ECOSYSTEM FOR VIRTUAL ENTERPRISE

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B2B collaboration ecosystems existing today are mainly based on standards such as RosettaNet and ebXML. Those ecosystems are not able to accommodate all kinds of enterprise relationship because the boundaries of the enterprises are so strictly imposed that resources participating in collaborative operations are hidden from enterprise partners. Our idea of a virtual enterprise ecosystem encourages enterprises to expose resources that allow virtual enterprises to access, manage and monitor all the resources within the scope of the virtual enterprise. This paper will discuss the virtual enterprise concept, the fundamental differences between B2B collaboration and virtual enterprise, and the critical services the virtual enterprise ecosystem needs to provide.

1. INTRODUCTION

As communication and networking technology advance, the virtual enterprise may no longer be just a theoretical concept. There are some e-business standards such as RosettaNet and ebXML that exist today to enable electronic collaboration among enterprises. However, these ecosystems are designed with the presumption that enterprise is the atomic unit for collaboration. To enable the creation and operation of virtual enterprises, a totally new ecosystem focusing on the virtual enterprise model will be required. This paper will discuss the virtual enterprise concept, the fundamental differences between B2B collaboration and virtual enterprise, and the critical services that are provided by the virtual enterprise ecosystem.

2. VIRTUAL ENTERPRISE

2.1 Definition

Our definition of virtual enterprise is a group of resources bundled together regardless of their physical location in order to achieve mutually agreed business goals in a collaborative fashion. The resources that virtual enterprises use may be owned and managed by different physical enterprises. The idea of the virtual enterprise breaks the boundary of the physical enterprise to enable electronic collaboration by linking together individual resources instead of entire enterprises.

2.2 Drivers for virtual enterprise

Market, technology and organizational changes are driving the evolution of traditional organizations towards virtual enterprises.

First, the evolution toward a serviced business world, where customers' expectations are growing, increases competition among suppliers and drives the margins down, forcing organizations to collaborate with others in order to better serve customers and bring development costs down. In such a context, B2B interactions need to be flexible to respond to changing market needs and be reliable to ensure the quality of service for the end customers.

Second, the rising adoption of web technologies at low bandwidth cost enables "seamless" connectivity between organizations. This makes electronic exchanges more likely to happen.

Third, organizational change within enterprises facilitates the evolution toward virtual business models. Employees are becoming more nomadic. Telework is developing. Enterprises are adopting intranets and bringing their information systems to the web to facilitate these new forms of work organization.

2.3 Virtual Enterprise Model

The major building blocks of the virtual enterprise framework include Resource, Infrastructure and Operation.

Resource

Resources include all the tangible and intangible assets that can be accessed and managed by the virtual enterprise. Resources help virtual enterprises handle individual tasks during operation execution. Virtual enterprises can discover and access the necessary resources without geographical limitation via resource directory. Resource directory allows resource information such as description, binding interface and service capacity to be published and searched. Contracts or agreements can be formed between virtual enterprise and the resources to guide resources' operations to, for example, maintain service level agreement or to limit distribution of sensitive information. Resources can be further classified into Application, Participator and Knowledge.

Applications such as ERP, CRM and SCM fully or partially automate many critical operations of enterprises. These enterprise applications help virtual enterprises to perform operational tasks by executing specific corporate functions

and managing assets such as warehouse and manufacturing line. When application service offering and virtual enterprise request are expressed using proper ontology, the matchmaking can be even more intelligent and instantaneous.

However, not all tasks can be performed automatically by applications. Virtual enterprises also need physical participants to carry out unstructured, open-ended and physical tasks. This participant could include actual human beings or robots. To be eligible as resources for the virtual enterprise, participants will need to have their skill sets, communication interfaces and collaboration preferences clearly defined and published to resource directories.

Knowledge is also an important intangible asset for enterprises. Knowledge of virtual enterprise could be as simple as the archived data from its own operation. Analyzing historical operational information can provide important insight for improvement. Applications and participants can reference the existing virtual enterprise knowledge resource for better decision-making.

Infrastructure

Virtual enterprise infrastructure includes organizational structure, policy, and communication. Organizational structure helps to define the relationship of the various resources belonging to the virtual enterprise. An organizational structure chart can specify not only the authority distribution and reporting mechanism for the different level of participant role in the virtual enterprise, but also the participant's right to access applications and knowledge.

Virtual enterprise policy is used to define business rules regulating the operation of the virtual enterprise. These rules provide guidelines for virtual enterprises to make operational decisions. Based on the defined policies, virtual enterprises can also form interface and service level agreements with resources utilized in operation.

Communication infrastructure supports and manages all communications among resources of the virtual enterprise. For human communication, the communication infrastructure supports interaction among participants through text, audio, and video using various applications such as email, instant messaging, videoconferencing, etc. For system communication, the communication infrastructure provides a virtual messaging platform to connect all the applications belonging to the same virtual enterprise.

Operation

Virtual enterprise operation can either be explicit or implicit. Explicit operations refer to business processes which define clearly the sequential activities to be executed. Implicit operations refer to open-ended projects, where participants achieve their goals through ad-hoc collaboration. Virtual enterprises can design, instantiate, manage and monitor both explicit and implicit operations.

Virtual enterprises need different applications to support both types of operations. Business process management systems using process execution engines will be able to support explicit operations, while team collaboration applications with various tools such as co-drawing, co-browsing will be able to support implicit operations.

3. ECOSYSTEM

3.1 B2B Collaboration

B2B collaboration relies on non-directive and standard interfaces for communication and coordination. Business documents are exchanged freely between individual enterprise partner's public interfaces while private implementations are completely hidden from enterprise partners. There is no single centralized entity coordinating the flow of business documents.

RosettaNet and ebXML are the two most popular B2B collaboration standards available in the market. Both standards specify clearly the interaction interfaces and chronographic exchange of information. Enterprise partners implement their own interfaces to handle the mutually accepted documents received from their partners. Enterprise partners do not know how their partners implement the interfaces and have absolutely no control over partners' implementations. Enterprise partners get only limited signaling information about the exchanging documents based on the process specification.

B2B collaboration could be efficient for situations where there are a large number of business entities participating in a limited number of highly standardized business processes. Trading is one of the most applicable scenarios for B2B collaboration. Since the public interfaces of the B2B collaboration processes are generic and rarely changed, business documents such as purchase orders and shipping notices from different trading partners can be processed at the same process interface. Although chronological order is specified for sending and receiving documents, B2B collaboration does not contain a mechanism to enforce documents to pass from one specific party to another.

B2B collaboration is data-centric because process interfaces are generic and individual transaction-specific information is stored in the exchanging documents. The data-centric approach works well when there are potentially many partners interacting with the same process interface at different times. However, such data-centric B2B collaboration processes won't be streamlined and interactive because the invoking party can only passively participate by sending documents to the receiving party, but it is up to the receiving party to interpret the document and to determine the follow-up actions. Therefore, B2B collaboration is also especially suitable for situations where business partners do not directly depend on or exert control over each other.

However, B2B collaboration will not work effectively in situations where two enterprise partners need to integrate together intimately. For example, when an enterprise acquires another enterprise or outsources some services to external parties, the two partnering enterprises may need to integrate their resources and processes closely in order to achieve new common goals. Although the two partnering enterprises are separate entities, they need to coordinate their efforts in order to maximize the benefit to the whole group. Because B2B collaboration does not cover process integration, it may be challenging to track the overall end-to-end processes running across the partnering enterprises.

3.2 Virtual Enterprise

Virtual enterprise provides an alternative way to integrate processes and to execute collaborative business operations across enterprise boundaries. Being the central unit, virtual enterprise actively drives the execution of business operations and manages its resources. Virtual enterprise ecosystem provides the mechanism to publish and to search resources and process interfaces so that the virtual enterprise not only can flexibly assemble resources regardless of their physical location, but also resolve proprietary process interfaces efficiently to integrate processes. Parent process can continuously be mapped to child sub-process across enterprise boundaries.

Therefore, the virtual enterprise business process and operation can be streamlined so that it supports direct control and real-time monitoring. This process-centric approach is extremely important for real-time enterprises which need to run zero-latency operations across geographical and enterprise boundaries.

The trust relationship among resources becomes very important within the virtual enterprise. Traditional enterprises normally manage their resources closely. However, within the scope of virtual enterprises, information and knowledge will be shared among those resources. The virtual enterprise ecosystem needs to ensure that the information and knowledge sharing is compliant with virtual enterprise's policy.

The execution of virtual enterprise business process is similar to the process execution using BPM (business process management) products, where a process engine invokes resources sequentially based on the specific flow. When BPM executes internal business processes within an enterprise, all the resources invoked belong to the same enterprise. Virtual enterprise process execution allows invocation and management of resources located in different enterprises.

4. VIRTUAL ENTERPRISE ECOSYSTEM SERVICES

The main responsibilities for the virtual enterprise ecosystem are to facilitate the creation of the virtual enterprise and to provide necessary supports for its operation. The ecosystem creates an environment where enterprises within the ecosystem community can make their resources available for composing virtual enterprises, so that partnered enterprises can build new operations together utilizing their existing resources.

Services offered by virtual enterprise ecosystem service providers can be classified into five main categories: matching, modeling, execution, monitoring and managing services.

Figure 1 – Individual resources bundled for virtual enterprise

4.1 Matching Services

The matching services mainly refer to the directory services where resources, business process templates and enterprise partner profiles are being published and searched. Providing the search criteria to the directory services, virtual enterprise designers can locate the elements they need in order to complete the virtual enterprise modeling. A key success factor for the ecosystem at this level is to be able to build trust between partners so that they will be willing to contract in a virtual manner. This could happen by providing partners with rating services that allow for the development of “reputation” within the ecosystem based on previous interactions with partners. The concept of rating could be extended to a “public process” rating where interactions between partners themselves are evaluated according to specific metrics.

Matchmaking services include business agreement facilitation services that should provide a negotiation framework and tooling between partners as well XML-based contract management solutions. Contract management solutions include functionalities such as legal background information, contract preparation tools and decision support tools aimed at managing legal as well as business decisions in the contracting process.

4.2 Modeling Services

The virtual enterprise ecosystem needs to provide tools to allow users to define all the elements for their virtual enterprise model. There are three main services related to modeling:

- Modeling Tool Service
- Process Template Repository Service
- Simulation Service

Modeling Tool Service

The modeling tool service should include a graphical tool where users can model and build virtual enterprise based on the virtual enterprise model. The general requirement for this modeling tool is to allow users to specify all the elements of virtual enterprise, including resources, infrastructure and operations. Additionally, it is important for this to be a web-based tool that works via Internet browsers, as users modeling the virtual enterprise may access this tool from any physical location.

Process Template Repository

The process template repository is a service designed to provide storage, sharing, and re-use of cross-enterprise processes. Its goal is to promote the re-use -- with minimal customization -- of cross-enterprise best-practices process templates. Process templates could be organized either around horizontal processes (inventory, approval, billing...) or around vertical processes (healthcare, manufacturing, insurance, financial services...), related to specific ecosystems.

To collaborate virtually, multiple partner enterprises need a common understanding that entails knowledge about how to link their processes together. Providing templates for collaboration should reduce the learning rope of cross-organizational process modeling. Specifically, this will be made possible by adopting a standard-neutral description of processes, compatible with multiple business process language and protocols such as ebXML, BPEL, and BPML.

The process template repository is interfaced with the modeling tool to allow the import/export of processes and their composition.

Simulation Service

The simulation service should include tools to simulate the interactions between the different partners of a virtual enterprise. Functionalities of these tools are to enable the simulation of the process execution, the use of the resources, the infrastructure transformation as well as the results of the interaction. Simulation service also contribute to setting the trust in the ecosystem

4.3 Execution Services

The execution services of virtual enterprise ecosystem are mainly responsible for maintaining virtual infrastructure and executing operations for virtual enterprise.

Communication Service

One of the most important services supporting the virtual enterprise's virtual infrastructure is the communication service. Virtual infrastructure needs to support various kinds of communication linking the human participants within the virtual enterprise.

Communication can be conducted through text using email and instant messaging, or through multimedia using voice and video conferencing and collaboration features such as co-drawing, co-browsing and co-editing. Using such

unified communication services, users can take advantage of the most effective way of communication in any given situation. The unified communication service should also be aware of the terminals and devices participants are using and optimize the result based on the configuration of the hardware.

Business Process Execution Service

Virtual enterprises can instantiate business processes and invoke the activities in the processes based on the defined sequence.

In addition to the basic process execution, transactional support for process could be very important, as some individual activities may be grouped logically as a single unit, and roll-back may be required when some of the activities in group don't go through. The virtual enterprise ecosystem needs to enable the resources that implement the process activities to provide transactional support for business processes.

A synchronized message storage and forwarding service would be another nice feature to allow nested processes to be executed more efficiently. Nested processes are often used in sub-process situations where process execution is paused and kept active until all the activities (or other sub-processes) within the sub-process are completed. As the availability of all the involved activities may not be known at initial invocation time, there is a strong need to have a storage and forwarding mechanism to queue the invocation message in case certain activities are unavailable momentarily.

Collaborative Project Synchronization Service

Not all processes are well defined with explicit structure. Collaboration projects often involve resources from various enterprises to achieve a common goal collectively. The idea of synchronization services (Perrin *et al*, 2002) is to define some generic communication patterns for the ad-hoc collaboration so that coordination could take place without specifying the chronological flow of information exchange.

4.4 Monitoring Services

Monitoring services are divided into real-time and historical monitoring.

Real-time monitoring service

The virtual enterprise ecosystem needs to enable virtual enterprise resources to expose the monitoring interfaces so that the status of business process instances executed outside the boundaries of the enterprises can be tracked. Although private implementations of the resources are hidden from the managing virtual enterprise, virtual enterprises will also need access to resources' status information such as availability, reliability and performance.

Historical reporting service

Besides real-time monitoring, the virtual enterprise ecosystem should also provide historical data for all the completed processes and projects for virtual enterprises. Those historical data will help virtual enterprise re-engineering their operations.

4.5 Managing Services

Managing services are the necessary services enabling the other services provided to enterprises in the ecosystem.

Identity Management

The main purpose of the identity management service is to facilitate communication among resources linked by virtual enterprise's virtual infrastructure. Virtual enterprise ecosystem needs to instantiate and maintain lots of virtual enterprises at the same time. However, practically, each virtual enterprise should be a separate entity, which has its own security requirement. Identity management service keeps track of the virtual identity of the resources and the virtual enterprise, so that virtual enterprises can allow "single sign-on" among their resources, and virtual enterprise ecosystem can represent multiple virtual enterprises and provides non-repudiation support for the operations of those virtual enterprises.

Resource deployment services

Virtual enterprises need to be able to control their resources. Some of the generic functions to control resources include invocation, suspension, resume and stop. Virtual enterprise ecosystem needs to provide some support for enterprises to expose their resources in order to ensure that those resources are compatible with the ecosystem. Therefore, when virtual enterprise operations are executed, the ecosystem can use those functions to manage the virtual enterprise operations.

Quality of Service

Quality of Service (Qos) mainly covers guaranteed delivery and enforcement of service level agreements for the ecosystem services.

The Qos service will persist with any message exchange before it reaches a target resource. In case of resource failure, Qos guarantee service will send the request in a later time when the target resource is up.

Service-level agreements (SLAs) are contracts between service providers and consumers that define the services provided, the metrics associated with these services, acceptable and unacceptable service levels, liabilities on the part of the service provider and the customer, and actions to be taken in specific circumstances. The Qos guarantee service can monitor the SLAs and prioritize requests according to SLAs.

4.6 Conclusion

The virtual enterprise framework will be the key for enterprises to become more real-time and flexible to react to changes in the market environment. Given the current market trends of globalization, mergers & acquisitions, and out-sourcing, it will be of great benefit for enterprises to migrate their IT infrastructure to support virtual enterprise framework so that they can take advantage of the virtual enterprise ecosystem. Virtual enterprise structure allows enterprises to remain flexible to work with any local and international partners and integrate their operations with partners cost effectively.

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