Inter-organizational Workflows – State of the art and trends

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Resumo – **Actualmente, os fluxos de trabalho extravasam muitas vezes as fronteiras das organizações, incorporando acções realizadas por entidades externas (estes fluxos de trabalho são normalmente designados de inter-organizacionais). Forçosamente, os sistemas de gestão de fluxos de trabalho têm que acompanhar esta tendência e para tal, devido a necessária troca de informações entre sistemas, foram desenvolvidas diversas especificações como a *Business Process Execution Language for Web Services* (BPEL4WS) e a *Exchangeable Routing Language* (XRL). Neste contexto, este trabalho descreve o estado da arte e as principais tendências dos sistemas de gestão de fluxos de trabalho.**

Abstract—**Today's workflows are commonly defined beyond organization boundaries and workflow management systems' evolution tends to accommodate this recent trend. This type of workflows, also referred as inter-organizational workflows, implies data exchange between organizations and systems. Various specifications have been proposed to interchange workflow data such as Business Process Execution Language for Web Services (BPEL4WS) and Exchangeable Routing Language (XRL). In this context, this paper presents the state of the art of inter-organizational workflows and the main trends in technologies that support them.**

I. INTRODUCTION

The definition of Workflow and Workflow Management System (WFMS) are key concepts for this work and they can be defined as: "Workflow is the automation of a business process, in whole or in part, during which documents, information, or tasks are passed from one participant to another for action, according to a set of procedural rules" [1] and a WFMS as: "A system that defines, creates and manages the execution of workflows through the use of software, running on one or more workflow engines, which is able to interpret the process definition, interact with workflow participants and, where required, invoke the use of IT tools and applications" [1].

Workflow Management Systems are manly used for automating workflow inside a given department or company. These systems automate workflows defining work procedures routines and its relevant information, the role of participants at each step and the software applications required.

Nowadays, organizations have several workflows that cross their boundaries and that allows them to make extra profits, implementing, for example, a resource sharing schema. In addition, the rise of electronic commerce requires frameworks to implement inter-organizational applications and thus this became a new important investigation area [2].

This paper is structured as follows: after this introduction, where the workflow concept was presented, it will be presented the inter-organizational workflow concept in detail and the main technologies that supports it. In section 3 some trends and the future of inter-organizational workflows will be discussed.

II. BEYOND ORGANIZATION BOUNDARIES

Workflow is the automation of a business process that takes place inside an organization and is often managed by information systems that deals with controlling, monitoring and optimization of it. Inter-organizational workflows definition appears due to business processes that involve more than an organization. This type of processes is frequently found in virtual organizations, electronic commerce and international companies. Thus, inter-organizational workflows are workflows distributed over a number of different organizations.

Workflow management systems technologies are mature and deal well with intra-organizational workflows. Moreover, inter-organizational workflows have the following special characteristics that lead to specific functional requirements [3]:

- Interoperability that implies interface agreement between systems and organizations, and provide a common understanding of the data and services exchanged [4].
- Autonomy of organizations must be taken in account. The workflow lifecycle comprises lots of stages and different kinds of organizations autonomy that are relevant. These stages comprise design autonomy at build time, communication and execution autonomy at run time, and association autonomy at "agreement time".
- Open environment, which must be considered in system design because of legal, security, privacy and trust constraints. These types of constraints don't exist in intra-organizational environment.

- Some languages proposed to manage specific characteristics of inter-organizational workflows will be presented in heading C of this section.

A. Example of inter-organizational workflow

In this part of the article it will be presented an inter-organizational workflow example to illustrate the complexity of dealing with it and to illustrate the aspects of relationships between what is seen externally and it relation with organizational internal aspects. This example points up the *Personal Income Tax (in Portuguese: Imposto sobre o Rendimento de pessoas Singulares)*, which normally involves three participants: the citizen, a Tax expert person and the government. In Portugal, the money paid to employees by the employer is subject to government IRS Tax. This process includes a few steps: (i) corporations have to send an annual statement to citizen; (ii) the citizens collects all other necessary documents to present the annual report and (iii) delivers all data to tax expert' person; (iv) that presents the tax report to government entity till the end of March each year. The government checks the annual report, calculates the tax duties and returns a tax assessment notice to the citizen. Nowadays, in Portugal, the stakeholders in this public administration process use online service, which allow citizens and companies to submit their annual tax statements via internet. This process must be realized according restrict security requirements like integrity, confidentiality and non-repudiation.
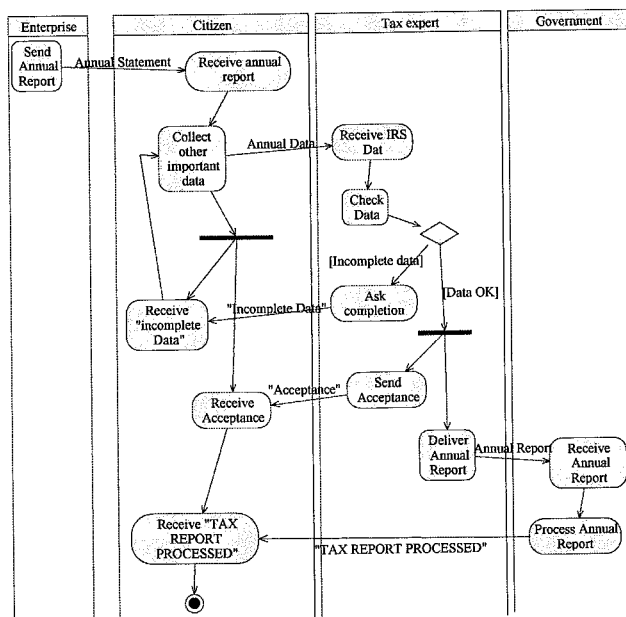

Figure 1.   Example of a choreography for *Personal Income Tax*

The business process can be roughly defined by the following steps (Figure 1.):
- The enterprise sends the collaborator annual statement to citizen.

- The citizen collects other IRS important data and sends it to a Tax Expert.
- Tax expert checks the information for validity and completeness, and rejects the documentation in case of information missing and notifies the citizen. The citizen complements the information and resubmits it.
- The Tax Expert processes the data and on behalf of his client (the citizen) forwards the processed annual report to the Government.
- The Government calculates the amount of tax duties and returns the tax report processed to the citizen.

Figure 1. shows, through a UML Activity Diagram, three entities collaborating in an inter-organizational business process. We can see: a) the behavior of the participant subjects and the corresponding message flow between them; b) the required interfaces called by the participants; c) the flow control of tasks that result in messages exchanged between participants.

B.   Inter-organizational workflows characteristics

Inter-organizational workflows have special characteristics identified by analysis from several industrial and commercial processes:
- The number of organizations involved in inter-organizational workflows is normally large.
- Organizations that participate in inter-organizational workflows try to get extra profits from them [5].
- The geographical dispersion of organizations can create problems.
- In general the ownership of tasks, information and resources is decentralized for each business process [6].
- Resource management become more complex due to the new way of resource consumption (who, when, cost).
- Unpredictability and dynamics of business processes, for example due to incidents and inevitable delays.

In addition to these characteristics, inter-organizational workflows imply that organizations share process description, types and instances of workflows. This data share includes, usually, important details of internal business processes, action plans, tools and resource usage. It is clear that organizations don't want to share these types of information because they are considered classified and competitive value information. On the other hand, the participation in inter-organizational workflows increase productivity, quality and make organizations more competitive. Besides that, inter-organizational workflows allows contribution for larger projects and, eventually, a resource sharing schema [6].

Nowadays, several authors refer that some important issue categories limit the acceptance of inter-organizational workflow systems [6]:

- Organizational: The differences between products, tasks, business rules, structures and allocation of responsibilities descriptions difficult the integration of business processes that cross companies' boundaries. Tight and expensive agreements between organizations are necessary to allow these descriptions sharing across them.

- Task definition and management: At workflow management level, the abstraction of a workflow element and its asynchronous re-insertion often causes severe problems in whole workflow.

- Business process monitoring: distributed systems make tasks difficult to monitor and to record management data such task completion time, resource allocation time, among others.

Traditional workflow management systems architectures based in rigid principles of a centralized problem, often used to manage provisional problems, are no longer adequate to technical challenges imposed by new generation of business processes. In the recent past, some techniques, supported by distributed networks of autonomous software agents that adapt to circumstances, resulted in improved workflow management systems. Some agent-based workflows systems like [7], [8] and [9] were proposed to enhance workflow management systems in order to accommodate inter-organizational business processes. The software agents take full responsibility for process provisioning, enactment and compensation [6]. These systems are based in agents' intelligence and capability to interact with process participants in order to achieve business goals. Nevertheless, this type of systems has functional lacks in comparison with centralized ones, in terms of management and resource control, which creates problems in commercial exploration.

Today, inter-organizational workflows management systems are mainly supported by a set of interoperability languages that will be described in the next section.

C. Inter-organizational workflow languages

Inter-organizational workflows systems need to exchange structured information between multiple instances of software in order to achieve the goal of coordinated production of goods and services. Web services based solutions for distributed systems are a technology used also by systems that manage inter-organizational workflows. These systems use choreography description languages to describe the externally observable behavior of a business entity in an inter-organizational business process [10]. The choreography description language concept derives from the fact that organizations consider them intra-organizational processes as crucial assets for their business [10]. With this concept, it also emerged multiple choreography languages (often referred to as coordination protocols) that allow collaboration rules definition without revealing internal matters of business processes. Using these languages, organizations can specify which information is visible for the other business process players, and the information needed to continue to process interactions. Currently, Business Process Modeling is a subject of various specifications and standardization efforts.

Different consortia, as well as individual software sellers and academic groups have proposed metamodels and related interchange formats for Business Process Modeling. In [11] a list of 13 high-level metamodel concepts were defined, which allow to specify the time to send information to defined participants and the options available to continue the interaction.

It is possible to identify several Business Process Modeling Languages and interaction protocols that supports inter-organizational workflows [11] but, in this paper, only the most stable ones will be referred:

- BPEL4WS: The Business Process Execution Language for Web Services (BPEL4WS or BPEL) provides a language for the formal specification of business processes and business interaction protocol. It defines a model and a grammar for describing the behavior of a business process based on interactions between the process and its partners [12]. It defines how interactions between partners are coordinated and the logic associated to this coordination. It also supports business exceptions and faults common in organizations. Additionally, it is possible using BPEL to define the compensation method for activities in case of exceptions. In BPEL, tasks are calls to Web Services identified by Web Service Description Language ports that have inputs and outputs. Simple Object Access Protocol (SOAP) is the base protocol for BPEL data exchange. The roles of business process participants are defined by partner link types [12].

- BPDM: The Business Process Definition Metamodel (BPDM) is a framework for understanding and specifying processes of an organization or community [13]. With BPDM is possible to define data concerning two fundamental and complementary concepts: i) "Orchestration"; ii) "Choreography." Orchestrations are represented through sequences of tasks, with branching and synchronization, to achieve process goals. Choreography in BPDM is supported by a Service Oriented Architecture (SOA) and helps to keep the enterprise loosely coupled from others that can participate in the business process.

- BPSS: The Business Process Specification Schema includes a metamodel and XML Schema to define

Web Service choreography. The goal of the ebXML Specification Schema is to provide the bridge between e-business process modeling and specification of e-business software components. It does not address implementation aspects like data handling or process instance identification. It supports the donation of roles, exceptions, and transactions in an inter-organizational message exchange [11].

- XRL: The Exchangeable Routing Language is an instance-based workflow language that uses XML for the representation of process definitions and Petri nets for its semantics [14]. Since XRL is instance-based, workflow definitions can be changed on the fly and sent across organizational boundaries [15].

- WS-CDL: The Web Services Choreography Description Language is "an XML-based language that describes peer-to-peer collaborations of participants by defining, from a global viewpoint, their common and complementary observable behavior; where ordered message exchanges result in accomplishing a common business goal" [16]. To accomplish WS-CDL standard it must be defined a contract containing the "global" of common ordering conditions and rules of messages exchange. It must also be produced the common and complementary observable behavior of all the participants involved, which allows each participant to build and test solutions. A global specification is realized by combining the resulting local systems, on the basis of the appropriate infrastructure support [16]. It is build based on WSDL and SOAP and provides algebraic flow control primitives. WS-CDL also supports data handling, role definition, as well as exception and transaction modeling [11].

- WSCI: The Web Service Choreography Interface is an XML-based interface description language that describes the flow of messages exchanged by a Web Service and participates in choreographed interactions with other services [17]. WSCI is a set of extensions of WSDL to describe the message exchanges that must happen to achieve business process goals. It also supports roles, exception handling and data transaction definition.

- WSFL: WSFL stands for Web Services Flow Language, is a language developed by IBM and was one of the predecessors of BPEL. It doesn't support transactions, graphical position information, and statistical data.

- XLANG: The XLANG is other BPEL predecessor. It extends WSDL and provides both, the model of an orchestration of services as well as collaboration contracts between orchestrations. It provides means for defining message correlation,

roles, events and exception handling as well as transaction declaration [11].

These languages were designed to allow systems to support inter-organizational workflows, however Jan Mendling, Gustaf Neumann, Markus Nüttgens concluded in [11] that the languages designed doesn't accomplish all needs of inter-organizational workflows definitions and support. The needs identified in this study where the 13 metamodel concepts defined in the same article [11].

A recent study [18] presents the -uWDL (ubiquitous Workflow Definition Language), a new language for workflow definition that allows context information specification for transition conditions of workflow services. In the same study it is proposed a framework, the uFlow, based on a structural context model and in uWDL. The two components where designed based on knowledge structure to express the context information in a simple and flexible way [18].

There are other works around context awareness workflow definitions languages. FollowMe is an example and is a context aware computing infrastructure. The features of FollowMe infrastructure uses semantic web languages to define business process data and includes an ontology based context model, a workflow based programming model and a middleware, which integrates context and workflow facilities to help build context-aware applications [19].

Kyuongho Shin, Yongyun Cho, Jaeyoung Choi and Chae-Woo Yoo studied uWDL and proposed a new language to define ubiquitous workflows. The proposed language is based on uWDL and can specify context information on the transition constraints of a workflow, and support various workflow functions and adaptive services [20].

III. TRENDS AND FUTURE

The number of organizations covered by business processes is increasing as far as efficiency and quality of Workflow Management Systems raise. Moreover, these cross organizations processes create virtual organizations, a major trend in cooperative business [8]. The cross boundaries business processes allows many ways of cooperative business relations, like outsourcing, supply chains, or temporary consortiums.

The Business Process Modeling Languages, already defined, supports most of the needs for Inter-organizational Workflow Management Systems. In despite of this, none of the Languages defined addresses all of the 13 concepts defined in [11]. Consequently, a lack is identified: a common and accepted interchange format for business process models is missing. These languages are mainly supported by XML definitions and the choreography and orchestrations of processes are defined using XML Schemas. Furthermore, the data is exchanged using Simple Object Access Protocol, a XML based protocol [21].

Microsoft uses XLANG and supports it in .NET framework, allowing developers to build systems

according this definition. It is one of the most widely used frameworks to develop applications and inter-organizational workflow systems due to its integration with Share point Server, which supports workflow definition and execution. However, the Orchestration Engines based on BPEL like *Oracle BPEL Process Manager*, *Net Beans Enterprise Pack* and *Apache ODE* are also important market players. It is difficult to identify a tendency of market share in Orchestration Engines and Frameworks at the time what this article is written.

A key research area in inter-organizational workflows is the inclusion of context information in business process definitions. The workflows exchanged data is not only result values but also context information as types, values, and relations among the data types. Security issues related with web services support protocol (SOAP) are also a key research area in inter-organizational workflows.

IV. FINAL REMARKS

Workflow management systems are being developed in today's organizations to support a wide range of business processes. This process automation makes organizations more competitive through reliable, trusted and efficient procedures. The evolution of communication mediums enhances fast interchange of large amounts of data between organizations. Besides, communication infrastructure allows organizations to share responsibilities in a business process in order to create certain types of products or services. Thus, workflows became inter-organizational workflows. Technologies to support this "new" type of workflows must guarantee that only strictly needed data is exchanged between organizations. It has been proposed some XML based chorographical and orchestral languages to allow workflow data exchange between organizations. These languages fail in some aspects as referred in [11] which make this a today's main research area. In this paper has been presented some of these languages and it is possible to conclude that they are mainly supported by XML concepts and that they didn't cover all actual needs.

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