A New Approach to Semantically Derive Enterprise Information Architecture from Business Process Architecture

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Abstract: The design of enterprise information architecture (EIA) is a critical success factor of the information management capability of an enterprise. The EIA design not only supports business process re-engineering activity but can also facilitate radical design of new business processes. This paper demonstrates that EIA can be derived semantically from the business process architecture, hence overcoming the classical problems of time-consuming interviews for business information analysts by using semantically enriched BPA to derive information entities and processes with the help of domain and process ontologies. The cancer care and registration process of a health organisation has been used as a case-study for demonstration purposes. This approach is currently being transformed into a generic Framework for semantic enterprise information architecture design with an aim to bridge the gap between business architectures and enterprise information architectures.

1 INTRODUCTION

Classically, the EIA design activity consisted of building a map of a firm's information resources and business functions based on time-consuming managerial interviews. The subsequent time requirements led to an increasing lack of interest from the strategic management in this vital design effort. However, a consistent emphasis on the vitality of IA (Information Architecture) design in relation to a firm's business processes and information resources has remained the case (Martin, 1989; Teng and Kettinger, 1995) in the business information management research community.

Recent research has identified that the information management capability of an enterprise has a significant contribution towards development of its capabilities in customer management, process management and performance management (Mithas et al., 2011; Sauer and Willcocks, 2003). The Information Management (IM) Capability may be defined as the ability to provide data and information within the desired accuracy and time scale for a given enterprise business process. This implies that the design of information architecture (IA) is of pivotal importance for developing the IM capability. The enhancement implied by this ability develops customer management (CM) capability that generates opportunities to develop customer relationships both as consumers and innovation partners. The IM capability can also contribute towards developing and redesigning business processes for carrying out the activities of an enterprise, reflecting on the Process Management (PM) capability of the enterprise, (Mithas et al., 2011).

The design of enterprise information architecture may, however, remain irresponsive to requirements of gathering business analytics data as well as to changes in business strategy unless it incorporates a comprehensive analysis of business information into the EIA design. Business information resources (business entities and processes) of an enterprise can have pivotal role in information (data) quality, security and corporate strategy as the requirements from these enterprise areas translate into how well and what information resources are managed in the enterprise, and to what extent they correspond to the business process architecture of the enterprise.

This paper puts forward an approach that bridges this gap between business architecture and enterprise

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information architecture using semantic technologies. Semantic information about the business process architecture can be used to derive information architecture of the enterprise which is not only responsive to business information needs but that can also provide leverage to the design of new business processes. Section 2 discusses the classical and contemporary attempts to BPA-oriented EIA. Section 3 discusses the proposed approach that semantically derives EIA entities and processes of the enterprise from BPA ontological artefacts. Section 4 demonstrates the current work through a case-study in cancer-care domain while identifying some adjustments for the parent framework that conceptualises the BPA methodology. Section 5 discusses issues in this approach that we currently face with some possible remedies, and Section 6 concludes this paper.

2 RELATED WORK

Non-Semantic approaches to IA design include enterprise data model approach by (Brancheau et al., 1989), long-range information architecture and ends/means analysis approaches (Wetherbe and Davis 1983), critical success factors approach (Rockart 1979), Information Engineering (IE) based approaches (Martin, 1989) such as IBM's Business System Planning (BSP) and strategic data modeling (SDM). Among these approaches, the enterprise data model approach and the IE-based approaches were business process-centric; however, the IE-based approaches lacked appeal due to the absence of technological advances of today (Kettinger et al. 1996; Teng and Kettinger, 1995). More recently, the EIA is seen as a part of the overall enterprise architecture (EA) of an enterprise and is also mentioned as data architecture. Examples of these approaches include Zachman's Information Systems Architecture (ISA) (Zachman, 1987; Sowa and Zachman, 1992), the Architecture Development Model (ADM) by TOGAF (TOGAF, 2009) and the CEiSAR model (CEiSAR, 2008).

Semantic approaches for Enterprise Architecture (EA) include the TOronto Virtual Enterprise (TOVE), (Fox et al., 1995), however, no semantic approach to generate a data (or information) architecture of an enterprise is process-centric. Genre and Ontologies Based Information Architecture Framework (GOBIAF) by (Kilpelinen, 2007) is based on information need interviews and not based on the knowledge of business entities and processes. The Field-Actions approach by (Pascot et al., 2011) uses field actions for incorporating business process information and uses HL7 ontology but it lacks derivation of information architecture of an enterprise.

3 THE PROPOSED APPROACH

3.1 EIA Semantic Derivation

The approach presented in this paper derives the EIA elements from the fundamental elements of business process architecture of an enterprise modelled using the Riva BPA methodology (Ould 2005). The Riva methodology concentrates on the business of the enterprise and collects essential business entities (EBEs) without which the enterprise will cease to perform its function. It may also collect additional information which is related to a particular way by which an enterprise may have decided to run its business (called designed business entities or DBEs). It extracts from these business entities a set of units of work (UoWs), each of which leads to a business process at the operational (case processes – CPs), managerial (case management processes – CMPs) and strategic (case strategy processes – CSPs) levels respectively. It must be noted here that the CMP and CSP processes are not carried out by business managers or enterprise strategists, rather their names indicate the very nature of the tasks they carry out for a particular EBE of UoW. The CMP and CSP, however, can be used by business managers and / or CIOs to induce changes in BPA for the corresponding entities corresponding to any new decisions made at the enterprise level. This needs to be carried out using enterprise information systems which rely on the EIA, hence highlighting the need for the EIA elements to be directly derivable from the BPA.

3.2 The BPAOnt Ontology

The elements of Riva BPA methodology by (Ould, 2005) were conceptualised into the BPAOnt ontology (Yousef et al., 2009) in their BPAOntoSOA Framework. This ontological representation of BPA can be named as semantically enriched BPA. The BPAOnt ontology was developed in OWL (W3C-OWL, 2004) and contains BPA concepts like EBE (essential business entity), UOW (units of work), Riva_Relations (within UOWs), CP (case process) and CMP (case management process), and relationships among these concepts which makes a good starting point for

the design of the EIA. The starting point for the BPAOntoSOA Framework are crude BP models of an enterprise modelled using Role-Activity Diagrams (RADs) or more recent BP modelling languages like BPMN (Yousef et al., 2009). The business information that causes the development of BPA of an enterprise should rather originate from some other sources, in our view, such as business documents etc. However, the BPAOnt ontological concepts developed through the BPAOntoSOA Framework are considered enough for our approach to start deriving the EIA elements.

As the effort of developing the semantically enriched BPA is a one-off activity for an enterprise corresponding to the developed business process architecture, and needs only minor adjustment corresponding to business change, an Enterprise Information Architecture that holds direct additional knowledge of business processes helps improving the automation of the EIA design process. Thus, it reduces the time requirements for interviews and questionnaires in the sense that the knowledge of business entities and processes is already captured through a semantically enriched BPA. However, this time-saving is more relaizable once the process of semantically enriched BPA development is automated by either accessing machine-readable business process models and workflows or by using natural language processing techniques to analyse business documents and extract business process architectural elements.

3.3 EIA Derivation

The enterprise IA contains design elements that are derivable from the BPA and are one step closer to the systems level because EIA elements represent explicit concepts that can be programmed in an object-oriented environment to develop a business information system that can not only capture events in the enterprise, but can also respond to those events. The EIAOnt ontology has been designed in OWL (W3C-OWL, 2004) using the approach by (Noy and McGuiness 2001) and based on IA concepts by (Gilchrist and Mahon, 2004) and (Evernden and Evernden, 2003; Brancheau et al., 1989), and forms a major component of the BPAOntoEIA Framework. Fundamental EIA elements are EIA entities and EIA processes which are conceptualised as `InformationEntity` and `EIAProcess` concepts respectively in the EIAOnt Ontology. The `InformationEntity` concept is based on the Bung-Wand-Weber's ontological model of information that provides ontological basis for both *concrete* (physical) and *conceptual* (non-physical) entities (Wand and Weber, 1990). Although this type of entity classification provides a sound ontological basis for specification and semantic representation of EIA entities, yet this classification may not be essential for designing and implementing enterprise information system based on these entities. This framework consists of a three-step approach for EIA derivation:

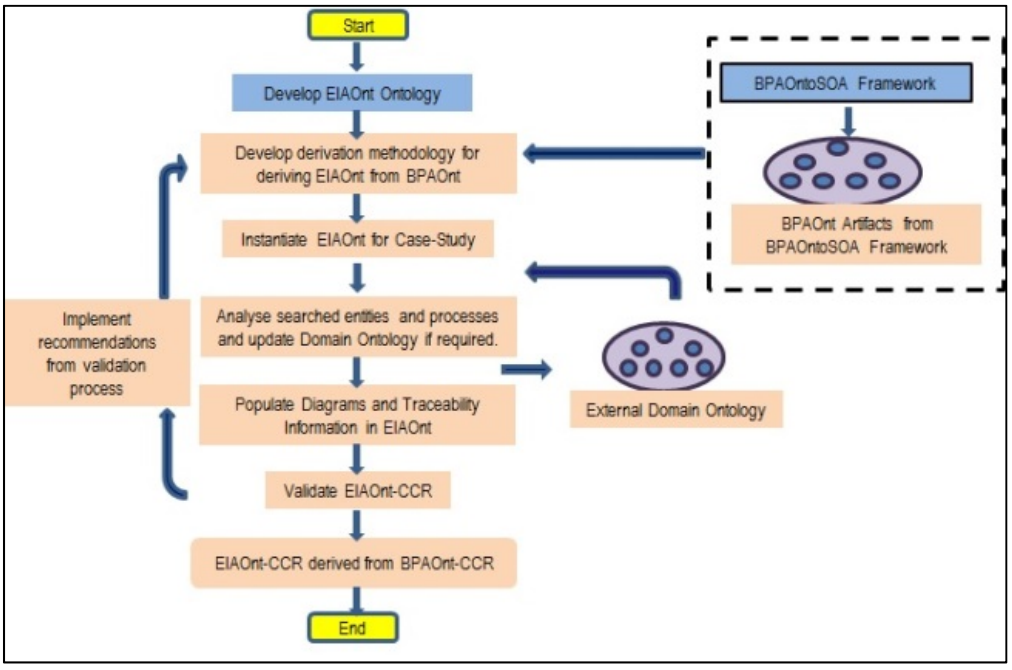

Figure 1: The proposed approach for Deriving EIA from Enterprise BPA.

1) The first step of this approach derives initial set of EIA entities and processes from the EBE and process instances of the BPAOnt ontology by instantiating the BPAOntoSOA Framework for a particular enterprise. The semantic derivation of the EIA entities includes which EBEs qualify to become EIA entities and classifies each of them into concrete and conceptual entities. The semantic derivation also includes derivation of EIA processes from process concepts of BPA, and also captures the associated relationships among process instances, which are *taxonomic* (whole-part) and / or non-taxonomic.
2) The second step of this derivation uses the instances of the EIA information entity and process concepts of the EIAOnt ontology to search for related concepts in external domain ontologies. This also includes identifying the taxonomic and non-taxonomic relationships among new and existing case-study entities and processes. The search for related entities and processes may also result in formation of new external domain ontologies or updating enriching external ontologies through a structured process of searching and cataloguing EIA information entities and processes.
3) Finally, more complex EIA elements such as EIA traceability matrices, EIA diagrams (such as Information flow diagrams and / or Entity-Relationship diagrams) and EIA information views are to be derived. As the name suggests, the EIA traceability matrices provide traceability information for information entities (IEs) corresponding to EBEs in BPA, IEs vs EIA Processes, and the like to ensure that all EIA elements are traceable to generate complete information flow diagrams for an EIA process.

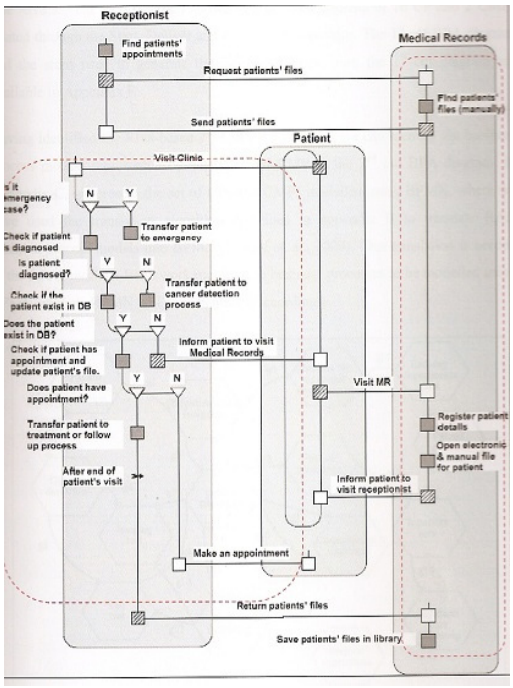

Figure 2: RAD Model of the CCR Patient General Reception sub-process.

4 THE CANCER CARE CASE-STUDY

We demonstrate our new approach by applying it to one sub-process of the Cancer Care and Registration (CCR) process of King Abdullah Cancer Centre in Jordan. The CCR case-study was used by (Yousef et al., 2009) in her research for identifying services corresponding to the BPA elements. The CCR case-study includes the sub-processes of the Patient General Reception, Hospital Registration, Cancer Detection, Cancer Treatment and Patient Follow-up. Of these, we use Patient General Reception sub-process that models the process of a patient's general reception at the Cancer Care Centre. Figure 2 shows the RAD (Ould, 2005) model of Patient General Process.

4.1 CCR BPA Elements

The EBEs and UoWs generated by the instantiated by BPAOntoSOA Framework are listed in Table 1. The output of CCR BPA is described as BPAOnt-CCR in Figure 1. The units of work are listed in bold. Corresponding to every UoW listed, the Riva BPA methodology generates an instance of CP concept and one instance of CMP concept. Before identifying EIA elements, we propose to complete the BPAOntoSOA framework by adding an instance of the CSP concept for every unit of work.

4.2 The CCR EIA Elements

The BPA elements generated by BPA (Table 1) form the basis for the EIA entities and processes in BPAOntoEIA Framework. The semantic derivation process for EIA entities includes SWRL rules that identify which EBEs qualify to become EIA entities. The EBEs, which are semantically derived as EIA entities, are classified as *concrete* or *conceptual* entities. This basic classification is useful because it can facilitate the decision-making processes within

Table 1: BPA elements for the Patient General Reception sub-process in the CCR case-study.

EBEs or UoWs
Patient General Reception
Receptionist (General)
Patient
Medical Records
Appointment
Patient File
Emergency Unit
Cancer detection unit
Database
Patient details
Case Processes (CPs)
Handle Patient general reception
Handle a patient medical record
Case Management Processes (CMPs)
Manage the flow of Patient general reception
Manage the flow of patient medical record

business information system, e.g. supply chain and delivery of a printed book or an electronic book (ebook) version and decide upon cost of delivery accordingly. In the CCR context, EMERGENCY UNIT is a physical entity and has a location, whereas DATABASE is a conceptual entity.

The EIA derivation function generates the CRUD (Create, Read, Update and Delete) processes for every EIA entity. The CRUD processes are sub-concepts of EIAProcess concept in EIAOnt Ontology. The CPs and CMPs also form an initial set of EIA (non-CRUD) processes. Once relationships between these concepts are established and traceability among these elements is determined, the EIA design function then moves on to search in external domain and process ontologies, using automated ontology search processes to look for related entities and processes. This is possible only when domain specific knowledge for a particular business exists, e.g. cancer care domain knowledge for CCR case-study. If there is no domain specific knowledge, the EIA design process can then develop new domain knowledge as its by-product. The search may result in significant increase in the number of EIA entities and processes. The traceability for these newly found EIA elements should establish many-to-many relationships between EIA entities and the initial set of EIA entities which were originally EBEs in BPA. Many-to-many relationships also exist between EIA processes and the EIA entities they access, use and / or modify. Table 2 lists the set of EIA entities and processes in the case-study sub-process after searching for related entity and process concepts in the NCI Thesaurus (Ceusters et al., 2005) and the Medical Ontology by Advance Genome Clinical Trials (ACGT) project (Cocos et al., 2008). We have noted that entities in these ontologies are not classified into *concrete* and *conceptual* entities and we therefore recommend constructing a new ontology using this classification for EIA entities. The complete EIA for CCR is referred to an EIAOnt-CCR in Figure 1.

Table 2: Count of EIA elements derived from BPA for Patient General Reception sub-process in CCR case-study after look-up in ACGT Medical Ontology for entities.

EIA Element	Count
EIA Entities	**10**
Entities derived from BPA	8
Entities searched from domain ontologies	2
Concrete entities	5
Conceptual entities	5
EIA Processes	**41**
EIA Processes	3
CRUD Processes	32
IE Management (IEMP) Processes	3
IE Strategy Process (IESP)	3
EIA Traceability Matrices	4

In this table, the IEMP processes are the processes for CMPs in the BPA that manage CPs, and the IESP processes correspond to CSPs.

5 DISCUSSION

The derivation process of these EIA elements has highlighted a number of important issues which can be significant for a complete and correct design of an EIA. Firstly, we note that this approach significantly depends upon the correctness and completeness of the Riva BPA elements identified by instantiating (Yousef et al., 2009)'s BPAontoSOA framework. The starting point of the BPAOntoSOA framework is, however, the business process models of the case-study enterprise that were originally developed through on-site interviews in a previous research (Aburub, 2006). We suggest that the input for BPA development needs to be business documents and business use cases and not necessarily BP models. This, however, should not affect the correctness and validity of EIA as the

needed BPA elements are instances of the BPAOnt concepts, and hence it will generate an EIA corresponding to these BPA elements.

Secondly, although this approach causes EIA design to be heavily dependent upon the business process architecture, yet this becomes a strength and not a weakness of the approach because our proposed EIA is more business process-aware and it is more responsive to business process change if it includes a change management mechanism that tracks any changes in BPA and makes corresponding adjustments to EIA architectural elements. The changes in BPA translate into changes in Riva BPA business entities, processes or relations between its units of work. The change management mechanism of the EIA should capture these changes and initiate EIA 'change processes' to assess the impact of these changes and implement them. Thus, future information requirements, that are not yet expressed in process models will need to emerge from a review of BPA models (driven by strategic management), followed by change in EIA. This limitation or dependence should be seen as an opportunity to review business process architecture. Future information requirements that do not need change in process models may be met through change management processes acting independently of BPA.

Thirdly, the EIA derivation process needs to identify *whole-part* relationships among the EIA entities derived from BPA and also for the entities searched from external domain ontologies. This includes identifying which EIA entities are merely multiple instances of another entity and whether this parent entity needs to be included as an EIA entity or not. We may call this *refactoring* of EIA entities. For instance, there are 10 RECEPTIONIST EBE instances in the BPA. This leads the information architect to define one RECEPTIONIST instance with a variable place of deployment. Furthermore, the RECEPTIONIST entity may be a sub-entity of a PERSON entity of which PATIENT is another sub-entity. The *whole-part* relationship may be added to the information about EIA entities using OWL properties and SWRL rules (SWRL, 2004).

Fourthly, in order to ensure the correctness of EIA derivation approach, human input from information architect (IA) may be essential at certain stages of EIA derivation. For example, the IA's input may be required when refactoring of EIA entities and processes is carried out. This may be carried out through special-purpose dialogue boxes, which may render the above derivation process semi-automated rather than being fully automated, hence further work for further evolution of the current work.

Finally, limitations of such an approach to derive EIA from BPA emerge from those of BPA methodology. This approach is critically dependent upon the Riva methodology as the underlying BPA methodology. This is because the Riva BPA methodology is systematic and focuses on business entities and process in a way that brainstorms all entities and units of work that lead to processes, thus identifying the business components along its natural fault-lines and hence providing a comprehensive (initial) set of EIA entities and processes.

6 CONCLUSIONS

We have presented a new generic approach for semantically deriving the Enterprise Information Architecture of an enterprise from its Business Process Architecture. We have also demonstrated results of this derivation using a real and validated case study based on Cancer Care and Registration in Jordan, namely the CCR case-study. Moreover, we have identified some shortcomings in the current BPAOntoSOA framework algorithm with respect to the extraction of EBEs from business processes and hence the reflection on the inclusion of case strategy process (CSP) in the BPAOnt ontology for a given BPA case. Currently, this approach is limited to the derivation of the fundamental EIA elements such as EIA entities and processes, and the traceability matrices that ensure forward / backward traceability from/to these elements. This approach is to be extended to generate more advanced EIA elements such as information views and information flow diagrams while exploiting the dynamic relations within the BPA's units of work and the traceability of EIA entities and EIA processes that access these entities. Further research includes the generalisation of this approach to a validated Semantic Framework, with maximum automaticity, for deriving the design of an enterprise information architecture from the given business process architecture of that enterprise.

REFERENCES

Aburub, F. A. F., 2006. *A Business Process Improvement Methodology Based On Process Modelling, Applied To The Healthcare Sector*, Phd Thesis, Bristol Institute

of Technology (BIT), University of The West of England.

Brancheau, J. C., Schuster, L. and March, S.T., 1989. Building and Implementing an Information Architecture. *SIGMIS Database,* 20(2), Pp. 9-17.

Ceisar, 2008. *Enterprise Modeling, White Paper*, Downloaded From URL: Www.Ceisar.Org, [July 6, 2011].

Ceusters, W., Smith, B. And Goldberg, L., 2005. A Terminological And Ontological Analysis of the NCI Thesaurus. *Methods of Information in Medicine,* 44, PP. 498-507.

Cocos, C., Brochhausen, M., Bonsma, E. And Martin, L., 2008. *Design Principles of the ACGT Master Ontology: Examples and Discussion.* Deliverable 7.7. Madrid, Spain: UPM.

Evernden, R. And Evernden, E., 2003. *Information First: Integrating Knowledge and Information Architecture for Business Advantange.* Oxford, UK: Elsevier Butterworth Heinemann.

Fox, M. S., Barbeceanu, M.and Gruninger, M., 1995. An Organisation Ontology for Enterprise Modelling: Preliminary Concepts for Linking Structure and Behaviour. *Computers in Industry,* 29, Pp. 123-134.

Gilchrist, A. and Mahon, B., Eds, 2004. *Information Architecture: Designing Information Environment for Purpose.* London, UK: Facet Publishing.

Kilpelinen, T., 2007. *Genre And Ontologies Based Business Information Architecture Framework (Gobiaf)*, University of Jyvaskyla.

Martin, J., 1989. *Information Engineering: Introduction.* Usa: Englewood Cliffs, New Jersey: Prentice-Hall.

Mithas, S., Ramasubbu, N. and Sambamurthy, V., 2011. How Information Management Capability Influences Firm Performance. *Mis Quarterly,* 35(1), Pp. 475-500.

Noy, N. and Mcguiness, D. L., 2001. *Ontology Deelopment 101: A Guide to Creating Your First Ontology.* SMI-2001-0880.

Ould, M., 2005. *Business Process Management: A Rigorous Approach.* UK: British Computer Society.

Pascot, D., Bouslama, F. and Mellouli, S., 2011. Architecturing Large Integrated Complex Information Systems: An Application to Healthcare. *Knowledge and Information Systems,* 27(1), PP. 115-140.

Rockart, J. F., 1979. Chief Executives Define their own Data Needs. *Harvard Business Review,* 57(2), PP. 81-89.

Sauer, C. And Willcocks, L., 2003. Establishing The Business of The Future: The Role Of Organisational Architecture And Informational Technologies. *European Management Journal,* 21(4), Pp. 497-508.

Sowa, J. F. And Zachman, J.A., 1992. Extending And Formalizing The Framework For Information Systems Architecture. *IBM Systems Journal,* 31(4), PP. 590-616.

Swrl, 2004. A Semantic Web Rule Language Combining OWL and RuleML, URL: Http://www.w3.Org/ Submission/Swrl/, [November 10, 2010].

Teng, J. T. C. and Kettinger, W. J., 1995. Business Process Redesign and Information Architecture: Exploring the Relationships. *DATABASE Advances,* 26(1), PP. 30-42.

TOGAF, 2009-Last Update, The Open Group Architecture Framework (TOGAF). Available: http://www. opengroup.org/architecture/togaf9-doc/arch/ [February 25, 2010].

W3C-OWL, February 10, 2004, 2004-Last update, OWL Web Ontology Language Overview. Available: http:// www.w3.org/tr/owl-features/ [July 1, 2009, 2009].

Wand, Y. And Weber, R., 1990. An Ontological Model of an Information System. *Software Engineering, IEEE Transactions on,* 16; 16(11), PP. 1282-1292.

Wetherbe, J. C. and Davis, G. B., 1983. Developing A Long-Range Information Architecture, *Proceedings of National Computer Conference*, May 16-19 1983, ACM, Pp. 261-269.

Yousef, R. M., Odeh, M., Coward, D. And Sharieh, A., 2009. Bpaontosoa: A Generic Framework To Derive Software Service Oriented Models From Business Process Architectures, *Second International Conference on Applications of Digital Information and Web Technologies, IADIWT '09* 2009, Pp. 50-55.

Yousef, R. M., Odeh, M., Coward, D. and Sharieh, A., 2009. Translating Rad Business Process Models Into Bpmn Models: A Semi-Formal Approach. *International Journal of Web Applications (IJWA)*.

Zachman, J. A., 1987. A Framework for Information Systems Architecture. *IBM Systems Journal,* 26(3), PP. 276-292.