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VE Architect-Driven Service-Oriented Business Network Process Realization

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Abstract— **Business opportunities are not permanent. Enterprises to instantly meet them collaborate with each other through realizing business network processes (BNP) in which their activities are done with various partners within a network. Recently, these business network processes are enabled with Service-Oriented technologies, that we call them Service-Oriented Business Network Process (SOBNP). In today's dynamic and changing environment Virtual Enterprise (VE) architects require a flexible framework through which they could design and realize SOBNP instantly. In this theme, there exist a number of frameworks that constitute the SOBNP, but they almost neglect two salient issues: a) Covering and incorporating high-level (i.e. business level) and low-level (i.e. technical level) requirement in business process creation; b) Adjusting to the VE architect without deep knowledge of computer science. Thus, the main objective of this paper is to propose a framework and related tools and techniques to constitute SOBNP, as a main building block of Instant Virtual Enterprise (IVE), which address two above-mentioned issues. The framework namely SOBNP Realization consists of three phases including requirements specification, ontology-based partner search and selection, and BPEL (Business Process Execution Language) process synthesis. A prototype system is implemented to demonstrate the concept of VE architect-driven SOBNP realization in IVE.**

Keywords: Semi-automatic realization of business network process; Service-oriented Business Network Process; Ontology-based partner selection; Instant virtual enterprise, BPEL process.

I. INTRODUCTION

Rapidly changing business atmosphere and turbulent market conditions cause business opportunities change over and over. To meet these business opportunities enterprises require collaborating with each other through realizing business network processes (BNP) in which their activities are done with various partners within a network [1]. In fact, the competitive market requires that these BNPs to be realized highly agile, effective and efficient. Such an agility and effectiveness lead to the formation of highly dynamic virtual enterprises within supplier networks, which are referred as instant virtual enterprises (IVE) [1]. In this regard, Presley et al. [2] stress that the rapid formation and reconfiguration of enterprises and their processes provide complexities for process engineering and integration. In the context of this paper, a business process is composed of activities and every single activity is defined as any organized behavior that transforms an input into an output through executing a sequence of actions.

BNPs can be utilized through diverse technologies including service-oriented computing (SOC) [3][4], agent-based approaches [5], and so on. Our approach for BNPs realization is based on service-oriented technologies including web services, Business Process Execution Language (BPEL), etc. Consequently, in this article BNP is called Service-Oriented Business Network Process (SOBNP). In SOC, a business process is a coarse- grained -

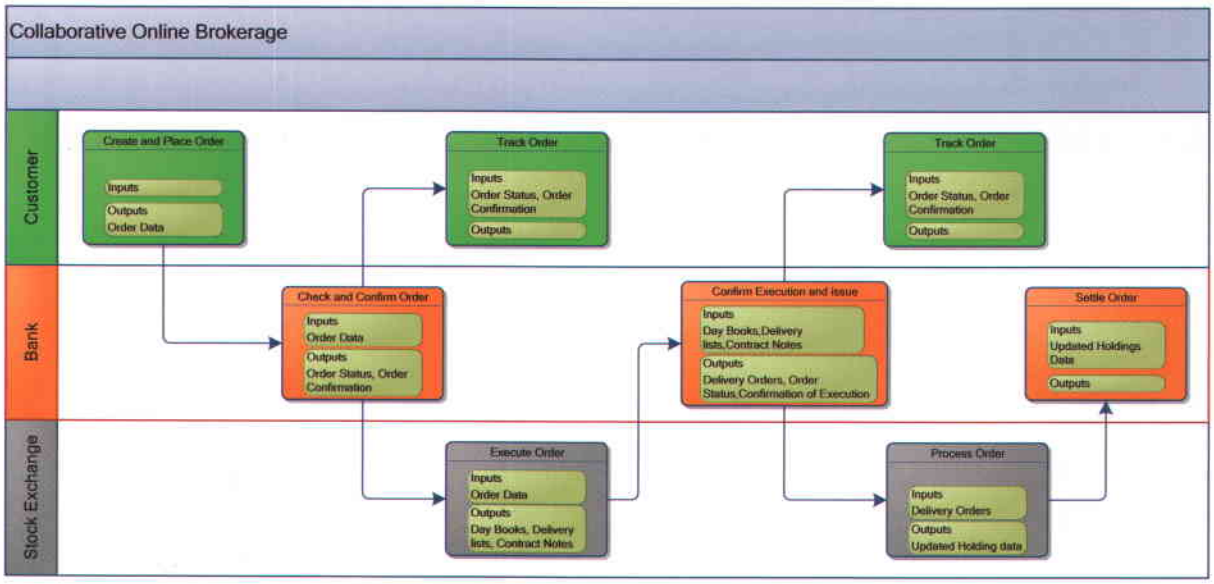

Figure 1. Collaborative Online Brokerage business process

Composite web service executing a control flow to complete a business goal. Among various technologies, BPEL (Business Process Execution Language) is a de-facto standard that is utilized to realize required orchestration and choreography between diverse web services [6]. In fact, BPEL is a workflow-oriented composition model and provide flexible business processes.

There exist a number of frameworks that could constitute the SOBNP but they almost neglect two important issues including covering business-level and technical-level requirement in business process realization, and adjusting to the VE architect without deep knowledge of computer science. Thus, this paper is to propose a framework and related tools and techniques to constitute SOBNP which meet two above-mentioned issues. In other words, the framework namely SOBNP Realization not only embodies both high-level and low-level requirements, but also it has been tuned that could be employed by novice process owners, VE architects, business managers or business domain experts.

The remaining of the paper is organized as follows. Section 2 elaborates the motivation of the work through a real-life scenario. Section 3 discusses the related work. Section 4 presents the SOBNP realization framework. Subsections A, B, and C, explain in detail the major components of the framework. Section 5 discusses preliminary implementation of prototype system. Section 6 evaluates the framework using two approaches: scenario simulation, and gathering experts' judgments through a survey. We next sum up the discussion and provide some conclusions in Section 7 and 8, respectively.

II. Motivating Scenario: Collaborative Online Brokerage

Collaborative Online Brokerage is one of the important business processes of the banking industry. As the process mapping, Figure 1, shows three parties including a customer, a bank, and a stock exchange carry out securities transactions. In fact, efficiency is increased through the electronic support and automation of information and communication processes both within banks and between organizations[7].

By using the appropriate brokerage solution, the "new intermediaries" enable the entire business transaction to be carried out efficiently from the initiation of the transaction up to transaction execution. The greatest potential for this increased efficiency lies in the electronic support and automation of information and communication processes both within banks and between organizations.

In reality, such a business process must be supported with different partners within a network of organizations. Meanwhile, highly flexible and changing environment causes the combination of partners to execute such a business process alters over and over. Therefore, the VE architect requires a flexible tools and techniques for business process realization to instantly meet new business opportunities.

III. Related Work

To the best of our knowledge, SOBNP realization in IVE with proposed approach is almost non-existent in the literature; however, this section reviews the closest work to our approach.

In [3], authors propose dynamic VE integration via business rule enhanced semantic service composition. Its composition architecture realizes dynamic formation of business workflows through three steps: abstract workflow formation, concrete workflow formation, and workflow execution via web service selection. However, in this approach abstract workflows are pre-defined. This means the approach is not flexible. Beside, the paper lacks on introducing partner selection procedure.

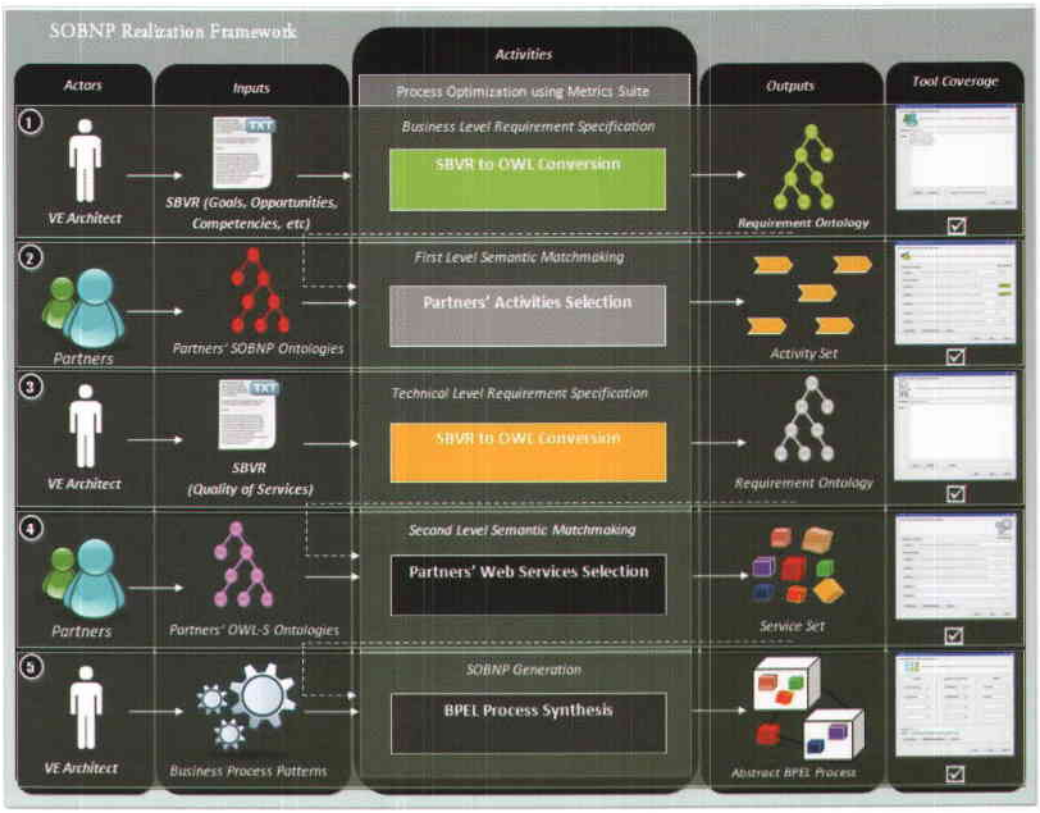

Figure 2. SOBNP Realization Framework

In [1], Grefen and his colleagues develop a novel approach that, firstly, focuses on dynamic, multi-party market scenarios, in which complex instant VEs are created to follow market movements and secondly, covers the entire spectrum from high-level, global business goals down to low-level, local business processes. Even though their contribution has high-quality, it is not adjusted and tuned respecting to the VE architect. Moreover, unlike the SOBNP Realization their framework is not semi-automatic. As a matter of fact, the procedure of partner selection in their framework is not automatic.

In [8], authors present a goal-directed composition framework to support on-demand business processes. In their framework composition schemas are generated incrementally by a rule inference mechanism based on a set of domain-specific business rules enriched with contextual information. Although the proposed framework is one of the high-quality service composition frameworks in recent years, it has some shortcomings. Firstly, their ontology matching algorithm primarily considers the simple subsumption between the concepts in the ontology, and ignores their detailed semantic difference. In other words, some parameters such as concept definition, path type between resources, etc. have been neglected. Secondly, their approach has mainly been developed for business process realization within an organization. In other words, in cannot be used for business network processes which must be constituted through collaborating various organizations within a network.

IV. SOBNP Realization Framework

In the proposed framework that is depicted in Figure 2, SOBNP is generated during three phases. In the first phase that is requirement specification, the VE architect specifies requirements with a known business rule language, that is, Semantics of Business Vocabulary and Business Rules (SBVR) [9]. This phase is divided into two steps: step number 1, and step number 3. Step 1 is to take business-level (i.e. high-level) requirement of VE architect in which goals, opportunities, competencies, desired resources can be conveyed. In a similar way, step 3 takes technical-level (i.e. low-level) requirements in which the VE architect could specify the desired Quality of Services (QoS) for the identified services.

Second phase deals with partners' activities selection. This phase is also divided into two steps: step number 2, and step number 4. Indeed, according to the specified requirements, which have been conveyed in business rule form in step 1 and 3, qualified activities and services, respectively, are identified. It should be noted that step 2 and 4 utilizes the same algorithm for partner selection. In fact our framework utilizes an ontology-based partner selection algorithm to effectively select the most appropriate partners within a network. The algorithm is, indeed, a semantic matchmaking method, since it can play a vital and effective role in partner selection in virtual enterprises [10][11][12].

Finally in the third phase, the VE architect specifies the control-flows between the qualified services using the workflow-patterns (step 5). As a matter of fact, the VE architect must identify the

required patterns among the selected services and generate the expected SOBNP with the aid of provided tools. Third phase also includes a background activity that is process optimization. This activity, in fact, examines the designed SOBNP on the basis of a metrics suite. Our metric suits encompasses five metrics that analyses four key quality features of BPEL business processes including business value [13], reusability [14], context-independency [15], complexity [16], and granularity [13]. In other words, these metrics guarantee that the output BPEL process meet the key quality features. In the following sub-sections, the details of phases are revealed.

A. Requirement specification

In the first phase, SOBNP realization framework deals with VE architect in order to grasp his/her requirements. Requirements can be specified and conveyed via business rule languages. A business rule is a statement that defines or constrains some aspect of the business. Business rule languages are going to be the common language among various enterprises.

There are miscellaneous languages for business rule specification such as RuleML[17], SBVR[9], SWRL[18], and so on. Each of these languages has both advantages and disadvantages. In this regard, [19] explores the pros and cons of state of the art for business rule languages.

SOBNP realization framework leverages SBVR language since the SBVR has salient advantages including quite straightforward structure, and notably easy to use for business people [19], that is, for someone without training in formal methods. Both former and latter features make it appropriate for our framework since our approach should be close to the end user (i.e. VE architect).

A.1. SBVR Language

One of possibly many notations that can be used to express the SBVR meta-model is SBVR Structured English[9]. In other words, SBVR Structured English is a notation which is used to define SBVR vocabulary, definitions, and statements. Even though the semantics of definitions and rules can be formally represented in terms of the SBVR vocabulary and, particularly, in terms of logical formulations, but SBVR Structured English is natural and easy to use for business people.

A.2. Requirement Ontology: Transformation of SBVR from CIM to PIM

Requirement ontology is, in fact, the representation of a request using ontology languages that capture consensual knowledge of requirements in a formal way. In fact, it specifies the expected competencies of desired partner. In this subsection, we aim to discuss how the VE architect can verbalize requirements and thereafter how the corresponding ontology of requirements has been generated.

As discussed earlier, SBVR is conceptualized optimally for business people and designed to be used for business purposes independent of information systems designs. According to Model Driven Architecture (MDA) models [20] SBVR language is situated in computational independent model (CIM) [21]. Therefore we have to transform it from CIM model to platform independent model (PIM) to make it appropriate for applying required computations and processing. Since SOBNP realization framework leverages ontology-based techniques for partner selection, we have to transform specified requirements which are in SBVR into corresponding ontology. Among various ontology languages the framework leverages OWL-DL [22] because it provides required expressiveness and also most of the existing tools support that. Therefore, we have to generate corresponding OWL-DL of SBVR. Further, generated OWL-DL is utilized to choose desired activities semantically.

As stated, our framework needs to be semi-automatic; hence the transformation from SBVR to OWL-DL must be automatic. In this regard, our framework leverages Attempto Controlled English (ACE) [23]. ACE is a subset of English (i.e. controlled English) that can be unambiguously translated into first-order logic (FOL). Following, the produced FOL can be translated to OWL-DL, with the aim of Attempto Parsing Engine (APE) web service which produces concerned OWL with ACE sentences.

Owing to the fact that the business vocabulary and rules in SBVR underpinned by First Order Predicate Logic, it is rational and feasible to distinguish the relationship between ACE construction rules [24] and SBVR Structured English. In other words, it is possible to easily recognize that to what extent ACE supports SBVR Structured English, since ACE function words such as determiners, quantifiers, prepositions, coordinators, negation words, etc. are predefined and cannot be changed by users.

A.3. SOBNP Ontology

After taking VE architect's requirements (using business rule language) and translating them into corresponding ontology, the framework utilizes a semantic matchmaking algorithm that tries to find the partner that its ontology match with the expressed requirement. Therefore, there is a key assumption in the proposed approach that is every partner in the network defines and organizes relevant knowledge about activities, processes, organizations, skills, competencies etc. using OWL-DL ontology language. In reality, such an assumption is trivial, since in the last decades many projects aimed at creating ontologies concerning the domain of virtual enterprises including Collaborative Network Organization (CNO) ontology[25], TOronto Virtual Enterprise ontology (TOVE)[26]. However, these ontologies do not overlay the required scope and depth in SOBNP Realization framework.

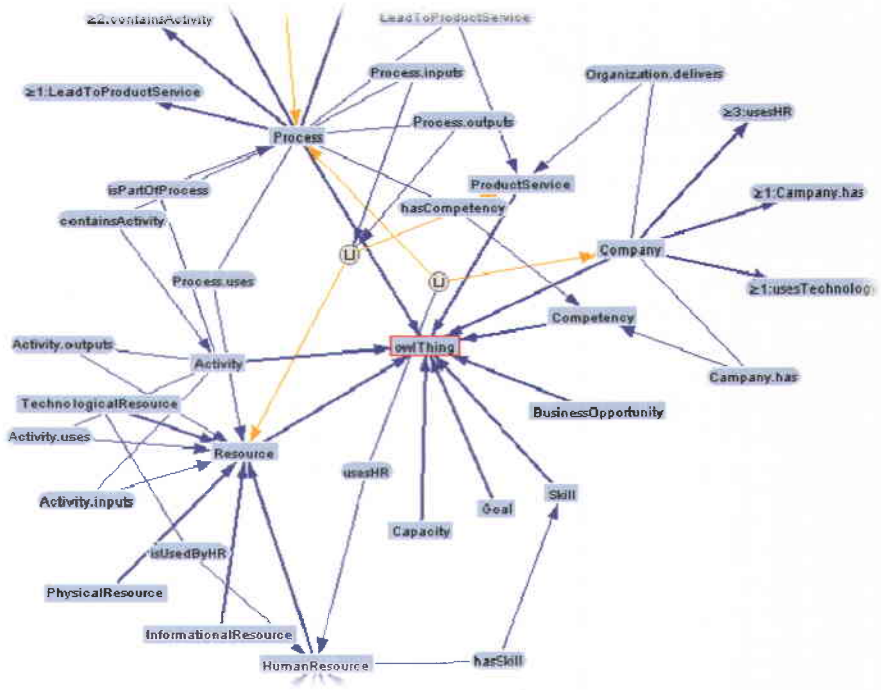

Figure 3. Some elements of SOBNP ontology

To construct the required ontology, we follow some of steps and recommendations of Noy and McGuinness's methodology [27] which relies on developing an ontology using Protégé tool [28]. The methodology consists of seven steps including defining ontology scope, reusing existing ontologies, enumerating major terms, defining classes and class hierarchy, defining slots (i.e. class properties), defining facets of slots, and creating instances.

To determine the scope of the ontology, we need to sketch a set of questions (i.e. competency questions) on the condition that the ontology should answer [29]. By inspiration of Hepp and Roman's work[30], here are some of the questions for determination of SOBNP ontology scope:

- What is a business opportunity?
- What are the goals of a particular SOBNP?
- Does a particular SOBNP contribute to a business opportunity?
- Which set of activities does constitute a particular SOBNP?
- What are the conditions of a qualified activity?
- What kinds of resources exist for a particular SOBNP?
- For each activity in a particular process, what are the pre-state and post-state?

After scope determination, it is expected to reusing the existing ontologies to eliminate cost, time, and effort for building the ontology. There are two major efforts such that their partial combinations can make extensive progress in SOBNP ontology development. These ontologies are CNO ontology [25] and Multi Meta-Model Process Ontology (m3po)[31].

In [32], Plisson et al, proposed CNO ontology, which is also referred as Virtual organization Breeding Environment (VBE) ontology. The proposed ontology overlay two different level of knowledge in a network. First level deals with common knowledge about the organizational structure itself and the second one copes with the domain specific knowledge that such networks cover. Even though CNO ontology satisfies some semantic issues of our framework; it lacks to supply the required depth of knowledge that we have to know about each partner within a network, for instance, the sub-processes or activities of a particular process. On the contrary, some elements of CNO ontology are outside of our ontology scope, for instance, some kinds of CNO concepts (e.g. Virtual team, professional virtual community), some VBE roles (e.g. VBE Support Institution), etc.

In this regard, M3po embodies five aspects of workflow specifications including functional and behavioral, informational, organizational, operational, and orthogonal. In the same way, we include some parts of functional and behavioral aspects and exclude the other aspects on the basis of SOBNP ontology scope.

Table 1. The characteristics of SOBNP ontology

Characteristics	SOBNP Ontology
Max Depth of Ontology	4
Number of Concepts	23
Number of Relationships	34
Super/SubClassOf Relationships	25

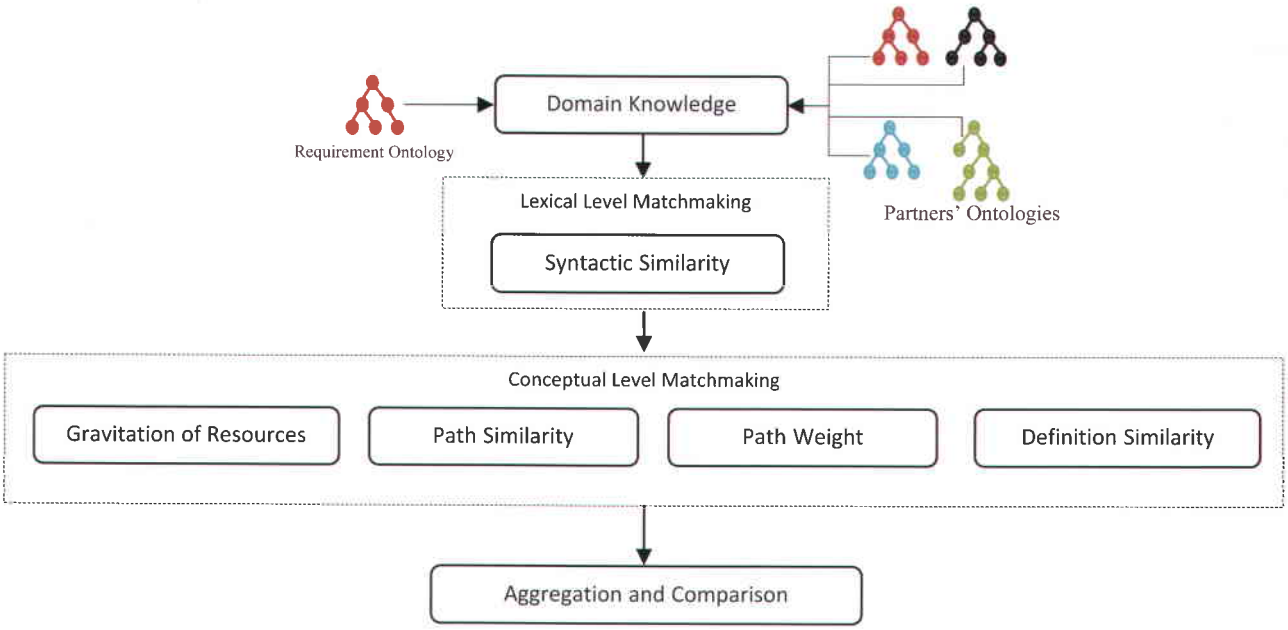

Figure 4. framework of hybrid ontology-based partner selection

Instantiation of SOBNP ontology can be achieved semi-automatically or manually. Moreover, provided any partner within a network does have any existing ontology, it is beneficial to integrate it to SOBNP ontology via ontology merging methods. Figure 4 represents some of the concepts from SOBNP ontology. Besides, Table 1 denotes the characteristics of the designed SOBNP ontology.

B. *Ontology-based semantic partner selection*

In this section, we are going to match the requirements, which are now in OWL-DL, against the SOBNP ontology. The proposed partner selection algorithm identifies the best partner through semantic similarity measurement between VE architect's requirement ontology and partners' ontologies.

The proposed SOBNP Realization framework utilizes the ontology-based partner selection algorithm that has thoroughly been discussed by the authors in [33][34]. The approach for semantic matchmaking consists of three phases including Lexical level matchmaking, Conceptual level matchmaking, and Aggregation and comparison, Figure 4.

First of all, both requirement ontology and partners' enterprise ontology, as inputs are inserted into the framework. In fact, it is expected to find the best partner who satisfies the requirement as much as possible. At the first phase, the framework measures syntactic similarity of resources (i.e. concepts or concept instances) between two ontologies. Thereafter, at the second phase, the resulted sets which are the outputs of syntactic similarity analysis are going to be examined via semantic-based techniques including gravitation of resources, path similarity, path weight, and definition similarity. At the third phase, Conceptual similarity values are compared in order to identify the qualified partner.

C. *Synthesizing abstract BPEL process*

This section aims to describe the third phase of SOBNP creation. In this phase the VE architect have to express the process patterns among selected activities to synthesize desired SOBNP. In other words, we have to synthesize the activities in the activity repository for the purpose of generation abstract BPEL of the desired SOBNP. Synthesis is the process of producing one specification from another at an appropriate level of abstraction, while significant features of the source specification are kept in the target one [35].

Although a body of work has been reported on generating process models in the area of service oriented computing, but most of them are not suitable to novice process owners, VE architects, business managers or business domain experts. For instance, Yu et al. [35] propose an outstanding method for generating process model on the basis of temporal business rules. Their method uses PROPOLS language [36] for specification of the rules. However, in our perspective the PROPOLS language requires that the end-users do have background in formal methods in order to express rules accurately.

Thus, regarding SOBNP realization framework needs an approach that gets harmonized with its demand; we use workflow patterns for synthesizing process model. According to our framework requirements, utilizing workflow patterns is an appropriate choice, since they are easy to use for VE architects and their semantics is clear already. Workflow process schemas are defined to specify which activities need to be executed and in what order. Van der Aalst and his colleagues [37] introduce 26 workflow patterns, but not all of them do have common-use in business process schema generation.

Table 2. Workflow patterns and their corresponding BPEL constructs

Workflow Patterns	BPEL Construct	BPEL Code
Sequence	<Sequence>	<sequence standard-attributes> standard-elements activity+ </sequence>
Parallel Split	<Flow>	<flow standard-attributes> standard-elements <links>? <link name="ncname">+ </links> activity+ </flow>
Exclusive Choice	<Switch>	<switch standard-attributes> standard-elements <case condition="bool-expr">+ activity </case> <otherwise>? Activity </otherwise> </switch>
Simple Merge	-	This pattern is supported directly by means of the <Switch> construct and alternatively by using links with disjunctive transition conditions inside a <Flow> construct.

Our framework and its supported toolset, in initial phases utilizes four basic control flow patterns including Sequence, Simple Merge, Exclusive Choice, and Split Parallel through which VE architect could synthesis expected SOBNP. These patterns have equivalent BPEL constructs. Table 2, denotes the above-mentioned patterns and their corresponding BPEL constructs.

V. System Implementation

In the previous sections, we have described an abstract architecture of SOBNP realization framework. In this section, we discuss the architecture and technologies that have been employed for the purpose of realizing the system. Totally, the system has an interface for business rule specification and three modules. Figure 5 shows the architecture of implemented tool. First module copes with generation of corresponding OWL-DL of SBVR. The second module deals with semantic-based partner selection and the last one concerned with synthesizing composite process model.

For user interface module, we have chosen the Eclipse rich client platform. For generation of corresponding OWL-DL of SBVR module we have used ACE parsing engine. For partners' activities selection, we have used Secondstring Java package [38] for syntactic similarity measurement and Jena package [39] for semantic based similarity

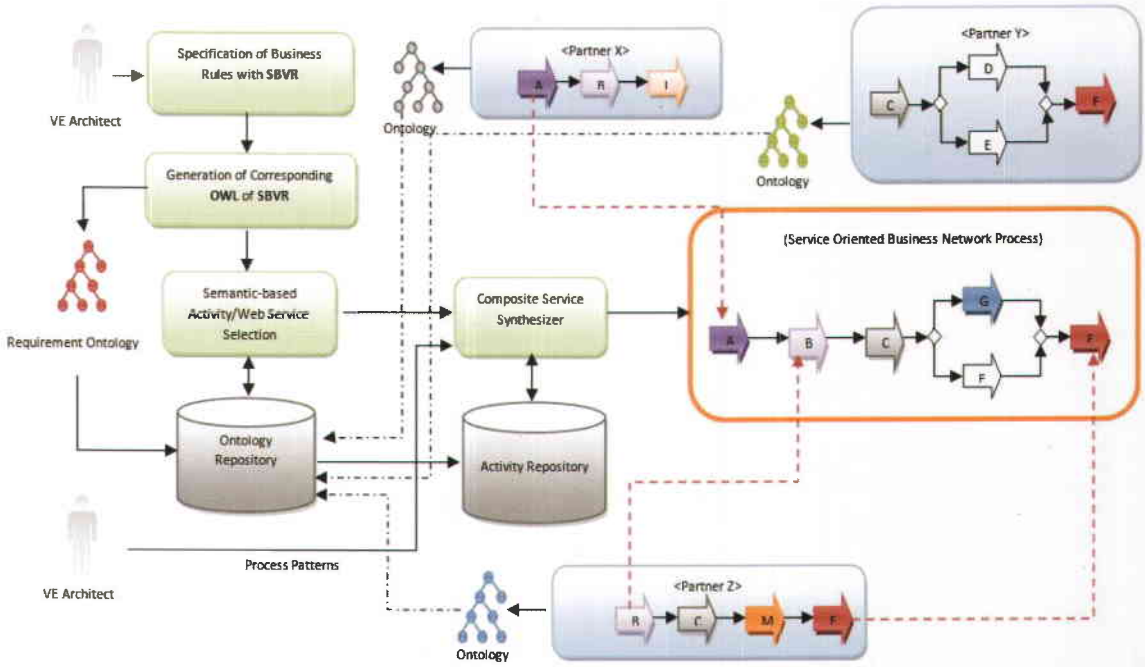

Figure 5. Architecture of prototype

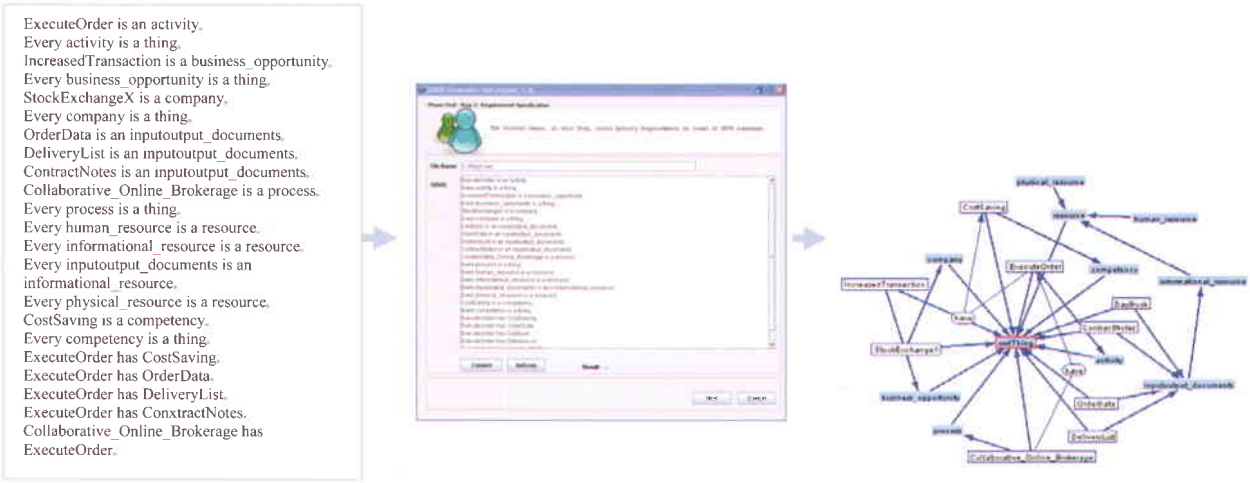

Figure 6. Business requirement specification and translation process

measurement. Jena is a Java framework for building Semantic Web applications.

VI. SOBNP Realization Framework Evaluation

This section aims to evaluate and validate the proposed framework through two approaches: a) Scenario simulation; b) Gathering experts' judgments through a survey. In fact, the first approach demonstrates, firstly, how our framework works, and secondly, how easily and instantly a VE architect could constitute the expected SOBNP. On the other hand, the second approach examines that if the proposed framework meets the expressed claims in terms of experts' views.

A. Scenario Simulation

In what follows, we will show how our framework generates SOBNP in terms of the business scenario that was described in section 2 (i.e. Collaborative Online Brokerage).

A.1. First step of Phase one: High-level Requirement Specification

As discussed earlier, in the first step of the phase one, the VE architect must express his/her high-level requirements including goals, activities, opportunities, competencies through SBVR. Figure 6, denotes a sample high level requirement for the given scenario in which a VE architect specifies his/her business requirements about ExecuteOrder activity. In fact, even though there are some Stock Exchange organizations that have such an activity, but some of them may satisfy the expected requirements. The output of this step is the corresponding ontology of specified requirement that is requirement ontology, Figure 6.

A.2. First step of Phase Second: First-level Matchmaking

In the next step (Step 1, Phase 2) the VE architect must match the requirement ontology with partners' ontologies to identify and select best partners. This step is done through ontology-based partner selection tool that is depicted in Figure 7.

This should be noted that, the VE architect could select best partners for all of the activities once. However, if we repeat these two steps for every activity separately, the obtained results would be more desirable. This is due to the fact that, each partner may excel at one activity; hence if we analyze partners separately, each of them has a chance to be selected for participation.

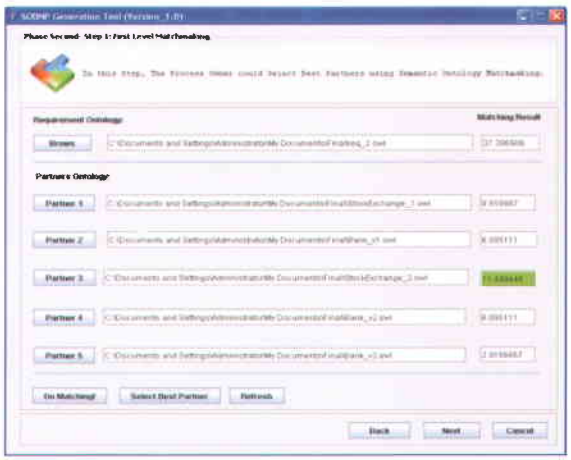

Figure 7. Ontology-based partners' activities selection form

A.3. Second step of Phase One: Low-level Requirement Specification

In the second step of the first phase, VE architect must specify the detailed requirement about each web service that supports selected activities in previous step. To be more specific, we assume that there is a web service that support ExecuteOrder activity, for instance. This web service may have various versions with different QoS; hence VE architect must express the expected QoS. Figure 8, indicates the sample low-level requirements that express the expected QoS for ExecuteOrder web service. The output of this step is low-level requirement ontology, Figure 8.

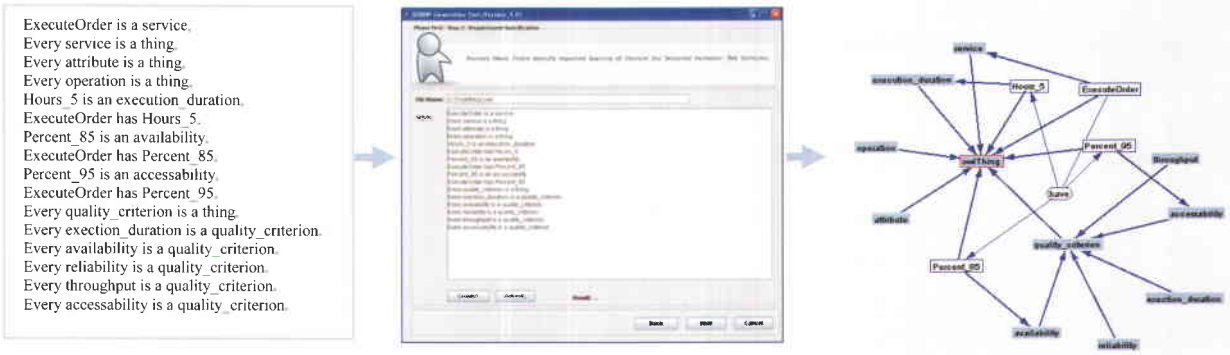

Figure 8. Technical requirement specification and translation process

A.4. Second step of Phase One: Low-level Requirement Specification

In second step of the phase two, VE architect must match the low-level requirements with OWL-S partners' ontologies. It should be noted that step 2 and 4 utilizes the same algorithm for partner selection. Figure 9 shows ontology-based partners' web services selection form.

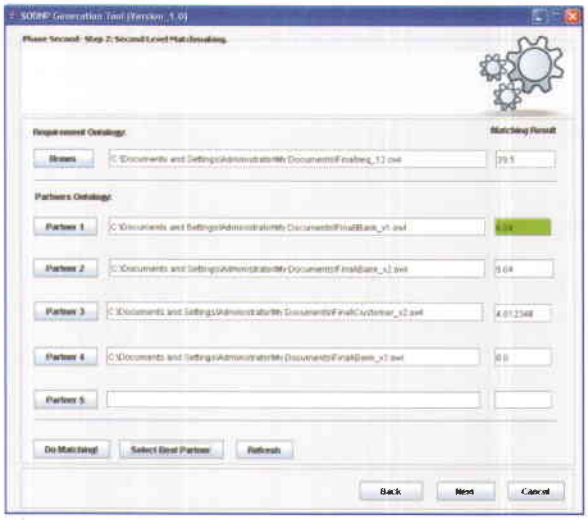

Figure 9. Ontology-based partners' web services selection form

A.5. Phase third: BPEL Process Synthesis

After identifying the best partners, VE architect must determine appropriate patterns between selected web services and synthesize the abstract BPEL for desired SOBNP. For the given example the patterns is set as depicted in Figure 10. Thereafter the corresponding process model is synthesized by the tool and the output BPEL process is formed. For readability reasons, the produced Abstract BPEL are modeled and represented through Eclipse BPEL Designer plug-in [40].

B. Framework capabilities analysis

To evaluate the SOBNP framework, we have employed the Sol methodology framework [41], which pays explicit attention to all the important aspects of a development methodology. Sol's framework defines a set of essential factors that characterize an information system development process and classifies them into a way of thinking, a way of modeling, a way of working, and a way of controlling. The way of thinking of the process provides an abstract description of the underlying concepts. The way of modeling of the method structures the models, which can be used in the information system development. The way of working of the process organizes the way in which an information system is developed. It defines the possible tasks that have to be performed as part of the development process. The way of controlling of the process deals with specific management aspects of the development process in terms of the resource management, actors' roles, intermediate and final results.

We utilize the above-mentioned aspects to verbalize and determine both general and specific capabilities of our proposed process and framework, and then used these capabilities to design questionnaires for conducting users' evaluation of our process. The users' evaluation of our process was collected through a survey. To gain experts' judgments, firstly the framework was introduced for them. Thereafter, we simulate some sample scenarios using the prototype system through which they could observe if the framework is usable and nifty.

The interviewees could answer a question based on

Table 3. Survey participants' profiles

No of Experts	Profile	Practical years experienced in IT field in years
1	PhD student in Industrial Eng. Tarbiat Modares University.	9
1	PhD student in Management. Tarbiat Modares University.	7
1	PhD student in Software Eng. Shahid Beheshti University.	5
3	BSc. and MSc. in Software Eng. Amirkabir University, I.A. University	7
3	MSc. students in Software Eng. Shahid Beheshti University.	4

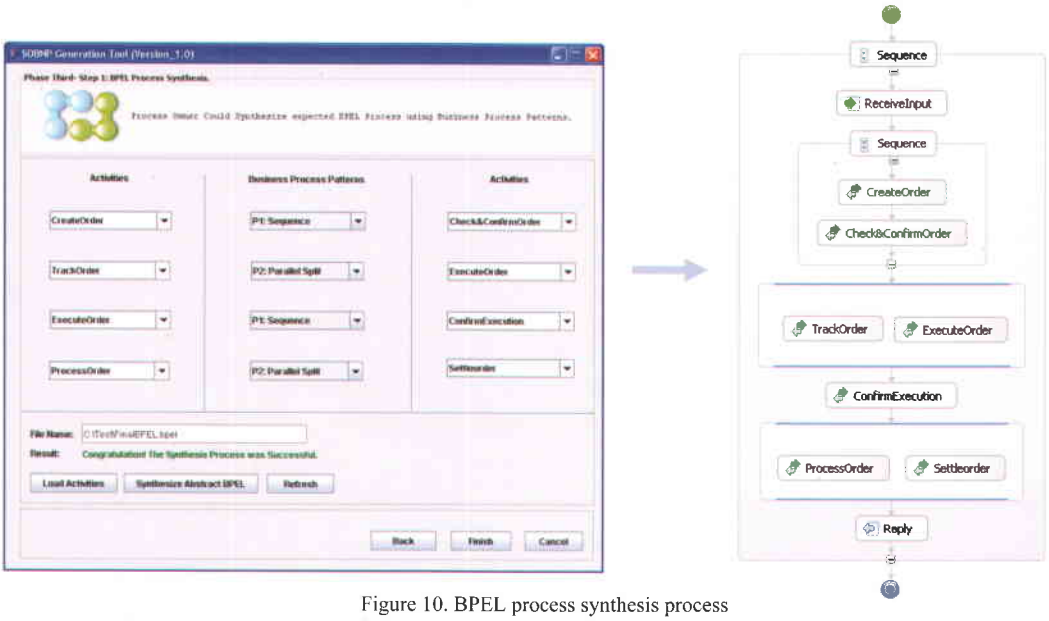

Figure 10. BPEL process synthesis process

a five-point Likert scale [42] ranging from (1) strongly disagree, (2) disagree, (3) neutral, (4) agree to (5) strongly agree. We had nine participants in the survey from both academic and industry. Table 3 denotes survey participants' profiles. These experts were selected based on the following criterion:

- They must have experience in business process engineering projects.
- They must have experience in development and deployment of information system projects.

After gathering experts' judgments, the authors use statistical test to gain confidence for the directions of the outcomes. Table 4 and 5 denote the questionnaire and the experts' answers with respect to the provided questions. In the survey Table, M denotes the mean that is the average of the given grades, STD denotes the standard deviation, and NP represents the number of positive responses, i.e. responses 4 or 5.

According to the obtained results, we obtained indications of positive evaluation of our proposed framework from persons involved in with the framework explanation and its toolset simulation through statistical analysis of the answers which are shown in Table 3 and 4. With respect to the point that the mean value more than 3.5 indicates that the statement is agreeable by the experts, among the 14 statements in questionnaire, just statement number 5 gets the value of 3.22 which obviously is less than 3.5. The statement number 5 question that if the framework can be employed in the scale of real enterprises and networks. Since the SOBNP Realization framework is one of the rare semi-automated approaches for IVE creation that has been adjusted to be employed by VE architect, it seems trivial that the work needs to be matured further in the future to get ready for actual use in real world networks of organization.

VII. Discussion and Future Directions

A.1. Converting requirement from SBVR to OWL

One of the key challenges in our approach is concerned with our translation. It is not possible to transfer all the SBVR Structured English via ACE since not every English sentence is an ACE sentence.

Table 4. Experts' answers with respect to general capabilities of the SOBNP realization framework

No	SOBNP Realization framework capabilities	1	2	3	4	5	NP	M	STD
1	Both framework and its concerned toolset are easy to use, straightforward and trouble-free.	0	0	1	5	3	8	4.22	0.62
2	The overall performance of the framework and its toolset is acceptable.	1	0	1	6	1	7	3.66	1.05
3	The framework accelerates the process of IVE creation.	0	0	0	5	4	9	4.44	0.49
4	The framework simplifies the process of IVE creation.	0	0	2	2	5	7	4.33	0.81
5	The framework can be employed in the scale of real enterprises and networks.	0	3	3	1	2	3	3.22	1.13
6	The framework shows the importance of automated approaches for SOBNP creation.	0	0	0	6	3	9	4.33	0.47

Table 5. Experts' answers with respect to specific capabilities of the SOBNP realization

No	SOBNP Realization framework capabilities	1	2	3	4	5	NP	M	STD
1	The VE architect could generate expected SOBNP without deep knowledge of computer science.	0	0	2	6	1	7	3.88	0.56
2	The framework could generate business processes at different level of abstractions.	1	0	1	7	0	7	3.55	0.95
3	The framework covers both high-level (i.e. business level) and low-level (technical-level) requirement in business process creation.	1	0	1	5	2	7	3.77	1.13
4	The framework realizes the requirement specification phase properly.	0	0	1	5	3	8	4.22	0.62
5	The framework realizes the partner selection phase properly.	0	0	2	2	5	7	4.33	0.81
6	The framework realizes the process model synthesis phase properly.	0	0	2	4	3	7	4.11	0.73
7	The developed methods and algorithms have appropriately been integrated into the framework.	0	0	3	2	4	6	4.11	0.87
8	The framework could be integrated with business modeling and software development environments.	0	1	3	3	2	5	3.66	0.94

In addition, OWL-DL does not capture the full semantics of SBVR [43]. It means there are FOL definitions expressing the SBVR structures that cannot be rendered with OWL-DL. For that reason, the fundamental work on improving the translation approach is ahead.

A.2. Nested control constructs

The implemented prototype in its initial states does not support complex business processes in which the process could have nested control constructs. Moreover, in those cases the determination of nested controls could be hard and complicated for VE architect; hence we aim to develop some heuristics through which the VE architect could synthesize complicated SOBNPs straightforwardly. To be more specific, the authors want to provide an environment through which VE architect could, firstly, specify some control-flow rules among the activities using SBVR. Thereafter, the system infers the rules and generates some potential process models. Finally, VE architect could select the one which is exactly what he/she expected.

A.3. Metrics Suite

As cited in section 4, third phase includes a background activity that is process measurement and optimization. This activity examines the designed SOBNP on the basis of a metrics suite. Now, we are engaging with the implementation of the metrics suite module of our SOBNP Realization framework in Automated Software Engineering Research group (ASER [1]). Thereafter, we also intend to put the approach to the test to evaluate and verify the framework and computations against more actual utility and real life cases.

1 http://aser.sbu.ac.ir/

VIII. Conclusion

Dynamic market conditions require a flexible framework through which novice VE architects, business managers, or business domain experts could design and realize business processes instantly. In this paper, the authors presented a framework and associated techniques and toolset to semi-automatically realize SOBNP in IVEs. The approach has two salient features that in combination make it stand out with respect to other approaches. Firstly, it has been tuned to the end-user (i.e. the VE architect) who does not have deep knowledge of computer science. Secondly, it covers business level and technical-level requirements in business process creation. A proof-of-concept prototype system implemented to demonstrate the concept of VE architect-driven service-oriented business network process realization in IVE.

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References

[1] P. Grefen, et al., (2008) Dynamic business network process management in instant virtual enterprises, Computers in Industry (Ind), doi:10.1016/j.compind.2008.06.006

[2] A. Presley, J. Sarkis, W. Barnett and D. Liles, (2001) Engineering the Virtual Enterprise: An Architecture-Driven Modeling Approach; International Journal of Flexible Manufacturing Systems, Volume 13, Number 2 / April, 2001.

[3] G. Chen, W. Ren, J.B. Zhang, Z. Yang, C.P. Low, C. Sun, D. Chen, (2008) Dynamic virtual enterprise integration via business rule enhanced semantic service composition framework. 3rd IEEE Conference on Industrial Electronics and Applications. ICIEA 2008.

[4] B. Zhou, Z. He, J. Tang, (2005) An adaptive model of virtual enterprise based on dynamic web service composition, in: Proceedings of the 5th International Conference on Computer and Information Technology, Shanhai, China, 2005.

[5] T.J. Norman, A. Preece, S. Chalmers, N.R. Jennings, M. Luck, V.D. Dang, T.D. Nguyen, V. Deora, J. Shao, W.A. Gray, N.J. Fiddian, Conoise: (2003) agent-based formation of virtual organisations, in: Proceedings of the 23rd SGAI International Conference on Innovative Techniques and Applications of Artificial Intelligence, 2003, pp.353–366.

[6] M. B. Juric, B. Mathew, P. Sarang, (2006), Business Process Execution Language for Web Services, Packt Publishing, Birmingham, B27 6PA, UK, Second edition.

[7] SAP Solution Composer, (2006), available at: http://www.sap.com/solutions/businessmaps/composer/index.epx

[8] L. Zeng, et al. (2008) "Dynamic composition and optimization of Web services", Distrib Parallel Databases 24: 45–72 DOI 10.1007/s10619-008-7030-7.

[9] OMG: Semantics of Business Vocabulary and Business Rules (SBVR), Second Interim Specification; September (2006), http://www.omg.org

[10] L. Li, B. Wu, and Y. Yang; (2004) An Ontology-Oriented Approach for Virtual Enterprises; APWeb 2004, LNCS 3007, pp. 834–843, Springer-Verlag Berlin Heidelberg 2004.

[11] J. Huang, J. Dang, and M.N. Huhns, (2007) "Ontology-Based Partner Selection in Business Interaction," Handbook of Ontologies for Business Interaction. Peter Rittgen, editor, IGI Global, 2007, pp. 364 - 380.

[12] C. Wang, et al (2008) A comprehensive semantic-based resource allocation framework for workflow management systems; IEEE Network Operations and Management Symposium, 7-11 April 2008. DOI=10.1109/NOMS.2008.4575225

[13] A. Khoshkbarforoushha, R. Tabein, P. Jamshidi, F. Shams; (2010) Towards a Metrics Suite for Measuring Composite Service Granularity Level Appropriateness, IEEE Congress on Services (SERVICES 2010) July 5-10, Hyatt Regency Miami, FL, USA.

[14] A. Khoshkbarforoushha, P. Jamshidi, F. Shams, (2010) A Metric for Composite Service Reusability Analysis, International Workshop on Emerging Trends in Software Metrics (WETSoM), ICSE 2010, Cape Town, South Africa.

[15] A. Khoshkbarforoushha, P. Jamshidi, A. Nikravesh, F. Shams, (2011), Metrics for BPEL process context-independency analysis, Service-Oriented Computing and Applications, Springer London, pp.1-19, DOI: 10.1007/s11761-011-0077-8

[16] J. Cardoso, (2007), Complexity Analysis of BPEL Web Processes, Software Process Improvement and Practice, Wiley InterScience; 12, 35–49.

[17] RuleML: The Rule Markup Language, available at: http://ruleml.org/

[18] SWRL: A Semantic Web Rule Language Combining OWL and RuleML, available at: http://www.w3.org/Submission/SWRL/

[19] L. Braye, S. Ramel, B. Grégoire, S. Leidner, M. Schmitt; (2006) State of the Art Business Rules Languages; Public Research Centre Henri Tudor, EfficientSwift/D3.1; September, 2006;: http://efficient.citi.tudor.lu/cms/efficient/content.nsf/0/4A938852840437F2C12573950056F7A9/$file/BusinessRulesLanguages_D3.1.pdf

[20] OMG: Model Driven Architecture - http://www.omg.org/mda/

[21] J. L. Martínez-Fernández, , J. C. González, , J. Villena, , and P. Martínez, (2008). A Preliminary Approach to the Automatic Extraction of Business Rules from Unrestricted Text in the Banking Industry. 13th international Conference on Natural Language and information Systems vol. 5039. Springer-Verlag,. doi: http://dx.doi.org/10.1007/978-3-540-69858-6_29.

[22] W3C: OWL Web Ontology Language Overview - http://www.w3. org/TR/owl-features/

[23] N.E. Fuchs, U. Schwertel, S. Torge, (1999) Controlled natural language can replace first-order logic. 14th IEEE International Conference on Automated Software Engineering, 1999. DOI=10.1109/ASE.1999.802325

[24] The ACE 6.0 Construction Rules; available at: http://attempto.ifi.uzh.ch/site/docs/ace_constructionrules.html

[25] The CNO ontology; available at: http://kt.ijs.si/software/CNOntology/onto.zip

[26] M. S. Fox, (1992) .The TOVE project: A common-sense model of the enterprise, in Industrial and Engineering Applications of Artificial Intelligence and Expert Systems, Lecture Notes in Artificial Intelligence, no. 604. Berlin, Germany: Springer-Verlag, 1992, pp. 25.34.

[27] N. F. Noy and D. L. McGuinness, (2001) .Ontology development 101: A guide to creating your first ontology. Stanford Knowledge Systems Laboratory, Tech. Rep. KSL-01-05.

[28] The Protégé project. (2000). Available at: http://protege.stanford.edu

[29] M. Gruninger, and M.S. Fox, (1995). Methodology for the Design and Evaluation of Ontologies. In: Proceedings of the Workshop on Basic Ontological Issues in Knowledge Sharing, IJCAI-95, Montreal.

[30] M. Hepp, D. Roman: (2007) An Ontology Framework for Semantic Business Process Management, Proceedings of Wirtschaftsinformatik, February 28 - March 2, 2007, Karlsruhe (forthcoming).

[31] A. Haller, E. Oren, P. Kotinurmi, (2006) m3po: An Ontology to Relate Choreographies to Workflow Models; IEEE International Conference on Services Computing. SCC apos; 06. DOI=10.1109/SCC.2006.65

[32] J. Plisson, P. Ljubic, I. Mozetic, N. Lavrac, J. Stefan Inst., Ljubljana; (2007) An Ontology for Virtual Organization Breeding Environments; IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, Volume: 37, Issue: 6; pp: 1327-1341; Nov. 2007.

[33] A. Khoshkbarforoushha, M. Aghdasi, (2009) "Rule-Based Service Oriented Business Network Process Realization in Dynamic Virtual Enterprises", Proc. of IEEE International Conference on e-Business Engineering (ICEBE 2009), Macau, China.

[34] A. Khoshkbarforoushha, M. Shamsfard, M. Aghdasi; (2010) "VE Architect-Driven Partner Selection: Ontology-Based Approach"; Expert Systems with Applications, Under Review.

[35] J. Yu, YB. Han, J. Han, Y. Jin, P. Falcarin, M. Morisio, (2008), Synthesizing service composition models on the basis of temporal business rules. Journal of Computer Science and Technology 23(6): 885-894 Nov.

[36] J. Yu, T. Phan, J. Han et al. (2006) Pattern based property specification and verification for service composition. In Proc. 7th Int. Conf. Web Information Systems Engineering, Wuhan, China, LNCS 4255, pp.156-168.

[37] W. M. P. van der Aalst., A. H. M. Hofstede, B. Kiepuszewski, and A. P. Barros. (2003) Workflow patterns. Distributed and Parallel Databases, 14(1):5–51.

[38] W. Cohen, P. Ravikumar, S. Fienberg, SecondString Project Page: http://secondstring.sourceforge.net/

[39] HP Labs, (2002). Jena: A Semantic Web Framework for Java. Available at: http://jena.sourceforge.net/.

[40] Eclipse BPEL Designer Plug-in: Available at: http://www.eclipse.org/bpel/.

[41] H.G. Sol, (1990) "Information Systems Development: A Problem Solving Approach", Proceedings of the International Symposium on System Development Methodologies.

[42] R. Likert, (1932). "A Technique for the Measurement of Attitudes". Archives of Psychology 140: 1–55.

[43] P. Ceravolo, C. Fugazza, M. Leida, (2007) Modeling Semantics of Business Rules; IEEE-IES Digital EcoSystems and Technologies Conference. DEST '07. Inaugural DOI=10.1109/DEST.2007.371965

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