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Business Service Integration using Dependency Structure Matrix in view of e-Government System

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***Abstract*— In a Service Oriented Enterprise, the business functions are delivered as a series of services. These services are integrated together to build solutions that serve a particular business need. The service functionalities are software components. Service-orientation is applied through Service Interface Layer which contains abstracted business and application functionalities in the form of services. This layer facilitates enterprise integration. Business Process integration in an enterprise is the linking of individual process pieces together. It needs to indicate the complex information flow between components in a concise and visual method. This paper proposes the Design Structure Matrix as a tool to represent and manage dependency complexity for facilitating the business process integration. This concept is exemplified using a public service, Passport, which is provided by Government of India in its e-Government system.**

Keywords- Service Oriented Enterprise; Service Component Architecture; Design Structure Matrix; Service component; Service dependency; Dependency Modelling, Business Service Integration; Business Process

I. INTRODUCTION

An enterprise architecture describes the Enterprise systems (ESs) which are the enterprise-wide systems of information [11]. ESs need renovation with adaptable, flexible, and reusable architecture due to the frequently changing business requirements and the rapid development of technology [14]. To reduce coupling in legacy applications, Service Oriented Architecture (SOA) has been applied in many software systems. It is done by assembling loosely coupled services that can be used in multiple business domains. Thus, SOA based business driven architectural framework that defines and exposes an organization's core business processes leads to the evolution of Service Oriented Enterprise (SOE) [8][31][16]. It is a view of the enterprise in which everything is seen in terms of services including its interactions and interdependencies between components [31]. SOE is an organization whose business and IT architectures are converged based on the enterprise business service model to gain business goals in the most efficient way and is an ultimate future state of service oriented integration [9]. Business functions of SOE are provided as a series of services and are integrated together to create solutions that serve a particular business need [2]. These composite applications can contain both new services created specifically for the application and also business function from existing systems and applications, reused as part of the composition [13]. Business Process (BP) consists of a number of tasks which need to be carried out and a set of conditions which determine the order of the tasks. In the same way a Business Service (BS) of SOE consists of Service Components (SCs) that includes service composites and atomic services belongs to multiple systems [16]. In an enterprise view, SCs replicates the business functionalities and the integration of these constituents provide BSs and BPs [27]. The identification of services are most essential and are based on activities of a BP model [33]. Business activities execute distributed workflow that can trigger at run time. The discovery, ranking and selection are based on compliance with required business and interaction protocols, and optimization [22].

BSs are constructed by integrating SCs as well as BSs are composes to form BPs. It requires to establish the relationships between them and also to coordinate the flow of deliverables among them. This is very challenging process and a suitable layered integration architecture is required [34]. Enterprise Application Integration (EAI) development is the key to large scale software systems integration [25]. Service-centric software applications and systems can easily be assembled, integrated or migrated. Hence, a service-centric EAI is the suitable solution for BS integration [9]. Service-centric integration is a layered modelling and architecture approach in the services context [9]. In SOE the SC functionalities are software components that requires to indicate the information flow between components [8]. Hence, enterprises need a programming model that specifies how to create, implement, and reuse services, and also states how to assemble or compose services into solutions [25]. Service Component Architecture (SCA) is such a model for service construction, service assembly, and deployment [10][12][13][15][20][28]. It supports components defined in multiple languages, deployed in multiple container technologies, and with multiple service access methods [2][15]. Thus the dependencies of SCA components within a BP of an enterprise are formal operational semantics [34]. The recognized methods for representation of dependencies are workflow based and it represents the tasks only [21]. Thus a semantics based concise representation method is essential to represent the dependencies of SCs replicated in business activities. Thus, this paper propose Dependency Structure Matrix (DSM) as a tool for managing dependency complexity to facilitate integration [1][17][18] [19][29][32].

II. BUSINESS SERVICE OF SOE IN SCA PERSPECTIVE

An automated business organization encompasses multiple BPs with multifaceted interactions between them [33][24][14]. This increase the complexity of BP management and also rises up the gap between IT and business in an enterprise system.

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The SOE overcomes this boundaries [9][26] in a Service Interface Layer (SIL), that can directly interact and map the BPs [30][33]. SIL is expected to contain abstract representations of services that comprises the components of BPs. The services are accessed through the standardized interfaces. A SC offer or require some operation activities that described as a defined business function. These components are interacting through message exchanges which represents the business workflow. In an SCA perspective, a BP can be built from various independent services from service layers of BSs, service Composites (Cs) and SCs [22]. The interactions between these layers providing the necessary platform to create dynamic BP. The SC implements a business function that specifies in any technology and it is the main building block of a BS in SOE [16]. It provides and consumes services to/from other dependent component and these service dependencies are known as references [15]. These are combined into assemblies to form a composite which is combined to form a BS that leads to a business solution. BSs are integrated to construct BPs in SOE [14][26][27][34].

The SOE based BP modeling includes two phases, componentization of business process and tie up the service orientation principles to these components. A complex service provided by an enterprise to its customers has been broken down into simple SCs that envelop small, isolated and distributed business functionalities. This allows enterprises to deconstruct its business through business components corresponding to the business performance with specific boundaries. Decomposition of BP based workout pattern is the systematic approach for transforming a BP into service-based models [33]. This is done by the identification and modeling of business components corresponding to processes, activities and tasks of the BP [14][23][27].

A. SCA Model of Business Process in e-Government System

In order to illustrate our approach, we use a citizen-friendly public provision 'Passport Service', delivered by Government of India in its e-Government (EG) domain. In this example, we envisaged EG as a SOE that is entitled as service-oriented e-Government enterprise (SOeGE) [3][4][6] and the public services are the BPs [5][7]. The central administrative government agency, Passport Department of India, established under the Ministry of External Affairs provides this service. Local Police Station which comes under the Ministry of Home Affairs verifies citizen's identity and has no direct control by the central Department. Passport Department receives the filled application from Citizen, process it and issue the passport as per the status of identity verification by the Police Department.

According to the componentization of BP into SCA modelling elements, Passport Service is decomposed into BSs. Then deconstruct each of these BSs to corresponding Composites (Cs) that exposes business functionalities in the Passport processing [5][7]. These composites are mapped to the functional activities and are identified as the SCs. The configuration of the decomposed BP elements formed the SCA system. It contains three BSs or subsystems such as Passport application processing (BS1), Citizen Identity Verification (BS2), and Issuing Passport (BS3); five service Cs includes Application Submission (C1), Application Scrutiny (C2), Police verification (C3), Passport Granting (C4), and Passport Preparation (C5); formed by twelve SCs as Submit Filled Application (SC1), File Application (SC2), ACK Application (SC3), Application form verification (SC4), Send for Police verification (SC5), Inquire Status (SC6), Police Verification (SC7), Update Status (SC8), Check Status of Verification (SC9), Granting Passport (SC10), Printing of Passport (SC11), and Dispatch of Passport (SC12) [5]. The hierarchy of these elements and their dependencies are exposed in Figure 1.

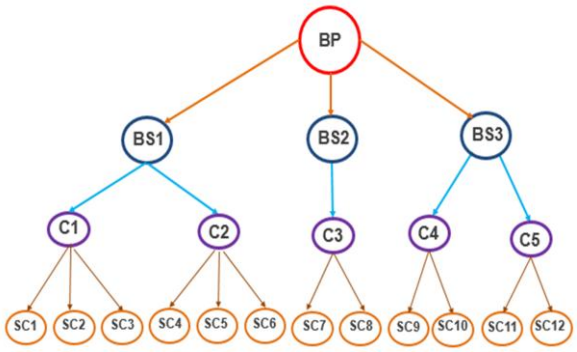

Figure 1. Directed network graph of Decomposed Business Process

The SCA model represents the integration of related business functions in the form of BSs with its corresponding Cs and SCs [5]. Configuration and administration of elements includes the external services, entry points, and wires used to interconnect them. Figure 2 illustrates how these elements of SCA model are integrated and how the business objectives are realized through IT solutions in a SOE based EG system. This helps to understand the complexity of BP integration

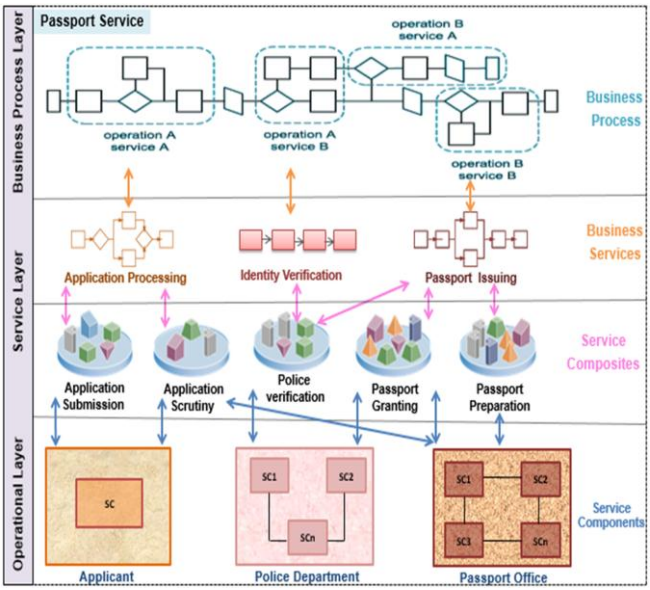

Figure 2. SCA Model of Passport Service in SOE view of e-Government

III. BUSINESS SERVICE INTEGRATION USING DSM

BS integration is the linking of individual process pieces together to accomplish a business functionality in an enterprise. In the SCA perspective of BSs are subsystems and are integrated using service composites with its corresponding SCs. Integration of SCs to form BSs requires the establishment of relationships between them and the flow of deliverables among them to be coordinated. This is very

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challenging process and the existing dependency representation methods are inefficient in its size and complexity. Hence, we proposes DSM to represent the service dependencies in a BP of an Enterprise [1][21][29].

A. Design Structure Matrix (DSM)

DSM is a tool for representation and analysis of system models in view of decomposition and integration [32]. It can be used to identify dependency between activities towards the process sequencing. A DSM can display the relationships between entities of a system in a compact, concise, visual, and analytical format. There are four DSM applications like component-based, team-based, activity-based, and parameter-based to represents relations among components, tasks or activities, and basic functional parameters respectively in the system. These are categorized into Static DSM and Time-based DSM [32]. DSM displays the network structure of a complex system in terms of square matrix with identical rows and columns label representation of components. The off-diagonal elements represents dependencies between the components. It uses several types of analysis to optimize the system tasks, such as partitioning, clustering, and simulation [21][29].

B. Business Process Representation Using DSM

The SCA view of Passport Service in Figure 2 defines the structural elements of the system with the interactions between them. Since DSMs are inherently hierarchical, they make it easier for architects to rapidly zoom in and zoom out the structure of larger systems [1]. Hence, a compact and useful abstraction of the system model can represent in DSM to visualize and identify the dependencies between processes and activities of the system. A component based DSM is used to represent the interdependencies between decomposed BSs of a BP, passport service. While the task based DSM is used in activity representation which stimulates the service composites in SCA view. A combined DSM is used to integrate the components with system boundaries.

Figure 3 exhibits representation of the dependencies among decomposed entities of passport service in a component based DSM. These components have serial dependencies, and the figure shows BS2 depends on BS1 and BS3 depends on BS2. BS1 and BS2 provides deliverables to BS2 and BS3 respectively. The dependencies among activities of composites also represented in figure 3. C1 provides deliverables to C2, therefore C2 depends on C1. C2 provides deliverable to C3, so C3 depends on C2. Similarly C4 depends on C3 and C5 depends on C4. This is a serial mode DSM and the marks appeared in the lower-triangular region. It indicates that the dependence of upstream activity will be created while there is downstream information. The activities make an assumption about the information and it needs from another activity.

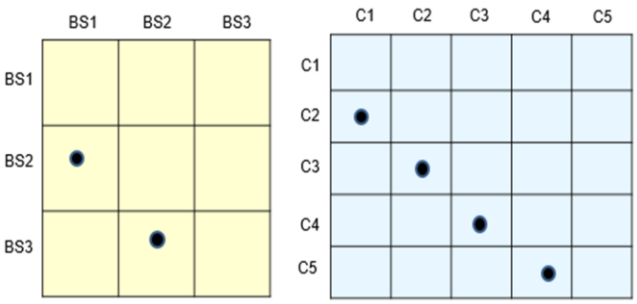

Figure 3. DSM representation of Decomposed Components

C. Business Servics Integration in a Business Process

The Business Processes of complex systems are enmeshed in a larger environment and the functionality depends on how well its activities work together to achieve a result. Process modelling helps to identify the BSs, related activities and its deliverable flow with dependencies. Process integration is important when there are large number of dependent activities to coordinate. In the DSM, the sequence for executing the activities are revealed by mixture activities of different processes. Large, detailed DSMs are built by integrating smaller ones. These DSMs can be used to represent the dependencies among BSs with its integral activities in a BP. This integrated DSM represents the entities from separate organization boundaries with activities belongs to different owners. A serial mode integrated DSM for a Passport Service have been built by combining the two DSMs in Figure 3. This integrated DSM represents the BP with its dependencies among activities in different boundaries as shown in Figure 4. The activities make an assumption about the information it needs from another activity of different boundaries. Integration of activities create information that may cause changes to previously executed activities. It is designated by the marks in rows to the left of the diagonal.

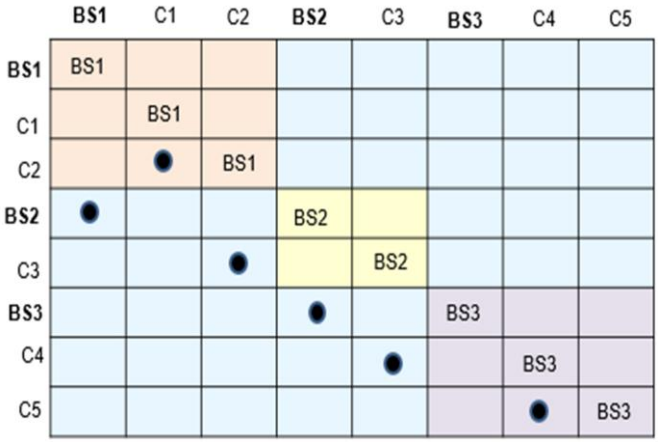

Figure 4. DSM representation of Business Service Integration

The representation of large number of BPs and its dependencies in an Enterprise System are covered in the entire process models. These models can easily represented in an integrated DSM. Therefore DSM representation eliminates the complications of conventional process models through its concise and visual format. Hence, our proposed method is suitable in an Enterprise System context.

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IV. CONCLUSION

Integration of service components to form business services and then business processes in an enterprise requires the establishment of relationships between them. The flow of deliverables among them should be coordinated according to the business needs. The representation of this information flow with its dependencies of service components is a very challenging process. This paper proposed DSM to represent the service component dependencies in a business process. The described method is exemplified using a public service in e-Government system. This is usable in practice, and yet offers benefits that have not been available in previous approaches. The concept we have designated does not disrupt the standard development methods, but it offer a view of architecture and architectural conformance. This methodology will be valuable for distributed organizations like e-Government.

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