Managing Complex Business Services in Heterogeneous eBusiness Ecosystems – Aspect-based Research Assessment

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Abstract

The distinctive feature of eBusiness applications is their complexity due to the large number of factors that have to be taken into consideration and aligned with regard to the products and services offered. Besides, the rapid adoption of eBusiness has resulted in an ever-increasing set of complex applications and IT infrastructure components to be managed.

Thus, in this paper, we address the substances specific for the complex service management and identify some possible problem areas arising from contractual agreements between involved parties as well as from the directions of where service management is heading nowadays. Initially we examine what may be perceived as heterogeneous and agile eBusiness. We perform an aspect-based analysis of researched scientific literature: a detailed assessment of various definitions, requirements and other facets specific to the dynamic nature of service management in heterogeneous e-Business environment. Furthermore, we evaluate business-driven against conventional approaches to design SLAs; finally we examine various service management models giving priority to on SOA architecture.

Keywords: Heterogeneous eBusiness; Service Level Agreements; Service Level Management; SOA; Web Services Distributed Management

1. Introduction

The distinctive feature of eBusiness applications is their complexity due to the large number of factors that have to be taken into consideration and aligned with regard to the products and services offered, the business processes used, the organization and the information technology (IT) applied [1].

Besides, the rapid adoption of eBusiness has resulted in an ever-increasing set of complex applications and IT infrastructure components to manage. And, the productivity can be lost if geographically dispersed employees do not have the IT resources they need to perform their jobs. The underlying coordination of computing workload and integration with eBusiness applications are highly needed.

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Furthermore, the demands the enterprises face in managing their IT infrastructures may have shifted during the past several years with the dramatic rise of eBusiness. Forging collaborative links for improved efficiency and maintaining continuity with quality vendors may be key business objectives.

Thus, to provide a valuable, robust eBusiness infrastructure, management software solutions above all should deliver rapid time to value. First, the solution should be quickly installed and made fully operational to yield immediate return on investment. Second, the solution should address the integration of an IT infrastructure from the host system to the Web edge server to the end-user device. Third, scalability across a large number of endpoints—sometimes into the hundreds of thousands—can be critical. Finally, and equally important, is the ability to manage across heterogeneous operating system platforms [2].

Consequently, in this paper, we address the substances specific for the complex service management and point to some possible problem areas arising not only from contractual agreements between involved parties but also from the directions of where service management is heading nowadays. This in turn sets inevitably new requirements forward as far as functionality, design and standards to be considered [4].

Initially we examine what can be perceived as heterogeneous and agile eBusiness, as one could think that the agile part is almost embedded in the nature of eBusiness. One possible definition can be found in [3], who describes dynamic eBusiness as a “development of an environment where service customers and service providers collaborate with each other over the Internet, negotiate terms and conditions electronically, connect with each other dynamically, transact business and tear down their relationship when it is no longer needed”.

This development has tight links with the rise of use of the Internet in business environment, which goes in line with the pace of research devoted not only to finding new functionalities but also to managing what is already a substantial amount of different standards and making them work together [4].

The agile services in turn are the core of the dynamic eBusiness [3]. Those business services are often delivered not just by a single provider, but rather by multiple suppliers, on demand and on frequent need to be specifically tailored to customers’ needs. In a view of this, the business service management systems face certain challenges. And, in further instance, technical requirements can be derived from the heterogeneous and agile nature of eBusiness.

Closely linked to the subject of business service management is the so-called Service Level Agreement (SLA). This is the actual basis that outlines what service provider (SP) and customer have agreed on, e.g. in terms of quality or availability of service. In next sections, we discuss the issues across SLAs and business service management in detail [4].

2. Outline of Challenges by Complex Business Services Management

One of the most significant challenges in managing complex business services lies in the ability to support facilities that are continually evolving in structure and quality levels [5]. The management framework should allow the service provider to create application service offerings that are built on the top of its existing service resources and it should enable the service provider to be able to fulfill customer expectations for different service and service quality requirements in a cost effective manner. A service provider should be capable of exploiting economies of scale by sharing service resources across all customers [6]. This reduces both the cost of providing dedicated resources for each customer and the associated management overheads, but however introduces the additional complexity of providing differentiated levels of service quality to each customer [7].

Besides, the service provisioning has brought new challenges in how to manage these services so that high availability is guaranteed [8]. Typically, service providers have well-developed network management infrastructures to operate their physical networks of servers, switches, routers, links etc. [9]. Thus, an important objective is to leverage the existing network management infrastructure and enhance it to provide service management [10]. In order to provide end-to-end service management for every customer, the service provider must deploy a service management system in addition to the operational management system [9].

Furthermore, a service in an eBusiness environment typically comprises instances of distributed components that belong to multiple monitored domains, therefore requiring the management of that service to span multiple monitored domains. Service management domains [9] are virtual domains built from resources and relationships pertaining to the monitored physical domains. Providing management services in a heterogeneous eBusiness environment poses a number of challenges, due to the dynamic nature of the eBusiness, including [8]:
- efficient management systems in the customer and service provider environments to enable appropriate monitoring;
- active detection of contract violation, finding the source of the violation and initiating corrective measures;
- operational problem determination across the multiple organization boundaries involved in the implementation of an eBusiness service [4, 7].

3. Service Ecosystems in Heterogeneous eBusiness Environment

A service ecosystem is a marketplace for trading services in which services are developed, published, sold and used [11]. Service ecosystems have changed the way of service delivery and service consumption among actors/parties, who perform specific roles for the operation of the ecosystems. Such actors, being service providers, consumers, mediators and intermediaries, ensure the livelihood of the ecosystem. Particularly, the service infrastructure provider provides service infrastructures/frameworks upon which other actors of the service ecosystem operate [4].

Furthermore, business has been changing continuously with the advancement in Internet technologies, enabling cross-enterprise collaboration. Web Service technology that follows the Service-Oriented Architecture (SOA) [12] based architectural style has contributed substantially to the efficiency of cross-enterprise collaboration and to address the accelerating pace of changes, such as intra-organizational changes, changes in market demands, rules and regulations, and the changes in the supporting technologies.

Recently, the successes of the companies like Amazon, Google, and Salesforce, have demonstrated the real commercial success of web service technology as a means to create value for customers. Such commercial successes have given rise to web service ecosystem that has radically changed the way we discover and invoke service in the Internet. A web service ecosystem is a logical collection of web services in which service delivery is subjected to constraints at business level [13]. The service ecosystem is an evolutionary step of SOA in which services are not only means to achieve heterogeneous application integration, but services are envisioned as tradable products. As a result, web service ecosystems are the marketplaces for trading services in the Internet.

While trading services, service ecosystems bring together the consumers and service providers in which various other actors from different legal bodies are involved for supply, delivery, and consumption of services. As envisioned by [13], service ecosystems consist of the following actors: consumers, providers, brokers, mediators, and intermediaries. However, [13] fail to mention an essential actor within a service ecosystem - the service infrastructure provider. The service infrastructure provider is an enabler for proper functioning of other actors in the service ecosystems as it provides computing infrastructure and/or set of additional functionalities such as service cataloguing (i.e., registry), composition, monitoring, and versioning of services in the service ecosystems [4, 11].

4. Service Level Agreements and Business Services Management

The Internet technologies facilitate development of an environment where companies are outsourcing activities (namely, that are not a part of their core competencies) to the third-party service providers.

Customers and service providers can allocate and identify each other over the Internet, negotiate the terms and conditions electronically, connect with each other dynamically, transact business and cease their relationship when the service is no longer required. One of the key enabling factors for the provision of services in this environment is the agreement of an electronic contract between the service provider and service consumer. With the introduction of Service Level Agreements (SLAs) between the members in active eBusiness environment, management facilities are required to ensure that the service is delivered within the bounds of the SLA [14]. These management facilities allow for the definition and management of quality of service (QoS) parameters and service level guarantees in the SLA, and can detect violations during the interaction between a customer and a service provider. The management service is also responsible for a problem determination, solution and for the reporting performance data [7].

Yet, even within eBusiness the actual contents of given SLAs vary greatly, with different metrics used and implemented in different ways, and this despite the efforts of the Application Service Provider Industry Consortium on categorizing SLAs and respective metrics into four groups [15]:
1. application SLA - application availability, performance and security;
2. network SLA - network availability, throughput, security and latency;
3. hosting SLA - server availability, backup and rotation, disaster recovery and physical server security

The [16] gives an example of how differently SPs (Service Providers) may define “application availability”, e.g.: user(s) being able to establish a TCP connection to the appropriate server, or customer’s ability to access the software application on the server.

![Complex Service Composition](image1)

(a) Complex Service Composition

![Simple Service Composition](image2)

(b) Simple Service Composition

Fig. 1. Simple (1b) and Complex (1a) Service Composition Scenarios [17].

For a SP being able to manage dynamically SLAs - would be of great benefit, possibly leading to gains from effective use of resources and quick adaptation to current market trends, conditions as well as customers’ wishes. For a customer, an SLA is some kind of warranty e.g. that the provisioned service will be available in specified quality for given amount of time. Frequently, service providers and customers, who often deliver together with other SPs further services to their customers (Fig. 1), have to decide first on agreement conditions, i.e., metrics.

Besides, over the years various approaches to describe web services have emerged: Web Services Policy Language (WSPL), Web Service Level Agreement (WSLA), WS-agreement and WS-policy to name a few, aim of which is to bring management of SLAs closer to “dynamic” standards. Some of them (WSLA) complement the Web Services Description Language (WSDL) [17]. Choice of the framework used proves again to be crucial as they present different advantages and reveal respective limitations [18]. In this way, the WSDL presents a general standard for description of WS capturing the location of the WS and what it can do, but it is unable to describe the web services as commodities because it has nothing to do with the quality of web services [18]. WS-policy conveys static properties of web service entities (security, authentication), giving consumer flexibility in choosing service of their choice. WSPL incorporates more sophisticated possibilities regarding policies, whereas WSLA uses templates which make closing agreements more straightforward process. WS-agreement aims at unifying the underlying terminology, structure and concepts [4].

4.1. Business-driven vs. conventional approach to designing SLAs

The conventional approach may be characterized as seeking either to maximize SP’s profit or to minimize costs of providing required services at given level. By concentrating on just two parameters (minimum service availability - AMIN and maximum mean response time - TMAX) [19] point out weaknesses of this approach to design SLAs (Figure 2a) and their impact on the outline of the server(s) providing the service.

![Conventional SLA Design Approach](image3)

(a) Conventional SLA Design Approach

![Business-driven SLA Design Approach](image4)

(b) Business-driven SLA Design Approach

Fig. 2. SLA Design Approaches [19].

The SP, once customer’s requirements have been stated in a SLA (and then transformed into IT parameters), tries...
to optimize his server cluster to make provisioning of the service financially viable. So only SP’s parameters are taken into account when designing the server(s). In [19], we can see two major drawbacks of such an approach. One is that the relevant threshold values are chosen rather than subjected to an optimization process. Other, in conventional approach to SLA design only SP’s perspective is depicted in greater detail whereas this of the customer’s has rather insignificant input.

Business-driven approach on the other hand tries to improve the relationship between SPs and customers by linking IT-infrastructure failures to business losses (Figure 2b). This approach evaluates customer’s business loss resulting from degraded quality of service. SLO thresholds are only quantified once appropriate IT infrastructure - one that maximizes both SP’s and customer’s profit margins have been determined. SLO thresholds are then used in mutual service level agreement. This, when compared with the conventional approach, inverse order makes it possible that both SP’s and customer’s perspective are taken into account in the optimization problem and not only this of SP’s. In their tests [19] show that the business-driven approach results in better profits for both parties involved. Appropriate parameter values in SLA are undeniably of great importance to the overall functioning of the service(s) and thus one should make sure that these parameters are not simply guessed, but validated [4].

4.2. SLA and Heterogeneous e-Business ecosystems

While discussing service level agreements, we have already touched on some of, what are considered to be, typical SLA problem areas. According to [15] those are: monitoring the end-user experience or technology components, unclear and incomplete service specification, cost management, difficult to understand and change SLAs, development of SLA semantic model, SLA management for on-demand services, SLA in relation to electronic service composition and web services. Obviously, an optimal service management system could take care of all of the problematic points. This task is however not easy to implement, as further complexity is added shortly.

The possibility for customers to choose among many different service levels (with respective pricing) means flexibility. SP, which does not offer this customizable service, may find itself no longer competitive.

For composite/or/mashuped services, where they are composed of multiple standalone applications, reliability of every single one can decide whether customer uses it. If just one component is not working, as it should - the whole service may be at risk, as customers may quickly look for alternatives online. The dynamic nature of web services requires its automated creation, negotiation, publication, activation and monitoring [15]. This poses one significant requirement on the framework, apart from the already discussed ones - namely this framework has to support interoperability with vast numbers and kinds of devices, standards and other frameworks. What is in question is the heterogeneity. On top of differentiated hardware enterprise networks contain equally, if not even more, diversified software [20].

One way to deliberate heterogeneity is presented in [21], where it is considered with regards to three aspects: terminal, network and service heterogeneity. Under terminal heterogeneity characteristics of the device receiving the service are concerned [4].

5. Service Management Models and eBusiness Ecosystems

In this section we take a closer look at researched articles on the subject of service management. The intent here is not to discuss one single model in great detail as approaches vary in their methodology and implementation. The objective here is to provide an overview of researched scientific literature and where necessary - to delve into relevant matters, often in context of what was discussed in the previous sections. Articles by [7, 23÷25] were provided as introductory to this subject.

If to recall briefly what is expected from a service management system following points have to be considered: support of dynamic services, flexible with regards to on-demand and customizable quality levels, optimizing costs and resources. Last but not least, system is supposed to work in heterogeneous networks. Challenge for the researchers is to develop a system fulfilling all these requirements. [7] state the following: although a number of frameworks have addressed each of these areas separately, to-date no frameworks has been proposed that provides an integrated approach to solving these issues.

Since then new trends and paradigms have emerged dedicated to resolving this problem, preeminently Service Oriented Architecture (SOA), which has become a “buzzword” – according to [26]. Authors of this paper also see it
this way, that SOA methodology has had a significant impact on how management systems are currently perceived and thus how they are constructed [4].

5.1. Approaches to Dynamic Service Management

In this group one of the most associated articles found is [7]. It presents a so-called Dynamic Service Management framework. With this model authors address key requirements of dynamic service management. They also provide an analysis of what was state of the art in this field at that time [23÷25].

In [23] authors present an approach to managing on demand SLA contracts with Cross-SLA Execution Manager (SAM). With use of optimizing algorithms SAM – contract execution manager, evaluates and if necessary, reschedules service management tasks in order to minimize eventual penalties from violating SLA. The [7] points out that this re-prioritization of tasks does not happen on dynamic basis, which is not in line with earlier mentioned expectations.

The authors in [25] deal in their work with SLA management in federated systems. These are systems “composed of components within different administrative components cooperating to provide a service”, which in turn can “span multiple heterogeneous control domains”.

The authors in [7] call their SLA manager “Conformance”. This takes care of dynamic service creation and management, i.e. QoS monitoring. But again, as [7] points out, “Conformance” is based on fixed, to each customer-dedicated resources.

This means that SP could not reallocate his resources dynamically, which could lead to an undesirable situation, where servers dedicated to one customer are under great strain or even missing some computing power when dealing with sudden peak in demand, while servers dedicated to a second customer are running almost idle.

The authors in [21] present an approach to distributed network management in response to dynamic services and in accordance with service level agreements. Authors call it “AcMe” (Active Mediator) - independent management entities orchestrating operation of a single network domain. Making use of the three-dimensional Service Concept authors relate to the process of network configuration as inherently dynamic and leading to generation of according Service Level Specifications (SLS). For SPs “AcMe” is reported to represent an optimal equilibrium between maximizing usage of its resources and contribution to profit margins.

In [3] a contract-based approach to SLA management is proposed. Having analyzed many SLAs used in ASP industry, authors of this study tried to develop a generic model for service contracts. Developed with dynamic eBusiness in mind, this framework supports automated deployment, monitoring and in contract violation identification.

Now we turn to approach to service management in service provider environment proposed by [7] - Dynamic Service Manager (DSM). It presents a potentially valuable tool for SPs to help them support dynamic and customizable on-demand services with optimal and cost-effective resource allocation. The [7] constructs two models, on which they later evaluate their DSM framework. They conclude “there is great potential in using DSM to implement applications that are similar in nature”.

We continue with work presented in [27]. Therein developed SLA management instance SAMI - an architecture that supports negotiation and runtime management of SLAs. Authors stress on the generic architecture of their system that allows for inter-domain use of SAMI. This is meant to function at the same level as (managed) services so that no additional disruptions emerge, but it does not interact with them apart from provisioning, adjusting and monitoring. It is however possible to introduce hierarchies as an independent echelon over existing services. [27] Distinguish in their illustration of SAMI in the term of service two instances: Software as a service (SaaS) and Infrastructure as a service (IaaS).

Last model to be mentioned in this section is the one proposed by [28]. Service Level Analysis Method (SLAM) is a conceptual framework for business driven SLA management. As it does not deal with dynamic service creation in SP environment, it possible to say that it offers an interesting approach to integration of IT systems and business operations and, which has proven successful when implemented in an enterprise [29].

5.2. Models based on SOA architecture

We begin this subsection with the goal-oriented, agent based approach presented in [30]. Authors want to
develop a new service management framework that is built on three main components: therein discussed services management model, a procedure for generating components as stated by model specifications and thirdly and infrastructure pulling management tasks and user interaction together. Service management model is implemented with use of several ‘constructs’ managed resources, events, agents, event streams and management goal graphs and is depicted on an example of a web server.

Fig. 3. Agent based service management model [30] Streams and Management Goal Graphs.

While the construct of managed resources may be obvious, we briefly add detail to events, agents and graphs. An event is defined as either an occurrence of a situation or an incident in a service or the system. Agents (Fig. 3b), of which there are three kinds: sensors, actors and effectors, have the task to accept new events from (multiple) streams.

This gives start to ‘local processing’ leading to either creation of a new event stream or applying changes to the managed/management system. Agents themselves perform relatively simple tasks, but they may be bundled into ‘management goal graphs’ (Fig. 3c) to perform complicated management scenarios (Fig. 3a). Choice of agent-based architecture over more common centralized approach [30] argument with three points - that the agent approach: shows more of adaptability, can better deal with overloads and that there is ‘no single point of failure on in it’.

In [29] authors propose SOA-oriented federate SLA management structure capable of handling complex network environments. They employ ‘dynamic service management loop’ for processing procedures in a way that network is structured in three divisions: management, control and network resource. To ensure compatibility with autonomous, distributed and disparate services authors use a federated approach in form of a service module - bus structure.

Besides, a model described in [31] manages services by their ‘functional and non-functional’ characteristics embedded here in SLAs. This study is done in context of provisioning streaming services, where rather large amounts of data is transmitted over longer time periods. Special care was taken to ensure respective QoS terms and their delivery at runtime [4]. This model is however not capable of automatic composition of services as it uses libraries with predefined values to schedule services accordingly [31].

6. Conclusions

One can certainly say that the subject of service management is truly versatile. It gives roots to many related questions, optimization problems and as many methodologies and various standards.

The authors of this paper tried to approach the subject by first scaling some light on the (heterogeneous) environment of dynamic service management. For this reason Section 1 points to most important requirements and challenges faced within the field. With that preliminary and in our opinion, necessary work done, Section 2 and 3 then concentrate on various models introduced in scientific literature, voluntarily distinguishing between models developed in accordance with SOA methodology and those that do not [4]. For a service provider a tool that gives the advantage of maintaining, administering and monitoring resources in a dynamic, flexible and cost-optimal way is undoubtedly of great value. Yet with the constant flow of technological improvements and inventions new challenges are being put forward, and an exploration of such a frameworks continues.
References


2. Software Group, Automated control of your e-business applications and infrastructure, A technical discussion of configuration and operations management, G325-6775-00, IBM Corporation, April (2002).


