Semantic Web Technologies and E-Business:

Toward the Integrated Virtual Organization and Business Process Automation

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Chapter V

Semantic Web Services and BPEL: Semantic Service-Oriented Architecture Economical and Philosophical Issues

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Abstract

An emerging technology like business process execution language (BPEL) and its implementation in BPEL for Web services (BPEL4WS) gives extra possibilities in describing business processes. It further adheres, as a technology, in a consistent way to the underlying Web service-based implementation technology and is a perfect fit for service-oriented architectures (SOA) as they are currently implemented throughout organizations as a successor to enterprise application integration (EAI). However, BPEL4WS, in its current implementation, will only serve in a static way for production workflows. In this chapter we discuss how Semantic Web services

through a semantic service-oriented architecture (SSOA) can be used to extend BPEL4WS to create ad hoc and collaborative workflows.

Introduction

New (business) applications based upon Web services are very promising. An example is enterprise resource planning (ERP) with Web services. Today, more and more vendors agree upon Web services standards. One of them is BPEL4WS. However, at this moment only static workflows can be created with BPEL4WS.

Since SOA has made a breakthrough in EAI and e-business and since SOA uses Web services, we will look at the possibilities of SOA in this context.

Today, programmers still need to make the link between a Web service and the application that supports a particular step in a business process. Semantic Web services may add a dynamic dimension to workflow systems. In this way it becomes possible to automate ad hoc and collaboration workflows. The BPEL workflow manager can decide, based on the results returned by Semantic Web services, which Semantic Web services will perform the next step in the workflow.

This and the other services of SOA need to be adapted to the semantic technology. This is our contribution to the SSOA.

In the remainder of this chapter, the following topics will be treated in more detail:

- business context of an organisation;
- business processes and workflow where BPEL4WS could be used with Semantic Web services;
- BPEL4WS and dynamic workflows;
- issues about information management;
- decision-making process, since software has to make autonomously itself some decisions;
- the roadmap of SSOA; and
- finally, further research concerning SSOA and the conclusions.

Business Context

Business Environment

In this ever faster changing world organisations have to be very flexible in organising their resources and processes. As a consequence the speed of decision making has to increase, otherwise opportunities may be lost. However, the problem is not only the speed but also the selection of relevant and correct intelligence in the wealth of information to support the decision making

Information and communication technology (ICT) could be an answer to these issues, but then the human factor will always reduce the speed of treating information. Therefore ICT applications must receive more autonomy to collect and interpret information into intelligence and to make the decisions themselves.

This implies that an ICT application must be capable of interacting with its environment to acquire and use resources in a coherent way to attain its goals. An example is the use of *intelligent agents.* An intelligent agent is software that can define its own strategy to attain its objectives. Strategy implies the appropriate use of the right choice of resources. If the resources are not known in advance then the intelligent agent has to know the characteristics of the resources to make the right choice of resources. Consequently, it has to treat semantics.

Because, nowadays, the Internet is the virtual space where everything is happening, we will look at Semantic Web technologies. But first we will discuss the functioning of an organisation (processes) and the use of its information, so that the context of Semantic Web technologies is defined.

Capability Approach

The board of directors of an enterprise would like the enterprise to have some effects on the society (outcomes) by using its *capabilities,* which will then perform actions (output) to obtain these effects. The sum of these effects is the vision of the enterprise. The wanted effects will be described in a number of scenarios. Therefore, the chief executive officer (CEO) will configure capabilities, as the product of capacity and competence, to perform actions for all relevant scenarios. In the ever faster changing world, these capabilities have to be flexible and easy to reconfigure.

Modules deliver the necessary capabilities, where one module can serve multiple capabilities. An example is the Belgian Defence. The Belgian political leaders wanted to have some effects on the society (outcomes) by using the military power, which have to perform actions (output) to obtain these effects. The wanted effects are described in a number of scenarios (such as peace keeping operations, humanitarian actions). Therefore, the Military Command had configured capabilities to perform actions for all scenarios. However, due to budgetary and operational reasons, not all scenarios can be covered at the same moment. So the political leaders have expressed which has to be the maximum deployment of forces (capabilities) at the same time. Then Military Command has defined modules which can be used for minimum one capability, but also for the maximum asked capabilities (at the same time).

The modules are composed of resources. In the process area of capabilities generation, modules and/or resources are acquired following investment and recruiting plans (acquisition function). So we have a schema of outcomes – outputs – capabilities – modules – resources.

Each capability produces one or more outputs to its (internal and/or external) clients. The client expects a level of quality and service related to this output. In a business-process-to-business-process context the output (quantity and quality), time frame, and services are described in a service level agreement (SLA) (Rabaey, Vandenborre, Tromp, & Hoffman, 2005).

In Figure 1 a capability is composed of modules, but each module can be seen as a capability itself composed of other modules. By drilling down we reach, at a certain point, modules that cannot be decomposed anymore into other modules. This is the atomic module, and it has only resources such as material and human resources to manage.

Figure 1.

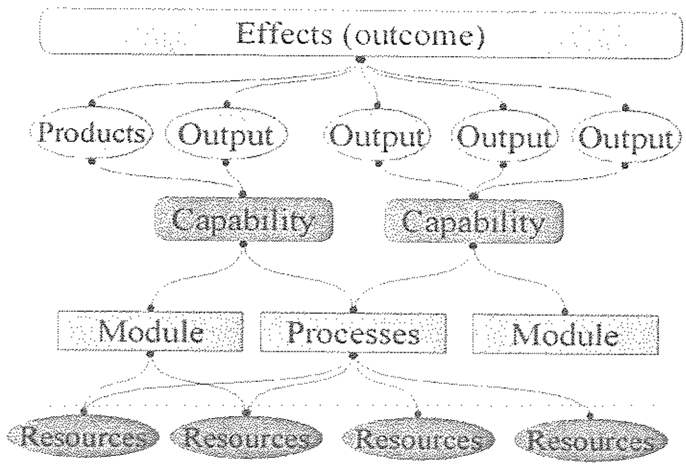
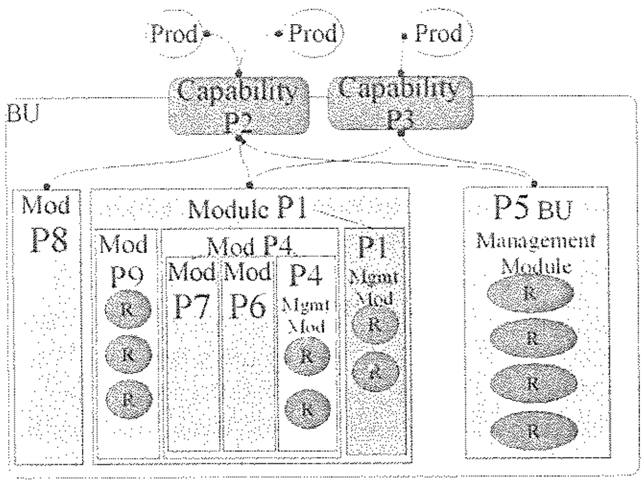


Figure 2.



In Figure 2 we see that a business unit has two capabilities P2 and P3. P2 has three modules: P5 which is the management module of P2 (and P3) and is atomic, P8 from an external partner, and P1. P1 itself has as capability two modules: P4, P9, and P1-M (the management module of P1). P4 has three modules: its management module, P7 and P6. So each capability can be decomposed until it reaches atomic modules or modules serviced by partners, this is why we call this the *Matryoshka* representation.

For example, a Chinese business unit XYZ has two capabilities (P2 and P3) to produce goods, but not simultaneously. Module P1 (production) and P5 (management) form the capability P3 to produce a good for the domestic market.

If XYZ wants to export a similar type of good to the U.S. market then XYZ needs module P8 from a partner to adapt the product to the U.S. regulations. However in this case, XYZ is capable of producing an additional product.

Module P1 is the main production process, which besides the management module, is composed of P9 (assembling) and P4 (delivering parts). The latter is managed by the P4 management module. P7 and P6 are the modules of the suppliers of parts.

Each capability has always its own management module to manage the modules and/or resources in the capability container.

The modules (processes) are described in a business process management (BPM) tool of the enterprise. Probably all the supporting processes will be put in a catalogue called *service* (processes) *catalogue*. However not only business processes but also ICT programs may be part of the service catalogue. Especially programs which are (hidden) workflows can, besides providing information, also provide services or products: car assurance, travel tickets, ordering and receiving goods in a production line (see next paragraph).

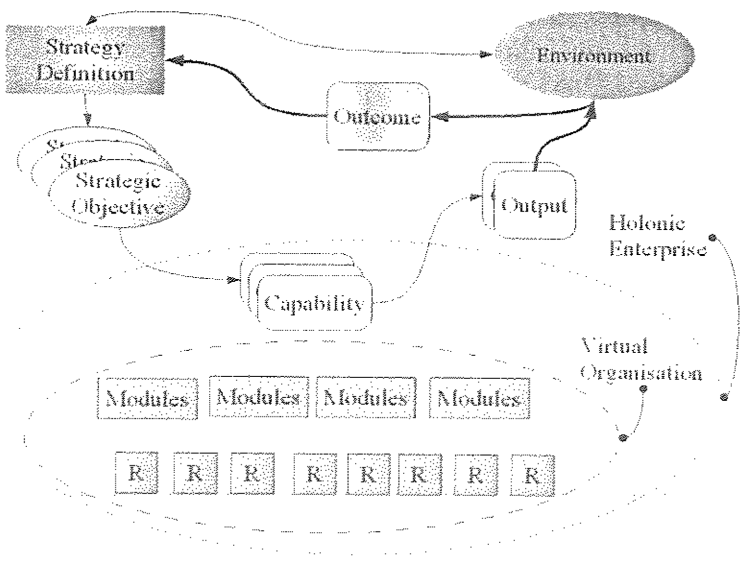
Virtual Organisation

As seen previously, services can be delivered by external partners. These services may be the deployment of resources in a module or one or more modules (processes) in the capabilities (outsourcing). If all modules are outsourced then a capability is a virtual organisation of modules.

A step further is the creation of virtual capabilities: the holonic enterprise. One of the results of the interpretation of the work by Hammer and Champy (1993) was the Holonic Enterprise by McHugh, Merli, and Wheeler (1995). Companies work together in a virtual space called the Holonic Enterprise (Figure 3). It is a networked organisation where (ideally) every company does outsource its noncore business to the other nodes (called holons). The huge obstacle at that time was the heterogeneity of applications and computer systems. Easy integration of the processes through ICT was quite impossible.

Fortunately, the Internet hype moved people and companies to more open standards. Technologies such as GRID computing (Zimmerman, Tomlinson, & Peuser, 2003) can even make the ICT infrastructure transparent to the ICT applications. GRID is

Figure 3.



a resource-sharing technology without a central control instance, spanning multiple institutions across the network. GRID technology covers any type of computing resource (storage, CPU, etc.) as well as applications supporting business processes and their individual activities. It promotes flexible configuration of business processes running on a GRID infrastructure and therefore enables short response times and on-demand adaptations to business requirements.

So a GRID refers to an infrastructure providing the applications of business processes the transparent use of ICT services, like storage, data repositories, wherever they are provided. Like the Holonic Enterprise, a GRID creates a virtual organisation and implements a sort of meta-operating system (meta-OS) providing applications with functions and services that shields the underlying system resources and their specific implementation technology.

Regarding the ICT applications themselves, we may introduce SOA. SOA suits well to support the capability approach. The main purpose of SOA is to detect discrete functions contained in enterprise applications and to organise them along with new functions (building blocks) into services that will be used by the business processes, discussed in the next point. A service may be information or a decision providing function or a workflow. The latter is also presented as an automated business process, therefore an application and as already mentioned, ICT programs can also be modules (services catalogue).

Business Processes

Strategy

Regarding the military (Bernard, 1976; Liddell Hart, 1991), *grand strategy* is the art to combine resources of an organisation to attain its objectives. This is determined by the first principle of the Art of War, being the balance between objectives and resources. If a company uses too many resources to attain the objectives, then it is not efficient. If too few resources are used, then the company will not be effective and it will not attain its objectives.

As a result of the balance between goals and means, two types of strategy will be derived from the grand strategy: the *business strategy* and the *resources strategy*. Examples of resources are human resources, financial resources, and ICT.

The business strategy will define strategic objectives that have to be attained by the (core) business units through their processes. Linked to these strategic objectives are the key performance indicators (KPI). The balanced scorecard (BSC) created by Kaplan and Norton (1996) is an efficient management tool to communicate the strategy in the organisation and to collect the feedback of that strategy by exploiting the KPI (Rabaey, 2005).

The strategy itself is realised by business processes. These processes may belong to one or more organisations.

Processes

Rabaey, Hoffman, and Vandenborre (2004) define a business process as a logical set of activities that consumes resources to attain its objectives. In the organisation of the business processes, we have the second alignment of goals and means. The resource managers and the business unit managers will discuss the operational use of resources (organisation) in an interdisciplinary forum; interdisciplinary because of the multitude of functional domains (Rabaey, 2004a). The result is the providing of the resources and their service levels (SLA).

From a business perspective, a resource or service provider will be evaluated on the delivery of the service (SLA) and the quality of service (QoS). Thus the BSC of the resource or service provider (strategy) will hold strategic objectives focused on the SLA (Rabaey, 2004b).

Anyhow, the deployment of resources in a business process is the result of a decision process (of the interdisciplinary forum). If software must be able to choose and to deploy itself the resources and the modules of its capability (see the *Capability Approach* section), then it must be capable to understand the characteristics and the purposes to attain its imposed objectives.

Rabaey, Leclercq, Vandijck, Hoffman, and Timmerman (2005b) give an example when they conceptually describes a system to simulate the capabilities generation and operational use of these capabilities based on intelligent agents. The characteristics of the resources modules are defined in a *knowledge base,* which the intelligent agents can query. These agents interact with each other until a certain number of scenarios are defined (optimisation of the capabilities generation within budget restrictions).

Workflow

Automating partly or totally a business process was first done by a workflow system. Before discussing BPEL4WS or BPEL in the context of SOA, workflow is looked at in more detail.

Kobielus (1997) defines a *workflow* as "the flow of information and control in a business process" (p. 32). Plesums (2002) adds explicitly the ICT aspects to the workflow definition: "In the last 15 years or so we finally have developed tools to not only do the work, but to manage the workflow. More than just procedural documents, that workflow process is defined formally in the workflow computer system. The process is managed by a computer program that assigns the work, passes it on, and tracks its progress" (p. 19).

The Workflow Management Council (WfMC, 1995) states: "Workflow is concerned with the automation of procedures where documents, information or tasks are passed between participants according to a defined set of rules to achieve, or contribute to, an overall business goal. Whilst workflow may be manually organised, in practice most workflow is normally organised within the context of an IT system to provide computerised support for the procedural automation" (p. 6), and therefore WfMC defines workflow as "The computerised facilitation or automation of a business process, in whole or part" (p. 6), and a workflow system as "A system that completely defines, manages and executes workflow through the execution of software whose order of execution is driven by a computer representation of the workflow logic" (p. 6).

Workflow systems are often related to business process reengineering (BPR) because of the fundamental rethinking of business processes with ICT. Riempp (1998) starts from these optimised processes to the execution of the workflows (pp. 47-52). (See Figure 4.)

The optimised business processes are often represented through a graphical business process model. However the BPM tools do not only "draw" the business processes but add management attributes to the business processes and their business process steps, such as the needed competence to execute an activity, or the used ICT applications.

Figure 4. (Source: Riempp, 1998, pp. 47-52)

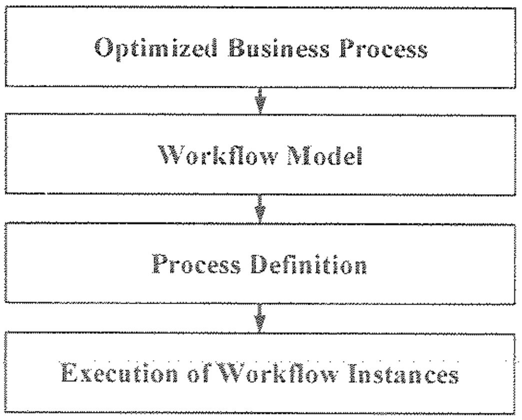
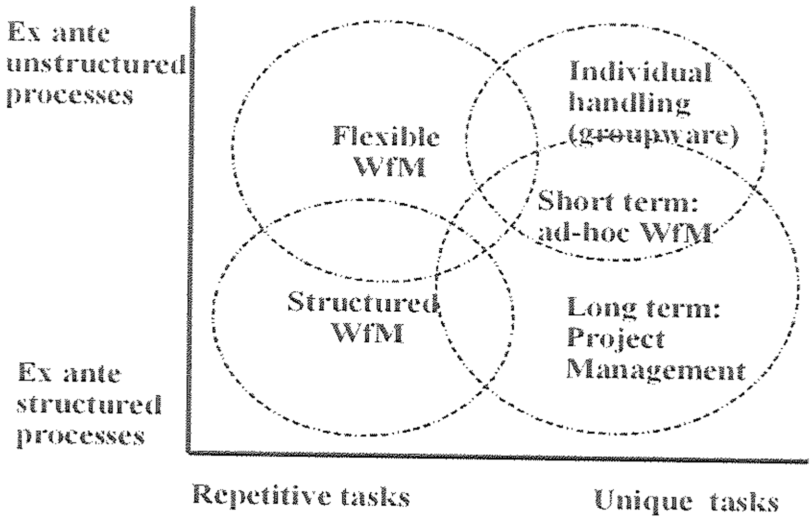


Figure 5. (Source: Riempp, 1998, p. 52)



The workflow model is derived from the business process model. Mostly it is described in a formal (graphical) language. In this way the business process is defined in the workflow system and is ready to be executed if it is instantiated.

Different types of workflows exist (Plesums, 2002; Rabaey, Vandijck, & Tromp, 2003; Riempp, 1998). The first type is the ad hoc or collaborative workflow and is characterised by negotiation, and a new workflow is defined for each use.

The second type is the production workflow. A production workflow is predefined (ex ante structured) and prioritised. It is mostly linked to customised ICT applications. Thus it supports high volumes and there are no negotiations about who will do the work or how it will be handled.

The third type is the administrative workflow, and it is a cross between the ad hoc and the productive workflow with lower transaction rates and form-based, recurrent processes.

So we have unstructured and structured workflows to do unique or repetitive tasks. Riempp (1998) depicts (see Figure 5) the management categories of unstructured versus structured processes (workflows) on one axis and repetitive versus unique tasks on another (p. 52).

Regarding the unique tasks, for the ex ante structured processes Riempp (1998) defines project management. The less structured is the individual handling, where groupware can be used. The ad hoc workflow management (WfM) is in between.

For repetitive tasks, the production and administrative workflows are designated concerning the ex ante structured processes (structured WfM). Flexible workflow management has no type. In this case usually an ad hoc WfM is used to quickly build workflows, which are later transformed into structured workflow types.

Organising the resources and modules in a capability is at the tactical level, as is the designing of the workflows. The steering and the executing of the workflows are at the operative level. In the situation of ex ante structured processes no collaboration issues exist, nor do decisions have to be made.

The opposite case is the situation of ex ante unstructured processes. Although the WfMC (1995) writes that "documents, information or tasks are passed between participants according to a defined set of rules" (p. 6) in a workflow, decisions need to be made to choose the next step in the workflow.

The mentioned rules concern "the execution of software whose order of execution is driven by a computer representation of the workflow logic" (WfMC, 1995, p. 6). The rules are applied to the metadata and some attributes of the workflow objects.

In an ex ante unstructured process the next step is decided by the performer of the current step. When the performer is a human being then he has to know the (business) rules which have to be applied in that particular case. If we would like to automate the workflow (process) then we need to substitute the human for a software program. Therefore, it must have the knowledge to analyse the context to decide which will be the next step. Without semantics, the software can only decide at a syntactical level, not at the knowledge level.

So no semantic issues can be treated in the higher defined framework of the WfMC, however if software has to resolve the problems related to the ex ante unstructured processes, then semantics have to be taken into account.

Business Process Execution Language

From a business perspective, Web services can be viewed as the latest, dynamic stage in the e-business evolution, but also as a simple low-cost enterprise application vehicle supporting the cross platform sharing of functions and data (Zimmerman et al., 2003). The greatest advantage in the business and technical domains is that either party can continue to use his/her own technology without being influenced by the technology of the other parties. Existing skills and assets can be fully leveraged; implying that the investments in the organisation of processes and the used are safe (Rabaey et al., 2003). This is the case for operative collaboration, but business integration on the strategic and tactical level implies, nevertheless, considerable changes in the business and resources strategy (Rabaey, Vandenborre, et al., 2005).

By using a universal communication medium (Internet, extranet) and an integration system, a company can attract additional partners (customers, suppliers, government, etc.) and improve its organisational effectiveness and efficiency (Barry, 2003) in a SOA environment (see also http://www.service-architecture.com). As a matter of fact, Web services make it possible to exchange data and to participate in business processes between companies as well as different business units within the same company.

A Web service can also be the interface between an application and the so-called executable workflows. BPEL4WS is the main effort in this domain.

The BPEL4WS or BPEL is an extensible markup language (XML)-based language for the formal specification of business processes, where each step in the business process is executed by a Web service (Barry, 2003; Rabaey et al., 2003). But the BPEL itself is also a Web service, meaning that a Web service can not only be a procedure or activity, but also a real business process with long cycle transactions. So, in the services catalogue not only business processes are registered, but also Web services (see the *Capability Approach* section).

Rabaey et al. (2003) state that the vision behind high-level description languages such as BPEL4WS, is the paradigm shift from distributed computing to distributed business process execution. BPEL4WS is an XML-based standard, which enables users to specify processes as an aggregation of Web services. The service flows define the order of activities, where a flow is a directed graph representing activities as nodes and interactions as links connecting the nodes. The activity implementations are described via Web services description language (WSDL) port types.

With BPEL4WS, generic (abstract) processes can be defined that contain empty activities. The work on the business process definition can therefore be separated from its implementation (in analogy with the object-oriented paradigm).

So if we look at the higher mentioned definition of a business process as a set of logically connected activities to attain a certain objective, then Web services can represent these activities or can be this executable business process, which can be internal to one organisation or can span several organisations.

Cross Border Business Collaboration

Doshi, Goodwin, Akkiraju, and Verma (2005) state that since SOAs are more widely deployed, it will become more common to use Web services to link both intra-enterprise and inter-enterprise to attain the common business objectives (business process integration and management [BPIM]).

Rabaey, Vandenborre, et al. (2005) goes into more detail on the consequences of business integration on the business and resources strategy. Since the capability approach is used, it becomes more and more difficult to determine to which enterprise a capability belongs. The borders are those of the capability. Moreover, with the holonic enterprise collaboration is preferred above integration. Therefore, we propose the term cross border business collaboration (XBC).

Dynamic Workflows

Semantic Web

With the increasing introduction of SOA in enterprises and government organisations, there will be a lot of BPEL available on the Internet. As a consequence, the number of Web services will exponentially grow. Similar to Web pages, it will become more and more difficult to discover the right Web service (BPEL); so some intelligence will be needed to help the applications or the people to find the Web services that are required.

The solution for the problems with the Web pages is the Semantic Web. It is the representation of data on the World Wide Web. It is based on the resource description framework (RDF), which integrates a variety of applications using XML for syntax and uniform resource identifier (URI)s for naming (see http://www.w3.org/2001/sw).

The idea behind the Semantic Web is to make the Web as intelligent as possible. Therefore, the Semantic Web uses technologies such as RDF, agents, and databases. Rabaey et al. (2003) introduces business intelligent agents (BIA) to aid users or applications to choose the best Web service, so these Web services are classic Web services, not Semantic Web services.

Intelligent Agents

Knapik and Johnson (1998) quote Atkinson: "Intelligent Agents are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires." Another quote of them is about a generic operation definition (of Majewski). An intelligent agent (IA) should have:

- **Autonomy:** Agents operate without the direct interaction of humans or others, and have some kind of control of their internal state.
- **Social ability:** Agents interact with other agents (and possibly humans) via some kind of agent communication language.

- **Reactivity:** Agents perceive their environment and respond in a timely fashion to changes that occur in it.
- **Proactivity:** Agents do not simply act in response to their environment; they are able to exhibit goal-directed behaviour by taking the initiative (For ethical reasons, some authors as Murch and Johnson [1998] do not accept that intelligent agents are self-motivating.).

Business Intelligent Agents

Related to business processes, intelligent agents act and react to their environment, which in this case is the *business context*, which Rabaey et al. (2003) calls BIAs. A program (or another intelligent agent) or a human (through a Web application) can activate the BIA. In the first situation, the BIA can work autonomously; in the other situation, it will assist a human in the selection and handling of the Web services.

BIA can be used to perform a business process or a part of a process, but business processes imply business transactions. The BIA should not only be able to build up *transactions* but also resolve the problems of stopping an ongoing, not fully terminated transaction just like BPEL4WS.

The business context can be described in an enterprise knowledge management system (Rabaey et al., 2005b). Agents can be used to manage internally the gained knowledge. Yoon, Broome, Sing, and Guimaraes (2005) propose a system of intelligent agents where one is a supervisor who controls the information flow between the sensors and the agents responsible for the knowledge management.

Regarding Web services, Maamar, Sheng, and Benatalah (2003) propose a system of interleaving Web services, meaning that the composition and execution of Web services may be done in parallel. As a consequence, this allows handling the execution of context of the Web service (dynamic information). They use intelligent agent software to implement this capability, and by doing this, Web services can delegate their work to each other. Recently Mateos, Zunino, and Campo (2005) discussed the use of MoviLog for developing intelligent agents that interact with Web services (see next point).

Research has also been done to *dynamically* bind Web services, so that Web services provide clients with run time information that is pertinent to its execution and business logic. When faced with multiple service providers who can provide the same functional service, the client can dynamically select the current best service provider for its required service, according to the client's constraints and information gathered about the service providers at run time (Padovitz, Krishnaswmy, & Loke, 2003).

Besides working with Web services, the BIA must work with nonWeb services programs. This implies that the BIA must be capable of generating another type of agent, which interfaces with those systems. In the other way, the BIA is also a service for other programs, so it can publish its services just as Web services. In that case the BIA has to generate another agent that will be responsible for the publishing and handling of Web services requests.

BIA and Semantics

The BIA may not only be able to choose the best Web service but it can also chain up different Web services to a workflow. Opposite to BPEL4WS, BIA can design *dynamic workflows*.

But Doshi et al. (2005) discuss the problems of working with Web services in the case of dynamic workflow composition. Doshi et al. state that the advent of Web services has made automated workflow composition relevant to Web-based applications. One technique is the artificial intelligence (AI)-based classical planning. However, workflows generated in this way suffer from the paradoxical assumption of deterministic behaviour of Web services, then requiring the additional overhead of operative monitoring to recover from unexpected behaviour of services due to service failures, and the dynamic nature of real-world environments. Doshi et al. propose a solution based on Markov decision processes (demonstrated with a supply chain scenario).

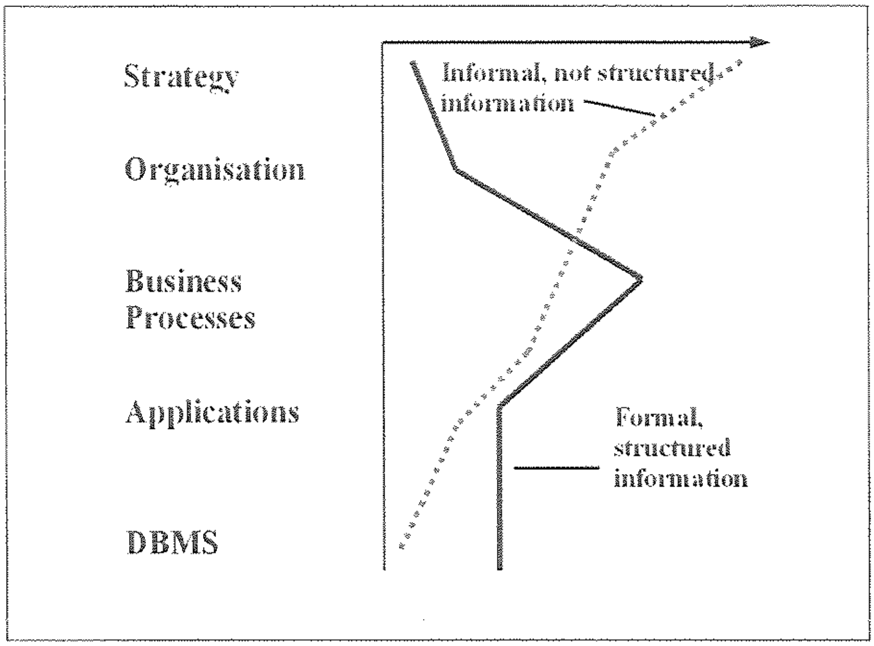
Indeed with the classic Web services, BIA will be confronted with semantic issues. It is preferable that the detected Web services are provided with semantic capabilities. Hausmann, Heckel, and Lohmann (2005) propose a model-based development of Web service descriptions wherein *ontologies* are combined with a unified modelling language (UML)-based description of the service. This should enable a precise matching concept, so that the formation of ad hoc collaborations on a global scale is rendered possible.

Recently Mateos et al. (2005) discussed the use of MoviLog for developing intelligent agents that interact with Web services. Mateos et al. are extending MoviLog to handle ontologies written in DARPA Agent Markup Language + Ontology Inference Layer (DAML+OIL) a Web resource description language that extends RDF.

Regarding the use of intelligent agents and Semantic Web services, a lot of research has to be done. Hopefully, the results of this research will be generally accepted, so that people can focus on the business context and not on useless Babel-like confusion.

Until now the focus has been on processes, workflows, and the possible use of Web services or intelligent agents to render the processes more dynamic and flexible. However, ICT treats also another aspect of the organisation: information.

Figure 6.



Embedded Information System

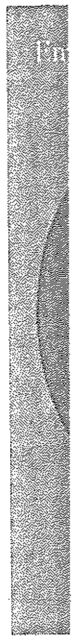
Information

Organisations and their processes cannot function without information. To determine the strategy, an organisation will bring its means and its goals in balance (Bernard, 1976; Liddell Hart, 1991). Therefore it will seek a permanent way for information that can be transformed to intelligence (analysed and integrated information needed for a decision process (Rabaey, 2005). This strategy is then deployed throughout the organisation to the processes. As already treated, processes are the modules which form the capabilities to produce the output (see Figure 6).

An information system supports the information housekeeping of the organisation and its processes. "The term 'information system' means a discrete set of information resources organized for the collection, processing, maintenance, transmission, and dissemination of information, in accordance with defined procedures, whether automated or manual" (U.S. Office of Management & Budget [OMB], 1996).

Instead of exchanging information between processes and managing these processes, the automation of an information system into applications tend to facilitate the

Figure 7.



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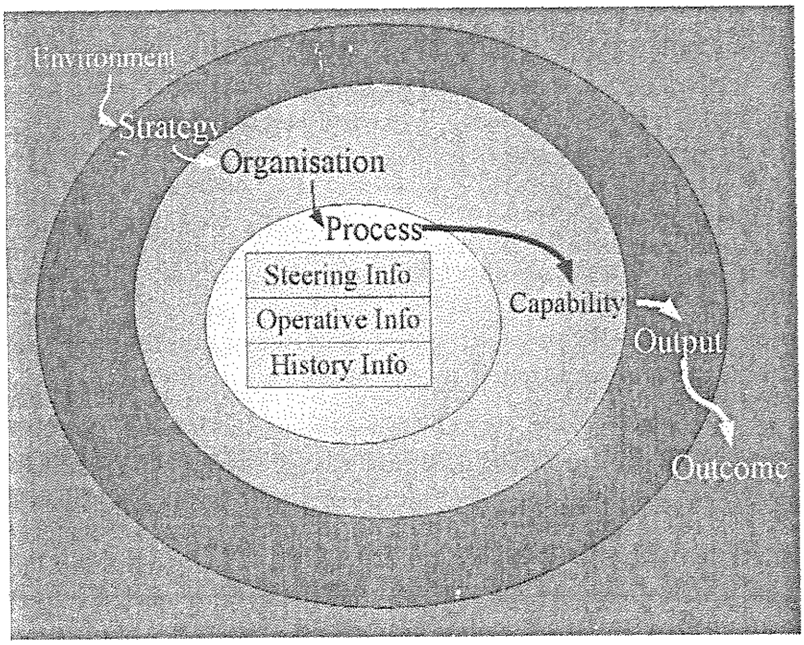


information exchange between applications, meaning that applications start to live their own lives and that processes have to adapt to the applications (e.g., ERP).

However, the information in the *processes* should be used on different levels: steering information, operative information, and historical information. These types of information will be found in BPM tools. In the last few years we can see an effort to merge BPM aspects and ICT aspects into one tool. However, a mental gap exists between both worlds. BPM people think process wise, while ICT people think application wise, meaning only some parts of the processes are automated and relevant information is stored in databases. Reporting on transactions is based on the information kept in these databases. As a matter of fact, only historical information is kept in these databases. Information about steering and executing the processes are not stored in databases.

Some of the information (steering and operative) can implicitly be registered in the models of automated workflows. But a data query cannot be performed on these models.

Figure 7 shows the volume of informal and formal information in an organisation. As we may see regarding the formal information, the business processes hold the most information due to the fact that they contain the business context, the steering and operative information.

Research by Rever SA (a spin-off of the Belgian University Notre Dame de la Paix) shows that 40-60% of the data structure and flow in ICT are in the applications and are thus not in databases. The University Notre Dame de la Paix is developing the software DB-Main to do a reversed engineering by analysing the databases and the programs. The result is a *conceptual model* from which a logical model for any type of database system can be derived down to the operative schemes (Hainaut & Henrard, 2003; Hick & Hainaut, 2003; Henrard, Hick, & Thiran, 2003).

Since the environment of the organisation is permanently changing and thus the organisation also, the information system of the organisation has to be adapted to the new situation. As a consequence, part of the databases will change, so that after a while a new reengineering has to be performed.

So, if a business process could be fully automated and it holds itself the information, then a consistent part of the producible and needed information will be embedded in the business process. This is even possible for processes in XBC. Referring to the capability approach, the housekeeping of the information of a capability is done by the management module (see also Vandenborre, Heinckiens, Hoffman, & Tromp, 2003). This can be done with SOA and Web services by providing the organisation with a flexible architecture of easy customisable applications.

Virtual Data Federation

The consequence is that if somebody needs to collect information then that person will have to query each process management module. This resembles to Virtual Data Federation or Enterprise Information Integration (EII) issues.

Friedman (2004a) writes:

Gartner positions EII as a goal, not a technology. The goal is to achieve a state where the various data assets of the enterprise are integrated to best meet the needs of the business:

- *Delivering a timely and complete view of critical entities and events*
- *Providing connectivity and accessibility to data across multiple platforms and databases*
- *Ensuring the consistency of data underpinning related applications*

As such, the goal of EII differs little from the general goals of data integration, which has been a focus of enterprises for the last three decades. (p. 1)

At its core, EII technology performs virtual data federation based on distributed database queries (Friedman, 2004b, 2005).

However, the biggest problem is to know if the semantic of one item is the same in all the databases. This is the added value of software like DB-Main (Hick & Hainaut, 2003), which produces a conceptual or semantic model of the organisational information. From there on through logical and physical models the operative models are defined. Again, this will only be a snapshot if the maintenance of all models is not done. In this era of globalisation and merges, the chance is great that information re-engineering will frequently be performed.

Two kinds of capabilities with embedded information systems can be determined. Self-supporting capabilities have their own embedded information system, self-ordained capabilities also, but they can determine their own strategy related to their environment.

Decision Making

Intelligence

If software has to choose itself other resources, then it may have to seek for information to prepare its decision making. The needed information to reduce the uncertainty of the decision maker at a level that is acceptable is called intelligence.

As mentioned previously, collecting intelligence is the only rule of the first principle of the Art of War (balance between resources and objectives). To the military "Intelligence is the product resulting from the collection, evaluation, analysis, integration, and interpretation of all available information, that concerns one or more aspects of foreign nations or of areas of foreign operations, and that is immediately or potentially significant to military planning and operations" (*Defense Security Service Definitions*, 2005).

This definition says that not all information is intelligence and that only after a process of collecting, evaluating, analysing, integrating, and interpreting of information, intelligence can be created. Once the intelligence is created, then it can be used for two purposes (Figure 8):

Figure 8.

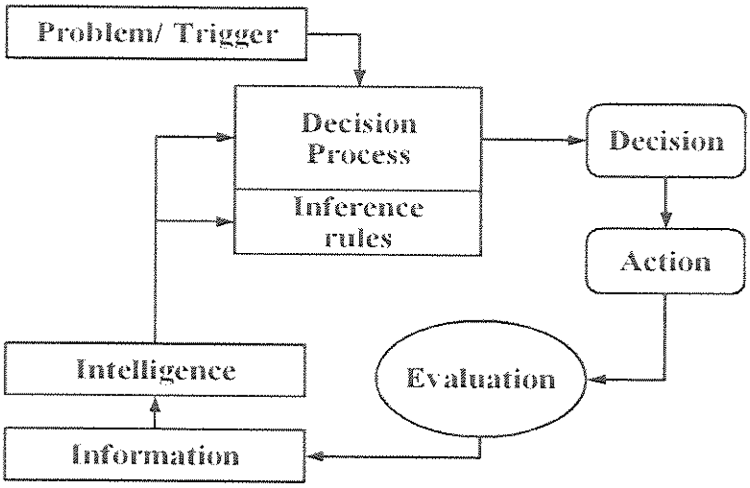
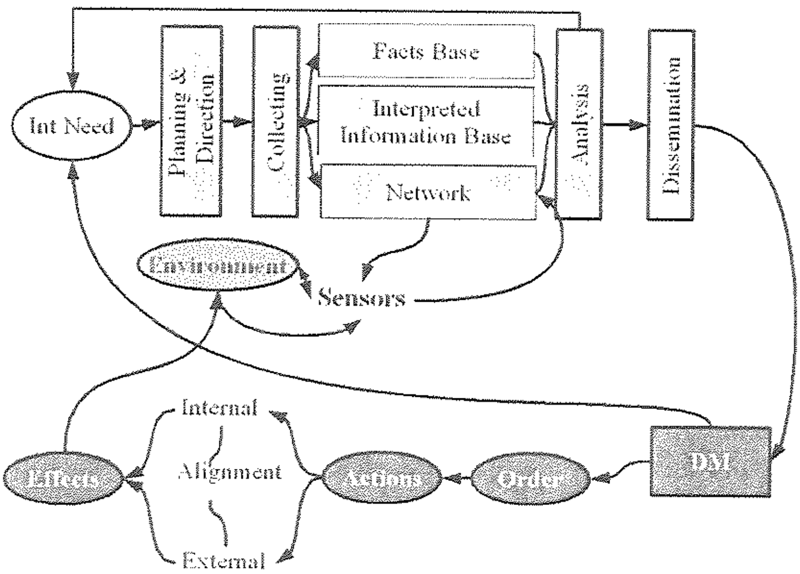


Figure 9.



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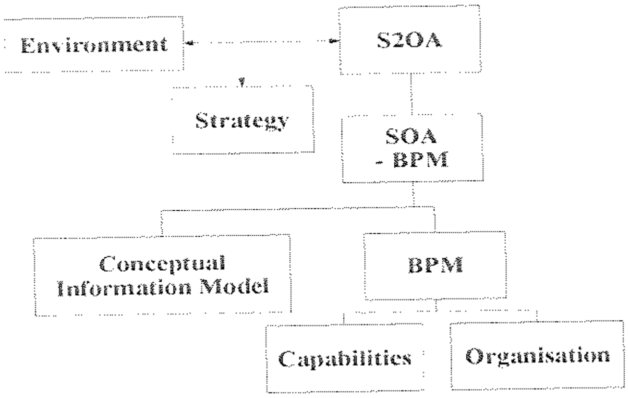

- reduction of the *uncertainty* around the solution for the problem and
- improvement of the *inference rules* of the decision process.

The reduction of the uncertainty can be linked to the context of the decision maker (awareness) and the needed information to make decisions, while inference rules are related to the knowledge domain of the decision maker.

If the decision has been taken that caused an action then the effect of this action has to be evaluated to learn from this action (feedback). Otherwise the decision maker cannot learn from his/her success or failure. So if the software has to make a choice to use a resource (Web service), then it must be able to execute this decision process.

If we combine the decision process with the intelligence process, then a two-way communication is needed: One way to express the information need from the decision-making process to the intelligence process and another in the opposite direction with the asked information (pull) or with spontaneously generated intelligence.

The intelligence process will check if the need can be covered with information in its intelligence base (see Rabaey, Leclercq, Vandijck, Hoffman, & Timmerman, 2005a for more details), if not then it will give its network (sensors) the order to seek for the relevant information. If it is found then the assessment process leading eventually to intelligence will be started.

Rabaey et al. (2005a) proposes a SOA-based solution because of the fact that the intelligence capability can be formed of modules, which correspond with business steps in the intelligence process. An intelligent agent-based solution can be found in Yoon et al. (2005).

Regarding the intelligence process, a conclusion is that no commercial software is yet capable to design (tactical level) processes, nor defines objectives at strategic level, like humans can do. However at operative level it is possible.

Semantic Service-Oriented Architecture (SSOA)

Now that we have discussed the capability approach, business processes, the information issues, and the intelligence process, regarding Semantic Web services and business intelligent agents, we may conclude that SSOA will not be there tomorrow. Certainly, in the domain of information management there are a lot of problems, which are necessary, not all technical problems, on the contrary. Nevertheless, Semantic Web technology is the way to go and it proves already its utility.

Regarding the SSOA, the information issues have first to be resolved. Figure 10 depicts the roadmap.

The *conceptual information* has (urgently) to be defined, simultaneously the organisation has to be defined, and the business processes have to be modelled in the BPM tool following the capability approach.

Once BPM and the conceptual information model are defined, then they have to be merged into SOA-BPM, where the capabilities should manage their own (embedded) information system. The next step is the introduction of *semantics in the capabilities* (SSOA), so that they manage their own modules and resources and interact with their environment (self-supporting capabilities), or even define their own objectives (strategy) in a relationship with the environment (self-ordained capabilities).

But, as already mentioned, it has to start with the conceptual information model to solve the problems of information management.

Further Research

Service-Oriented Investment

Rabaey, Vandijck, and Hoffman (2005) propose a method to *evaluate* EAI, which has been extended to SOA and XBC. It maps the interactions between processes and applications and assesses different aspects (business coverage, technical stability, costs) in a global view, which is then presented to the interdisciplinary forum.

At first glance, this is typically an investment method for ICT projects. However, with the SOA fitting the capability approach, the question can be asked, if this method can be adapted to fit capability investments.

Instead of applications (rendering information services), all services are then evaluated. The service-and-effect diagram is then the map on which the interdisciplinary forum can decide. Due to the complexity of this map and therefore a high degree of uncertainty, classical investments are inadequate. Since uncertainty is an important factor, options could be used.

An option can be defined as "a right but not an obligation, to buy or sell something at a predefined price on or before a certain date (Miranda, 2003, p. 167). Options were originally meant for financial markets (financial options) where the underlying asset is of financial nature (such as a stock or an exchange rate). Real options have tangible assets or projects as underlying asset.

The different options are sequentially put in a tree structure. In a branch, an option can only be realised if its predecessors exist. However with the capability approach, services (capabilities) can be used anywhere, they are independent from most of the other services (in the realisation).

The service-oriented investment will be tested in real cases.

Accounting System

"There ain't such a thing as a free lunch." So, the use of Web services must be paid. Sometimes the customer cannot know how many Web services will be implicated, because if Web services have the same intelligence as BIA, then Web services can invoke other Web services or even BIA. In this situation we have a cascade of Web services and/or intelligent agents. However, it would be more preferable that the business process itself—through its intelligent agents—could determine which Web service is the best suited to fulfil its need, regarding some criteria as objective coverage, reliability, availability, and price. The cascading of Web services with the control of the business process or at least the logging by the business process must be considered to evaluate the QoS of the different Web services. Research has to be done to find a system of evaluation of QoS (e.g., estimated response time, reliability, expected output), combined with the financial evaluation.

Security System

Related to the accounting system and its QoS, is the security system. Is the called agent or Web service, really what it is supposed to be? In the static way of finding and using Web services, the programmer checks the credentials of the called Web service. In the case of, for example, dynamic workflows, the calling Web service has to figure itself out if the called Web service is the right one. Therefore authentication and authorisation should be managed by approved independent "certifying" agencies, so that the calling Web service can be sure that it will be using the right (called) Web service.

Conclusion

The question was, by adding semantics to Web services, are dynamic executable workflows possible? Can BPEL4WS be made dynamic, so that ad hoc, productive, and administrative workflows can be designed and executed with the same technology?

First the capability approach was discussed, and SOA is well suited to adopt this approach. At first glance, BPEL4WS with Semantic Web services could be used, but at this early stage only for operative tasks (not at the strategic or tactical level).

The discussion on information showed us that the related problems are important enough that by not first solving these problems the good use of semantics in Web technology is jeopardised. Certainly, this is true when this "information" is used to create intelligence to reduce the uncertainty of the decision maker (thus software) and to improve its inference rules.

Finally, we have proposed a roadmap to reach SSOA.

References

Barry, D. K. (2003). *Web services and service-oriented architecture*. Amsterdam: Morgan Kaufmann.

Bernard, H. (1976). *Totale Oorlog en revolutionaire oorlog, Band I*. Brussels: Royal Military Academy (in Dutch).

Defense Security Service (DSS) Definitions. (2005). Retrieved October 24, 2006, from http://www.dss.mil/isec/appendixc.htm

Doshi, P., Goodwin, R., Akkiraju, R., & Verma, K. (2005). Dynamic workflow composition using markov decision processes. *International Journal of Web Services Research, 2*(1), 1-17.

Friedman, T. (2004a). *Clarifying the meaning of enterprise information integration*. Gartner.

Friedman, T. (2004b). *'EII' vendors offer virtual data federation technology*. Gartner.

Friedman, T. (2005). *Acquisitions expand Sybase's data integration offerings*. Gartner.

Hainaut, J.-L., & Henrard, J. (2003). *The nature of data reverse engineering*. Université De Notre Dame à Namur, FUNDP, Namur.

Hammer, M., & Champy, J. A. (1993). *Reengineering the corporation: A manifesto for business revolution*. New York: Harper Collins.

Hausmann, J. H., Heckel, R., & Lohmann, M. (2005). Model-based development of Web service descriptions enabling a precise matching concept. *International Journal of Web Services Research, 2*(2), 67-84.

Henrard, J., Hick, J.-M., & Thiran, P. (2003, May 22). Strategies for data reengineering. In *Proceedings of FNRS contact day on Software (re-)engineering*, Louvain-la-Neuve, Belgium.

Hick, J.-M., & Hainaut, J.-L. (2003). Strategy for database application evolution: The DB-MAIN approach. In G. Goos, J. Hartmanis, & J. van Leeuwen (Eds.), *Proceedings of 22th International. Conference on Conceptual Modelling (ER 2003)* (LNCS 2813, pp. 291-306). Springer Verlag.

Kaplan, R. S., & Norton, D. P. (1996). *The balanced scorecard: Translating strategy into action*. Boston. Harvard Business School.

Knapik, M., & Johnson, J. (1998). *Developing intelligent agents for distributed systems*. McGraw-Hill.

Kobielus, J. G. (1997). *Workflow strategies*. Foster City, CA: IDG Books Worldwide.

Liddell Hart, B. H. (1991). *Strategy*. London: Meridian.

Maamar, Z., Sheng, Q. Z., & Benatalah, B. (2003, July 14-15). *Interleaving Web services composition and execution using software agents and delegation*. Paper presented at Web Services and Agent-Based Engineering (WSABE2003), Melbourne, Australia.

Mateos, C., Zunino, A., & Campo, M. (2005). Integrating intelligent mobile agents with Web services. *International Journal of Web Services Research, 2*(2), 85-103.

McHugh, P., Merli, G., & Wheeler III, W. A. (1995). *Beyond business process reengineering*. West Sussex: Wiley.

Miranda, E. (2003). *Running the successful hi-tech project office*. Boston: Artech House.

Murch, R., & Johnson, T. (1998). *Intelligent software agents*. Prentice Hall PTR.

Padovitz, A., & Krishnaswmy, S., & Loke, S. W. (2003, July 14-15). *Towards efficient selection of Web services*. Paper presented at Web Services and Agent-Based Engineering (WSABE2003), Melbourne, Australia.

Plesums, C. (2002). Introduction to workflow. In *Workflow Handbook 2002 of Workflow Management Council*. Retrieved October 24, 2006, from http://www.wfmc.org/

Rabaey, M. (2004a, May 23-26). *Investment in ICT: A holistic business approach*. Paper presented at the 15th Information Resource Management Association (IRMA) International Conference, New Orleans, LA.

Rabaey, M. (2004b). *Strategic decision-making regarding EAI*. Ghent University, Institute of Permanent Education.

Rabaey, M. (2005, June 1-2). *CAF and e-cost*. Paper presented at the 2nd CAF Event, Luxembourg.

Rabaey, M., Hoffman, G., & Vandenborre, K. (2004, April 3-7). *Aligning business and resource strategy: An interdisciplinary forum for investments*. Paper presented at the 13th International Conference on Management of Technology (IAMOT2004), Washington, DC.

Rabaey, M., Leclercq, J.-M., Vandijck, E., Hoffman, G., & Timmerman, M. (2005a). Intelligence base: Strategic instrument of an organisation (NATO IST-055 Specialist Meeting). The Hague, Netherlands.

Rabaey, M., Leclercq, J.-M., Vandijck, E., Hoffman, G., & Timmerman, M. (2005b). Resources and capabilities planning with an intelligent agents dynamic system. *Division Concept of the Assistant Chief of Staff Evaluation*. Belgian Ministry of Defence.

Rabaey, M., Vandenborre, K., Tromp, H., & Hoffman, G. (2005, September 26-29). *Classification of IT-integration based on business collaboration*. Paper presented at IPSI 2005 Montenegro.

Rabaey, M., Vandijck, E., & Hoffman, G. (2005). *An evaluation framework for enterprise application integration*. Paper presented at the 16th IRMA International Conference on Software & Systems Engineering and Their Applications (ICSSEA), San Diego, CA.

Rabaey, M., Vandijck, E., & Tromp, H. (2003, December 2-4). *Business intelligent agents for enterprise application integration*. Paper presented at the 16th International Conference on Software & Systems Engineering and their Applications (ICSSEA 2003), Paris.

Riempp, G. (1998). *Wide area workflow management: Creating partnership for the 21st century*. London: Springer-Verlag.

U.S. Office of Management & Budget. (1996). Memorandum for heads of executive departments and establishments: Management of federal information resources (OMB A-130). Retrieved October 24, 2006, from http://www.whitehouse.gov/omb/circulars/a130/a130trans4.html

Vandenborre, K., Heinckiens, P., Hoffman, G., & Tromp, H. (2003, June 3-6). *Coherent enterprise information modelling in practice.* Paper presented at the 13th European Japanese Conference on Information Modelling and Knowledge bases, Kitakyushu, Japan.

Workflow Management Council (WfMC). (1995, January 19). Reference model—The workflow reference Model (WFMC-TC-1003, 1.1).

Yoon, V., Broome, B., Sing, R., & Guimaraes, T. (2005). Using agent technology for company knowledge management. *Information Resources Management Journal, 18*(2), 94-113.

Zimmerman, O., Tomlinson, M., & Peuser, S. (2003). *Perspectives on Web services.* Berlin: Springer.

Glossary of Terms

Business intelligent agent (BIA): BIA is an intelligent agent that dynamically executes business processes or part of it, to attain its imposed business objectives.

Business process execution language for Web services (BPEL4WS or BPEL): BPEL4WS (or BPEL) is an XML-based language for the formal specification of business processes, where each step in the business process is executed by a Web service.

Cross business border collaboration (XBC): XBC is a framework where EAI, EII, and the capability approach are merged in a SOA.

Capability: Capability is a logical set of modules (processes) to produce one or more outputs with a certain service level.

Information: Information is any communication or representation of knowledge such as facts, data, or opinions in any medium or form, including textual, numerical, graphic, cartographic, narrative, or audiovisual forms (OMB A-130).

Intelligence: Intelligence is the product of the intelligence process, which collects, analyses, integrates, and interprets information. It disseminates the intelligence to the customer, with the purpose to reduce the uncertainty on a problem (decision) and/or to improve the inference rules.

Semantic service-oriented architecture (SSOA): SSOA is the addition of Semantic Web technology to service-oriented architecture, so that SOA-related service can be made dynamic.

Workflow: Workflow is the computerised facilitation or automation of a business process, in whole or part.