Modelling Information Systems Using Nomis
A Practical View of Its Aplication and Its Insights to Business Processes

José Cordeiro
E.S.T. Setúbal, I.P.S, Campus do IPS, Setúbal, Portugal
jose.cordeiro@estsetubal.ips.pt

Keywords: Information Systems, Information Systems Modelling, Human-Centred Information Systems, Human Relativism, Organisational Semiotics, Theory of Organized Activity, Enterprise Ontology, NOMIS.

Abstract: NOMIS – **NO**rmative **M**odelling of **I**nformation **S**ystems presents a new way of think, model and develop information systems. This new approach has its foundation in a simple and specific ontology known as Human Relativism (HR). HR philosophical stance acknowledges the *human element* central role within any information system (IS) leading us to use *observable human actions* as the IS kernel modelling element. Using *observable human actions* is claimed as a step towards achieving the desired modelling objectivity and precision that most natural sciences and engineering have. NOMIS has also its roots on three IS socio-technical approaches, namely Organisational Semiotics, the Theory of Organised Activity and Enterprise Ontology from where its specific vision and views of IS are *inspired*. Modelling IS with NOMIS can be done by representing NOMIS Vision with the NOMIS Models - a set of diagrams and tables using the NOMIS provided notation or, otherwise, a set of UML profiles created for it. In this paper we provide an overview of NOMIS and some modelling application examples that intend to highlight some new and important concepts introduced by NOMIS. Our focus will be in the most innovative aspects and their relevance to business systems understanding and modelling.

1 INTRODUCTION

Information systems failure was a popular research topic two decades ago (e.g. Sauer, 1997). Nowadays, computerized systems (CS) have evolved, people got familiarized with them and, many issues now go unnoticed. Some of them are revealed when we want do something with a CS and we find out that that particular action is not available, or when we don't know how to do it because there is no information to help us and many other common situations. Also Information System Development (ISD) and, in particular, computer programming is still lacking a solid theoretical foundation. Requirements are gathered with no solid rules; programs are developed based mostly on practice guided by experience and established software patterns, programming structures and data models have many different flavours depending on the implementation.

NOMIS – **NO**rmative **M**odelling of **I**nformation **S**ystems presents a new way of think, model and develop information systems (IS) that intends to improve modelling objectivity and precision. This is accomplished by: (1) adopting a new ontology named *Human Relativism* that recognizes the central role of the human element within an IS, the unpredictability factor it introduces, and a way of reduce this unpredictability; (2) proposing a new vision of IS composed by different views *inspired* by the ideas of three known socio-technical approaches namely Organisational Semiotics (Liu, 2000), the Theory of Organized Activity (Holt, 1997) and Enterprise Ontology (Dietz, 2006); (3) defining a modelling notation and a set of diagrams to represent NOMIS Vision and views.

In this paper NOMIS Foundations, including HR, NOMIS Vision and NOMIS Models, will be briefly presented. The focus and contribution, however, will be in the most innovative aspects of NOMIS approach and its effects on modelling of business systems. This will be shown using a simple case study that will be modelled using NOMIS Models where some key concepts will be highlighted. The examples will highlight some issues of current business modelling and some neglected and new aspects of it.

Cordeiro J.
Modelling Information Systems Using NomisA Practical View of Its Aplication and Its Insights to Business Processes.
DOI: 10.5220/0005425001250134
In *Proceedings of the Fourth International Symposium on Business Modeling and Software Design (BMSD 2014)*, pages 125-134
ISBN: 978-989-758-032-1

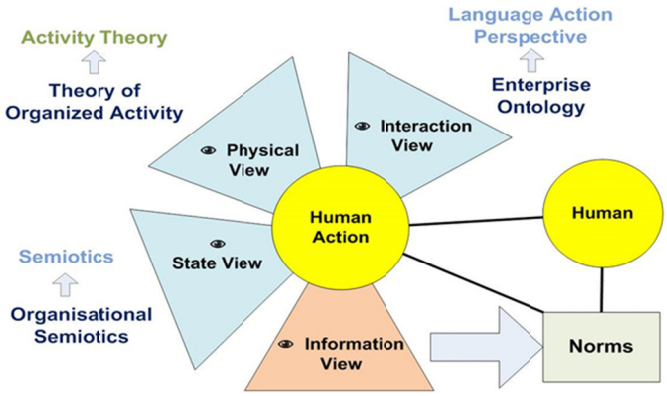

Figure 1: NOMIS Vision – its views and foundational theories.

2 NOMIS FOUNDATIONS

2.1 Human Relativism

Human Relativism (HR) (Cordeiro et al, 2009) is a philosophical stance that differs from *objectivism* by recognizing a reality dependent on the observer. This *experienced reality* in HR does not deny the existence of a single objective reality, therefore does not adhere to *subjectivism* as well. Dependency on the observer or human subject is of utmost importance for information systems (IS) where the first central piece is the *human element.* Realizing that each person has a different view of the IS which is grounded in her experience, emotions, perception, understanding, values, knowledge, etc. is a first step to acquire the necessary precision needed to accurately understand, model, design and develop IS solutions. A second central piece of IS is information, a misunderstood concept (see, for example, Falkenberget al, 1996) that is also dependent on the human element.

From this view computers and computer systems play a secondary supportive role. The *essential* IS is a *human system*.

HR introduces the important notion of *observability* seeking to deal with the unpredictability originated from a reality dependent on the subject. From a human perspective, information is obtained by an individual after a first step of *perception*, where reality is aquired through the human sensitive system and a second step of *interpretation, an inter-subjective* process of meaning making. According to HR, the result of the first step determines the *observable* reality, that should be free from interpretation and can be made objective. Therefore, HR makes the following key assumption:

Anything that is observable will be more consensual, precise and, therefore more appropriate to be used by scientific methods.

Within IS, the human element is the source of unpredictability that constraints the universality of concepts and the correct and adequate gathering of actions and processes. In fact, in IS, information depends on individual interpretation, also performed business actions depend on human performers.

The corollary obtained from HR is that the focus on *observable elements* will reduce the ambiguity and unpredictability of IS and IS modelling in particular. As the human element is the source of unpredictability, we should focus in its observable aspects namely *observable human actions*. These exclude inter-subjective actions, like intentions, judgements, values or decisions, at least their hidden and subjective parts. Also, dealing with information, attention and distinction should be made between the observable part, the physical things that carry the information and, the mental aspects of its acquisition.

2.2 NOMIS Vision

NOMIS theoretical foundations came from three different IS socio-technical approaches, namely the Theory of Organized Activity (TOA) (Holt, 1997), Enterprise Ontology (EO) (Dietz, 2006) and Organisational Semiotics (OS) (Liu, 2000). Each of these theories applied a specific view and modelling of the business domain focusing in activities and performance of (human) actions (TOA), human communications (EO) and context for actions together with the dependency between context and actions (OS). NOMIS takes some essential aspects of these views in its own vision and expands them in

a more realistic, comprehensive and concise view of the IS reality.

NOMIS foundational theories share a key common element – the *human action* – as *the* driver of information systems. Actually, all things done or to be done within any IS are driven by human actions. Motivated and supported by HR, and central in the foundational theories, NOMIS central element is the *observable human action*. It is shown at the centre in the NOMIS vision presented in Figure 1.

NOMIS Vision, besides the *observable human action* central element and, the three views inspired by NOMIS foundational theories adds a fourth view – the information view – acknowledging the importance of information. The remaining elements from figure 1 are the human performer behind each action and *Norms*. Norms or *social norms* are a concept inherited from OS that is used to regulate human actions and provide a way to model expected behaviour.

Each view and the norms concept will be briefly described and explained in the next sub-sections. A deeper discussion on the presentation and analysis of the foundational theories of NOMIS and its vision can be found in Cordeiro et al, 2010.

2.2.1 The Interaction View

The Interaction View covers the communicational dimension of human action. All (human) interactions involve communication and communication itself is a form of interaction. Any business or organisation is driven by a network of people performing actions coordinated by communication; interactions link people. This perspective draws a special attention in how people interact and, in particular, communicate.

This view covers the IS modelling perspective of EO and extends it. It is not restricted by the single interaction pattern – the business transaction pattern – used in EO to model organisations.

In this view the different aspects involving interaction, such as who are the communicating actors, what interactions they perform, what communication links or channels connect them, and other observable aspects may be addressed and represented.

2.2.2 The State View

The state view looks into environmental conditions or states and their dependencies that enable a human agent to act. It is concerned with context, state and state dependencies related to human actions. This is an essential perspective behind OS. The environment, including the appropriate elements, enables or affords the human agent the ability to execute a certain action. These states are called in NOMIS *environmental states* (ES). ES usually represents essential business states that are related by existence dependencies to other ES. An ES can be composed by a single physical element (a *body*), or a single information element (an *information item*), or a group of different bodies and information elements in a particular state. The elements composing an ES have some observable form that may include information by referring to its physical representation.

2.2.3 The Physical View

The physical view is focused on the material and observable aspects related to human actions. This view covers the material dimension of human action expressed by TOA and addresses actions and their relationships to *bodies*: how *bodies* are affected and carried by actions. A particular representation under this view is the representation of business processes showing action sequences and activities. It is important to note that in NOMIS, business process models show different elements and follow different rules. As an example, in NOMIS vision, only human actions should be included, action sequence relates to expected human behaviour regulated by norms and the initial activity before entering an action and the final activity after leaving it represent states of the environment.

The physical context is another aspect of the physical view that can be specified, for example, by locations (space and time) used for a group of actions.

2.2.4 The Information View

The Information view covers the information dimension of human action. The importance of information is recognised by all information system theories and its significance to human action should be emphasised. Most of human actions depend or rely on information in different ways. Some of them cannot even be performed without it. Therefore the identification of the important information required for each action must take special attention. There are some assumptions NOMIS makes in alignment with HR and its foundational theories: (1) information does not exist without a material support: a body or a human actor and, (2) information is created by humans or special bodies known, in NOMIS, as *instruments* and can only be consumed by humans. From a human action perspective there is a focus on what information is required or consumed by the

human performer, what information he/her has access and what information he/her produces. From a design perspective, it is useful to identify and model all information useful for a human action. This means, an awareness system.

Information is also used by *norms* where it is related to agents and human actions. This is another responsibility assigned to the information view - to identify and represent the information needed by norms.

2.2.5 Norms

NOMIS views previously described provide a coherent and comprehensive view of IS centred in human action and information. Each of them offers a different perspective, however they are related in a coherent and consistent model of the IS. The elements shown and represented in each of them should be the same. A coordination act from the interaction view is a human action and can be used in all other views, the same should happen for any other human action, body, human performer and information item depicted in any view. Besides those connection points NOMIS uses also the OS *norm* concept to regulate human actions and provide a way to model expected behaviour. In this case, behavioural norms, which are related to human actions, are used. Behavioural norms are represented analytically in a semi-formal way as defined in OS as follows:

IF condition **THEN** agent
ADOPTS attitude **TOWARD** something

This form includes the key components of NOMIS: human performers as agents, human actions as attitudes and environmental states as conditions.
Besides regulating human behaviour, groups of norms are used to establish another kernel concept of NOMIS that is imported from OS - information fields (IF) – where specific terms and behaviours are understood in a similar way by the members of a community under those IF. This notion is used in NOMIS to define the boundaries of the terminology used in a particular IS.

2.3 NOMIS Models

Models, and modelling artefacts, are used to show simplified views of the reality, capturing its essential elements according to a particular ontology. This representation of the reality may be seen as a specific language and, as any language, determine the way world is perceived, the way plans are established and the way world is acted upon. Following these ideas, NOMIS Models define a new notation that includes a set of tables and diagrams to represent the different NOMIS views according to its Vision. Although there is a pre-set of representation artefacts suggested for each view these should not be seen as the only ones that can be used for that view and purpose. Besides the NOMIS notation also the Unified Modelling Language (UML) was extended with a set of dedicated profiles and can be used to represent NOMIS (Cordeiro and Liu, 2007; Cordeiro and Liu, 2008).

Because of space restrictions NOMIS model notation will not be described here, nevertheless examples will be given in the next section using UML profiles that will be fully explained.

3 MODELLING INFORMATION SYSTEMS WITH NOMIS

NOMIS Vision provided in the previous section establishes a new way of understanding and analysing IS. This Vision has consequences on the way we model the IS, some of these consequences are issues found in current modelling approaches, some other relate to innovative aspects not currently addressed. These innovative aspects will be the focus of this paper. In order to illustrate these aspects a simple use case of a library system will be used. A few parts of this use case will be modelled using NOMIS Models applying its UML profiles.

3.1 The Library System Use Case

The library system use case is described and proposed in Dietz, 2006 as a basis for modelling using the EO theory. It is enough for this paper to know the general idea behind it. It is just a library that lends books to their clients requiring, in this case, a membership. There are processes for lending and returning books, for applying for membership, including a special applying process for a reduced membership fee. The actors and the action and activities locations are also identified.

3.2 Applying NOMIS – Preliminary Steps

NOMIS Modelling approach does not propose a modelling methodology. Therefore, a preliminary step will be to analyse the problem and to extract its key elements according to NOMIS Vision and

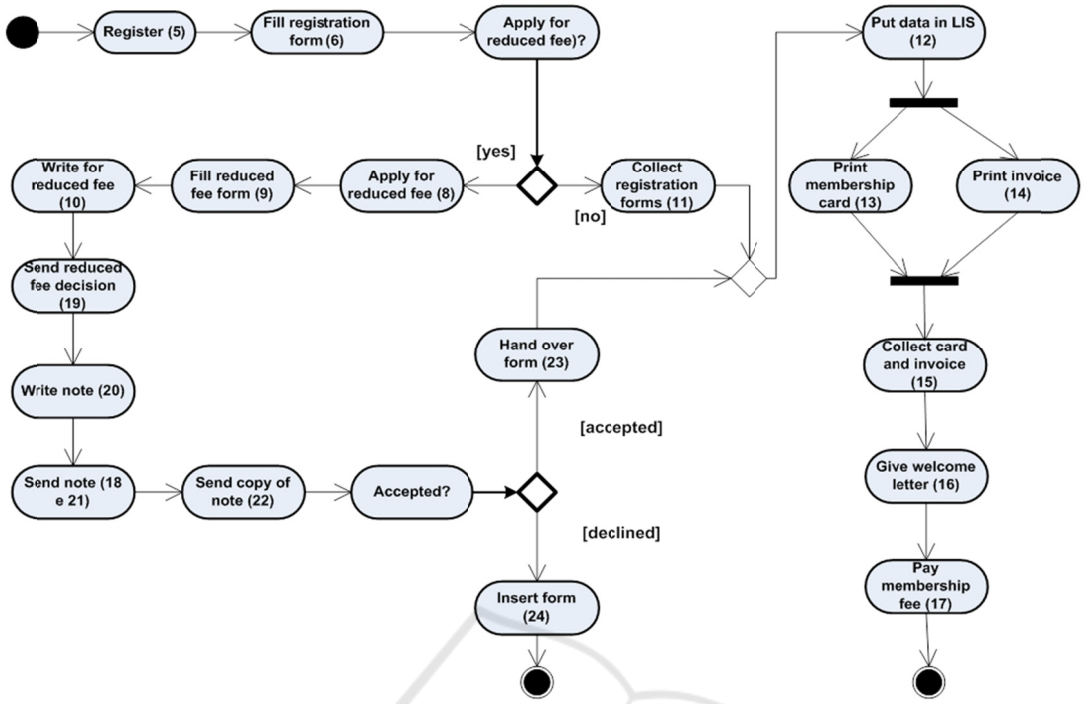

Figure 2: An Action Sequence Diagram of the library registering process.

modelling views. In this case two key elements that are also at the kernel of NOMIS views are human actions and their performers. These elements together with some other information will be collected using a special artefact named Human Action Table (HAT). HAT registers human actions, their related human actors, namely the initiator of that action and the addressee in case he/her exists, and also related action elements such as physical elements (*bodies*), *information items* and locations. Using HAT elements will facilitate the description of business processes that may be depicted with a NOMIS action sequence diagram (ASD). In figure 2 there is an example of an ASD describing the registering process required by a person to become a library member in our case study. A first distinction of NOMIS vision and other modelling approaches is that actions addressed and shown by NOMIS must be always *human observable actions*; Human actions clearly distinct what is done by computers from what is done by people. Additionally, only human actions, through their performers, have assigned responsibility, intention, commitment, and other important human and business aspects. Focusing on human actions also reveals the non-deterministic nature of the relationship between them. Effectively, action sequences determined by human actions are regulated by norms depending on people expected behaviour. Anyone following these norms may decide to break these rules.

3.3 States, Environmental States and the State View

The notion of a state is present in other modelling approaches but NOMIS defines it in a particular way. We will start with a simple *body state* that relates to a physical element that exhibits a specific condition. An example could be a form with two possible states filled and unfilled. Not all *body states* need to be addressed. From our library use case an important *body* with some relevant specific states is the *book*. A library book may be available for lend, lent or, otherwise, not available for lend as it was not registered in the library system. Each different state will allow different human actions. Figure 3 shows the book state diagram (similar to a UML state diagram). In this figure the letter I inside a circle means an *informational state*. This type of state cannot be extracted directly as it is defined by information recorded elsewhere. Although it seems a simple detail it is important. For example, if the "lent" information is recorded in a book using a label or something else this state could be extracted by anyone or any physical tool as it is *observable information*. The notion of *observability* from Human Relativism applied here is acting as a step

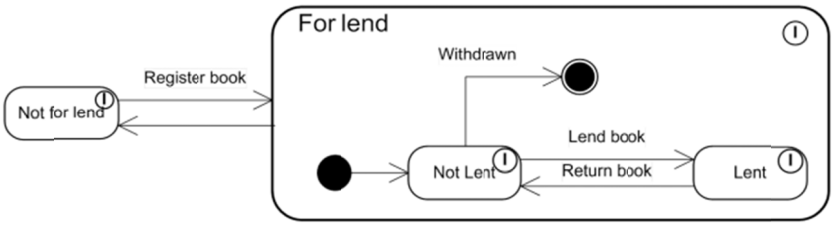

Figure 3: A Body State Diagram of a library book.

toward the desired IS modelling precision. NOMIS also defines human roles as specific (human) states acknowledging the physical (or *body*) nature of human beings.

NOMIS uses a broader notion of a state as well: the *Environmental State* (ES). An ES in NOMIS gathers all the necessary pre-conditions for a specific human action to occur. These conditions or states should be defined using NOMIS elements, namely bodies, information items and human performers. We think the idea behind ES is one of the most innovative ones created by NOMIS. An ES may be understood as defining a place from where paths are originated and end to. Paths are business processes (BP). An analogy with physics would relate ES to potential energy and BP to kinetic energy. This analogy may be used to highlight the instability problems that we have modelling BP. BP are subject to change, like trying to model or determine the trajectory of a projectile compared to the stability provided by the starting and target position. It is possible a projectile to reach the target from a wide variety of ways (BP) but the target position (ES) will stay mostly stable. In the library system case study, there are four important ES, namely book lent, book for lend, membership and paid membership fee. These ES depend on each other: a lent book needs a book for lend and a valid membership; a valid membership needs a library member with a paid fee. Figure 4 shows those ES together the dependencies between them represented with dashed arrows.

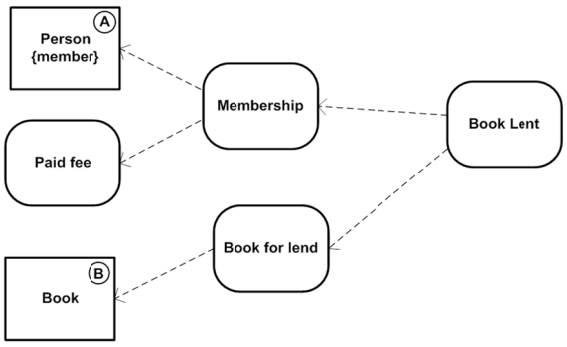

Figure 4: An Existential Dependency Diagram of the library system.

ES in NOMIS are not just concepts; they are completely defined using NOMIS elements as mentioned. A membership ES is composed by the library member, an *information item* with the member contacts, name, legal information and a paid fee information. It is relevant to observe that looking at the identified states, BPs used to reach them corresponds to main library system BPs. A membership ES is reached by following the "to register" process, the book lent ES is reached with the "to lend a book" process, the book for lent is reached by an ordering and registering the book process and so on. Any of these BP may be changed with time although most states will remain valid for the library system.

3.4 Library Action Views

NOMIS interaction and physical views are focused in human actions and their components. The first one deals with human communication and other forms of interactions and the second one with actions and participating bodies. Within these views all type of actions and their sequences can be modelled using ASD. Actions can also be grouped using activities that are, in NOMIS, *composite actions*. Some groups of actions can form patterns that can also be defined in NOMIS. Patterns usually have placeholders in the place of specific actions. These last aspects can be found in other modelling approaches. One interesting aspect of NOMIS is the ability to show action and activity patterns using templates.

Both the physical view and the interaction view use similar diagrams to represent action sequences that are similar to UML activity diagrams. In the case of the physical view these diagrams also include the representation of locations and actor roles as *swimlanes*, and *bodies* and its *states* as *object nodes*.

The interaction view also allows presenting interactions between actors by using a Human Interaction Diagram (HID). Using these diagrams permit us to acknowledge the different actions and

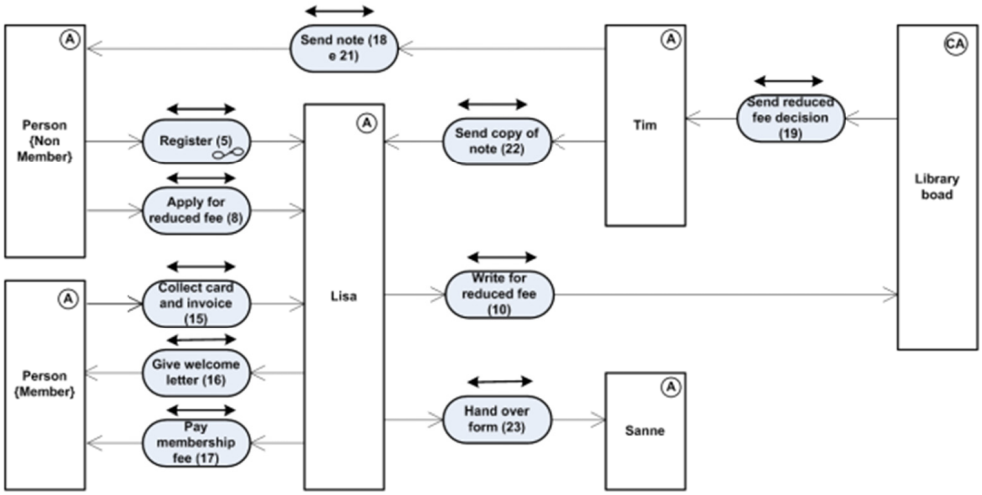

Figure 5: A Human Interaction Diagram of the library system.

activities where more than one person is involved. In figure 5 a HID of the library is presented. This diagram shows different interactions (with a double arrow on top) related to a single human action or a group of actions or interaction activities (activities have a special symbol inside, see (5) in the figure). This view highlights the important dimension of communication and collaboration sometimes missing or not emphasized in other modelling approaches.

The physical view has also another representation artefact, namely the Action View Diagram that is used to show individual actions together all related elements specifically its human performer, involved bodies and needed information items. This last element has a special relevance. The focus on human actions reveals us the need to support these actions and, information items, besides those directly used in the action, such as information on why, when, how to perform the action become important action helpers. For the information system being developed these helpers may also be part or constitute a dedicated awareness system.

3.5 Information and Norms

NOMIS information view goes a step further in information analysis. Following the general principles of HR, there are at least three things to note about information: 1) information cannot be seen independent from a human interpreter; 2) information is always carried by a physical element or *body*; and 3) information about a body may not be observable. Regarding 1) NOMIS has an Information Connection Diagram (ICD) where actions, information items and their supporting bodies are represented. In these diagrams is possible to show the information transferences between bodies. An interesting example is the library registering process. During this process the registration data is communicated by the future member to the librarian that introduces it in the library system. From the IS point of view there is a fundamental difference between being the library to introduce the information in the system or the applicant. In the first case the information item moves from the applicant to the librarian and then to the library system. This may lead to data errors during the transfer process, an example would be a misunderstanding of a particular data element by the librarian. The ICD would show this information transfer clearly. In 2) the highlight is the ability to have different bodies carrying the same information. Finally, 3) may be related to the issue identified before of some bodies having specific *information states* meaning that they are not *observable*. As an example a book in the library may not be for lend. This information cannot be extracted from the book if it is not observable. To distinguish between a body observable and not observable information makes an important difference.

NOMIS Norms relates information or environmental states to actions and their human performers. Business rules under NOMIS are mostly norms. NOMIS classifies Norms as:

1. **Requirement Norms**: needed for the action execution
2. **Trigger Norms**: action triggered given some information made available.

Table 1: Results of applying the CQF to the selected modelling techniques.

	NOMIS	DFD	EM	UML	RAD	BPMN
Organisational (Who)	(Human) Actor	----	----	Actor	Role	Participant
Functional (What)	Activity	Process diagrams	----	Use case	Process and roles	Process maps and descriptions
Behavioural (How)	Action	Processes	----	Action	Action interaction	Activities
Temporal (When)	Existential dependency	----	----	State event	State event	Events
Contextual (Where)	Environmental state / Information field	Context diagram	----	----	----	Pools and lanes
Motivational (Why)	----	----	----	----	State description (goal)	----
Resource (With)	Body	Data flow, data store	Entities	Object	----	Data Object
Conceptual (Which)	Information Item	----	Entity type	Classifier	----	----

3. **Information Norms**: as helpers or just informative for individual actions

Most norms are implicit and only those relevant to the system should be modelled.

As a final remark related to norms is that norms regulate expected human behaviour. They are a form of having some system stability although peopl behave according to different system of norms. As an example in our homes with our family we have a particular behaviour, surely not the same behaviour we adopt in our work organization. The same happens with different fields of knowledge; the terms and ontologies defined for libraries are different from those of medicine for example. Each system of norms defines a specific *Information Field* (IF). This notion used by NOMIS has its origin in Organisational Semiotics. The importance for modelling the library system is that we will find at least two different and simultaneous IF: the first one is the librarians that have their own terms and field knowledge and the second one is the public in general that lends books. NOMIS Vision calls our attention to these differences that should be taken care in IS modelling.

4 DISCUSSION AND RELATED WORK

In order to evaluate NOMIS modelling innovative aspects it will be useful to compare its key notions with other modelling approaches. First, it is important to know and understand how information systems development (ISD) uses or relies on modelling. In practice, modelling is commonly applied in ISD through visual representation techniques being diagrams the most common one. It is also common to differentiate between process modelling techniques and IS modelling techniques where process analysis and modelling is studied under the separate and related field of business process management and, data analysis and modelling together with object-oriented analysis and modelling remain within the information systems field. George Giaglis (2001), for example, propose a taxonomy of business process modelling and information systems modelling techniques where he studies and compares commonly used modelling techniques of both perspectives.

Typical dimensions for comparing modelling techniques are the functional, behavioural, informational and organisational perspectives (e.g. Giaglis, 2001; de Cesare and Serrano, 2006). However, for this comparison, it seems a better choice to use the Common Questions Framework (Cordeiro and Filipe, 2005) that covers all dimensions mentioned before and adds a few important ones. To stress the modelling differences between NOMIS and other modelling approaches we choose to select just a small group of well-known modelling techniques commonly used, namely:

- IS modelling techniques: Data Flow Diagrams (DFD), Entity Modelling (see Avison and Fitzgerald, 2006) and Unified Modelling Language (UML) (OMG UML, 2014)

- Business process modelling techniques: Role Activity Diagrams (RAD) (Ould, 1995; Ould, 2005), Business Process Modelling Notation (BPMN) (OMG BPMN, 2014).

The results of applying the CQF to these modelling techniques is shown in table 1. This table helps to have a broader view of the main aspects covered by each technique. In this case NOMIS furnishes a better coverage of the analysed dimensions together with UML and BPMN, although BPMN is more specific. It should be noted that many methodologies use more than one modelling technique (for example EM and DFD) to help them representing better the organisational domain. Nevertheless, this broader view does not really emphasize the benefits of using NOMIS, in this case it is necessary to look into a few particular aspects of NOMIS. To start with, the human centeredness of NOMIS realized by its exclusive modelling of *human observable actions* is one of the most important differences to other approaches. Anything done in a business or organisation is *always* done by humans through human actions. Any action performed by a machine becomes part of its technical implementation and at most, may only be judged and accepted in the business domain. Also, this focus on human action allows some key social aspects to be correctly addressed, such as responsibility, commitment, interests and intentions that have a strong emphasis in NOMIS foundational theories. The next difference is the use of context in NOMIS. In NOMIS context is addressed in different ways: firstly through the use of environmental states which are necessary conditions for a group of actions to be performed, secondly regarding each individual action by covering all elements, including information items related to that action and, thirdly, through information fields that provide a field of shared understanding for each IS used element. The analysed modelling techniques do not restrict actions to human actions mixing technical details with organisational elements and making difficult to understand and establish properly the organisational-technical boundary. Also these techniques do not make a proper context for understanding each model element. NOMIS does this by allowing each element to be perceived under an information field (IF) scope allowing for a similar element be understood differently under different IFs also represented in NOMIS models. Another difference is coherence and consistency as any NOMIS views *sees* the same reality where an element of one view is always related to the same element in another view. This cannot be done when a methodology chooses to use different modelling techniques for representing the same organisational reality. In this case UML may overcome this difficulty, however UML was not thought to model the business domain which results in having many problems to represent it besides mixing technical details and using an *object-oriented* paradigm (Avison and Fitzgerald, 2006). Another differentiating aspect of NOMIS is human communication that is not addressed by other modelling techniques despite its importance in organisations. In this case BMPN is an exception having a conversation diagram and recognizing the important of this organisational view. A last major distinct aspect in NOMIS is the notion, representation and use of norms. All analysed modelling techniques use a sequential or parallel flow for actions, but they do not recognise it as being human dependent and possibly not followed (also, because they use the same flow for machine actions). In NOMIS the use of norms recognizes properly the human dependent nature of human action process flows.

5 CONCLUSIONS

This paper briefly presented NOMIS – a new modelling approach for information systems that integrates the theories of Organisational Semiotics, Enterprise Ontology and the Theory of Organized Activity. NOMIS is strongly founded in the philosophical stance of Human Relativism that is expected to provide the necessary modelling precision. NOMIS is fully described in (Cordeiro, 2011).

The focus of this paper was to show some important innovative modelling aspects of NOMIS that may be useful for a better understanding of IS and business systems. These aspects were also compared within different dimensions with similar concepts used by a small set of other well-known modelling techniques.

REFERENCES

Avison, D. and Fitzgerald, G., (2006). *Information Systems Development: Methodologies, Techniques and Tools*, *4th Ed*, McGraw-Hill Education, UK.

de Cesare, S. and Serrano, A., (2006). Collaborative Modeling Using UML and Business Process Simulation. In *Proceedings of the 39th Annual Hawaii International Conference on System Sciences*, Vol. 1.

Cordeiro, J. (2011). *Normative Approach to Information systems Modelling*. PhD Thesis. The University of Reading, UK.

Cordeiro, J. and Filipe, J., (2005). Comparative Analysis of Ontology Charting with other Modelling Techniques. In *Proceedings of the 8th International Workshop on Organisational Semiotics*. Toulouse.

Cordeiro, J. and Liu, K., (2007). UML 2 Profiles for Ontology Charts and Diplans - Issues on Meta-modelling. In *Proceedings of the 2nd International Workshop on Enterprise Modelling and Information Systems Architectures*. St. Goar, Germany.

Cordeiro, J. and Liu, K., (2008). A UML Profile for Enterprise Ontology. In Proceedings of the 2nd International Workshop on Enterprise Systems and Technology. Enschede, the Netherlands.

Cordeiro, J., Filipe, J. and Liu, K., (2009). Towards a Human Oriented Approach to Information Systems Development. In *Proceedings of the 3rd International Workshop on Enterprise Systems and Technology*. Sofia, Bulgaria.

Cordeiro, J., Filipe, J. and Liu, K., (2010). NOMIS – A Human Centred Modelling Approach of Information Systems. In *Proceedings of the 4th International Workshop on Enterprise Systems and Technology*. Athens, Greece.

Dietz, J., (2006). *Enterprise Ontology, Theory and Methodology*. Springer-Verlag, Berlin Heidelberg, Germany.

Falkenberg, E., Hesse, W., Lindgreen, P., Nilsson, B., Oei, J., Rolland, C., Stamper, R., Van Assche, F. Verrijn-Stuart, A. and Voss, K. (1996) *FRISCO : A Framework of Information System Concepts*, The IFIP WG 8.1 Task Group FRISCO, December 1996.

Giaglis, G., (2001). A Taxonomy of Business Process Modelling and Information Systems Modeling Techniques, In *International Journal of Flexible Manufacturing Systems*, 13, pages 209-228.

Holt, A., (1997). *Organized Activity and Its Support by Computer*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Liu, K., (2000). *Semiotics in Information Systems Engineering*. Cambridge University Press, Cambridge, UK.

OMG BPMN [online], (2014). Object Management Group / Business Process Modelling Notation. Available from: http://www.bpmn.org [2014].

OMG UML [online], (2014). Object Management Group Unified Modelling Language. Available from: http://www.uml.org [2014].

Ould, M. A., (1995). Business Processes – Modelling and Analysis for Re-Engineering and Improvement. John Wiley & Sons, Chichester, England.

Ould, M. A., (2005). Business Process Management – A Rigorous Approach. The British Computer Society, Wiltshire, UK.

Sauer, C., (1997). Deciding the Future for IS Failures: Not the Choice You Might Think. In *Re-Thinking Management Information Systems*. Galliers, R.D., & Currie, W. (eds)., Oxford University Press.