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Oliver Christ
SAP Research

Christoph Schroth
SAP Research

Till Janner
University of St. Gallen

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A HYBRID FRAMEWORK FOR AUTOMATED AND ADAPTIVE E-BUSINESS PLATFORMS

Oliver Christ, SAP Research CEC, St. Gallen, Switzerland

Christoph Schroth, University of St. Gallen, Institute for Media and Communications
Management and SAP Research CEC, St. Gallen, Switzerland

Till Janner, University of St. Gallen, Institute for Media and Communications Management
and SAP Research CEC, St. Gallen, Switzerland

Abstract

The automation of business transactions between corporations has been dominated by proprietary and inflexible EDI solutions for a long time. During the last years, novel XML-based standards emerged which have a wider scope than EDI but strongly differ with regard to granularity and industry-focus. Due to the abundance of many complex standards with limited diffusion among users and industries, especially small-and medium-sized enterprises (SMEs) have not yet managed to automate the execution of business transactions and to seamlessly interconnect their respective IT applications. In this work, we propose a novel approach which builds on a composite of existing standards and combines them towards a hybrid architecture facilitating electronic business transactions. The Web Service stack represents the technical foundation of this approach, while parts of the ebXML standard are leveraged to ensure a common understanding of business information and processes between trading partners. A central server acts as repository of formal agreements, common data and process modeling artifacts and allows for intermittent connectivity of the users. Decentral adapter components enable connecting heterogeneous legacy applications of the users to the central server. The resulting approach can thus be considered as hybrid regarding the degree of centralism involved and with respect to the combination of the Web services stack and the ebXML standard as an infrastructural foundation.

Keywords: e-Business Platforms, Enterprise Application Interoperability, Semantic Interoperability, Seamless Cross-Organizational Interoperability, UN/CEFACT, e-Business, Core Component Technical Specification, CCTS, ebXML, Web Services, Service-Oriented Architecture, SOA

INTRODUCTION

The emergence of novel high performance communication and information technologies has inspired enterprises to automate their cross-organizational business relationships. Companies that adopt e-Business solutions may capitalize from reduced operating costs and improved gains, increased customer satisfaction and retention, faster and more efficient internal processes, improved supply chain integration, and technological advancements (Hoyer et. al. 2006). Especially SMEs, however, still have not yet widely adopted such solutions due to a variety of reasons: The lack of significant financial and human resources for implementation, but also the failure to recognize the immense benefits of engaging in e-Business are often mentioned as main hurdles in literature (Levenburg and Magal 2005).

In this paper, we present a novel e-Business architecture that combines parts of existing major standards and specifically aims at fulfilling the requirements of SMEs. The Web Services stack builds the technical foundation for the actual execution of transactions on the basis of loosely coupled services, while parts of the UN/CEFACT e-Business stack (Janner et al. 2006) and the ebXML framework (Hofreiter et al. 2002, Eisenberg and Nickull 2001) are leveraged for the initiation of business relations, the collaboratively defined orchestration of services and also for establishing a common understanding of business processes, message structure and semantics. Active, Web Services-based adapters at the client side shield technical peculiarities of local IT installations and ensure seamless collaboration of the diverse stakeholders, while a central server enables users to register themselves, to model supported processes and data and to publish them as trading preferences as well as to negotiate the exact conditions of an electronic business relationship. Finally, we propose an automated, collaborative and context-sensitive business process and data negotiation methodology. The resulting architecture can be considered as hybrid regarding the degree of centralism involved and with respect to the combination of the Web services stack and the ebXML standard as infrastructural foundations.

The remainder of the paper is organized as follows: In Chapter one, we briefly elaborate on the specific characteristics of SMEs, motivate the need for a way out of the business standards dilemma and also present an overview of existing e-Business platforms. Chapter two proposes the Web Service stack and the ebXML standard as technical foundations of the envisioned architecture which is finally introduced in Chapter three. Chapter four closes this work with a short summary and an outlook on future developments in the field of e-Business.

1 RESEARCH FRAMEWORK

This chapter is devoted to providing the research framework for the proposed e-Business architecture. After elaborating on the specific characteristics of SMEs which are in the focus of our research, we motivate the need for a way out of the business standards dilemma. Finally, we present a brief overview of existing e-Business platforms.

1.1 Characteristics of Small- and Medium-Sized Companies

This section provides a brief overview of the analysis performed to get insights into the characteristics of SMEs which represent the target group of our envisioned e-Business architecture. In the European Union, SMEs are the predominant form of enterprises. Defined as companies that employ fewer than 250 persons and have an annual turnover not exceeding 50 million Euro and/ or an annual balance sheet total not exceeding 43 million Euro (European Commission 2003), SMEs are not necessarily miniature versions of larger enterprises (Chen et. al. 1998). Related to their environment, structure,

strategy and decision process as well as the psycho-sociological context such as the dominant role of owner-manager, the following characteristics distinguish SMEs from large enterprises:

- **Specialization and Individuality.** First of all, SMEs mostly act on business markets that are not covered by large enterprises. Characterized by a high specialization and individuality, many SMEs pursue a segmentation or niche strategy that leads to a certain strength in competition (Porter 1980).
- **Proximity to markets and customer focus.** Compared with large enterprises, SMEs are strongly focused on end-users and their individual needs.
- **Flexibility.** SMEs expose more dynamic structures than large enterprises and are thus capable to react agilely to changing market demands.
- **Limited resources.** SMEs are constrained by tight resources, in particular with regard to building IT applications on their own. Most SMEs prefer to use over-the-counter software rather than developing and maintaining their own IT solutions.
- **Technical heterogeneity.** Smaller firms often lack a coherent Information and Communication Technology (ICT) strategy. For instance, IT landscapes consist of heterogeneous systems, reaching from Enterprise Resource Planning Systems (ERP) to spreadsheet-based island applications for conducting their every-day business transaction (European Commission 2005).

The framework for e-Business platforms which we envision takes into account these characteristics to ensure its adequacy for the target user groups.

1.2 The Business Standards Dilemma

As argued in (Malone 2001, Porter 2001), the emergence of novel information and communications technologies has created new opportunities for automating cross-organizational business processes. However, for efficient setup and operation of e-Business solutions, interoperability of information systems and, therefore, standardization of information sharing is essential. Numerous e-business frameworks have been developed during the last years which mostly build on the XML (Extensible Markup Language) standard for representing the information to be exchanged between companies. As a consequence, businesses have a wide variety of different and partly vertically oriented frameworks available. CIDX (Chemical Industry Data Exchange), cXML (Commerce XML), ebXML (Electronic Business XML), OAGIS (Open Applications Group Integration Specification), papiNet, PIDX (Petroleum Industry Data Exchange), RosettaNet, UBL (Universal Business Language) and xCBL (XML Common Business Library) represent only a small selection of some of the existing e-Business frameworks.

Nurmilaakso et al. (Nurmilaakso et. al. 2006) have published an analytical framework to analyze and compare these frameworks with regard to granularity and adaptability of process and data standardization, industry-focus and drivers of the framework as well as characteristics such as formality and openness of the related standardization organization. According to this analysis, most frameworks still focus on standardizing business documents, whereas a common understanding of inter-organizational processes is still evolving. Many frameworks can also be partly considered substitutes to others but have a different scope or industry-focus.

The large number of overlapping and conflicting vertical industry standards with different scope and granularity represents a major obstacle to enterprise application interoperability especially for SMEs. The marketplace is looking for a single standard or platform that allows for automating business transaction in an efficient fashion. This work is devoted to presenting a Web Services-based approach which shields adopters from complexity and allows for seamless operations on the basis of collaboratively designed processes and business messages.

1.3 E-Business Platforms

After elaborating on the diverse existing standards for formally describing business processes and messages, this section provides an overview of existing platforms which implement some of the above presented standards and represent technical solutions for facilitating and automating cross-organizational business relationships.

From encapsulated marketplaces...

... to enterprise application interoperability

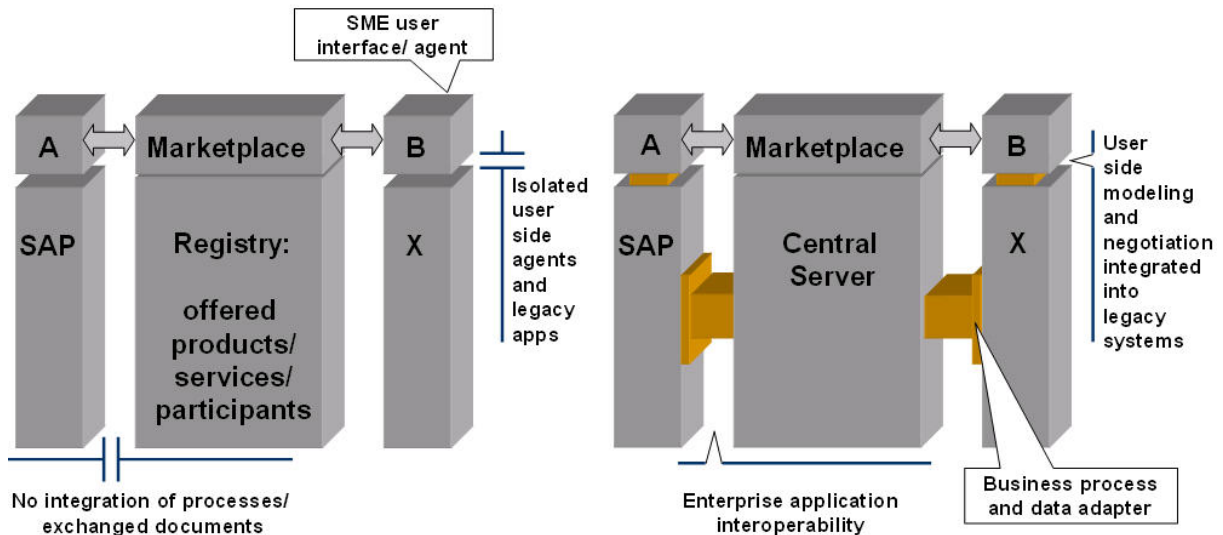


Figure 1-1: From encapsulated marketplaces to enterprise application interoperability

E-Business platforms and solutions have so far mostly been realized on the basis of centralized models (Androutsellis-Theotokis et. al. 2004). Frequently, a central instance mediates between at least two users, provides functionality for searching, negotiating and binding between trading partners. In (Androutsellis-Theotokis et. al. 2004), **eBay** and **Yahoo** are cited as typical examples for such conventional e-Business platforms that focus on private users. **Alibaba**¹ extends their scope towards a B2B platform, where vendors and buyers can seek and negotiate with each other on the basis of a comprehensive directory. The platform does not allow for connecting enterprise applications but rather offers a portal which is limited to a presentation-layer marketplace without application functionality. Buyers and sellers are enabled to directly interact via the Alibaba platform and agree upon a business relationship, but are not supported with respect to the automation of the resulting processes. **SupplyOn**² represents a further example of an e-Business platform as it offers access to collaboration folders, a business directory for seeking adequate trading partner, sourcing and document management as well as support for the setup of cross-organizational business processes on the basis of EDIFACT-messages. Last, **Covisint**³ offers its users a central messaging hub that combines secure transport and transformation between numerous different messaging formats, protocols and system interfaces. Both EDI and XML-based technologies can be used to connect different local IT systems via interfaces to the Covisint messaging hub in order to automate the seamless collaboration of enterprise systems across company boundaries. Due to the scalability problem and also the risk inherent to a single point

¹ <http://www.alibaba.com/>

² <http://www.supplyon.com/>

³ <http://www.covisint.com/>

of failure, current research focuses on the creation of e-Business solutions that are based on a P2P infrastructure rather than a central entity as in the examples presented above (Svirskas et. al. 2004).

The analysis of existing e-Business platforms shows that many currently existing e-Business platforms act as fully encapsulated, central marketplaces which reside on the presentation layer as depicted on the left side of Figure 1-1. Users are enabled to access directories to find and negotiate with potential trading partners. However, their respective local applications cannot be interconnected via those platforms to allow for seamless cross-organizational business process execution. Apart from that, user interfaces (mostly Web browser-based interfaces) are not connected to local IT installations as well, leading to yet another media brake when performing business transactions electronically. The right side of Figure 1-1 shows the vision of an integrated and efficient solution that takes into account the specific needs of SMEs: A server allows for connecting local systems via business process and data adapters, while user interfaces (which may be used for retrieving and negotiating with partners as well as executing and monitoring the actual process) are also directly interlinked with the users' local IT installations. As described above, the Covisint platform takes a first step in the direction of such an integrated solution but still involves significant manual effort which is not acceptable for SMEs as users of an e-Business platform.

2 ARCHITECTURAL BUILDING BLOCKS FOR THE INTEGRATED E-BUSINESS FRAMEWORK

This chapter is devoted to explaining the major composites of our envisioned integrating e-Business architecture framework. We thereby pursue a hybrid approach that builds on parts of the ebXML (Hofreiter et. al. 2002) standard and the Web Services stack (Alonso 2004). The comparative analysis provided in (Yan et. al. 2006) serves as a foundation of the following sections.

2.1 Web Services

Web Services (Alonso 2004) enable the setup of Service-Oriented Architectures (SOAs) which foresee the existence of three major roles: A service provider publishes his service interface via a service registry where a service requester can find it and subsequently may bind to the service provider. The Web Service Description Language (WSDL) thereby defines a uniform XML format for service interface descriptions and ensures that complexity inherent to applications is properly encapsulated and thus hidden from users. The Universal Description, Discovery, and Integration (UDDI) standard is leveraged to define publicly available service registries that are needed for service search, identification and invocation. The Simple Object Access Protocol (SOAP) specifies the data format and an exchange protocol for the messages to be sent between service providers and requesters. The Business Process Execution Language (BPEL) is an XML-based representation of the behavior of Web Services in a business process interaction. It describes the control logic required to orchestrate and coordinate Web Services participating in a process flow in an executable fashion. This stack of standards allows for the loose coupling of services (thereby minimizing mutual dependencies) and complies with some of the probably most-known principles in software-engineering, information-hiding and modularization. For our e-Business architecture framework, we envision to leverage the WSDL, the SOAP and the BPEL standards, but leave out the UDDI specification as we use parts of the ebXML standard as a foundation for a services registry.

2.2 ebXML

The ebXML standard (Hofreiter et. al. 2002) can be considered a composite of different specifications which together aim at providing a comprehensive technological foundation for realizing cross-organizational business processes. This composite differs from the above presented Web Services stack in particular with respect to message transport, security, service discovery mechanisms,

semantics, business process modeling and execution as well as the establishment of trading partner agreements. First of all, ebXML relies on the existence of a central registry that provides users with information about the business preferences of potential trading partners. Users are supposed to specify their technically supported processes in the form of a Collaboration Protocol Profile (CPP) and publish them via an ebXML-registry. Other users may then retrieve these CPPs, compare the contained information with their own preferences and may then decide to initiate a business relationship. The exact conditions of this agreement are codified in a Collaboration Protocol Agreement (CPA) which is stored in the registry as well. The Web Services stack, in contrast, relies on the rather simple UDDI standard as basis for service discovery and does not suggest any mechanisms for collaboratively establishing trading partner agreements. Besides this procedure for facilitating business relationships, ebXML also specifies an extension of the Web Service-based SOAP protocol which uses multipart MIME Attachments for message payload. As opposed to the Web Services stack, it also defines security-related algorithms. In the ebXML context, the overall choreography of a process to be executed between two or more trading partners and also the involved messages can be represented on the basis of the Business Process Specification Schema (BPSS) which provides semantics and structure of business messages, their content, sequence and timing. As opposed to BPEL, BPSS is not directly executable and also describes collaborations from a neutral perspective. BPEL describes collaborations from the point of view of the involved partners rather than providing a collaboration model from a bird's eye view. In contrast to mere Web Services, ebXML comprises the definition of standards for the semantically unambiguous definition of business information (CCTS) and processes (UMM). The next sections will thoroughly on these standards which are relevant for our architectural framework.

Core Component Technical Specification. The CCTS (UN/CEFACT 2003) defines the flexible assembly of business documents out of Core Components, the business data building blocks, which are stored and managed in a central Core Component Library (CCL) (UN/CEFACT 2006). Users may access this CCL and compose their business documents according to their individual requirements. This approach of assembling business documents on the basis of a common component repository is advantageous compared to other standards such as RosettaNet or EDIFACT which provide vertically oriented, proprietary and pre-determined business message definitions. The CCTS considers Core Components "blueprint" elements that can be restricted and contextualized by applying certain context information (Schroth et. al. 2007). In this way, context-neutral Core Components are transformed into user-specific business information entities (BIEs), but are still comprehensible to every other user.

UN/CEFACT Modeling Methodology (UMM). A syntax-neutral and technology-agnostic method for modeling business processes, UMM allows for capturing business logic. It is based on UML and encompasses a set of pre-defined patterns, process stereotypes and so-called tagged values and thus fosters reuse of already existing process components. On the basis of these stereotypes, whole business processes can be assembled that comply with the standard, thereby ensuring interoperability between different users (Hofreiter et. al. 2006a) UMM (UN/CEFACT 2005) features four views for modeling business processes of which each provides users with a different level of detail. The most detailed view (Business Transaction View, BTV) can be modeled with the help of UML-based activity graphs representing Business Transactions (BTs) and Business Collaboration Protocols (BCPs). Our envisioned architecture also considers BTs and BCPs as the major composites of the client-side business modeling environment. The BTs can be considered atomic process units and can be selected out of six basic patterns: information distribution, notification, query/response, request/confirm, request/response and commercial transaction. BTs comprise single activities, associated tagged values and determine the sequence flow between the different activities of the requesting and the reacting roles. Apart from that, they integrate message envelopes which can be described according to the CCTS rules. In (Hofreiter et. al. 2004), a methodology for the automatic mapping of BTs and BCPs into executable process descriptions (BPEL) is presented. Our e-Business framework utilizes this mapping and leverages the XML Metadata Interchange (XMI) standard to capture the graphical, user-side process and data models in a machine-readable format. We extend the UMM concept by introducing the differentiation between generic and specific business processes. This approach is

aligned with the above mentioned CCTS specification, which promotes the separation of generally applicable data Core Components and their restricted, context-specific versions (BIEs). Specific process models take into account the context-dependent user requirements and are in most cases only adequate for a limited number of users. We consider these specific models to be restricted subsets of the generic reference process templates that comprise all thinkable process steps which may be required for any of the different participating users. Type of business transaction, tagged values of business activities and tagged values for information envelopes (part of BTs) as well as tagged values, pre-and post-conditions of activities and transitions (part of BCPs) are used for customization and restriction purposes in our framework. With the help of the modeling environment that we present in the next sections, generic processes as well as generic Core Components can be restricted and further customized in an intuitive, graphically supported fashion.

3 A COLLABORATIVE AND HIGHLY ADAPTIVE E-BUSINESS FRAMEWORK

3.1 General Architecture

The overall architecture of our e-Business architecture comprises a server and user infrastructure, which will be explained in the following two sections. As mentioned above, it can be considered as hybrid regarding two separate dimensions: First, both a central server and decentral, active adapters on the client side exist. Apart from that, we build our approach on both the ebXML standard (for business relationships initiation and the assurance of semantic interoperability) and on Web Services as technical foundation for executing processes in a loosely coupled fashion.

3.2 Server Infrastructure

The server acts as a platform that enables its users to seek business partners, to negotiate the exact conditions of an electronic business relationship and to conduct collaborative business transactions. It comprises the following modules to facilitate the setup and execution of cross-organizational business processes:

Registry and Repository for Generic Business Processes and Messages. The Registry/Repository part of our e-Business framework is highly dynamic and features efficient methods for quickly identifying CCTS and UMM-compliant modeling artifacts that match the respective requirements in the users' contexts. The repository first of all features a Business Document Library that consists of the CCTS-compliant UBL Common Library as well as the UBL Business Document Library. On the basis of these data modeling artifacts, whole business documents can be assembled in an interoperable manner. Second, generic UMM-conform business process models (Hofreiter et. al. 2006b) are stored as well. Both the data models and the process representations are stored in the form of XMI-based files and are also assigned context information to allow for applying context-specific restrictions on the generic templates as will be shown in the following paragraph. Last, the repository is also used to store the CPPs which reflect the respective users' supported processes as well as the CPAs that represent the agreements made in the course of negotiation processes.

Context-Specific Customization of Processes and Data. As described in Chapter three, the CCTS standard defines context as a means for qualifying and restricting Core Components according to their use in a specific business environment. We adhere to the context driver methodology as defined in the CCTS and also integrate the concepts presented in (Schroth et. al. 2007) for the application of context-based restrictions on process artifacts. In this way, the server is enabled to provide users with the process and data subsets that are adequate in their respective individual contexts. As will be shown below, our e-Business platform enables users to semi-automatically negotiate specific business processes and data based on the generic models stored in the server. Upon mutual agreement, the

specific business and data models (in XMI format) are transferred from the Client Interfaces to the server, which automatically generates executable BPEL code and XML schema files for the use in the adapters' BPEL engines or the server's Zero Client workflow engine. In our framework, we utilize the methodology presented in (Hofreiter et. al. 2004) for automated generation of BPEL code on the basis of UMM business process models. Regarding XML schema we refer to the Naming and Design Rules (NDR) issued by the UN/CEFACT which defines guidelines on how to express the UN/CEFACT Core Components in a uniform manner in XML syntax.

Message Database and Data Store-and-Forward Mechanism. In combination with the data store-and-forward mechanism, this database caches business messages which cannot directly be delivered from one trading partner to another. Especially SMEs are not continuously connected to the Internet and thus require an intermediary which allows for asynchronous and reliable message transmission.

User Negotiation Support. The server allows users to negotiate the details of the cross-organizational processes and messages that are exchanged in the course of these processes on the basis of the above mentioned modeling templates. The server thereby acts as an intermediary that relays offers back and forth between two partners until a consensus is reached or one of the partners quits the negotiation procedure. Upon an agreement, the server creates a CPA referencing the final business processes and data in an XMI-format, generates executable BPEL files as well as XML schema and stores the CPA for future change requests. The way the user is connected to the envisioned architecture determines which of the parameters of the process and data templates can be subject to bilateral negotiation: In case Zero Clients are used (which will be presented in the below) all elements of the templates can be modified individually during the negotiation procedure. If proprietary IT is connected to the systems via adapters, cross-organizational process and data descriptions can only be modeled within a range prescribed by the adapter (which will be elaborated on in the paragraphs below).

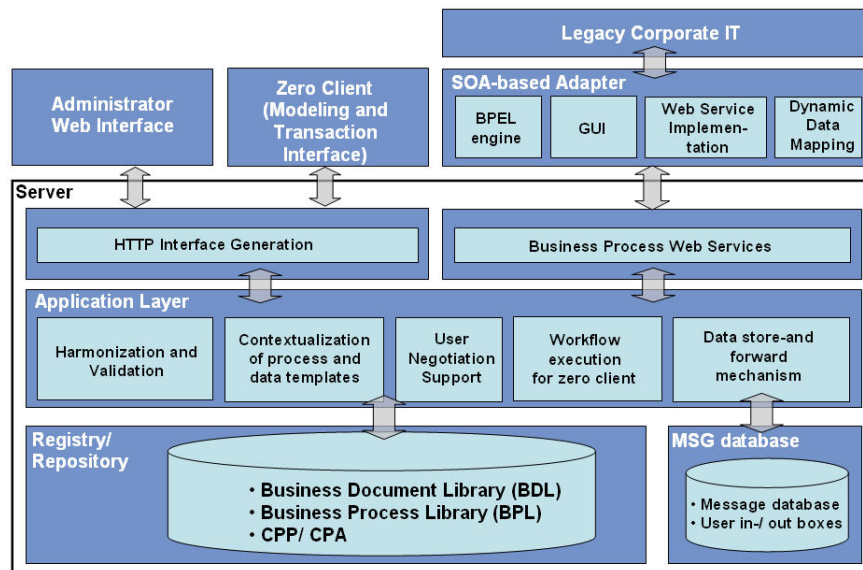


Figure 3-1: Overall Architecture

Harmonization and Validation. One important characteristic of our e-Business architecture is its extensibility: If existing process and data artifacts do not suffice to reflect the requirements of certain users, new ones may be designed and published in the central repository. To avoid an unrestricted publishing of newly assembled artifacts which might be redundant, we leverage the harmonization concept published in (Bedini et. al. 2006) to ensure data and process modeling artifact consistency.

Workflow Execution for Zero Client. In case users are connected to the system via Zero Client interfaces which will be presented in the following section, Web Services are not required. Instead, the processes trading partners have agreed upon are performed and centrally controlled by the server.

3.3 User Infrastructure

After presenting the major composites of the server infrastructure, we now elaborate on the two basic options for user integration. As SMEs with minor IT literacy and budget represent the target group of our envisioned e-Business platform, the provision of an interface that works independent from local IT systems is mission-critical. This interface which we refer to as Zero Client offers full functionality via a conventional Web browser, is controlled by the central server and accounts for the need of many users to automate transactions without having to spend any money for setting up or maintaining local enterprise application functionality. Web Services-based, active adapters are supposed to be used as an alternative in case the trading partners' local systems shall be seamlessly connected via the central server. The two optional approaches to integrating users into the e-Business platform are depicted in Figure 3-2.

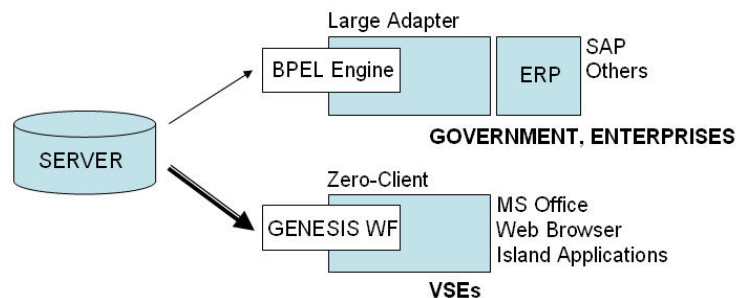


Figure 3-2: Large Adapter and Zero-Client as options for user integration

3.3.1 Zero Client

The Zero Client is used in case no legacy IT systems are to be connected to the system. It encompasses basically two components, the Modeling Interface and the Business Transaction Interface.

Modeling Interface. The Modeling Environment represents a human-machine interface and provides intuitive and graphically supported handling of process and data models on the basis of the building blocks stored in the server: Users are enabled to download generic template descriptions of business processes and data as well as to customize these according to their actual business requirements. As presented above, business process templates comply with the UMM standard, while data templates adhere to the CCTS-based UBL standard. The process model elements that can be modified are part of the BTs and BCPs as shown in Chapter three.

The modeling environment supports three core user activities: First, the registration of new users to the platform is facilitated by a guided workflow. Users can, in a simple drag-and-drop fashion, customize the generic processes provided by the central repository and thus define the exact business process they are willing and able to support. The resulting graphical model comprising the user-specific business processes and messages are stored as XMI-based files and together with an appropriate CPP (complying with the original ebXML specification) sent to the server. The server publishes the CPP and thus makes it available to all other users.

Second, the Client Interface supports users with searching for appropriate trading partners and the subsequent business agreement negotiation: A registered user may select one or several business processes from a given list (that reflects all processes published on the central registry) and view a list of potential business partners. For each of the possible trading partners, the searching user may download the CPP (which contains a link to the partner-specific business process and data description in an XMI format) and compare it with the transactions supported by himself. The respective process and data models are graphically superimposed to make potential differences visible and negotiable.

Controlled by the server, the users may then send specific process and data propositions to their partner, accept or deny changes and finally decide whether to initiate a business relationship or not. Due to the common data and process artifact repository provided by the server partners have a common understanding and interoperability issues are avoided. The semi-automatic negotiation procedure as proposed in this work is different from existing approaches (Rinderle et. al. 2005) as it is extremely flexible and allows for collaboratively defining the way (with regard to both processes and business data) trading partners interact.

The third category of activities enabled by our Client Interface covers change requests regarding CPPs and CPAs. Users may update their profiles which are stored and published in the server or re-negotiate existing business transaction agreements. Due to space constraints, the exact protocols for these activities will be presented in future publications.

Business Transaction Interface. The Business Transaction Interface is devoted to providing the human-machine interface during business process execution. It features in- and outboxes for business documents and workflows that guide users through the previously determined business transactions. Incoming XML-based messages are transformed into human-readable formats by an XSLT-based transformation script. Future publications will present in-depth descriptions of this interface's first prototype as developed in the context of the GENESIS⁴ project.

3.3.2 Adapter for Incorporating Legacy IT Systems

To interconnect local legacy applications to our e-Business architecture, Web Service-based adapters encapsulate their proprietary business functionality as services with uniform interfaces (WSDL-based) that comply with the architecture's standards for capturing semantics of both processes (UMM) and data (UBL).

Located on client side, their main components are, besides the Service Interfaces, a BPEL engine for the execution of cross-organizational business choreographies, a GUI that allows users to conduct control activities as well as a mechanism for dynamic data mapping. In the course of the GENESIS project, such adapters are being built for local ERP systems provided by SAP and the Greek vendor SingularLogic. It is important to mention that the service descriptions exposed toward the e-Business platform must reflect the respective underlying systems' capabilities correctly. Message descriptions (in UBL format) are required to contain those data fields that can be processed by the encapsulated legacy system, while exposed services must exactly map functions supported by the underlying application. Negotiations with potential trading partners are limited to the actual choreography of different services and to details of exchanged messages as will be shown in the following paragraphs. However, in case one partner has a certain service not available, it can not be included into the common business process choreography.

BPEL engine. Each of the adapters features a BPEL runtime environment that is capable of executing the process code provided by the server upon mutual agreement of the trading partners. Messages that comply with the UBL standard are exchanged according to the choreography that is stored in the form of a CPA within the server's registry.

Dynamic Data Mapping. The key task of the data mapping mechanism implemented into each adapter is to transform CCTS-based, UBL compliant messages into the underlying system's format. Besides this, it is capable of dynamically taking into account specific requirements that may result from negotiation procedures. The following case shows an exemplary scenario for this mechanism to become a vital prerequisite for cross-organizational interoperability. During the negotiation phase, two business partners A and B may recognize that the invoice document processed by A's ERP system features certain data fields that are unknown for B's ERP (e.g., due to different practices in the

⁴ <http://www.genesis-ist.eu>

respective countries). Despite of the different message formats, the partners may still agree to initiate the business relationship: B modifies the data mapping of its adapter in a way that it transmits messages to B which contain dummy entries to meet the formal constraints of A's ERP system. However, in case B's legacy system does not only require some data, but also correct entries (e.g., due to legal constraints), the business relationship cannot be initiated.

GUI. Every adapter comprises a graphical user interface (GUI) that provides users the same functionality as the Zero Client. Trading partner search, negotiation of inter-organizational processes and messages as well as transaction monitoring are realized by the adapter and visualized via its GUI. The limitation of modeling activities according to the capabilities of the respective encapsulated system as outlined above is the only major difference to the Zero Client.

4 CONCLUSION

The advent of high performance information and communication technologies has enabled enterprises to automate cross-organizational business transactions (Malone 2001). Benefits of performing transactions electronically include extending market reach, saving time, cutting costs and responding to customer queries more agilely. However, as argued above, significant hurdles must be taken to successfully deploy and operate e-Business solutions: Substantially different standards prevent from a common understanding of both business processes and exchanged data, while high cost and complexity of existing solutions impede fast adoption by potential users. Readily available platforms exist that facilitate the retrieval, negotiation and finally the establishment of electronic business relationships. However, in most cases, they solely reside on the presentation layer and do not allow for automating the actual execution of business processes in an intuitive and efficient fashion. These fully encapsulated, central marketplaces also lack any means for enabling the integration and interconnection of legacy enterprise applications.

In this work, we propose a novel e-Business architecture that aims at fulfilling the specific needs of SMEs with regard to the automation of business relationships. It offers an intuitive and graphically supported way to model and register user-specific business processes and messages, to search potential business partners, to semi-automatically negotiate business conditions and to conduct business transactions via a central server. Users are allowed to connect to the system via a Web browser-based Zero Client or to integrate their existing local IT applications via Web Services- based adapters.

The architecture can be considered hybrid with respect to the degree of centrality and the combination of Web Services and the ebXML specification as underlying infrastructure. The central server thereby takes over a mediating role and provides a common semantic basis that facilitates interoperability of both process and data models. It also simplifies the system's adoption by SMEs who frequently do not have any local IT installations in place. Via simple Web browser- based interfaces (Zero Clients), all functionality of the e-Business platform is available, irrespective of the business partner's IT equipment. The above presented adapters, on the other hand, encapsulate proprietary local application functionality as Web Services and represent the major decentral component of our architecture.

Significant parts of the above presented architecture are currently being prototyped in the course of the EU-funded GENESIS project. Future work will focus on publishing comprehensive use-case descriptions as well as the results of interoperability testing with existing corporate IT systems.

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