Supply Chain Platform as a Service: a Cloud Perspective on Business Collaboration

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Abstract

The integration of Cloud computing and business process shapes modern enterprises significantly. A service-oriented supply chain is promising to promote the creation of value-added services through different levels of service provisioning. However, existing supply chain as a service rigidly provides one solution for different enterprises, inevitably inhibiting the potential of business collaboration to a higher level. This paper proposes a supply chain platform on top of cloud infrastructure, which allows creating, publishing, sharing and maintaining supply chains for various enterprises. This paper identifies the key components of the proposed platform, and current research shows a promising effort towards a full-fledged supply chain platform, which leads to the success of dynamic and automatic business collaborations.

Keyword: platform as a service, supply chain, cloud computing.

I. Introduction

Recent advance in cloud computing [4] is moving the world into the age of service-oriented economy. Hewlett Packard has projected a view of everything-as-a-service [2]. Following this grant vision, sectors such as manufacturing, IT, finance, healthcare and government, have been transforming their modes of operation into a service-oriented architecture. This paper views that a business process includes a set of services, which can be published, shared and orchestrated to form

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a more complex service with added values. A business process is represented by a generic supply chain in this paper. Different from manufacturing supply chain, components or products of a supply chain are not only manufactured articles but also provisioned information.

This paradigm shift brings great challenges to industry and government. Because large amount of information needs to be collected, managed and analyzed, it is difficult for most organizations to success with its own resources. As data scales, companies find that their IT support structure is not agile enough to scale in a cost-effective manner. Cloud computing offers an unparalleled opportunity to those enterprises. Cloud provides the infrastructure that makes it possible to scale services exponentially and flex resources rapidly in response to changing demands. The characteristics of incremental scalability and infrastructure flexibility allow service providers to respond more quickly and efficiently to variable demands. Meanwhile, on-demand and secure resource provisioning capabilities of cloud computing eliminate the cost to procure hardware/software and the cost to manage them. The utility-based economics drive more and more industries and government agencies to adopt cloud-based architectures.

Existing solutions of supply chain management (SCM) such as Salesforce [5] are essentially Software as a Service (SaaS), rigidly attempting to provide one software solution for all enterprises. Although customization is allowed to a limited extend, it is inevitably preventing dynamic business collaboration. This paper proposes a Supply Chain Platform as s Service (SCPaaS) to support the formation of collaborative business processes on-the-fly. It is inherently a Platform as a Service (PaaS), and distinguishes itself in the offer of a common platform for various service providers to create, publish, discover, share and maintain their services. To support business collaboration, SCPaaS comprises key components including supply chain formation and orchestration, dynamic optimization, and automatic execution with notification, monitoring and tracking.

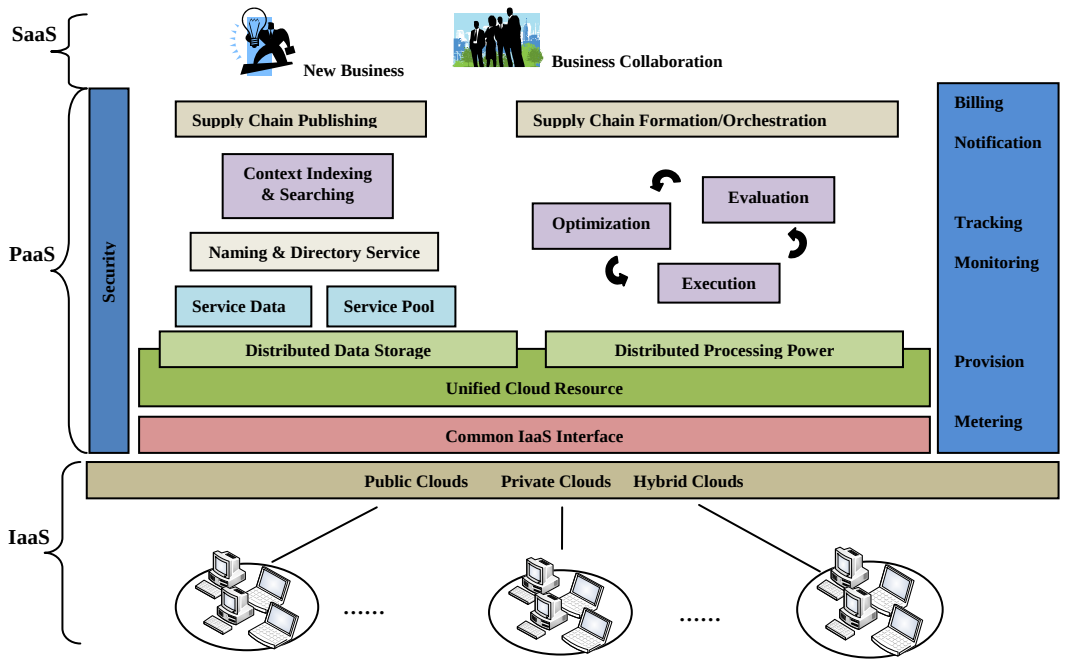

Figure 1. Overview of Supply Chain Platform as a Service

II. Key Components of Supply Chain Platform as a Service

A. *Overview of SCPaaS*

Figure 1 shows the overview of proposed SCPaaS on top of cloud infrastructure (IaaS). This platform is built on the hybrid cloud to utilize heterogeneous resources. A hybrid cloud is a combination of public clouds (e.g. Amazon EC2 [1]) and private clouds (e.g. Eucalyptus and Amazon VPC [1]). SCPaaS provides a unified view over cloud resources, such as processing power, and storage across different IaaS providers. The rational is to make use of a wide range of resources and not to be strictly tied to a particular IaaS provider, in case of IaaS failure. Therefore a common IaaS interface is proposed [8], which translates service implementations to various IaaS providers.

In order to support new level of business collaboration and promote new business idea in the SaaS layer, key components of SCPaaS are built on the unified cloud resources, and leveraging storage and processing power provided by cloud computing. Distributed data storage holds data related to supply chain execution, including business analytical information, service execution history, etc. A pool of service including service implementation and description is also hosting in cloud storage.

Information is indexed and registered with naming and directory services to facilitate searching and enhance context level semantics. In the other hand, distributed processing power provides necessary computational resource for supply chain operations, such as optimization, execution and evaluation. On the top of SCPaaS, supply chain formation and orchestration is supported to define the nature and goals of business collaboration. Meanwhile, the proposed platform permits new services to be published and shared to promote new business opportunities. The details of key components are explained in following sections.

B. *Supply Chain Formation and Orchestration*

A service model is defined to standardize the description of a service. Business process across different sectors is defined by interface, competency and Service Level Agreement (SLA). *Interface* specifies how a service can be invoked, defining necessary preconditions (e.g. inputs or materials); *Competency* specifies the functionality and expected deliverables (e.g. products or information); *SLA* specifies a set of negotiable Quality of Service (QoS) parameters with pricing. The generic service model provides the necessary means for publishing, discovery and sharing, and supply chain composition become possible with a unified view of services.

A supply chain formation is a series of goal-driven activities that defined in high level. Low level details for which provider to choose is left undefined to allow dynamic service selection in real time. Meanwhile, an activity in a supply chain is sufficiently detailed in defining inputs and expected outputs, so that potential providers can be identified and discovered during subsequential supply chain optimization. Elementary services are orchestrated to form a supply chain, and in turn a supply chain is functioning as a service that is a composite of sub-services. The hierarchy of elementary services and supply chains allows added values to be accumulated, and a more beneficial business process can be created. As a result, collaborations between business partners evolve to a higher level. A goal-oriented methodology [6] has been proposed and implemented for modeling a wide range of business processes.

C. *Dynamic Supply Chain Optimization*

SCPaaS holds a pool of services published according to the defined service model. Cloud supports efficient indexing and searching over distributed and scalable data storages. However, service pool is changing dynamically as service is allowed to enter or leave and on or off at any time. In dynamic and uncertain environment, the objective of optimization is to discover suitable service providers to maximize the achievement of a supply chain in terms of QoS. The optimization includes service context filtering, performance prediction and SLA negotiation.

In context filtering, service requirements and service descriptions are compared and matched in the context level. It serves as the first step to discover related services and filter out those unrelated. A common ontology is defined for business collaborations to bridge gaps between human semantics.

In presence of multiple qualified services, it is essential to have an assessment on how a service is going to perform. Within the proposed platform, information regarding the fulfillment of QoS is shared among service providers. The availability of performance data enables a service provider to choose his partner based on historical performance. Simple regression method or complex machine learning approach [7] can be applied to obtain an expected service performance.

Based on estimated performance, supply chain can start negotiation over the SLA content and pricing with candidate providers. Work on automated negotiation algorithms from agent-mediated e-business [3] can be exploited. Negotiation refines a service contract considering trade-offs between QoS specifications and cost. Negotiation offers an effective means to maximize social welfare as well as improve resource utilization in the market.

D. *Automatic Supply Chain Execution and Evaluation*

Execution of individual services is automatically invoked by SCPaaS. Preconditions are checked and inputs are ensured to be received by underlying service provider before execution. Dependency among services is handled, permitting concurrent execution of paralleled services. Service providers take advantage of elastic capability of fast scaling and cost-effective technique by deploying service

implementation on cloud. Exact deployment is automatically controlled by SCPaaS, for which decisions are made in real time on network latency, load balancing, scalability and security. During the supply chain execution, SCPaaS constantly tracks and monitors the process to ensure the consistency and performance requirements to be satisfied under SLA. Execution process is notified in the critical events, such as failures, and delay to facilitate interruption or disaster recovery.

At the end of a service invocation, consumers have the chance to evaluate the service execution, as it is impractical to assume every service can be trusted or is reliable to perform expectedly. To ensure the enacted service process can be executed without disruption, the trustworthiness of a service provider is evaluated [9]. The overall reputation of a service is contingent on the timeliness, accuracy and consistency over the behavior observed by consumers and the contracted behavior promised by providers. Having detected that the supply chain performance needs to be improved, or services may fail, a close-loop reinforcement determines how an improvement can be achieved or the whole supply chain can be revised to maximize the business goal. The feedback control involves determining whether any new service should be considered into the chain, or whether existing service providers should be re-negotiated. If a reconstruction of supply chain is necessary, a new round of supply chain optimization is carried out.

III. Conclusion

The proposed SCPaaS provides a common platform for various enterprises to collaborate with each other and form their own customized supply chains to achieve the business goals. By considering everything as a service, traditional manufacturing and sectors like IT service provision can be unified under service model. Supply chain is abstracted in a high-level formation, and service providers are dynamically selected through optimization process. With automatic execution, consistency and performance of a supply chain are ensured. By publishing and sharing supply chains, complex services can be created with more added values. The success of proposed supply

chain platform helps alleviate barrier for business collaboration, and will promote new services and business opportunities as enterprises work closer to each other.

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