Van Dissel (1996, 287) argue that hub-like architectures act like an intermediary that mediates among business partners and defines standards as well as rules. Compared to sequential and especially to reciprocal structures this topology features the lowest interdependencies which are key in coordination processes (Malone and Crowston, 1994) and, thus, have a positive impact on networkability which may be defined as the ability to enable cost- and time-efficient cooperation processes among business partners (Österle et al., 2001).

The services of these intermediate structures may be derived from definitions of IT infrastructures. Weill and Broadbent (1998) define IT infrastructures as a collection of reliable, centrally coordinated services which comprise both technical and human capabilities. This IT infrastructure can be shared across organizational boundaries and enable more efficient business processes. Clark and Lee (2000) conclude that innovation of the inter-organizational IT infrastructure enables 'policy and process redesign', 'increased interdependency between firms', and 'expanded coordination', leading to improved 'channel performance'.

Implementation of 'business buses' are not new. For example, the common request broker architecture (CORBA) is a middleware technology from the 1990s which uses a 'software bus' for the communication between applications (Seetharaman, 1998). Many SOA concepts include an Enterprise Service Bus (ESB), which is an open, standards-based message bus designed to enable the implementation, deployment, and management of SOA based applications. The ESB not only supports distributed processing, but also, standards-based integration, making it an enterprise-wide backbone for web services (Papazoglou and vd Heuvel, 2007).

2.2 Web services and SOA

A web service is a technological concept referring to "a platform-independent, loosely coupled, self-contained programmable Web-enabled application that can be described, published, discovered , coordinated and configured using XML artefacts for the purpose of developing distributed interoperable applications" (Papazoglou and Ribbers, 2006). These properties ensure that web services can be obtained in interorganizational environments to complete a task, solve problems or conduct transactions using a standardized electronic application. Web services are based on service oriented computing (SOC), a computing paradigm that conceives services as the basic constructs to support the development of distributed applications in heterogeneous environments (Demirkan et al., 2009; Papazoglou and Ribbers, 2006). SOC depends on SOA as "a logical way of designing a software system to provide services to either end–user applications or to other services distributed in a network, via published and discoverable interfaces" (Papazoglou et al. 2006).

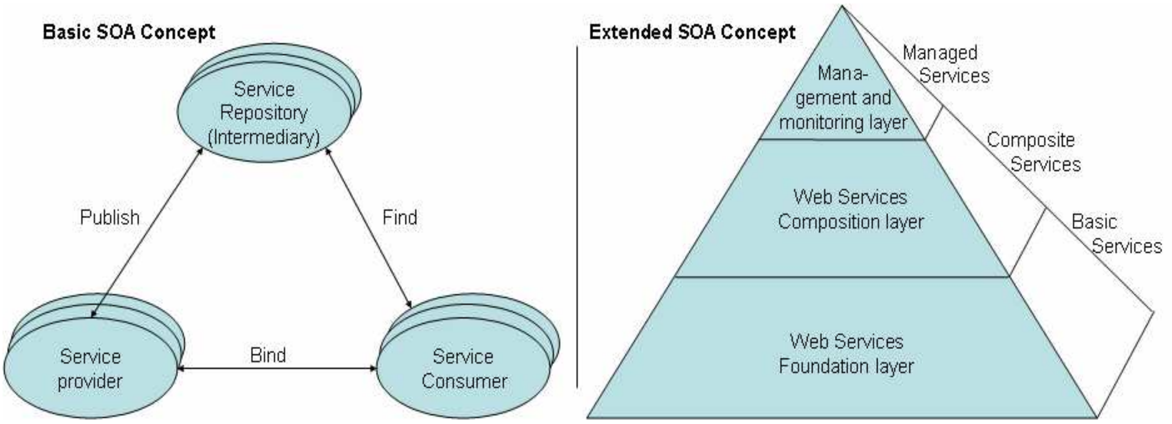

Figure 1: Basic and extended SOA concepts

When defining SOA, two concepts need to be distinguished. First, the *basic SOA* (Figure 1, left side) consists of service providers, service clients, and service brokers (Papazoglou, 2008, 23). Service providers publish their services in directories where these may be retrieved by service clients so that binding and service operation can take place. Service clients may be applications, processes or customers within or outside the organization. Although basic SOA may seem simple at first sight, the complexity of discovering, exploring, negotiating, and reserving services between different service providers is challenging for service clients. These may obtain and use simple services from service providers but may also obtain aggregated functionality from so-called *service aggregators*. This intermediary combines the roles of a service client (requesting simple services) and provider (providing aggregated services by combining simple ones) (Papazoglou and Van den Heuvel, 2007). Aggregators or service brokers also support the discovery and selection of service providers. As trusted parties they force service providers to adhere to information practices that comply with privacy laws and regulations, or in the absence of such laws, industry best practices. This involves describing business, service and technical information of the web service and registering that information in the service registry in the broker's format (Papazoglou and Ribbers, 2006). Following catalogue systems, service clients may search for and locate services in these directories (Legner and Heutschi, 2007).

Basic SOA provides a foundation for a distributed computing infrastructure, but it does not address overarching concerns such as service transaction management, coordination of service supply and demand, security, trust, and other concerns that are necessary for a robust and dependable SOA (Papazoglou, 2008). To address these concerns, *extended SOA* (xSOA) concept has been developed (Papazoglou and Van den Heuvel, 2007) (Figure 1 right side). The xSOA or 'web services functionality stack' consists of three layers: (i) the web services foundation layer, in which basic services are published, found, and bound that are widely accepted and implemented uniformly, (ii) the web services composition layer includes the necessary roles and functionality for the aggregation of multiple services into single composite services, and (iii) the management and monitoring layer, which ensures that services in lower layers are managed. Each layer depends on the functionalities of the lower level.

2.3 Web service markets

Following the SOA concepts directories are operated by intermediaries which may be internal or external to the organization. They can be regarded as a market where web services are traded between service suppliers and service clients (Van den Heuvel and Smits, 2007; Legner and Heutschi, 2007). Market transactions consist of different phases, like information gathering, agreement and settlement phase, according to the interaction process among market participants that lead to the exchange (Lindemann and Schmid, 1999). In traditional markets the role of the intermediary is to match buyers and sellers. Legner and Heutschi (2007) find that service directories and brokers fulfil the same role. The web services ecosystem shows typical characteristics of an electronic market, as directories establish many to many interactions that allow service providers to register new services and service consumers to search for and locate services (Legner and Heutschi, 2007). Web service markets may entail a virtual location where demand and supply meet and transactions are prepared, executed, monitored and settled (Van den Heuvel and Smits, 2007). Legner and Heutschi (2007) describe how the 'service sales process' of a web service provider is linked to the 'service purchasing process' of the web service consumer'. The service sales process consists of four main steps: (i) market analysis, creation of a new service, integration in the service offerings set, certification, (ii) publishing the services, (iii) provisioning of the services, and (iv) upgrading or phasing out the services. Steps (ii) and (iii) are typically done through web services intermediaries. The service purchasing process consists of (a) selection of a service, (b) integration of the service in the consumer side systems, (c) usage of the services, (d) replacement or migration of the services.

Web service markets enable the interaction between web service providers and consumers and require directories or databases for the publication and retrieveal of web service data. A web service registry in SOA is a searchable directory where service descriptions can be published and searched (Papazoglou, 2008, 24). While service discovery is enabled centrally by the registry, the binding and execution of the services are done on a bilateral basis between the service provider and the service requestor. Therefore service registration and service discovery are two core functions of the SOA approach (Papazoglou, 2008, 174). In practice, two directions are reported from research on SOA projects. First, case studies on SOA implementations show that companies establish and maintain their individual service repositories. All four cases described by Legner and Heutschi (2007) featured a "uniform service specification in a central service directory". Within a business network all participating actors would need to align their service directories, making it comparable to the efforts in the traditional EDI projects. Second, inter-organizational service directories emerged as dedicated business models. Actors, such as e-Sigma, Remote Methods, StrikeIron Global Directory, StrikeIron Marketplace, and X-Methods operate inter-organizational directories focusing on the functional areas information (service discovery), matching (service contracts), transaction (settlement of transactions), integration (service binding), and standardization (Legner, 2009, 72). The moderate growth of these directories illustrates that these providers have not shaped the 'universal solution' for SOA. In summary, several directions for directories have emerged. They underline that while the directories are regarded as necessary elements of any SOA, the institutional configuration of these directories still remains an open issue. Cases reporting a low reuse of services in SOA (Schelp and Aier, 2009) also point at the need for directories in sustaining the multiple (re-)use of services, another key idea of SOA.

2.4 UDDI registry and repository

The main approach towards a global and cross-industry directory standard is Universal Description, Discovery and Integration (UDDI). Although it was supported by dominant software providers, such as IBM, Microsoft, and SAP, UDDI failed in attaining this vision with only a small number of services being included in this global (super)directory. Instead, UDDI has become a standard hosted by OASIS (Organization for the Advancement of Structured Information Standards) and the providers and OASIS decided to use the agreed upon directory structures within their individual software solutions. While the institutionalization of the directories was left unanswered and left to the individual business networks and industry players, the UDDI activities yielded a standardized web service directory structure. This enables that queries can be issued to a UDDI instance (at design-time or run-time) (Clement et al., 2004) for (i) finding web services implementations that are based on a common abstract interface definition, (ii) finding web services providers that are classified according to a known classification scheme or identifier system, (iii) determining the security and transport protocols supported by a given web service, (iv) issuing a search for services based on a general keyword, and (v) retrieving the technical information about a web service and then update that information at run-time.

UDDI registries were proposed to include information in three areas: 'white pages' refer to a company's contact information (e.g. name, address, contact partner, tax ID number) and mainly serve service identification purposes, 'yellow pages' assign the services to predefined categories (e.g. automotive business), and 'green pages' include technical information on the service (e.g. address of the service, WSDL descriptions). However, these three parts of UDDI are not mentioned in the UDDI specification which mainly describes the application programming interfaces (API's) for using the directory (e.g. inquiry API, publication API). Following the distinction mentioned above, the registry mainly consists of the 'yellow pages' and versioning, the repository comprises the 'green pages' and acts as the 'central modelling and design environment' (Sambeth, 2006, 37). UDDI defines that a registry comprises one or more UDDI nodes, that these nodes collectively manage a well-defined set of UDDI data (also replication of various registry nodes), and that policy decisions for each policy decision point need to be made (Clement et al., 2004). For instance, the Enterprise Services Repository (ESR) by SAP is the design-time repository of Enterprise SOA service objects. Among the objects included are business objects, service interfaces (with associated operations, message types, and data types), process models (ARIS), business scenario and business process objects, and mapping objects (Sambeth, 2006, 36).

In summary, *service repositories* contain the actual services/ software components, and *service registries*, contain (only) the metadata on the services (SUN, 2005, 4; www.oasis.org). The registry helps web service consumers to select and find the right service while the repository is the actual location where services are stored in such a way that they can be deployed. Several software packages for integrated registry-repository solutions are available on the market, such as IBM WebSphere Service Registry and Repository, IONA Artix Registry/Repository, HP Systinet SOA Registry/Repository or ebXML Registry/Repository. Note that these products are independent of the implementation scenario and may support centralized as well as federated repository structures.

3 FRAMEWORK FOR ANALYZING SERVICE DIRECTORIES

As elaborated above, registries and repositories are intermediate structures in SOA and may be operated by intermediaries or individual enterprises. There is no unique global repository for registration and storage of services to support cross-organizational relations. Current practice in business networks is that multiple intra- and inter-organizational registries and repositories are used. The question is to find the optimal set of repositories and registries to fulfil the functional requirements in a business network. This chapter presents a framework to analyze the current situation in a business network and to create design options for service registries and repositories that may fulfil future business needs.

3.1 Reach, range and richness of web service markets

To analyze design options for service directories an established model is used (Evans and Wurster, 1997) which classifies electronic services as a trade-off between their reach (in terms of potential service users) and their richness (in terms of the amount of information per service). It supports the argumentation that physical shops feature high levels of richness and only a low reach, and electronic channels may combine high levels of richness and reach. This model has been modified by Wells and Gobelli (2003) to include not only reach (degree to which a firm can manage activities to connect to its customers) and richness (degree to which services match customers' exact wants and needs), but also range which relates to the size and breadth of the services offered to the customers. In other words, the reach of an intermediary in a web service market relates to the numbers of clients and providers that use the intermediary. Range relates to the number of different web-services offered by the intermediary. Richness relates to the level of aggregation of the web services offered.

With respect to *reach* of a web service market, the following aspects may be assessed: (i) the frequency of use of the market, (ii) the numbers of clients reached by the web services that the organization offers. It is hypothesized that high process standardization in the network relates to high reach of the intermediaries. With respect to *range*, the following aspects may be assessed: (i) the numbers of different web services offered by the intermediary, (ii) the number of intermediaries that offer the web services. With respect to *richness*, the following aspects may be assessed: (i) Granularity of the web services, more specifically (Haesen et al, 2008): Business granularity, functionality granularity, data granularity, (ii) Cohesion of the web services, (iii) Coupling of the web services: the degree of interdependence between any two business processes (weak coupling being preferred).

3.2 Standardization and web service markets

Ultimately, all web services and their metadata need to be stored and maintained as data in databases in a business network in multiple repositories and/or registries. The management of (master-) metadata is an established field in the area of enterprise resource planning (ERP) systems, but has also been developed in the context of collaborative or inter-organizational processes. Loser et al. (2004) suggest four design alternatives for collaborative service processes which are structured depending on the availability of global master data attributes on the one hand and the location of data creation and maintenance and/or distribution on the other. The first dimension describes whether attributes are shared between applications and the second whether data is entered and maintained centrally or de-centrally.

The first and most central architecture option is a *centralized master data system* which stores and maintains data objects which for all applications. For example, customer or product data are only entered changed and distributed using this system. In the inter-organizational context, master data systems have evolved in consumer goods industry with GS1 defining the European article number (EAN) and operating centralized object naming services (ONS). The second approach is a *leading system*, where one system is declared as responsible system for creating, maintaining and distributing master data. For example, the focal organization in a business network could operate such as leading system. The two remaining alternatives comprise applications where data are created and maintained locally. Master data harmonization via *standards* is one approach where global (enterprise-/network-wide) data structures are available and data is exchanged bilaterally between applications. A centralized view on data is not available. Finally, a *repository system* yields this ‘overview’ by centrally storing the assignments of the local master datasets.

3.3 Framework for analysis of service directories in business networks

The framework given in Table 1 distinguishes between the degree of concentration of repositories and registries (columns) and the level of standardization in the business network (rows). Column wise, service repositories and registries may be concentrated (centralized) in one location or in multiple locations (decentralized). Row wise, standards can exist on the network (or global) level and on the (intra-) organizational level. The two main design options for repositories and registries in business networks, represented by the four quadrants are:

- One (common) service registry and one (common) service repository for the network that includes all available web services. Web service markets in this design option will typically have a large reach (many providers and users in the network), large range (many web services), and low richness (web services of low granularity, limited cohesion and limited coupling).
- Multiple service registries and multiple service repositories, where each repository may support a specific business function (specialized repositories for sales processes, accounting, etc). Services typically have low reach (some clients and some providers in the network), low range (some web services for some processes only), and high richness (aggregated, specialized services)

The publishing, finding and binding of the services in the network will typically be supported by multiple intermediaries using centralized repositories and registries and localized repositories and registries and mixtures of these. Complexity will even increase because intermediaries may emerge and decline because they offer services in dynamic markets. For instance, Legner (2009, 75) concludes that provisioning of a service catalogue to enable service discovery does not provide sustainable value for web service intermediaries. Each cell in Table 1 represents a design option for service directories, repositories and intermediaries in a business network. Each design option in Table 1 is characterized by examples of reach range and richness of the web service markets.

	Origin of services (number of intermediaries)	
Level of standardization	Centralized (concentrated) origin of services (one service provider/intermediary)	Decentralized (de-concentrated) origin of services (several service providers/intermediaries)
Global standards	One (common) service-registry and intermediary One (common) service-repository for the network with all web services available • High reach (all clients in the network) • High range (all processes in the network) • Low richness (for simple non aggregated services)	Multiple service registries One repository for each registry • Medium reach (for some clients only) • Medium range (for some processes only) • Medium richness (incl. aggregated services)
Local standards	One (common) service registry Multiple focused service repositories, • High reach (all clients in the network) • Medium range (for some processes only) • Medium richness (including aggregated services)	Multiple service registries Multiple repositories for each registry • Low reach (for some clients only) • Low range (for one process only) • High richness (aggregated specialized services)

Table 1: Framework for analyzing service repositories and registries in business networks

In the following the framework will be used to identify design options for service repositories in two cases. In general, a case-based research strategy is applicable when control over events is not needed and when there is a focus on multiple level analyses (Yin, 1994). Following Provan et al (2007) and Driedoncks et al (2005) the development of a business network will be analyzed over time, identifying changes in structures, roles, and functions of intermediaries. The research method is qualitative and consists of a retrospective analysis of single network cases, based on structured interviews with actors involved in the changing markets and internal and web-documents describing business and technology aspects of the networks (triangulation). Again, in-depth analysis of single cases is an appropriate research strategy when it is difficult to separate a phenomenon from its context (Yin, 1994). Finally, two business networks that emerged and exist independently from each other were chosen. Both networks have implemented SOA to some degree and are in a situation of making strategic decisions for further developing their SOA.

4 SERVICE REPOSITORIES IN TWO CASES

4.1 DZ bank network

Banking is an industry which features a strong link to service orientation. First, banks traditionally aim to cover entire customer processes (or problems) which, for example, consist of bundled services from market information, checking accounts, deposits, and mortgages to the comprehensive services in the private banking sector. While manufacturing companies early focused on delivering competitive (single) products efficiently in a multi-tiered supply chain, banks kept the production of their multi-product (one-stop shopping) products primarily in-house (Homann et al., 2004). In view of the current financial crisis a growing pressure on cost-income ratios (CIR) leads bank to streamline their operations, thus fostering outsourcing and networking (Bryan and Daruvala, 2009). One aspect of this transformation in the banking industry is specialization and the emerging diverse landscape of service providers. For example, the investment process (Kohlmann et al., 2008, 143ff) comprises a total of twelve generic roles, such as sales bank, asset manager, portfolio manager, and custodian. Despite this growing distributed organization, services ultimately need to converge to the customer process. Thus, flexible bundling of financial services requires compatibility of the involved (web) services. Second, banks traditionally recognize IT-investments as core competency and have established large IT-departments for application development and operations. While these basic IT-operations were increasingly outsourced, banks are only at the beginning of introducing standard software packages like SAP. A global survey shows that the flexibility promised by SOA addresses one of the key shortcomings of existing core banking systems: 70% of the 1447 participating managers declared flexibility to be the largest problem with their systems (Accenture and SAP, 2005). Many studies believe that "In the future, bank's as-is architectures need to represent inter- and intra-enterprise SOA." (Hoppermann, 2008, 10).

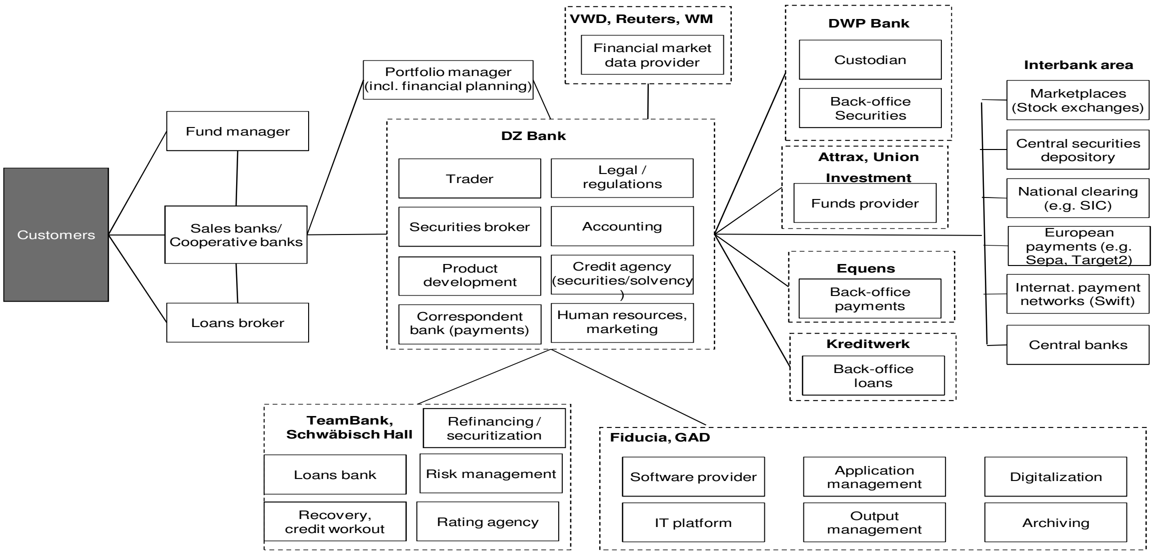

Figure 1: Banking network at DZ bank in Germany showing individual organizations as rectangles or as sets of business processes in dotted rectangles (simplified from Wolf and Kohlmann, 2009, 251).

DZ bank is a centralized bank owned by the cooperative banks in Germany and forms the DZ bank network. The German cooperative banks have 30 million private and corporate customers and a market share of 23% in Germany. DZ bank supports 14.000 branch offices with several products and services. Although the local banks source most (90%) of their services from DZ bank, they may also opt for providers outside the DZ network. In 2008, DZ bank had 24.642 employees in 913 subsidiaries with total assets of 427 billion Euro (DZ-Bank, 2009). Also, the local banks may either source services via DZ bank or directly from the service providers like Equens (payment processing), Kreditwerk (loans processing), and DWPbank (securities processing). Other providers in the network focus on products (e.g. loans with Teambank, home loans with Schwäbisch Hall, funds with Union Investment and Attrax, financial market data with vwd and infrastructure services with Fiducia and GAD). Like other banks, DZ bank and their subsidiaries have significantly invested in their IT-solutions in the past. Together with their subsidiaries Fiducia and DWPbank, the integrated system WP2 has been developed for security processing, together with GAD the core banking application Bank21 and Kreditwerk the ALP (Automatic Loan Processor) application. For example, Bank21 has interfaces to ALP, WP2 as well as applications from other providers, such as Equens for payment processing or Cardprocess for card-based transactions. Bank21 can be implemented with individual sales banks and can be hosted at GAD. The competitive aspect in the network is also reflected in the fact that Fiducia also offers their core bank system called Agree. So, the organizations in the banking network have developed a variety of direct and indirect business to business and process to process relations, based on a variety of service intermediaries

Several players in the network have discussed SOA. For example, GAD has designed Bank21 with 'service-based interfaces' in order to reduce costs when third-party applications need to be integrated. Kreditwerk reports results of their SOA based on SAP's ESR (cf. chap. 2.3) as does Fiducia for their systems. In addition, DZ bank has launched an overall SOA architecture project which mainly emerged as an enhancement to their existing EAI integration infrastructure (Anonymous, 2007). It is the goal of this project to establish a centralized service registry for service identification (index) and a service repository (service description using metadata); based on IONA's Artix solution. DZ bank SOA architecture defines the key elements of their SOA, the relationships between these elements and the link to the DZ. SOA organization is cross-functional within DZ bank. In view of this multi-vendor SOA, the VR Services initiative has been launched which aims at establishing a group-wide interface architecture across the solutions of Fiducia, GAD and DZ bank. Thus, design options for the service directory are:

- Option 1 (One common service registry and one common service repository). The solution of one centralized registry and repository for all members of the DZ bank network poses the largest requirements to the homogenization of the existing local services (e.g. Fiducia, GAD). In particular, participation and support on behalf of the business side is necessary. A considerable degree of central authority would be necessary for this option which is even more unlikely as the subsidiaries also have external shareholders as well as customers.
- Option 2 (One common service registry, multiple service repositories). In this option a centralized group-wide registry establishes an index of all services used within the DZ bank network. Individual providers, such as Equens and dwpbank, would operate their local repositories and propagate the description of their services to the central registry which would also be responsible for versioning the services for the sales banks.
- Option 3 (Multiple registries with repositories). Due to the established role of DZ bank in the network and the SOA harmonization projects that have already been initiated, a scenario lacking a centralized registry is unlikely.
- Option 4 (Multiple service registries and multiple repositories for each registry). In this option services are indexed in multiple registries (e.g. individual registries with traders, securities broker, custodians) and repositories which might be the case when services are used between international partners in the network which, for example Switzerland, have different regulatory requirements.

4.2 Municipality network

There are around 440 municipality organizations in the Netherlands, varying from small organizations with around 50 employees (in small municipalities) to large organizations (several thousands of employees). A municipality organization is the local, lowest level of government, performing a variety of activities including local political decision making and performing several public tasks including (i) land management (local zoning), (ii) urban development, (iii) transport and local infrastructure management, (iv) social affairs, employment and welfare, (v) economy and the environment, and (vi) education (see www.vng.nl). Municipalities cooperate on the national level in negotiations with other government layers and institutions. To do so they have established a representative organization and various platforms for planning of electronic communications (see www.egem.nl).

Total spending for IS maintenance and investments for all municipalities in the Netherlands is around 3 billion euro per year (see www.ame.nl, 2005), varying from 36 euro per citizen in small municipalities to 66 euro in municipalities with more than 100,000 citizens. Over the past decades, each government organization has implemented new business processes, new organizational structures, and e-government initiatives striving to deliver efficient and effective public services, transparent government, decentralized and meritocratic management of employees (OECD, 2005). Flexible and multichannel public services have been developed locally (on the municipality level) using local web service registries as well as several national service systems such as DigiD (for identity services), GBA (national database for registration of persons), NHR (national database for companies), BAG (addresses and buildings registry), BGT (national geographical information, land registry, and topographical information), based on national government reference architectures (NORA).

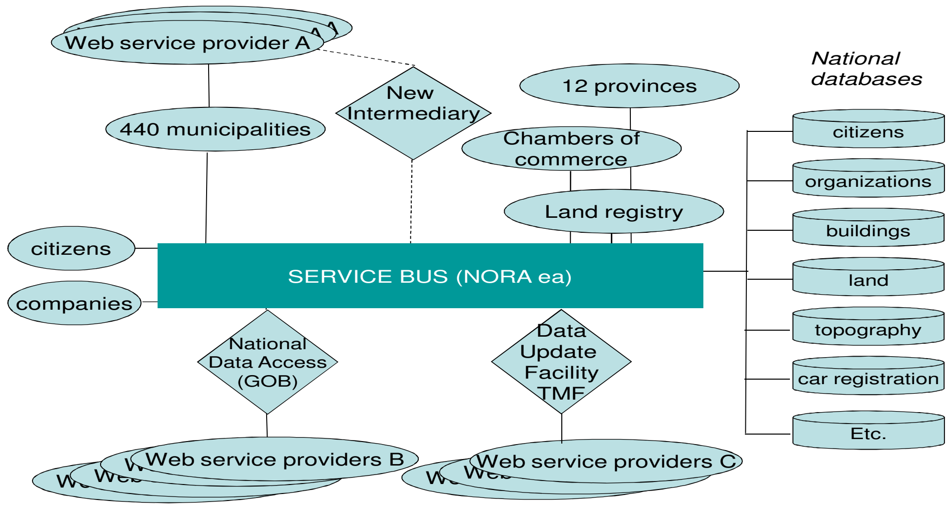

Figure 3: Municipality network with service bus, service clients, providers, and intermediaries

Figure 3 shows the business network consisting of 440 municipalities linked to citizens (17 million) and companies (appr. 1 million) and other government organizations (indicated by ovals in Figure 1). The national IT infrastructure (business bus based on NORA standards) links local municipality applications to national databases (right side of Figure 3) and contains two web service intermediaries (two diamonds): (i) National Data Access (GOB) with web services for data access, and (ii) Data Update Facility TMF with web services for data management. GOB and TMF have centralized service repositories and registries because of the required run-time availability of the services. Web services for TMF and GOB are provided by various web service providers B and C. A big advantage of these two networks is that municipalities no longer use local databases but link most internal applications to GOB and TMF.

A challenge for large municipality organizations is to establish aggregated services and automated business processes to support citizens and businesses by combining 'national' web services from GOB and TMF and internal web services and applications. In 2008, some of the 20 largest municipality organizations have started to make an inventory of the aggregated services that have been developed locally per municipality. For each aggregated service, an inventory was made of the more detailed services used to create each aggregated service, the service clients, and the (internal) web service providers (indicated by A in Figure 3). The first registry consists of 21 aggregated services (such as 'wedding service' and 'payment service') containing 43 basic services, and 22 service clients.

The municipalities have decided to select the service registry of one municipality to become their registry standard, aiming to realize a shared, centralized registry. This registry can be regarded as the first step towards a shared municipality registry and repository for course grained aggregated web services that provide municipality business processes. Thus, the design options in this network are:

- Option 1 (Local repositories only). This option foresees local repositories which include a limited number of services to support intra-departmental applications.
- Option 2 (Local repositories and local registries). Here, local repositories and registires are used for the web services in intra-organizational applications.
- Option 3 (Centralized repositories and registries). Finally, intermediaries that combine services from national repositories and registries (like DigiD) and ownership checks in the national register (Kadaster) create local aggregated specialized business functions.

With respect to the framework in Table 1, web service intermediaries with national registries and repositories refer to the lower left quadrant (high reach (many clients including non-municipalities), medium range (limited processes), medium richness (non-aggregated services)). Web service intermediaries are also present in the lower right quadrant (low reach (for only one or some municipalities), low range (only some processes supported), high richness (aggregated services)).

5 CONCLUSIONS

The aim of this research was to identify design options for directories in business networks based on the SOA concept. For this purpose, it combined the service oriented computing paradigm, web services market theory with elements from business networking. The framework is used to determine the current design of web service intermediaries, repositories and registries in business networks and potential changes of the design are identified based on requirements in the business domain. The design options are based on the range, reach, and richness of web service markets in the business network.

The framework was applied in a banking network and a local government network to discuss future configurations of repositories and registries within the individual networks. Despite fundamental differences between the networks (with respect to business focus and processes), both networks operate on national or international levels and featured a variety of actors which are potential candidates for providing directory services. Both networks show high variety in service aggregation, intermediaries that may operate on local, regional, or national scales and intermediaries that may focus on one business function. Both networks also show the strategic, political and organizational challenges which need to be addressed when designing directories in interorganizational SOA implementations.

This leads to a variety of questions for future research. First, establishing directories within business networks appears to be a step-like process. For example, both cases suggest that directories and intermediaries start with local repositories without registries, followed by selection of an intermediary to reuse web services based on local registries, in the end followed by (inter-) national registries and repository. More research is necessary to validate the nature and the sequence of these steps. Second, the suggested model has focussed on the distinction of repositories and registries from a topological perspective. Issues which refer to the replication and synchronization of the individual directories as well as the redundancies embedded in the directory architecture were not analyzed. Both directions also show that the implementation of the technological SOA concepts requires more results regarding the strategic, political and organizational implications and requirements of any SOA.

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