Implementing Next Generation e-Business Platforms for Heterogeneous SME Environments

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Abstract

Ever since the adoption of Internet and the relevant Internet-Based technologies by enterprises into their everyday business practise the vision of totally automated electronic transactions has been the Holy Grail of their efforts. In spite of competitive advantages, such as reduced transactional cost, seamless information flow, and better communication, the creation of a system clearly oriented towards promoting interoperability of existing systems and facilitating electronic transactions between partners of diverse nature still remains elusive for the majority of enterprises, especially for small and medium ones. Drawbacks, such as the high technical complexity of the existing solutions, the need for intervention of third-party systems in the transactions, the mandatory adoption of proprietary standards and practises have characterised this first generation of platforms for electronic transactions. Such problems can largely be attributed to the adopted architectures – primarily peer to peer and server based – that impose specific preconditions in the design and implementation of the systems. The present work is an attempt to define and justify a novel platform that shares common elements with peer to peer and server based approaches and relies on emerging technologies and standards in order to achieve application to application interconnection and seamless information flow directly among heterogeneous systems.

Keywords. e-Business, e-Government, electronic transactions, architectures, cross-organizational interoperability

1. Introduction

From small and medium sized enterprises (SMEs) to Forbes Global 2000 companies and from local and regional administrations to national and federal governments, the number of adopters of electronic transaction (e-transaction) infrastructures is constantly growing. However, the willingness of enterprises and governments to proceed to automated transactional and interconnected systems that would allow them

to interact with a number of heterogeneous partners is very often tackled by several restrictions that are imposed upon them by the specific technical characteristics of the implemented solutions. They range from the adoption of specific standards for the cross-organizational description of processes and the exchanged data to the expensive and complex customization of legacy applications for interconnecting them with partner systems. From a technical perspective, most of the existing restrictions and constraints are explicitly or implicitly imposed by the architectures of the implemented systems – namely peer to peer (P2P) and server based. As a consequence, current approaches do not unleash the full potential of e-transactions and other internet based solutions. Their adoption instead leads to significant organisational changes due to an inadequate integration into the operational philosophy of enterprises and governmental institutions. Therefore, in modern economy, the silver bullet decision does not lie in the dilemma whether to deploy e-transaction and other internet based solutions or not – since this is already considered a necessity – but how to deploy it technologically in order to achieve the biggest possible benefits [Porter (2001)].

An approach to overcome the mentioned drawbacks and limitations of current e-transaction solutions is the architecture presented in this work. The architecture is devoted to facilitating the conduction of e-transactions among heterogeneous partners - i.e. from SMEs to governments. Characteristic of the approach is the hybrid architecture that incorporates the advantages of both P2P and server based paradigms. The architecture enables its users to exchange business documents at runtime in a P2P manner supported by a centralized server that provides all the necessary preconditions for interconnecting their enterprise software applications.

The remainder of the paper is structured as follows. In chapter 2 we present a brief review of the state of the art in terms of enabling technologies in the field and relevant research projects. In chapter 3 we describe the approach of our hybrid architecture which is based on an evaluation of the two architecture styles P2P and server based in their “pure form”. In chapter 4 we present the evolutionary implementation plan to realize the e-transactions platform and the GENESIS project as a real life test-bed for the proposed architecture. Finally, in chapter 5 we summarize and give directions for future work.

2. Related Work

2.1 e-Business Enabling Technologies

The following section is devoted to providing a brief overview of contemporary e-Business frameworks and architectures. We focus on introducing technologies and major examples for both conventional centralized (server based) e-Business

architectures and novel approaches of fully decentralized, P2P-like systems. These frameworks sometimes overlap or even compete with each other [Bussler (2001)].

The BizTalk approach [BizTalk (2003)] for enabling B2B interactions is based on leveraging several standards and technologies including the Simple Object Access Protocol (SOAP), XML, and Multipurpose Internet Mail Extensions (MIME). It relies on a centralized schema repository and layered logical architecture. The schema repository provides means to publish and validate XML-based schemas and manage their evolution and relationships. The centralized architecture consists of three layers: application, BizTalk Framework Compliant (BFC) server, and transport. Applications communicate with each other by sending business documents through BFC servers (one per end).

ebXML (Electronic Business XML) aims at defining a set of specifications for enabling B2B interactions among collaborating enterprises [Kotok and Webber (2002)]. The basic part of the ebXML infrastructure is the repository, where all important information about businesses along with the products and services are stored. At the communication layer, messages are exchanged through the messaging service, which does not require on a specific transport protocol but of any common protocol such as SMTP, HTTP, or FTP.

The Business Process Modelling Notation (BPMN) specification provides a graphical notation for expressing business processes in a Business Process Diagram (BPD). It also provides a binding between the notation's graphical elements and the constructs of block-structured process execution languages, so that it can offer a direct mapping to the Business Process Execution Language (BPEL) [White (2005), Ouyang et. Al. (2006)]. BPEL is an orchestration language which defines a notation for specifying business process behavior based on Web Services and is used to model the behavior of both executable and abstract processes.

2.2 Relevant Research Projects

As described in [Androutsellis-Theotokis et. Al. (2004)], e-Business platforms and solutions have so far mostly been realized on the basis of centralized or client-server models: a central instance mediates between one or several users, provides functionality for seeking, negotiating and binding between trading partners and finally is devoted to orchestrating the collaboration processes. These traditional systems span from point-to-point EDI models, where business relationships are statically defined between two business partners to “many-to-many” net market models, which allow huge numbers of users to connect to a central hub and choose services such as basic directory indexing of products or even complex transaction logic and workflow processing.

Recent projects such as PRAXIS [Charalabidis et. Al. (2004)] and LAURA [LAURA (2006)] aim at defining architectures for a more distributed execution of e-Business. In LAURA, a fully distributed e-Business system especially suitable for SMEs has been set up. The envisioned architecture builds upon an Open Source based e-Business framework as the functional foundation and the ebXML specification is chosen as a basis for controlling cross-organizational collaboration. Adhering to the principles of a Service Oriented Architecture, the resulting system provides a modular set of services that together form the LAURA Business Collaboration Service. Techniques that have proven to be scalable and efficient in diverse P2P applications are leveraged to realize trading partner and product search procedures.

3. Towards a Hybrid Architecture for Next Generation e-Business Platforms

3.1 Pure P2P vs. Pure Server Based Architectures

e-Business infrastructures with a client-server interaction paradigm have been the natural consequence of the emergence of 2-tier IT infrastructures. Different flavours of client-server constellations exist, ranging from centralized hub-and-spoke systems to point-to-point links between two trading partners [Svirskas et. Al. (2004)]. In all case, a central instance is responsible for mediating between clients – i.e. ensures their authenticity, controls message exchange and also offers functionality for seeking and binding potential trading partners. Especially when it comes to emerging e-Business applications such as the interconnection of enterprise services across the boundaries of firms, merely central systems are not an ideal solution to cope with the network load originating from the business transactions performed between trading partners. Opposed to this centralized architectural style are P2P infrastructures. P2P networks typically do not have the notion of clients or servers, but only equal peer nodes that concurrently work as both clients and servers to the other nodes that are part of the network. Instead of a central instance being responsible for the setup and control of business relationships, P2P e-Business systems enable users to dynamically and autonomously negotiate and establish an agreement on the automatic execution of business processes.

A P2P-based e-Business framework clearly provides paramount advantages in many respects. From an economic point of view, the absence of cost and risk of ownership and maintenance of a central server and the corresponding infrastructure can be avoided. In [Androutsellis-Theotokis et. Al. (2004)], the improved scalability and ability to deal with transient populations of users is stated as a further important argument for deploying distributed e-Business systems. Two trading partners do not have to exchange documents via a server that may be overloaded with traffic from

other participants but benefit from direct, unmediated and potentially synchronous P2P transactions. In [Kunzmann et. Al. (2006)] a number of methods to ensure security, failure recovery and high overall system reliability of P2P network architectures are proposed. Apart from that, the negotiation and establishment of collaboration protocol agreements (CPAs) is more complex than in the case of central systems: there is no central instance available that could provide standardized guidelines. Next, the progress and state of cross-organizational collaborations must be maintained ("mirrored") by all peers, since the orchestration of services is performed in a decentralized way as well. Additionally, further challenges such as the introduction of methods for non-repudiation, logging, time-stamping and maintaining of all transaction information need also to be investigated on. Table 1 provides the results of the comparison of the two approaches:

Table 1. *Pure P2P vs. Pure Server Based Architectures*

	Advantages	**Drawbacks**
Server Based	- Central authentication and identification management - Central set-up and control of business relationships - Easy maintenance of one single catalogue indexing all concurrent users - Maturity of the approach	- Communication between the users is only possible via the server - Possible high workload and limited scalability - Single point of failure
P2P	- Autonomously negotiation/ establishment of business relations - Democratic user participation, censorship resistance - Synchronous msg. exchange	- Sophisticated assurance of user authentication and access control - quickly changing network topologies require sophisticated and reliable mechanisms for partner retrieval - Immaturity of the approach

3.2 The Hybrid Architecture for e-Transactions

Major qualities any platform for e-transactions must comprise: First, the necessary functionality in order to enable the typical enterprise (usually SME) to conduct its business transactions over Internet by interconnecting its main transactional software applications and systems with those of collaborating enterprises, banking/social insurance institutions and governmental bodies. Second, in order to be applicable by SMEs, it must incorporate a high level of flexibility so as to facilitate the necessary enterprise application integration without requiring an extensive customisation of already existing systems or mandating fundamental changes in established business practises. The proposed hybrid architecture incorporates the two aforementioned qualities and also the advantages of both P2P and centralized server based

approaches. The architecture facilitates the direct exchange of business documents and relevant information between the partners through the provision of customized workflows, rules and data schemas by the server. The architecture comprises three main components which implement the following specific functionalities.

The *Repository* for generic business processes, documents and rules constitutes a vital subsystem for providing many of the capabilities of the proposed e-transaction framework. The Repository is highly dynamic and extensible and features efficient methods for quickly identifying artefacts that match the respective requirements in the users' contexts. The artefacts stored in the Repository include: XML representations of generic business process models, generic Core Components for representing the business data, and XML based descriptions of business and legal rules. The information is further enriched with context information (e.g. Classification Code Lists), and client specific information such as Collaboration Protocol Profiles (CPPs) and Collaboration Protocol Agreements (CPAs).

The second main component is the *Server*. While in pure server based approaches the Server constitutes the cornerstone layer which literally assumes the burden of trafficking the entire transactional load (partner negotiation, application interconnection, business document transformation and exchange) in this approach it is a component that provides a series of supportive services that eventually enable business partners to engage in electronic transactions. Specifically it comprises mechanisms for: registering and customizing business profiles for the users, seeking and identifying/matching business partners, and defining restrictions upon a specific transaction between partners in terms of process flows, document content and business rules. Also handled by the server are the generation of executable workflow code (e.g. BPEL) for a specific transaction between partners based upon existing process models in the repository, the restrictions on the process flow defined by the partners and business rules that shape the partners' transactions.

Third and last major component of the hybrid architecture is the *Adapter*. The Adapter is located at client/partner side of the proposed architecture and enables the integration of business functionality of existing enterprise software infrastructures following the service-oriented paradigm. To connect existing IT systems of the users to the server, a set of interfaces (in WSDL format) and message definitions is needed by the server according to the negotiation agreement between the clients. The implementation of the required business and technical functionality which is defined by the GENESIS service interfaces has to be implemented by the vendors of the specific ERP systems. To face the challenges of varying data mappings that may occur as a result of the diversity among the partners of the platform, the Adapter must also support an efficient data transformation layer to reduce the manual implementation efforts.

4. Implementation Plan for the Proposed Architecture

4.1 An Evolutionary Implementation Roadmap

The application of the proposed architecture in a real life platform for e-transactions is a fastidious task. In order to provide the aforementioned functionalities that the architecture demands a number of components (repository – server – adapters) need to be in constant interoperation. Hitherto, such components have certainly existed in numerous P2P and server based systems and have been technologically justified under several conditions. The proposed architecture though introduces a number of novel and largely unproven (in an enterprise context) technologies with an ultimate goal to alter the operational philosophy of these components as we know it in order to facilitate the provision of hybrid features. An example is the server who provides the fundamentals to setup e-transactions instead of handling the document exchange between the partners. In this way the actual message exchange occurs directly between the partners and adapters which instead of applying hard coded business logic draw their logic from the server according to the circumstances of each transaction. Therefore it would be prudent that the implementation of a corresponding platform should pass from a series of evolutionary stages regarding the dynamic behaviour and hybrid characteristics of the system in order to ensure the robustness and reliability that needs to be inherent in any transactional system. To this end, three distinct implementation stages are recommended for the proposed architecture (see Figure 1):

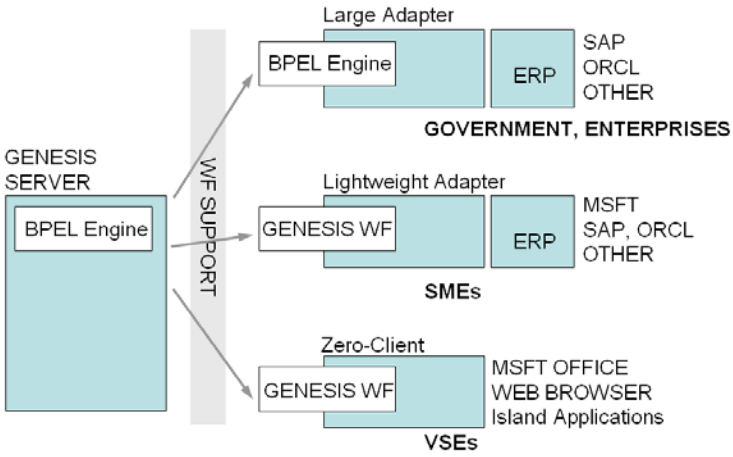

Figure 1. *Evolutionary Implementation Phases*

In the *Zero Client Implementation Stage* the Server, apart from the rudimentary functions of registering and maintaining user profiles and assisting in partner matching, provides web-based interfaces for registration, trading partner search, negotiation and process execution. At this point, the Server provides means to enable the central choreography coordination of business processes and requires no Web-Services. The Servers is in fact equated with the Repository where process and document templates are stored. To allow the asynchronous execution of business processes, the server consists of a message in- and outbox system for each of the participants. In the Zero Client case, no installation of an Adapter is required since the access to the platform is fully web-based which makes this stage attractive especially for very small enterprises (VSE). The web interface makes use of a transformation engine for the visualization of the business documents that are being exchanged.

In the *Lightweight Adapter Stage* a physical adapter will be provided by ERP vendors to the users of the platform. The adapter ensures the encapsulation of the existing enterprise application functionality via Web-Services. The binding to the legacy applications includes the transformation of the XML based business documents to the internal systems' specific data formats. The business process choreography among the partners is coordinated by the server. The adapter also provides a Graphical User Interface (GUI) for partner retrieval, negotiation and process monitoring purposes. This implementation stage supports environments of SME since this adapter can be preconfigured by the system vendors and easily used by the SMEs.

In the *Large Adapter ("P2P-setup") Stage* the both Server and the Adapters implement full dynamic behaviour. The Server, along with the XML schemas for the document mapping, utilises the process and rules models in the Repository in order to provide business partner with customized BPEL code that fits their particular needs. The coordination of the business process is now carried out in a decentralized manner. The now active and P2P-like acting Adapters implement and execute the business choreography which is represented by BPEL process descriptions. The BPEL code is delivered from the Server according to the adapters' mutual agreement (CPA). Due to the higher complexity of this approach the Large Adapter variant is most feasible for experienced SMEs and larger enterprises wwho have a complex IT landscape in place.

4.2 The GENESIS Project Test-Bed

Part of the work presented in this paper stems from GENESIS [GENESIS (2006)], a co-funded European research project of the interoperability cluster whose main objective is the research, development and pilot application of the needed methodologies, infrastructures and software components that will allow the typical European enterprise to conduct its business transactions over Internet. At the current point the modelling phases of the project regarding processes, data/documents and

rules are completed and the proposed architecture has been adopted as the architecture of the entire GENESIS platform. The Zero Client Implementation stage has been selected as the initial – entry point – stage for the implementation of the GENESIS platform due to the fact that there is already a considerable amount of input from the modelling phases to support the dynamic behaviour of this level. The information that has been gathered up to now and is implemented into the GENESIS repository comprises models of: private processes that are followed internally by business partners, collaborative process between two engaged parties that illustrate all the occurring interactions, and generic business information entities from which specific business documents are composed. These models are enriched with business and legal rules that define practises and policies.

Currently the support of the Zero Client and Lightweight Adapter stage capabilities of the system are under development with an objective that upon their completion the GENESIS Server will be able to analyze the document models in the Repository and create the necessary mapping schemas among the specific business documents that partners exchange.

5. Conclusion

In the present paper we have presented a brief state of the art in the area of electronic transactions and its including scientific fields in terms of relevant projects and enabling technologies. Additionally, we have provided an evaluation of the features of P2P architectures that promote the direct communication among peers as opposed to server based approaches that rely on a central instance as mediator between one or many clients. Following, we have defined a hybrid architecture that incorporates features both from the P2P and server based approaches in an effort to create a system with the ability to promote P2P electronic transactions between business partners through a centralized-sever based support. The architecture incorporates the necessary levels of functionality and flexibility so as to effectively support electronic transactions and at the same time to be easily implemented by SMEs without extensive customisation of their existing enterprise software applications. Furthermore, we have given an implementation roadmap for the proposed architecture through a series of evolutionary stages where the dynamic features of the architecture are gradually deployed in order to ensure the robustness and reliability of the overall platform.

Next steps in our work comprise the completion of a prototype platform based on the proposed architecture in the Zero Client and Lightweight Adapter stage and a further development of this prototype platform to the final Large Adapter stage where full

scale electronic transactions among peers will be possible through the provision of all the necessary transformation and business logic by the server.

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