Knowledge Enhanced Framework for designing e-Workflow Systems

Farhi Marir, John Ndeta
Knowledge Management Research Centre,
Faculty of Computing, London Metropolitan University,
London, UK
e-mail: f.marir@londonmet.ac.uk, ndetaj@hotmail.co.uk

***Abstract*- Traditional workflow framework in implementing e-business processes has ignored the worker knowledge, the user feedback and problems resulting of incompatibility of inter-organisation e-business processes. The limitation of this framework comes from its behavioural perspective, which focuses only on monitoring and detecting problems in the execution of homogenous intra-organisation business processes. As a result, e-business processes designed and implemented using this traditional workflow framework become increasingly inadequate in the new e-business environment which is characterised by an increasing pace of mobility, business collaboration between complementary organisations, discontinuous and unforeseen change in the business processes. This paper presents results of a research investigation confirming these limitations and proposes a knowledge enhanced framework for design e-workflow that captures the dynamics of e-business process.**

Keywords-e-workflow; framework; e-business process; knowledge management; design pattern

I. INTRODUCTION

Workflow management systems are designed to support business process modelling. Business process modelling is an effective tool for managing organisational change and is known to have brought benefits to many organisations. Organisations and their business processes undergo changes from time to time, and in some cases these changes are dynamic, discontinuous and complex. Organisations change either through anticipation of surprise (proactive) efforts to become more competitive or in response to a need to maintain competitiveness in a changing business environment [1]. During the last decade, workflow technology has become readily available [2]. They are built using a traditional framework for workflow modelling "Fig. 1" which is composed of four perspectives: functional, informational, organisational and behavioural Functional perspective decomposes process functionality into a task hierarchy that can be allocated to actors (human or software agents). Informational perspective however, describes the information objects that are consumed and produced. It also describes the business data, documents, and electronic forms that are transported between actor and the files and databases that store persistent application information. Organisational perspective specifies the roles and actors that are involved in the workflow execution and describes how the organisation configures its resources to perform business processes. Behavioural perspective specifies when and under which conditions a workflow is executed in which routes define the way the information and the knowledge are channelled through the different steps of the process and the rules reflecting the constraints of the business policies and practices.

A major limitation of this traditional framework is that it can typically only support simple, static and predictable business processes, such as insurance and travel claim processing. It is well understood for traditional intra-organisational workflow applications, which span only one organisation and are characterised by structured and predictable business processes and business environment. However, it is increasingly inadequate in the new online business (e-business) era that is characterised by increasing complexities, unpredictable and discontinuous change. Also, with the emergence of the Internet, e-workflow design and evolution within e-business environments where most organisations cooperates or outsource parts of their internal process, a new framework with additional perspectives and modelling concepts are needed for specifying the processes and knowledge flow between these organisation [1][3][4][5]. Furthermore, the perspectives of the traditional framework are not parametrically modelled and as a result they are not flexible and difficult to change.

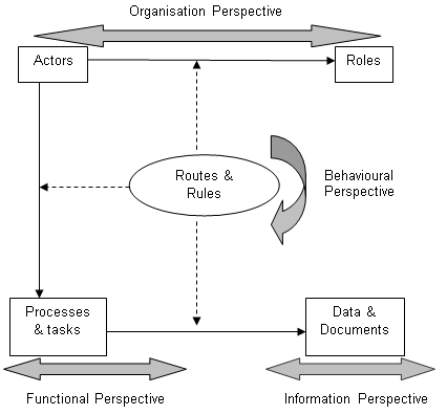

Figure 1. Traditional Framework.

These limitations are consolidated by several research works. Manolescu [6] started from the observation that current workflow systems do not provide the workflow functionality required in object-oriented applications; so, developers are forced to build custom workflow solutions. Furthermore, the thesis claimed that traditional workflow architectures are based on the requirements and assumptions that do not hold in the context of contemporary object-oriented software development. This

 ISBN: 978-1-61208-247-9

mismatch makes current workflow systems unsuitable for developers who need workflow within their applications. Zhuge et al. Reference [7] cited the fact that traditional workflow approaches are too rigid to adapt to the changes of domain business and are not useful in rapid development of virtual organisations. Once the domain business has changed, the system has to be re-designed. Chung et al. [1] stated that, while existing workflow management systems are widely used for the streamlined management of 'administrative' business processes, current systems are unable to cope with the more dynamic situations encountered in ad hoc and collaborative processes. Furthermore, the author's also stated that a major limitation of traditional workflow systems is that they can, typically, only support simple, predictable, but not the dynamically changing and complex processes that are present in many organisations. Ndeta and Marir [8, 9] confirmed through questionnaires and case studies the limitations of traditional framework when it comes to the development of e-workflow to support e-business processes.

This paper addresses the above limitation by enhancing traditional framework with a knowledge perspective that provides workflow modellers with processes and methods to dynamically capture explicit and tacit knowledge generated within or outside the boundary of the organisation. This captured knowledge will play a proactive role as a change manager monitoring and updating the other perspectives actions to reflect the dynamic changes of e-business processes and to increase the flexibility of workflow design and evolution.

The paper is organised as follows; section two is devoted to literature review and related work. Section three will present the proposed knowledge enhanced framework for e-workflow design, the workflow design pattern repository to support the proposed knowledge perspective and also the structure and access to the repository, and finally section four devoted to conclusion and future work.

II. RELATED RESEARCH WORK

Following the limitations of the traditional Workflow Management Systems (WFMS) as presented in the previous section, there have been numerous attempts to tackle these limitations. However, little of the published research work proposed to enhance the traditional framework instead most of the research works have focussed on the improvement of the workflow development within that traditional framework. Their approach focuses more on implementation issues and do not provide clear procedure on how to incorporate knowledge aspects in their e-workflow design.

Ndeta [9] integrated knowledge-based techniques with a workflow management approach to support processes change, trace decisions and to provide notification mechanism. This approach was applicable in civil and software engineering and focuses more on implementation issues and does not look at the other perspectives of workflow modelling e.g., informational and organisational perspective. Dellen et al. [10] provides process-oriented architecture for modelling inter-organisational workflow for e-commerce. It uses Petri-net formalism to model behavioural/dynamic aspects of inter-organisational workflows and the concept of soundness to verify the workflow model. The work failed to show how to model the other perspectives, which are essential during workflow specification and modelling i.e., organisational and information perspectives. The TBPM project in is based on a work carried out in the Enterprise project and centres on an intelligent workflow engine that includes an interactive process planner [11]. This approach focuses more on the functional perspective and implementation issues of workflow application development.

A number of research works use ontology as a tool for explanation and provides an algorithm to resolve the heterogeneity amongst the interfaces of web services and integrate it with workflow tasks. The approach focuses on the functional and information perspective of e-workflow modelling and fails to mention organisational and behavioural perspectives, which are essential if a complete picture of e-workflow modelling is to be exemplified.

Zhuge et al. [7] proposed a simulation-based development framework for establishing virtual organisations. The framework consists of a federation-agent-workflow (FAW) model, a set of rules for establishing the mapping from the domain organisation into the virtual organisation, a set of management services, and a macro development process. The framework unifies the traditional domain organisation and information system model into a virtual organisation model, and allows users to develop intuitive virtual organisations from the viewpoint of the domain. The virtual level is separated from the implementation level that consists of a runtime-support mechanism and a behaviour repository. The approach focuses on implementation issues in the form of a simulation framework. There are no clear procedure and step on how to model some of the workflow perspectives, i.e., functional and information perspectives. Chung et al.'s [1] their adaptive workflow approach uses the ontology and intelligent agents and knowledge based planning techniques to provide support for developing flexible workflow for the development of new product in the chemical industries, where the modelling focuses only on the functional perspective. Medeiros et al. [12] presented the on-going research on their scientific workflow framework called WOODSS. Conceived for supporting scientific work in environmental planning and distributed web-based applications for other scientific domains. The core of this

 ISBN: 978-1-61208-247-9

work is based on creating repositories containing workflow specifications and providing mechanisms for accessing this repository for reuse. This work does not provide generic solution for e-workflow development by ignoring the different perspective of the framework and focussing on the implementation of the repository. Van der Aalst et al. [13] used workflow-mining techniques to create a feedback loop to adapt the workflow model to changing circumstances and detect imperfections of the workflow design and also find explicit representations for a broad range of process models. The approach focuses more on the functional, organisational, behavioural and case perspectives and on implementation or operational issues in the form of reverse engineering. There is no clear procedure and steps on how to develop a workflow application. It is also not clear how the informational perspective of workflow modelling is dealt with in this approach.

There are several issues that have driven the traditional workflow approach into obsolescence. Workflow for e-business processes should be characterised by anticipating surprises, self-control in management, creation and renewal of knowledge, unstructured organisation, intangible assets and proactive work style instead of prediction, compliance, and utilisation of knowledge, tangible assets, and structured organisation and reactive respectively..

III. KNOWLEDGE ENHANCED FRAMEWORK

Workflow modelling and design is well understood for traditional intra-organisational workflow applications, which span only one organisation with structured and predictable business processes and business environment. Traditional framework shown in "Fig. 1" for designing workflow is appropriate for modelling business processes of such organisation as the focus is on the internal work processes and information processes perspectives within the organisation. Thus, designing workflows in the traditional framework is limited to modelling four internal perspectives of the organisation: (i) decomposing organisation process functionality into task hierarchy that can be allocated to existing actors (human or software agents) of the organisation (functional perspective), (ii) describing the organisation information objects (business data, documents and product specs) which are consumed and produced within the organisation (informational perspective), (iii) specifying the roles and actors which are designated by the organisation management to be involved in the workflow execution and describes how the organisation configures its resources to perform business processes (organisational perspective), and (iv) specifying the way the information and the knowledge are channelled through the different steps of the process and the rules and constraints of the organisation business policies and practices (behavioural perspective). If traditional framework is successful in designing workflow to support traditional business processes, it is increasingly inadequate to model e-business processes as it requires not only modelling internal organisation perspectives but coping with unpredictability and continually changes brought by e-business environment [1][6][7][10].

Furthermore, a questionnaire put by the team in collaboration with Workflow Management Coalition found that around 70% of workflow developers have noticed the limitations of traditional framework when designing e- workflow systems for organisation e-business processes [9]. This confirms that a new framework for designing e-workflow systems became a necessity due to the impact of e-business processes on organisation survival and growth in this global and knowledge economy.

This paper presents a new knowledge enhanced framework for designing flexible e-workflow systems, as shown in "Fig. 2" below.

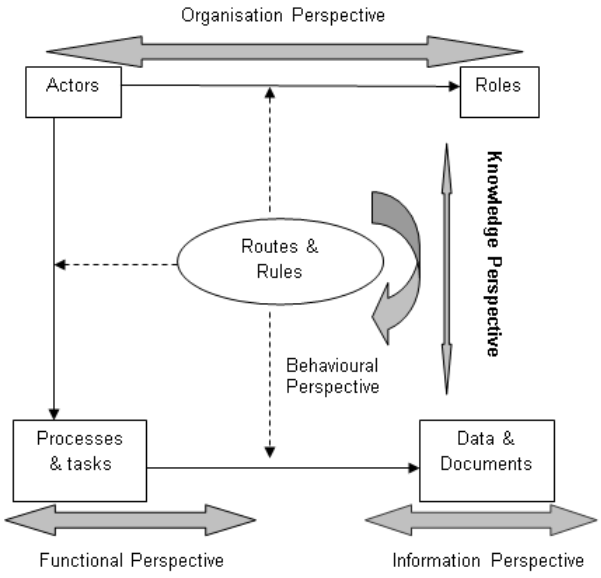

Figure 2. Knowledge Enhanced Framework for e-Workflow.

This new framework enhances traditional framework with a new knowledge perspective and provides new methods for developing e-workflow systems to support dynamic e-business processes. The proposed framework shown in "Fig. 2" borrows concepts and solution from both design and rule patterns to support flexibility during workflow modelling, design and evolution in the new e-business environment. Traditional approaches to workflow modelling mainly deal with the use of rules in specific contexts serving as a mechanism for workflow

 ISBN: 978-1-61208-247-9

enactment and evolution [14]. The proposed framework focuses on providing abstraction mechanisms to represent in an implementation-independent manner the knowledge and experience associated with workflow design. The additional knowledge perspective is set to capture explicit and tacit knowledge generated within or outside the boundary organisation. The knowledge perspective will use the captured knowledge to trigger changes needed to both the organisation e-business processes and the four perspectives of the traditional framework to reflect and satisfy the new requirements of internal and external stakeholders of the organisation. Some examples of the role of this knowledge perspective could be extracting knowledge from data and information flowing between the other perspectives, memorising successful stories and best practices within or outside the boundary of the organisation or recording views of external stakeholders such as customer on the organisation e-business processes. The captured knowledge could be fed back into the organisation to be used to undertake changes to their e-business processes and improve their e-workflow systems to respond to the e-business new requirements.

To support the knowledge enhanced framework, the new knowledge perspective will be consolidated with an underlying knowledge repository, which maintains a history of process structure, relating each structure to the types of tasks for which it is a suitable method.

A. Workflow Patterns-Based Knowledge Repository

The knowledge repository is designed using the concept of design patterns successfully used in object-orientation and component software engineering to suggest well-proven design patterns [15] in order to implement solutions for typical recurring problems. Patterns are a way for the designer to specify the workflow schema (process definition) by reusing previous experience and knowledge of the best e-business designers. This work is contributing to research work in the direction of formalising patterns in the workflow domain where substantial effort in the form of workflow patterns [2], workflow data patterns and workflow resource patterns [16] have been investigated. The proposed workflow design pattern repository is one of the possible ways to assist knowledge workflow designers and users in building their workflow models efficiently. This approach will avoid them re-inventing already existing solutions of problems, which are common in the domain context, thus enhances the competitive edge of the organisation. In addition to memorising previous successful workflow design, the knowledge repository will also memorise feedback and views from external stakeholders and competitors' successful e-business processes to trigger changes required in the organization and update their e-workflow and e-business processes [9]. In the sub-sections below, we present the workflow design pattern scheme that composes the knowledge repository and how it is indexed and retrieved. [9].

B. Workflow Design Pattern Scheme

Each workflow design pattern specifies a set of tasks, together with the ordering constraints and object flows between them. Thus, a workflow design pattern represents one possible means of achieving a given type of task by breaking it down into a particular structure of sub-tasks. Each workflow design pattern specifies a single level of structural decomposition. However, the decomposition is decomposed into a further set of tasks, for each of which further workflow design patterns may exist in the repository. These workflow design patterns may in turn be selected to specialise/instantiate the sub-tasks, and so a multi-level hierarchical process structure may be generated by composing many design patterns.

For any given task, there may be multiple possible workflow design patterns, expressing different ways of breaking the task down for different situations. In this research we focus on the patterns in business problem domain, where control flow and data flow interact. We select UML as an implementation language as it allows modelling of the various perspectives, i.e., process, organisation, behaviour and data. A workflow schema shown in "Fig. 3" depicts a simple workflow definition (schema) for the business process of booking a travel service from a network centric travel service provider.

The workflow schema has three other sub-workflow schemas relating to partner (associate) business service providers (BSP), airline reservation, hotel reservation and car rental reservation. Three additional sub-workflow design patterns are required, each for achieving the airline, hotel and car rental reservation sub-workflows task.

C. Workflow Design Patterns Indexing and Retrieval

Two main interconnected indexing schemes are provided in the workflow design pattern repository; workflow design pattern indexing scheme and the sub-workflow design pattern indexing schemes as shown in "Fig. 4".

Each of the indexing schemes is composed of two types of indexes with different functionalities. This is to reflect general and local context-sensitive of the workflow design patterns and its sub workflow design patterns. Classification indexes represent the global and local context features of workflow design patterns and their sub-workflow design patterns that represent the acquired knowledge and experience in the workflow domain. These indices are considered as difference-based indexing scheme by their main function of differentiating a workflow design pattern from another similar workflow

 ISBN: 978-1-61208-247-9

design pattern. However, these indexes are mainly used to classify and direct the retrieval to context-sensitive workflow design patterns and sub-workflow design patterns. This reflects the importance given to the context information which domain expert use to retrieve and adapt patterns. It also add an advantage to the proposed e-workflow approach by reducing the scope of the retrieval search space of classes of similar workflow design patterns rather than the whole workflow design pattern repository

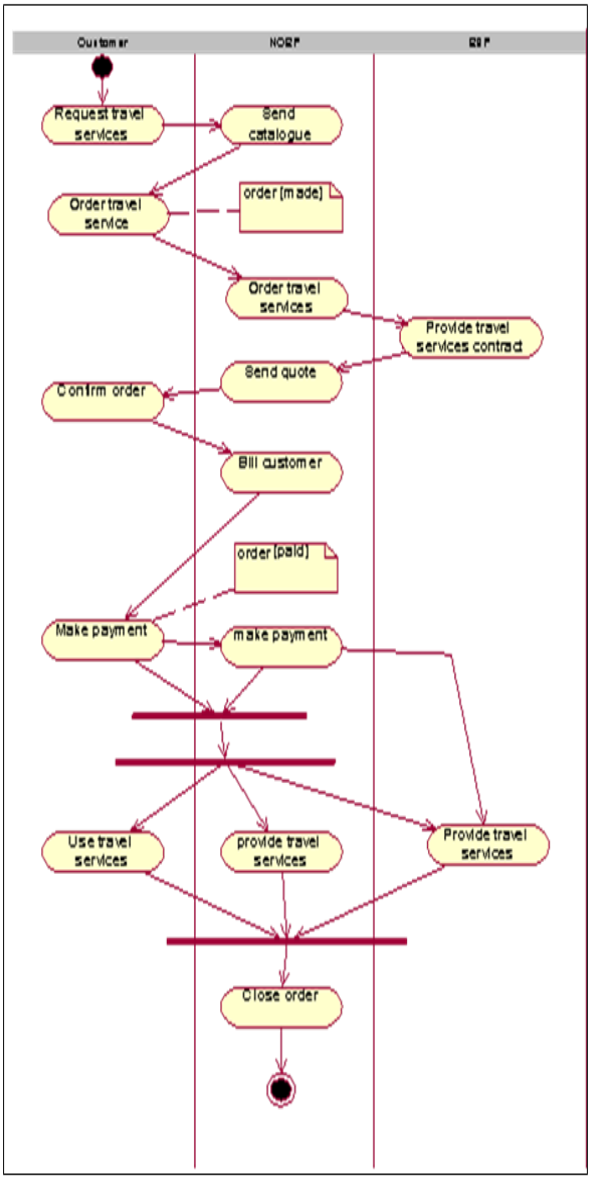

Figure 3. Travel Booking service workflow definition

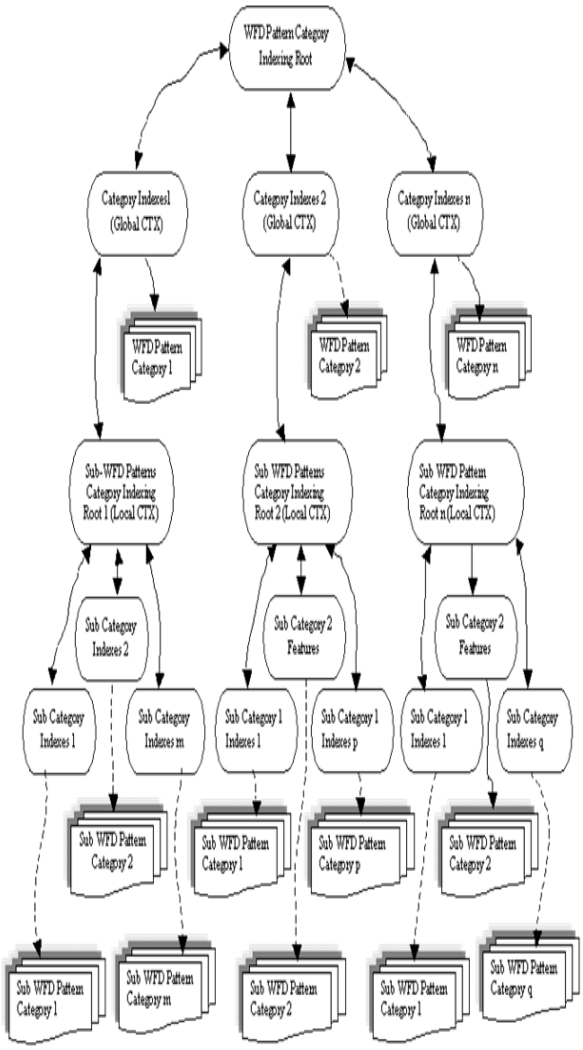

Figure 4. Indexing schema for Workflow design patterns.

.

IV. EVALUATION OF THE PROPOSED FRAMEWORK

The proposed framework for designing e-workflow from scratch requires less work than the traditional approaches do because of the process of reuse provided by the knowledge repository. Another advantage is that previous workflow cases can be adapted easily to new domain of business. Compared to traditional workflow approaches our proposed approach provides a consistent development process, so it meets the needs of virtual organisations for rapid, low cost and flexible development of workflow systems. The approach also takes into consideration all the perspectives involved in the design and modelling of e-workflow applications [17].

The traditional workflow systems evolving around the traditional framework principles have failed to provide support for knowledge workers in order to assist them in performing their daily tasks. This often causes delays in the work process when an exception occurs due to the fact that the workflow participant is not empowered with context-specific knowledge about the task within the work process [13]. This also causes delays for workflow

 ISBN: 978-1-61208-247-9

designers during workflow design and evolution in the new e-business environment.

For instance, in traditional framework, the functional perspective decomposes process functionality into a task hierarchy that can be allocated to e-actors (human or software agents) on the Internet. These functions are difficult to adapt when there is a change in the business process or business environment. This is largely due to the fact that the workflow designers or users are not provided with sufficient business processes related knowledge that is necessary to facilitate workflow process adaptation and maintenance if there is a change in the business environment. However, in the proposed framework, the knowledge repository that underlines the knowledge perspective is there to provide relevant information and knowledge for the workflow designers to adapt the task at hand.

The majority of conventional workflow systems have been designed to enable information management activities that target the capture of data and information as opposed to enabling knowledge management for harvesting knowledge itself [13]. Thus traditional workflow development frameworks and approaches focuses on information processing (or transaction led) rather than the knowledge creation and innovation which is vital for survival and growth in the new world of e-business and the emerging global and knowledge economy.

In the traditional workflow framework and development approaches, external roles are not well defined as the system fails to provide process related knowledge and knowledge flow for all the parties involved. If there is a breakdown during the execution of a workflow process, it is sometimes difficult to know who is responsible for the breakdown since the system fails to provide efficient flow of process related knowledge between the stakeholders involved in the execution of the e-workflow process. While in the traditional framework modelling the behavioural perspective was based on a high level of structure and control reflecting the internal organisation policy, the dynamics of the new e-business environment in which more than one organisation are sharing that e-business process require a different approach to organisational and workflow design. The knowledge perspective provided in the proposed framework allows e-workflow designer or users to develop flexible rules agreed between organisations who share the e-business processes.

The proposed framework has been tried successfully by a travel agent to assess their e-business processes. One of the e-business processes assessed was Flight + Hotel booking web based service. In the initial flight + hotel booking service, the customer while booking the flight is not given the possibility to alter the number of days required to spend in the hotel. We changed the Flight + Hotel booking service by providing on the web a facility for the user to put their comment why they did not proceed with the booking. When we analysed the comments of the customers we found that a large number of customers would like to book the flight with fewer days to spend in the hotel as they would like to spend some of the days with local friend or families within or outside the city deserved by the flight. Once, we changed the Flight + Hotel e-business allowing customers the flexibility to book Flight + Hotel with the possibility to alter the number of days to spend in the hotel, no customer has raised again that problem which might means that more customers have booked for Flight + Hotel service.

V. CONCLUSION AND FUTURE WORK

In this paper, we have presented a new framework that takes into consideration the knowledge dimension for the development of e-workflow to support continual and unpredictable changes of current e-business processes. A significant contribution of our proposed framework is not only limited to adding a knowledge perspective to traditional framework but by setting new relationship and dynamics between this knowledge perspective and the existing functional, organisational, behavioural and informational perspectives. In the proposed knowledge enhanced framework, all perspectives are integrated and all of them harbour some knowledge through common access to a knowledge repository that memorise best practices, previous experiences and stakeholders experiences. Furthermore, the paper has presented one realisation of the knowledge repository in the form workflow design pattern repository. We have also provided an input format for pattern creation, which would enable patterns content in the workflow design pattern repository to be structured and predictable. The paper has also provided an appropriate hierarchical structured indexing scheme for the repository to be able to retrieve most similar workflow and sub workflow design patterns. Future research work will focus on the architecture of the e-workflow design pattern providing mechanisms for accessing and managing the workflow design pattern repository and the use of exceptions as a basis for managing dynamic workflow evolution.

REFERENCES

[1] Chung, L.P.W., Cheung, H., Stader, J., Jarvis, P., and Moore. J., Macintosh, A. “Knowledge-based process management - an approach to handling adaptive workflow”, KBS, 2003, 16, pp. 149-160

[2] Van der Aalst, W.M.P., ter Hofstede, A.H.M., Kiepuszewski, B. and Barros, A.P. (2003) “Workflow Patterns”. Distributed and Parallel Databases, 14(1):5-51, 2003.

[3] Fahey, L., Srivastava, R., Sharon, J.S. and Smith D.E. (2001) “Linking e-business and operating processes: the role of Knowledge management”, IBM Syst. J. 40 (4) pp. 889-906

[4] Madhusudan, T., Zhao, J.L. and Marshall, B. (2004) “A case-based reasoning framework for workflow model management”. Data & Know. Engineering, 50, pp. 87-115

[5] R-Moreno, D.M., Borrajo, D., Cesta, A. and Oddi, A. “Integrating planning and scheduling in workflow domains”. Expert Systems with Applications, 2007, 33, pp. 389-406.

[6] Manolescu, D. “Micro-workflow: A Workflow Architecture Supporting Compositional Object- oriented Software Development. Ph.D. thesis, Graduate College of the University of Illinois at Urbana-Champaign. Urbana, Illinois, 2001.

 ISBN: 978-1-61208-247-9

[7] Zhuge, H., Chen, J., Feng, Y., and Shi, X. "A federation-agent-workflow simulation framework for virtual organisation development", Information & Management, 2002, 39, pp. 325-336.

[8] Ndeta, J., Marir, F., and Choudhury, I. "Knowledge enhanced e-workflow modelling – a pattern-based approach for the development of Internet workflow systems", Proceedings of the 7th European Conference on Knowledge Management, 2006, Budapest, Hungary.

[9] Ndeta, J. "Knowledge Enhanced Framework for the Design and Development of e- workflow Systems", PhD Thesis, London Metropolitan University, 2008, UK.

[10] Dellen, B., Maurer, F., and Pews, G. "Knowledge-based techniques to increase the flexibility of workflow management", Data & Know. Eng., 1997, 23, pp. 269-295.

[11] Van der Aalst. W.M.P. "Process-oriented Architecture for Electronic Commerce and Interorganisational Workflow", Information Systems 1999, Vol. 24, No. 8, pp. 639-671

[12] Medeiros, C. B., Perez-Alcazar, J., Digiampietri, L., Patorello, Jr. G. Z, Santanche, A., Torres, R. S., Madeira, E. and Bacarin, E. "WOODSS and the Web: annotating & reusing scientific workflows". 2005, SIGMOD Record, Vol. 34, No. 3, pp. 18-23.

[13] Van der Aalst, W.M.P., Reijers, H.A., Weijters, A.J.M.M., Van Dongen, B.F., Alves de Medeiros, A.K., Song, M. and Verbeek, H.M.W. "Business process mining: An industrial application", Inf. Systems, 2007, 32, pp. 713 – 732

[14] Casati, F., Fugini, M. and Mirbel, I. "An Environment for designing Exceptions in Workflows", Information Systems, 1999, Vol. 24, No.3, pp. 255-273

[15] Gamma, E., Helm, R., Johnson, R and Vlissidesn, J., "Design Patterns: Elements od Reusable Object-Oriented Software", 1995, Addison-Wesley Professional Computing Series. Addison-Wesley Publishing Company, New York.

[16] Russell, N., ter Hofstede, A.H.M., Edmond, D. and Van der Aalst, W.M.P. "Workflow Data Patterns". QUT Technical report, 2004, FIT-TR-2004-01, Queensland University of Technology, Brisbane.

[17] Ndeta, J., and Marir, F. "Towards the Development of a Conceptual Framework fro Knowledge Enhanced e-Workflow Modelling", Proc. 6th European Conference on KM, University of Limerick, Ireland, 2005.

 ISBN: 978-1-61208-247-9