Key Requirements for Predictive Analytical IT Service Management

Architectural Key Characteristics for a Cloud based Realization

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Abstract: While trying to maintain sustainable competitive advantage, IT service providers are challenged with tremendous service complexity and a low level of flexibility caused by the lack of transparency, constrained scalability and the missing ability to identify needed service measures proactively. For overcoming these challenges, this paper presents a well-evaluated set of identified key requirements for a feasible realization of a highly scalable cloud based architecture that supports predictive analytics in several domains of IT Service Management. This presented concept goes far beyond traditional approaches and pertinent state-of-the-art software solutions by focusing on business analyses based on knowledge creation and domain-independent knowledge sharing. The proposed approach is based on profound analyses of related work as well as modern service oriented design and business analyses paradigms. It provides semantic complexity handling, structured and multi-layered service interaction, cloud-enabled scalability management as well as predictive business analyses based on semantic reasoning, decision-making support and pattern recognition. The derived results eventually provide solution architects with a feasible and technical independent fundament for architectural implementation decisions. It ultimately enables IT service providers to cope with modern flexibility needs and complexity challenges and therefore to continuously satisfy customers to gain competitive advantage.

1 INTRODUCTION

A company's success fundamentally depends on its ability to develop sophisticated solutions, perfectly fitting to customers' requirements. Nevertheless, to guarantee sustainable success, bearing up customers' satisfaction is necessary, especially if requirements change. Hence, a flexible and agile service network is needed, adaptable to changes, but most of all adaptable to customers' requirements.

According to Porter's Five Forces, competitive rivalry in the IT area is significantly higher than in many other branches, primarily caused by a high threat of new entry and substitution (Fung, 2013, pp. 19,20). The internet and cloud computing eliminate many physical barriers of entering a new market (Fung, 2013, pp. 19,20). Due to the variety of IT services with similar functionality it is easy for customers to change to substitutes, whereas IT service providers have to deal with a high range of competitive companies, serving those customers (Fung, 2013, pp. 19,20). Thus, albeit it is comparatively easy to provide IT services, it requires a lot of effort to keep up with others by continuously satisfying customers and managing their requirements not just reactively, but in a proactive and predictive way for effective decision-making.

The ability for successfully managing services over a long-time period distinguishes an effective from an ineffective service provider. The key to success is flexibility in IT Service Management (ITSM), by constantly aligning and adjusting the service offers to the actual market need. Managing services means managing a network of interdependent components that have to be completely coordinated. Disability of coping with multitenant service dependencies leads to missing transparency in the service environment, which affects calculation and billing of services and makes analytics for business relevant financial decisions extremely difficult, or even impossible (Schwarz, et al., 2013, p. 1).

The strong influence of ITSM on Financial Management indicates the need for balance and flexibility over multiple domains, which is still an unhandled problem of current software solutions

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(Schwarz, et al., 2013, p. 1). IT is the most pervasive factor in business, affecting every single process and decision (Addy, 2007, p. 20). Therefore the discipline of ITSM is applicable for nearly all business domains relying on any kind of IT based service. Moreover, it is necessary to control all IT components from a holistic view, for constantly aligning the business strategy with the IT strategy, especially when environmental changes appear (vom Brocke, et al., 2013, p. 1).

Nevertheless, complexity is considered as the major challenge in ITSM. Complexity is referred to the management of service data and its relations (Benedettini and Neely, 2012, pp. 5,6). Interdependencies and data flows between services have to be determined easily and fast, so that possible effects of changes and events can be recognized ideally in real-time. Thus, efficient ITSM requires transparency of service-to-customer, as well as service-to-service interaction. Besides that, transparency is necessary between services and its underlying components, to ensure appropriate service functionality. In the same way profound knowledge of service relations is needed for defining and fulfilling cost-efficient service levels and consequently to ensure a particular Quality of Service (QoS) level. Constantly changing requirements necessitate QoS management techniques that are far beyond static provisioning of network resources (Kourtesis, et al., 2014, pp. 306,307). Higher elasticity and dynamic provisioning is needed, based on real-time decisions, reasoning and inference (Kourtesis, et al., 2014, pp. 306,307).

Second, the maintenance and continuous improvement of a service infrastructure, tightened influenced by IT outsourcing and cloud-oriented design, define a new level of complexity (Benedettini and Neely, 2012, pp. 5,6). Changing requirements often demand changing functionality, seamlessly integrated in the working service environment.

Up to a certain level, IT services seem to be manageable easily. With growing complexity, however, a point will be reached where the effort of complexity handling is higher than the services' benefit, leading to crucial cost inefficiency (Josuttis, 2007, p. 2). Consequently, the service infrastructure has to be designed and structured in a way that supports effective management of both mentioned complexity types on the one hand and enables seamless integration of new services on the other hand. The high level of complexity forces IT service providers to think of new ways for automatically managing a variety of data, variables and parameters, necessary for the operation of services and its resources (Kourtesis, et al., 2014, p. 308).

2 RELATED WORK

In the past years, different approaches have been presented in the area of ITSM, all with the overall goal to enhance efficiency, primary by using the Semantic Web concept. They provide sophisticated solutions with a precise goal for dealing with complexity in IT Service Management.

It is beyond doubt that these solutions provide value in the very specific field they are used, but the question arising is, if they are adaptable to other correlating areas as well at an adequate level of effort. Referring back to the de-facto ITSM standard, the Information Technology Infrastructure Library (ITIL), IT Service Management is defined as the discipline to deal with all processes in the service lifecycle (van Bon, et al., 2007, pp. 24-26, 42). Efficient ITSM needs a holistic view, accomplishing a platform that allows making use of the Service Oriented Architecture (SOA) and analytical benefits in any ITSM domain. The ability of using semantic knowledge must not be limited to one specific implementation, but has to be realized on a shared base. The semantic Wiki-based approach of Kleiner et al. (Kleiner, et al., 2012) perfectly fits to the issue of complexity in Incident and Problem Management and thus, it is closely aligned to exactly these ITIL processes. Although the semantic Wiki allows the integration of other applications, the platform is still limited to the information stored in the semantic Wiki. Jantscher et al. (Jantscher, et al., 2014) focus on reducing negative business impacts caused by wrong incident prioritization. They developed an example for analytical ITSM, the Incident Prioritizer, which is an AHP decision support system for the prioritization of incidents based on their business impact. For the prioritization process, relevant incident data is provided by an ontology, defining an ITIL-compliant service catalogue. Valiente et al. (Valiente, et al., 2012) deal with the service management problem of integrating service management processes, which are often specified in natural language. The paper aims to translate ITSM relevant information, expressed in natural language, to a computer understandable format, by using semantic technologies. Thus, Onto-ITIL is presented in this work, as an OWL based ontology, tailored to be used in ITSM, to overcome the gap between natural language process definitions and IT services, or more generally the gap between business and IT. Otherwise, the very generic approach of Freitas et al. (Freitas, et al., 2008) defines insufficient structure do be applicable in this stage for operative use. The idea of a generic ontology, usable for different domains, has definitely potential in theory, but not enough alignment to the ITIL processes for effective ITSM.

What is needed is an overall platform allowing the seamless integration of ITIL process solutions throughout the whole service lifecycle. The platform architecture has to be designed to support flexibility and to make services adaptable for changes. The approach of El-Gayar et al. (El-Gayar & Deokar, 2013) with its distributed model environment presents the key feature of using a service bus for enabling flexible changing of distributed models, based on specific problems.

Extending this approach of high flexibility and easy sharing and reusing of information to the field of ITSM, a platform can be realized that allows the integration of process solutions throughout the whole lifecycle and sharing and using knowledge in the whole environment.

3 RESEARCH QUESTIONS AND OBJECTIVES

When focusing on the implementation of existing concepts in the related work, the need for further development has been identified, missing a holistic approach for seamlessly integrating them. Thus, the presented approach in the upcoming sections tries to answer the following research questions:

- What are the key requirements for a scalable architecture to support predictive analysis in ITSM to be able to cope with the complexity of service interdependencies and heterogeneity as well as the lack of transparency?
- Is there a way for seamlessly integrating services and making use of provided functionality and commonly used data?
- Is it possible to provide a convenient way for scalability and extensibility management that allows flexible and on-demand use of resources?

4 PROPOSED APPROACH

In the first step, a long-term evaluation process was necessary to identify the major characteristics for predictive-analytical ITSM. They will be introduced in this paper as the eight key requirements of IT Service Management as they combine structure and process-oriented service management of ITIL, the architectural advantages of a SOA and the centralized integration of semantic technologies for handling service complexities. They have been identified as follows:

1. Structured Service Interaction
2. Centralized Service Orchestration
3. Multi-layered Software Architecture
4. Scalable Computing Architecture
5. Domain-independent Architecture
6. Common Information Integration
7. Predictive Analyses Integration
8. Natural Language Interface

These key requirements do not specify any technological implementations and thus provide a technology-independent, holistic view on an ITSM concept, tailored to be generic but structured, scalable and extensible, and applicable for several domains of ITSM. This overall concept provides an ITSM environment highly adjustable to any business needs for a clear alignment to the business processes and a strong focus on shared processible knowledge throughout the whole environment. The motivation for defining these eight key requirements is to provide a common foundation for the development of any ITSM approach with a focus on effective and predictive analytics. This foundation is not just applicable for dealing with one particular ITSM problem, but constitutes helpful practices at the starting point of any effective ITSM development.

4.1 Structured Service Interaction

Extensive service interaction is an indicator for a well-structured and working service environment. Each service provides defined functionality that can or has to be used by other services. Thus, service communication is inevitable for requesting and returning service provided information. Service interaction must not be avoided. It is an indicator for sophisticated capsulation of functionality and conforms to the concept of information sharing and reusing. The only condition for effective service interaction is to accomplish a structured and consistent way of communication. Communication between humans works as long as they understand each other. The same obtains for communication between services.

However, a network of services often consists of heterogenic technologies for service development. It is nearly impossible, or just manageable with high effort, to keep a service environment homogeneous, which is not the goal for effective service communication. Rather, it is necessary, in a network of various services, to define and enforce a communication standard valid for all service interaction.

In combination with a generic language, the service interaction has to be structured with defined communication endpoints. Interfacing the communication ensures that information exchange is consistent in the whole architecture, which facilitates the maintenance and extension of the service environment and supports the Service Transition phase. Using consistent communication interfaces, it is clearly defined how new services have to provide and how to retrieve information from others, which reduces the risk of incompatibilities in the Release Management.

4.2 Centralized Service Orchestration

Well-defined interfaces for service requests and responses are inevitable for service consistency and service integration and maintenance, but they do not prevent service networks of reaching a level of unmanageable complexity. Service communication has to be orchestrated over a centralized communication manager, a service bus, to provide a single point of contact for all service communication. Instead of directly addressing, services contact the centralized service bus, which handles the further processing of the service messages, based on a consistent and clear addressing schema for services.

However, effective communication management is not just relaying messages from service A to service B, without considering possible service downtimes or overutilization. Effective communication management has to accept the responsibility of managing message queuing and load balancing, to ensure a stable environment that can dynamically react on service failure. Hence, the service bus can perform message forwarding, without knowledge of the actual service location. The message sender and receiver can be located anywhere, as long as they reach the service bus communication interfaces, which enables the possibility for changing service location, for instance a transformation to the cloud, without losing connectivity to the service environment. This flexibility in service providing, in combination with low maintenance effort, makes complex service networks manageable, even if process requirements change. Decisions for outsourcing of service functionality do not depend on the service interdependencies anymore and can be performed completely based on cost and compliance reasons.

4.3 Multi-layered Software Architecture

Functionality has to be separated into services to provide a manageable structure and to be flexible for changes. Basically, service functionality comprises the ability to store and retrieve data, to process the data, if needed based on workflows, and to present the processed information, which can be described as the four service functionality layers. For sure, these layers can be developed for each service independently, but a structured separation in a standardized layer design, based on interface connectivity definitely supports the architecture's structure and consistency and prevents unnecessary heterogeneity. If all services store and retrieve data based on the same standardized platform for data storage, maintenance of service data is also limited to this platform and does not require skills in multiple technologies.

In addition, the integration of new services or the replacement of service functionality can be performed with lower risk of incompatibilities, if storage communication is accomplished over specified interfaces to a standardized storage platform. On the same way, service logic and service processes have to be implemented. Referring back to the structured and consistent service interaction, communication to the data storage and to other services over the service bus has to be accomplished over standardizes interfaces, independent from the logic technology.

The coordination of providing information through the data, logic and process layers, and the presentation of this information, in the presentation layer, is essential for bringing the service value to the customer. The challenge of this layer is to retrieve information over the services bus and to bring it into a specific view. The clear separation between information processing and information presentation allows the interaction of different presentation views with one underlying service module and vice versa. This structure comes up to the service catalogue concept, which allows the combination of service items to different service packages, adjusted to a customer's need and flexible for change. Besides that, this clear separation and the communication management of the service bus, allow the easy development of a presentation view for different devices, without the necessity of changing the service logic. The described aspects enable value-focused development of presentation views tailored to the customers' needs in all aspects, collecting the information needed and presenting it in the most convenient form. The outcome can be a mobile application for a maintenance worker or a classic desktop program for the controller, both accessing collected and tailored information.

4.4 Scalable Computing Architecture

Maintaining and improving an ITSM environment demands flexibility in scalability management. Dynamic reaction on changes is required, at best close to real-time, to ensure service operation without any difficulty. Thus, cloud platforms can be used, which allow dynamic on-demand resource allocation and flexible scalability as well as location independent service communication provided by a service bus.

Moreover, the layered design of a service allows the cloud-transformation of each layer independently from the other layers. Consequently, the service data storage could be transferred to the cloud, while the service logic is still located on premise. This layer based service design enables scalability management at component level and thus, provides the maximum of flexibility in resource provisioning. The emerging "Big Data" topic necessitates the ability for handling large datasets and vast amount of data for supporting predictive decision processes by extracting the maximum value of data (Kourtesis, et al., 2014, p. 310). Thus, highly scalable systems are needed to process such large volumes of data in real-time (Kourtesis, et al., 2014, p. 310).

Besides the advanced scalability management, the support for various presentation devices is a key feature of this cloud-enabled design. The driver for cloud integration is not just improved scalability management and multi device support. Moreover, elementary, financial and compliance aspects play a major role for switching to cloud resources. Thus, it is important that the ITSM architecture has the potential to switch to cloud resources with low effort and low risk of failure. In an effective ITSM environment, cloud decisions should only depend on financial and compliance aspects, but definitely must not be dependent on the technical ability to switch to the cloud.

4.5 Domain-independent Architecture

Ontology models are, like all models, limited to a specific area, domain or region. But for providing an efficient and holistic ITSM environment, limitations of ontology models and consequently limitations of knowledge are not eligible. Since it is not possible to define a model without boundaries, the ITSM environment has to provide the possibility to define various ontologies or service modules, respectively, representing all domains of expertise in ITSM. Nevertheless, a centralized administration of multiple models is nearly impossible, because the definition of each ontology model requires profound knowledge in this specific area as well as high maintenance effort. Therefore, a decentralized approach is needed, allowing clients to define ontology models on their own and sharing the reusing semantic knowledge over the service bus. Consequently, a system is required, which overtakes the management of the ontology creation, the update of ontologies and rules and the querying of ontologies.

4.6 Common Information Integration

Service functionality depends on processing data. As already mentioned, service related data has to be stored in the service data layer. Each service has its own specific data, only accessible by the service itself, independently from other services' data. Basically, all information needed by a service can be stored independently and separated from others, but this strict separation has one disadvantage. In an ITSM environment, many services depend on information that is related to the field of ITSM in general and commonly used. Thus, a strict separation of all service data leads to multiple storage of the same information, which is unnecessary. A better approach is to divide service related information and common information, accessible by all services. Besides the prevention of multiple data storage, a centralized common data library provides the possibility of effective maintenance and improvement of commonly used information without changing each service implementation.

4.7 Predictive Analysis Integration

For effective IT Service Management, an architecture that allows flexible collecting and tailoring of information for a specific customer is definitely needed and plays a major role for the successful value creation of a service. Nevertheless, the ability to provide information does not imply that the given information is useful for a specific purpose. It is not the ability of providing information, but the ability of providing knowledge that makes ITSM powerful - knowledge in the sense of unknown and implicit information and its combination and classification based on rules. Furthermore, this kind of knowledge defines a new level of predictiveness by solving complex dependency constructs and revealing behavioral patterns and further provides the base for proactive pattern recognition processes.

This new level of knowledge creation supports decision-making processes based on advanced analyses and the integration in decision support systems. Therefore both, service logic and service presentation need access to computable knowledge they can process, in other words, access to semantic information, which provides predictive knowledge, based on inference and reasoning. By using semantic technologies, the information value provided by services is extended to a maximum. A maintenance worker can definitely perform more efficient, if the given information reveals unknown relations and supports problem solving, not just reactively but also proactively, based on semantically processed analysis, pattern recognition and decision support systems.

Providing predictive knowledge and analyses in form of semantic ontology processing is a key requirement for effective ITSM and has to be permanently available for all services modules and presentations. Thus, a connection to the service bus has to be arranged, which allows all services in the service environment to access semantic information. The semantic ontology is also defined as a service, providing the ability for other services to query knowledge of a specific domain.

4.8 Natural Language Interface

Predictive knowledge is the key for all advanced business and service analyses and consequently for relevant decision making processes in any ITSM domain. Thus, central availability of knowledge was already defined as one of ITSM core characteristics. Nevertheless, providing the formal representation of semantic knowledge is not applicable in a multi domain ITSM environment. Knowledge has to be detached from the technology behind, by providing Controlled Natural Language (CNL) interfaces, allowing non-technical users to retrieve pure knowledge independent from formal language expressions. Predictive knowledge on-demand is the process of transforming natural language query statements of domain specialists into a query language for RDF like the SPARQL Protocol And RDF Query Language (SPARQL), returning knowledge, processible for analyses and decision making processes.

5 CONCLUSIONS

Flexibility is the major goal and complexity the major challenge of IT Service Management to continuously satisfy customers and to gain competitive advantage. ITIL, SOA, CNL and the capability for predictive analyses play a major role for effective ITSM, but have to be applied correctly to disclose their full potential, which is still unhandled sufficiently in the related work. Hence, this paper identifies the key requirements for effective and predictive analysis in ITSM, to increase the level of flexibility and make complexity manageable and knowledge available on-demand. This set of requirements is defined from a technical independent view, as a profound and generally feasible fundament for architectural implementation decisions regarding a holistic and scalable predictive-analytical ITSM approach. The consequent step is the conceptual realization of a sophisticated and detailed architectural design, based on these key requirements, including technical details and the implementation process.

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