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Abstract

The transition to electronic business has brought many changes in the business process. First steps in making business on the web have been web services, however the requirements for realization of multiple collaborations and automations are no longer satisfied simply by web services. New, more complex technologies for describing business processes are needed. In this paper we will compare the six most important ones: XLANG, WSFL (Web Service Flow Language), BPEL4WS (Business Process Execution Language for Web Services), WSCI (Web Service Choreography Interface), ebXML BPSS (Business Process Specification Schema) and BPML (Business Process Management Language). Based on the features they offer, we will compare them in a decision model and evaluate them with help of a utility function.

1.   Introduction

The way of doing business has changed and companies must follow the progress. The main stress is on automation of business processes including routine operations, conditionally defined processes and automatic handling of foreseen mistakes or known failures. Companies must adapt and follow the changes the economy dictates, where fast, safe and simple communication is of main importance and ensures new clients, new businesses and relationships marked with quality. Adapting business processes means defining them in one of electronic languages, for what we obviously need suitable technologies. Some of them will be described in this paper.

We will review and compare the most important technologies for electronic business orchestration: XLANG [1], WSFL [2], BPEL4WS [3], WSCI [4], ebXML BPSS [5] and BPML [6]. Development of technologies, described in this paper, began after 1996. All of the mentioned technologies are based on XML (Extensible Markup Language) and are built on the functionality of web services, where they reuse existing web service technologies, such as SOAP (Simple Object Access Protocol), UDDI (Universal Description, Discovery and Integration) and WSDL (Web Service Description

Language). We will see that they differ in some features while in others they are complementary. To evaluate them, we will define criteria and build a decision model.

The review of related research has shown that there are not many papers comparing those technologies. Other analyses on similar technologies for business process description have been made in [7], where the authors compare ebXML (electronic business XML) and RosettaNet, however without a decision model. The author in [8] compares B2B (business to business) standards, including RosettaNet, ebXML, OAGIS (Open Applications Group Integration Specification) and Simple Web Services. The same author explains how RosettaNet, ebXML, OAGIS and EDI (Electronic Data Interchange) fit together in paper [9]. Again there is no formal definition of a decision model. In [10] the author compares RosettaNet, ebXML, OAGIS, Web Services, xCBL (UBL) – XML Common Business Library (Universal Business Language) and cXML (commerce XML). There is a recently published paper by Dutch and Australian scientists in [11], which has similar contents and compares technologies like BPEL4WS, XLANG, WSFL, XPDL (XML Processing Description Language), Staffware, MQ Series Workflow, Panagon eProcess and FLOWer. Our paper however describes specifically the technologies based on XML language and web services in a more formal way, introducing a decision model, based on our previous publications, where we compared ebXML, XLANG and RosettaNet in [12] and [13] and evaluated them in a decision model, specified for small and medium sized companies. The contribution of this paper is a general overview and a formal comparison of technologies based on workflow patterns, suggested in [14].

Our paper is organized in the following order: to introduce the background of the problem, we will explain the evolution of electronic business technologies in the second section. We will also present web services as the foundation of the technologies for business process orchestration, which will be described in more detail in the third section. In the fourth section, we will define a multi-criteria decision model based on patterns, used in business process workflow description, and evaluate them. In the last, fifth section, we will give a summary of the results.

2.   eBusiness Technologies

The most important existing solution for electronic business is the UN/EDIFACT standard (United Nations/Electronic Data Interchange For Administration, Commerce and Transport), which beginnings go to early sixties. In 1968 the transport industry, which had most of its problems with large amounts of paper documentation, organized a committee, called the TDCC (Transport Data Coordinating Committee) for development of a standard business information interchange format. The committee defined data standards, message formats, and standard codes, communication protocols and other details, supporting the new concept of electronic data interchange among computers. In 1975 the TDCC released the first documentation for railway transport industry application and soon the interest spread to other industries [15]. Within years new diversities of the standard developed and it has been adapted to specific needs and requirements of other industries [5].

The UN/EDIFACT standard is coherent with technologies and demands of that era, when the priorities differed from the ones today. The experience has shown, that it has received recognition mostly in larger companies, while smaller and middle companies lack the resources [15].

However, the problem of most companies, larger and smaller, is still the communication with other companies. To patch this Achilles hill, we need suitable technologies for

describing business processes in a consistent and safe way. The W3C (World Wide Web Consortium) defined and introduced XML 1.0 in February 1998 and gained support by a large part of the industry [16]. XML language is a simplification of SGML (Standard Generalized Markup Language) and it is a universal language for document description [5]. The XML language enables the interchanging and interpreting of the documents without the human intervention in remote systems.

XML document is an ordinary text file with markups [3]. The combination of structure, flexibility and verification makes XML useful for electronic exchange of business messages between enterprises. While building larger processes, all business partners must agree upon the vocabulary, interfaces and the method invocation type, before they send individual messages. XML vocabularies can define all kinds of business documents or even whole frameworks, which provide interoperability and functionality [19].

After the Internet and XML language possibilities have been presented, the business world changed and the new age electronic business arrived. Electronic business has become reachable to all companies with cheap, fast and simple communication. The key technologies for communication among company's information systems are web services, however they do not fulfill all the needs. The main tendency of electronic business is a safe and flexible automation of business processes, wherever and whenever possible. In order to achieve this goal, new technologies for describing business processes have been designed [17], all based on web services.

The development of XML has expanded in two directions. The first important direction is the definition of standard dictionaries for defining document structure, shared and sent by enterprises. There are many organizations active on this field: OASIS (Organization for the Advancement of Structured Information Standards) [18], XML.ORG [19], UN/CEFACT [20] and so on. In Slovenia the GZS (Gospodarska Zbornica Slovenije - Chamber of Commerce and Industry of Slovenia) [21] also deals with similar activities. The second direction is the development of technologies, which enable interchange of XML documents through the web. The technological foundation for document interchanges is presented by web services.

Web services are components that communicate with SOAP protocol [22]. SOAP uses XML and formats the messages in a textual way. The interfaces, designed by web services, base on message interchange [16]. The most important part of web service development is the definition what kind of messages the web service will receive and what kind of messages will it shape in answer [22]. Web services are described with WSDL.

The WSDL is a language for describing web services and expressing their characteristics. It describes the basic format of web services, demanded across different protocols. It describes them from a technical perspective, however it contains only little about its context and even less about its potential collaborations of more web services with each other. The key success of e-business however lies in collaboration of more than one web services [23].

3.   Orchestration of Private and Public Processes

WSDL and web services do not fully support demands of electronic businesses like long-term interactions and records of complex states [11]. We need technologies for describing the flow, execution and orchestration of web services. Many of such technologies have been created in the past and they are meant for business processes description and

collaboration [12]. Most of them are supported by giants like Microsoft, IBM, Sun, BEA, SAP, Intalio or collaborated companies [17].

In this section we will focus on orchestration of public and private processes and compare the technologies XLANG, WSFL, BPEL4WS, WSCI, ebXML BPSS and BPML. Public processes include every type of action executed between organizations and are accessible to partner organizations. Private processes include only actions inside an organization and are hidden from outsiders.

The mentioned technologies offer similar features and address analogous views. In the following chapter we will give a short description and comparison of mentioned technologies. Relations between them are shown in Figure 1.
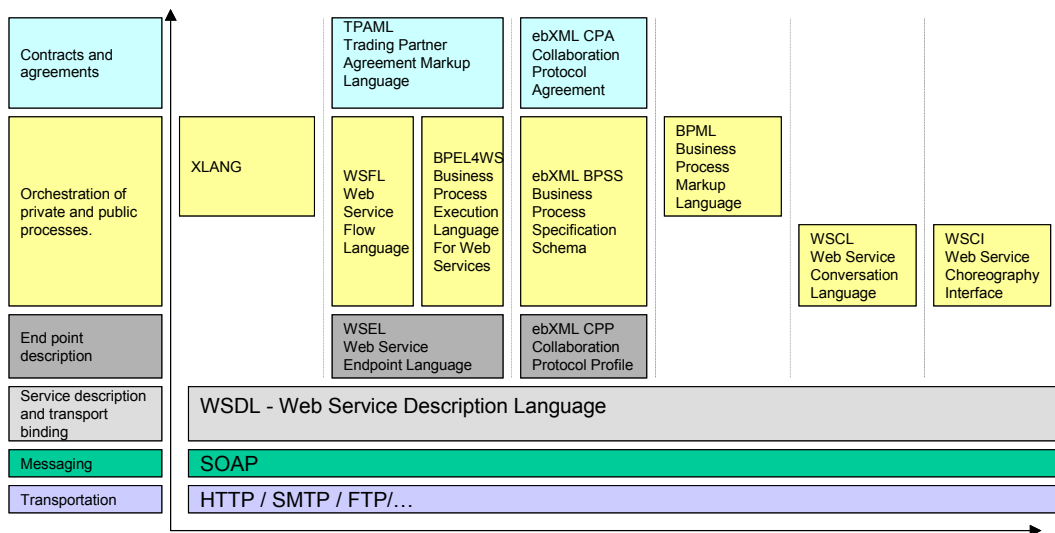

Figure 1: *Framework of Technologies for Describing Business Processes*

Table 1 shows when the technologies became publicly available respectively the publishing time of their first specifications. In the third column are given main initiators of each technology.

They all have many things in common; they all base on WSDL and web services and their mutual goal is coordination and automation of electronic business. Obviously they all try not to reprise the mistakes of EDI, which has been inflexible and inaccessible to smaller enterprises, since it required a large initial investment and expensive support. They also all use the XML language as the basic language for document interchange. Their design priorities and fields of concentration however differ [12].

Table 1: *About Technologies*

Technology	Starting year	Initiator
XLANG	2001	Microsoft Corporation
TPA	January 1999	IBM
WSDL	September 2000	Microsoft, IBM, W3C
ebXML CPA	February 2001	OASIS, UN/CEFACT
ebXML CPP	February 2001	OASIS, UN/CEFACT
WSFL	May 2001	IBM Software Group
ebXML BPSS	October 2001	OASIS, UN/CEFACT,
WSEL	December 2001	IBM
WSCL	March 2002	Hewlett-Packard Company
BPML	June 2002	BPMI.org, Intalio, SAP, Sun, Versata, CSC, SeeBeyond
BPEL4WS	July 2002	IBM, BEA Systems, Microsoft,
WSCI	August 2002	BEA Systems, Intalio, SAP AG, Sun Microsystems

XLANG

XLANG technology is used as the main technology for describing business processes inside the BizTalk initiative. The technology is focused on private processes and supports long-term operations and nesting. It is based on block structures with basic control flow, for example sequence, switch, looping [1] etc. XLANG is a notation for the specification of message exchange behavior among participating web services, supporting especially the automation of business processes [13]. It is expected to serve as the basis for automated protocol engines that can track the state of process instances and help to enforce protocol correctness in message flows.

XLANG offers a model for orchestration of services and contract collaboration between partners. It enables [12]:

- exception handling,

- restoring operations,

- behavior (container for the description of the service's behavioral aspects),

- actions (atoms of behavior, referencing WSDL operations on available ports; request/response, solicit response, one-way notification, timeouts and exceptions),

- control flow (sequence in which the service performs actions, providing support for looping, besides the regular elements),

- correlations (structure, the service uses to route messages to correct workflow instances),

- contents of transaction (context for long-running transactions),

- service management (features of service instance management),

- port mapping (method for plugging in the service user and the service provider),

- time-outs,

- custom correlation of messages,

- modular behavior description and

- contracts with multiple roles.

However, it does not define authentication or the quality of service nor the non-repudiation. The goal of XLANG is to make a formal specification of business processes as state-full long-running interactions [13]. XLANG is an extension of WSDL and dynamics in processes are supported with different flows; message flow, data flow and control flow. XLANG does support business process contracts, however they are merely mappings between two port types, which interact together, so we do not classify it on the level of contracts and agreements.

WSFL

WSFL (Web Service Flow Language), which main initiator is IBM, is meant for describing public and private processes. It allows business process description or interaction patterns, which base on web service operations. It manages two composition types of web services [24]:

- flow model with specification for execution of business processes,

- global model with specification for business collaboration.

The technology is not limited with a structure of blocks and is based on notation of directed acyclic graphs, which can also be nested. The interaction is supported with external conditions; activities and sub-processes can be interacted only while outgoing conditions are satisfied [2]. Part of the WSFL control flow is almost identical to the workflow of the language, used in IBM MQ Series [11].

BPEL4WS

The BPEL4WS technology (Business Process Execution Language for Web Services) has been created by IBM, Microsoft and BEA and integrates the features of XLANG and WSFL and supports the block-structured language with basic control flow language such as [11]:

- sequence,

- switch (for conditional routing),

- while (for looping),

- all (for parallel routing) and

- pick (for race conditions based on timing or external triggers).

It also supports graph notation, which ensures a large expressing power, but also a great deal of complexity. The executing business processes models real behavior of participants in a business interaction. Business protocols on the other hand are used for describing mutual processes of message interchange, without the exposure of inside behavior. Those descriptions for business protocols are abstract processes. The BPEL4WS technology is used for modeling the behavior of both execution and abstract processes [11].

WSCI

Sun, BEA, SAP and Intalio presented a technology for describing web services, WSCI (Web Service Choreography Interface), which describes the dynamic interface of web service participation in interchange of messages regarding on the results of operations, defined in a static interface. This is then expressed in a temporary and logical dependency between interchanged messages, together with sequenced rules, correlations, exception handling and transactions [4].

The WSCI technology describes the message interchange between web services, and offers a global, message-oriented view on interactions. It does not address the definition or the implementation of intern processes, which actually manage message interchange. The goal of WSCI technology is the description of public behavior of web services with an interface, oriented on the needs of the message flow, which would offer a global overview on the dynamics of message interchange [4]. It works in connection with WSDL or some other languages with similar characteristics.

ebXML BPSS

The initiative of OASIS and UN/CEFACT has created the ebXML BPSS (Business Process Specification Schema). It serves for describing collaboration, transactions and choreography of business processes. It is one of the ebXML technologies:

- Messaging,
- Registry,
- Core Components,
- CPP (Collaboration Protocol Profile) and
- CPA (Collaboration Protocol Agreement).

Using this technology, an actual flow of business process is specified [5]. The technology due to its favorable characteristics made an important role in electronic business. The main characteristics are:

- the ability to collaborate,
- workflow,
- transactions,
- exceptions,
- interfaces for services,
- security,
- dependability,
- agreements of business protocols and
- contracts.

The BPSS choreography includes transfers and business states, which include business activities, beginning, full state, split, merge and similar. If we research its place among ebXML technologies, BPSS is an upgrade of business process and information model,

and a foundation for the ebXML CPP/CPA. ebXML BPSS is complementary with BPML [25].

BPML

On the initiative of organization for managing business processes Intalio, the BPMI.org (Business Process Management Initiative) created the BPML (Business Process Markup Language), which is a meta language for modeling business processes and offers an abstract execution model for describing collaborations and transactions.

BPML defines a formal model for expressing abstract and execution processes and addresses all the views of business processes of companies. It supports:

- data management,
- conformity,
- exception handling and
- operation semantics.

It offers grammar in form of XML schemes, which enables definition interchange among heterogeneous systems and modeling tools. The BPML technology can describe a process in a specific language, defined on top of the extensible BPML scheme. We present business processes as a group of flows (control flow, data flow and event flow). We can also add format features for business and security rules and transactional context. The BPML offers support for synchronous and asynchronous distributed transactions and can therefore be used as process component for existing applications [6].

4. Comparison

Patterns

We have compared the described technologies based on patterns, objective measurements for comparing composition languages of web services [14]. We have chosen ten basic patterns like sequence, parallel split, synchronization, exclusive choice, simple merge, multi choice, multi merge, milestone, deferred choice and synchronizing merge and used them as criteria. They are used for describing the workflow in business processes [14]:

Sequence is used to create a dependency between two or more tasks. Its main mission is to prevent one task from starting before another one ends.

Parallel split is used when two or more activities need to be executed in the same time, simultaneously or in an optional order.

Synchronization is used if an activity cannot be started before the previous parallel threads are completed.

Exclusive choice is used when, based on the workflow control data, one of several branches is chosen.

Simple merge is used when two or more alternative execution paths are merged into one alternative without synchronization.

Multi choice is used when one or more of the alternatives can be selected and executed based on a decision or workflow control data.

Multi merge is used when more than one incoming transition of a merge is being activated and two or more branches reconvert without synchronization. If more than one branch gets activated, the activity following the merge starts once for every incoming branch that gets activated.

Milestone is used as a pattern that allows testing whether a workflow process has reached a certain phase. Upon reaching some border we would like to disable the activities that were previously enabled. An activity is enabled only if a certain, still valid milestone has been reached.

Deferred choice is used when one of more branches is chosen. The choice is not made explicitly and there are several alternatives offered to the environment. Only one of the alternatives is executed.

Synchronizing merge is used when multiple paths converge into one single thread. If there are more paths taken, synchronization of the active threads needs to take place.

Based on the presented patterns we have evaluated the technologies, whether they offer direct support for them or not. To evaluate the support for each pattern we have chosen an ordinal measurement scale where 3 stands for full support, 2 for partial support and 1 for no support. The results of evaluation are presented in Table 2.

Utility Function

We have defined a utility function, which organizes the results on scale between 0 and 1. The final results were calculated with help of two equations:

$$u_j = \sum_{i=1}^{10} \left(\frac{c_i(A_j)}{\sum_{i=1}^{10} \max(c_i(A_j))} \right)$$

Figure 2: *Utility Function*

$$U = \max_{j=1}^{N}(u_j)$$

Figure 3: *Maximum Utility*

Symbols in utility function are:

U – maximum utility,

u_j – utility of alternative j,

c_i – criterion i,

A_j –alternative j (XLANG, WSCI, WSFL, BPML, BPEL4WS, ebXML BPSS),

N – total number of alternatives.

The equation presented in figure 2 shows the utility function and the equation presented in figure 3 shows the maximum utility.

Table 2: *Comparison of Support for the Most Important Patterns for Workflow Description*

Pattern name	BPEL4WS	XLANG	WSFL	BPML	BPSS	WSCI
1.Sequence	3	3	3	3	3	3
2.Parallel split	3	3	3	3	3	3
3.Synchronization	3	3	3	3	3	3
4.Exclusive choice	3	3	3	3	3	3
5.Simple merge	3	3	3	3	3	3
6.Multi choice	3	1	3	1	1	1
7.Multi merge	1	1	1	2	2	2
8. Milestone	1	1	1	1	1	1
9.Deffered choice	3	3	1	3	3	3
10.Synchronizing merge	3	1	3	1	1	1
	0,87	0,73	0,80	0,77	0,77	0,77

For the purposes of evaluation of described technologies in this paper, none of the patterns have been preferred from the others, therefore no weights have been assigned and all criteria is considered as equal.

Results

The results are presented in table 2, which is divided in 7 columns. The first column presents patterns used as criteria and the rest of the columns show the evaluation of each technology. In the last row we show the results calculated by using the utility function. As seen in table 2, the technology BPEL4WS has a slight advantage over WSFL technology, followed by BPML, ebXML BPSS and WSCI, which have reached equal results, while XLANG has the least capabilities on given criteria.

In the decision model we see, that the basic features like sequence, parallel split, synchronization, exclusive choice and simple merge are covered by all of the technologies. They differ in more complex patterns like multi choice, multi merge, deferred choice and synchronizing merge. If the criteria were defined in more detail, we would identify additional slight differences, however this would not change the fact, that the technologies are all very similar. To summarize, these technologies are similar in many ways and organizations, which develop them, should work together and create one well-established and mature language.

5.   Summary

The need to do business on the net and to automate business processes is increasing, as is increasing the need for supporting technologies. Such technologies must satisfy certain standards, they must be flexible and available to all organizations, large but particularly to small and medium enterprises. Describing business processes must be relatively simple,

so that even non-programmers can use it, since the business process experts usually do not have the necessary knowledge, needed to work with complex languages.

In this paper we have identified, compared and evaluated the technical features of the six most important technologies for orchestration of business processes. Upon our findings we have defined a multi-criteria decision model for their quantitative evaluation. From this perspective we have determined that BPEL4WS offers slightly more than WSFL technology, which has an advantage over BPML, ebXML BPSS, WSCI and finally XLANG.

We can see that the described technologies offer similar functionality. The problem is that the users cannot follow them all. The only way to change this is to ignore standardization proposals, driven by commercial interests only, and search for well-established process modeling techniques. That kind of a selection will force vendors to start thinking about a more unified solution, since the features they offer are very similar. A unification of those technologies seams like a reasonable idea, which would enable companies to concentrate on one technology, thus eliminating the problems of interoperability and the relatively steep learning curve of existing solutions. This would enable companies to invest in business orchestration, which will provide benefits to the involved parties.

Nevertheless, the described technologies are important and companies will have to include them in the future and implement them in their information systems. The orchestration implementation of business processes is possible only if web services are developed with proper interfaces for communication with business partners, and if they are well integrated with proper internal information systems of the company like back-end or ERP systems. In our future researches we will try to determine the integration efficiency of those technologies with web services and do more precise analysis of their functionality.

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