Modelling Information Systems using NOMIS
An Overview of its Modelling Notation and Implementation

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Abstract: NOMIS is an innovative human centred information systems modelling approach that is based on human *observable* actions. Its goal is to achieve the desired objectivity and precision required to *engineer* information systems (IS). NOMIS proposes a vision into an IS from different views that are complimentary and comprehensive. Some of these views are adaptations and extensions of the theoretical IS insights provided by the theories of Organisational Semiotics, the Theory of Organised Activity and Enterprise Ontology. NOMIS also proposes a modelling graphical notation and a set of tables and diagrams to represent NOMIS vision and views. In this paper we provide a brief overview of NOMIS and its modelling aspects including NOMIS elements metamodel and NOMIS notation. A case study of a course system is used to show some practical examples of NOMIS notation application and also to deliver a real system according to NOMIS approach as one possible implementation.

1 INTRODUCTION

In spite many years of research and practice Information Systems (IS) are still developed with a loose understanding of information and how computers relate to human activities. From an information perspective, data as *information*, is stored in databases according to schemas developed without much business people intervention, or, otherwise, without objective guidelines for its conception. Many times these schemas are reproduced as user interface terms inadequately or not properly understood under the business context given the human nature of interpretation. Regarding human activities also often happens the supporting computer does not allow a human user for certain actions, or does not provide required information related to it.

NOMIS is an innovative human centred information systems modelling approach based on human *observable* actions that intends to improve modelling objectivity and precision. NOMIS proposes: (1) a vision composed by different views *inspired* by ideas from three known socio-technical approaches namely Organisational Semiotics (Liu, 2000), the Theory of Organized Activity (Holt, 1997) and Enterprise Ontology (Dietz, 2006a), and (2) its visual representation composed by different models represented with a set of diagrams and tables. For this representation NOMIS provides its own modelling notation.

This paper extends and complements the work presented in Cordeiro, 2015. In this previous paper NOMIS vision was described and an empirical case study of a library system was used to highlight some modelling aspects and to show a practical application of NOMIS modelling approach. That paper shown several diagrams using UML profiles adapted from Cordeiro and Liu, 2007 and Cordeiro and Liu, 2008.

In this paper NOMIS elements metamodel and its modelling notation are presented together with a real case study of an e-learning system. This case study is modelled with some diagrams using NOMIS modelling notation. Furthermore, an implementation prototype putting into practice NOMIS Vision and ideas is given.

This paper is organized as follows: section 2 gives a brief overview of NOMIS vision together with NOMIS elements metamodel and modelling notation. Section 3 presents a case study and part of its modelling, section 4 introduces an e-learning platform and the e-learning prototype and, section 5 concludes and points some future research directions.

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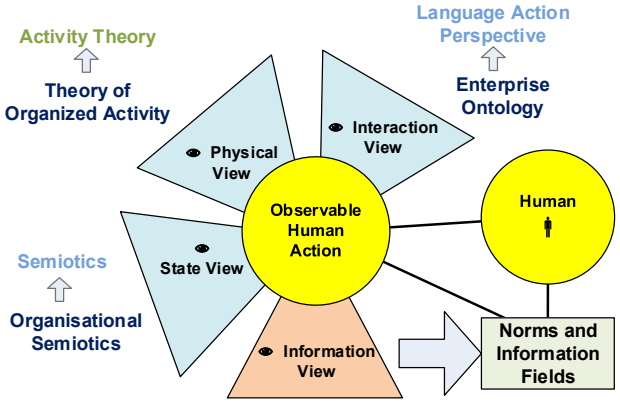

Figure 1: NOMIS Vision – its views and foundational theories.

2 NOMIS

2.1 Introduction

NOMIS – **NO**rmative **M**odelling of **I**nformation **S**ystems is a human centred modelling approach to information systems development (ISD). NOMIS as a social-technical approach understands information systems "as human activity (social) systems which may or may not involve the use of computer systems" (Buckingham et al., 1987). Nevertheless its ultimate goal is the development of computerized systems suited for human use within organisations.

NOMIS kernel elements are *human actions* and *information*, both connected to the central human element, mandatory in any information system (IS). Human actions are present in many social approaches to ISD such as the Speech-act approach (see Hirschheim et al., 1997), based on language-acts as human actions, or the Activity Theory approach (Leont'ev, 1978) based on human collective actions, which are, both, in the roots of NOMIS.

Human actions used in NOMIS are human *observable* actions, those perceived by the human sensory system. This particular focus comes from its foundational philosophical stance – Human Relativism (Cordeiro et al., 2009) – that sees *observable reality* as "*more consensual, precise and, therefore more appropriate to be used by scientific methods*".

The second kernel element in NOMIS is information, the basis of all information systems, still a misunderstood concept (see, for example, Falkenberget al., 1996). NOMIS understands information as the result of an *interpretation* process coming after *perceiving* the *observed reality*. Following this idea, information is only available from data after being interpreted by a human. There is no information without a human interpreter.

Information is the subject area of Semiotics which is the *study of signs* (see, for example, Chandler, 2002) where signs can be thought as information. In fact, Semiotics could be defined as the *study of meaning*: how meaning is created, represented, interpreted and communicated and meaning is all about information. Semiotics is also in the roots of NOMIS.

From a holistic view of human actions in general, NOMIS proposes a *vision* of information systems composed by a set of views addressing human interaction, action processes and context for actions inspired and based on, respectively, Enterprise Ontology (EO) (Dietz, 2006a), the Theory of Organized Activity (TOA) (Holt, 1997), and Organisational Semiotics (OS) (Liu, 2000). These views will be explained in the next section.

NOMIS views form a coherent and consistent vision of an IS from a human *observable* action perspective that is complemented with a fourth view related to *information* consumed, produced, stored and exchanged.

Considering the nature of human actions, NOMIS adds *Norms* as human behaviour regulators. *Norms* is a concept borrowed from OS (Stamper, 1996) that addresses and regulates sequences of human actions. Expected (human) behaviour is derived from *systems of norms* or *information fields* (IF) as they are called within OS (Stamper, 1996), where people tend to behave in a certain, expected and controlled way. Examples of IF are an organisation, a department, or even a family. IF and Norms are a *glue* connecting human actions and information.

NOMIS Vision is depicted in Figure 1.

Besides NOMIS Vision, NOMIS proposes a set of tables and diagrams and a modelling notation to

express and model IS that will be the basis for this work. A case study modelled and represented using NOMIS tables and diagrams can be found in (Cordeiro, 2015).

2.2 NOMIS Views and Vision

NOMIS Vision is the way NOMIS sees and understands IS. Its central element is the human and, in particular his/her *observable* actions. Focused in human actions it provides three different views or perspectives based on the theories of Enterprise Ontology, the Theory of Organized Activity and Organisational Semiotics as mentioned before. All of them were adapted and expanded in NOMIS. A fourth view addressing information is added. Each of these views will be briefly explained in the next subsections.

2.2.1 The Interaction View

The Interaction View covers the communicational dimension of human action. It is expected to model all forms of human communication and interaction within the IS. From these perspective besides looking at communication channels and interacting people also language-acts as seen in EO are modelled. Language-acts and any type of interaction acts may be represented by interactional patterns and reused in different contexts.

2.2.2 The State View

The state view uncovers and looks into environmental conditions or states that enable a human agent to act. It is concerned with context, state and state dependencies related to human actions. Its key element is the *environmental state* (ES) that is a composition of observable elements such as physical things (*bodies*) and/or information elements (an *information item* referred by its physical representation). The notion of ES is a NOMIS interpretation and adaptation of the *affordance* concept (Gibson, 1979 and, within OS, Stamper, 1996).

2.2.3 The Physical View

The physical view looks to material aspects related to human actions. A particular perspective addressed by this view is the representation of business processes showing (human) action sequences and activities. Also states and states transitions (driven by human actions) can be represented, which is a representation inherited from TOA.

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

2.2.4 The Information View

The Information view covers the information dimension of human action. Most of human actions depend or rely on information in different ways. There are some key assumptions NOMIS makes in this respect: (1) information does not exist without material support: a body or a human actor and, (2) information is created by humans or things (bodies) and consumed only 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.

2.3 NOMIS Models

Models are used to represent simplified views of reality, capturing its essential elements according to a particular ontology. Models define a language and, as any language, affects the way world is perceived. NOMIS Models are just a way of representing NOMIS vision of IS reality. Following a Semiotic triadic sign model (Pierce, 1931-58) NOMIS vision is just a concept, a form of seeing an IS, and NOMIS Models one possible representation of NOMIS Vision as shown in Figure 2.

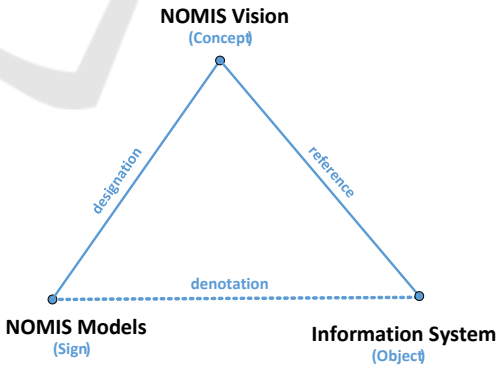

Figure 2: NOMIS Modelling Approach.

The *essential elements* represented in NOMIS Models correspond to the key concepts in NOMIS Vision and they are:

- Human Actions
- Actors – human performers
- Bodies – things

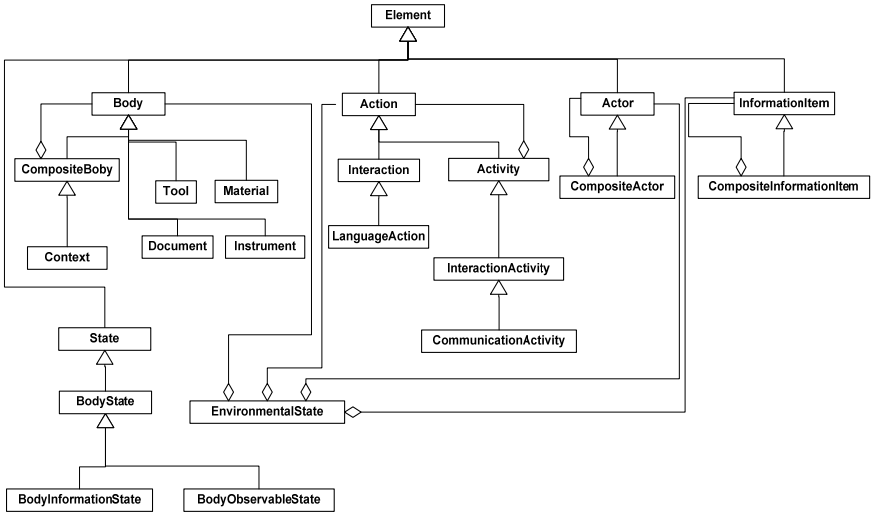

Figure 3: Metamodel of NOMIS Elements.

Table 1: NOMIS node elements notation.

Element	Symbolic annotation	Symbolic form	Element	Symbolic annotation	Symbolic form
Actor	A		Body	B	
Action	AC		Body State	BS	
Interaction	IA		Composite element	C Initial letter	
Language Action	LA		Environmental State	ES	
Information Item	I				

- Information Items
- Language Actions (or Coordination-acts)
- Environmental States

It is also possible to have composite elements: a group of human actions as activities, a group of actors representing a team or organisation, or a composite of bodies or information items. A complete Metamodel of these *essential elements* is shown in Figure 3.

To represent NOMIS elements a modelling notation is provided in Table 1. Elements can be shown as rectangles with symbolic annotation, as symbolic forms or as appropriate icons.

3 MODELLING INFORMATION SYSTEMS WITH NOMIS: A COURSE SYSTEM CASE STUDY

This section will present a case study of a course IS and will show a few models using the NOMIS modelling notation described in the previous section. There is no intent to provide the complete case study modelling but just a few aspects not covered in Cordeiro, 2015 and an illustration of some other aspects of the NOMIS modelling approach.

3.1 Case Study: An e-Learning System

This case study addresses a typical class course usually taught in licentiate degrees engineering courses at the School of Technology of the Polytechnic Institute of Setúbal. These courses run for a semester, having about 15 weeks of face to face teaching with one or more classes per week. Classes may be theoretical, practical, laboratories or theoretical-practical. Their duration varies between 1 hour and 2 hours. Apart from laboratories all classes take place in common class rooms equipped with a video-projector and a whiteboard. Before starting a course it is necessary to get information about enrolled students such as name, student number,

contact information, etc. and to prepare a few documents, namely a course form with information regarding course contents, evaluation method, bibliography and some other data. When a course is running, teaching is usually done face to face in a class room. It is common in these classes to give students some teaching materials such as presentation slides handouts, tutorials, articles, bibliography, exercises, etc. and some additional information such as deadline for exercises, evaluation schedules, extra class times, etc. Outside classes, teachers have attending hours for receiving students. Sometimes is also necessary to contact students when a situation demands it: it may be something preventing a class to be taught or other out of the ordinary circumstances. In some courses, there is a project work involving 1 to 4 students and they must meet and collaborate outside classes. After classes are finished there are student evaluations, and resulting grades should be written in a form (obtained before) and delivered to the school secretariat. Also, it is necessary to fill a report per class type and per course concerning student attendance, grades, subjects effectively taught and other related information.

Computer support to teaching uses the school IS for official information such as course syllabus, student and teacher information, course schedules, etc. and Moodle for course related information such as course materials, communication between teachers and students, etc.

3.2 Applying NOMIS – First Steps

Although NOMIS Modelling approach doesn't propose a methodology a first step is to find its kernel elements: human actions and their performers. These elements will be collected using a model artefact named Human Action Table (HAT). HAT registers human actions, their intervening human actors and related elements such as bodies (things), *information items* and locations. In Table 2 there is a simple example of a course HAT. At this point it is not necessary to have a complete description, and missing elements may help to uncover important details. Some human actions identified correspond to general activities, e.g. "to teach", in this case action detail or atomicity will depend on model's purpose, such as to communicate, to design or to implement the system.

Table 2: Initial Human Action Table of a course.

	Human Actions	Initiator	Addressee	Bodies	Information Items	Local
1	To teach (face to face)	Teacher	Student	Slides, texts, pens		Class room
2	To attend class	Student				
3	To distribute document	Teacher	Student	Document		
4	To inform about something	Teacher	Student		Information	
5	To inform about something	Student	Teacher		Information	
6	To create exercise	Teacher		Exercise form	Exercise information	
7	To request exercise execution	Teacher	Student	Exercise form		
8	To do exercise	Student		Exercise form		
9	To submit exercise	Student	Teacher	Exercise form		
10	To evaluate exercise	Teacher		Exercise form		
11	To write course report	Teacher		Course form	Report information	
12	To produce course information	Teacher			Course Information	
13	To distribute course information	Teacher	Student		Course Information	
14	To attend students	Teacher	Student			

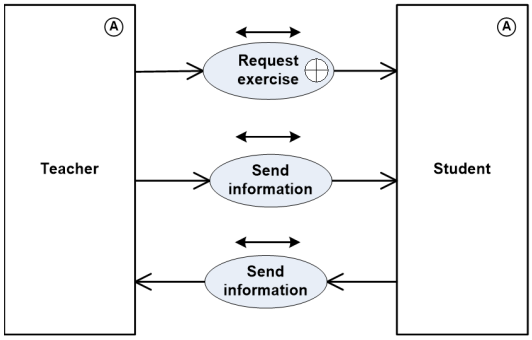

Figure 4: HID showing course interactions.

3.3 Interaction and Physical Views

As it is described this system doesn't have much elaborated action sequences, being composed mostly by interactions between teacher and students identified in the HAT by the initiator and addressee human elements. Two of these interactions are related to exercises requested by teachers and communication between students and teachers. EO models these kind of interaction using *business patterns* (Dietz, 2006b) understood as the fundamental building block for modelling any organisation at the ontological level. NOMIS is able to express these type of interaction patterns using Human Interaction Diagrams (HID) within the interaction view. In Figure 4 there is a HID showing both interactions. As in EO, in NOMIS the request exercise is depicted as a pattern – in this case a *composite interaction activity*. This means a composite action (expressed by the plus sign inside the activity symbol). This activity can be further decomposed using an action Sequence Diagram (ASD) from the physical view as an activity pattern. Usually, ASD diagrams are used to show typical business processes as a kind of UML Activity Diagrams but in this case it is used to show sequences of speech-acts as human actions (represented inside ovals). The emphasis here is the NOMIS ability to represent activity patterns as the one shown in Figure 5 where <work> may be replaced with different elements such as exercise, examination or even projects.

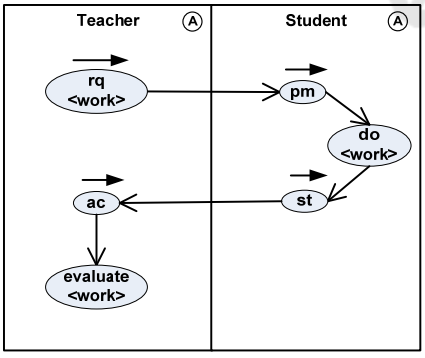

Figure 5: An ASD showing the request work pattern.

3.4 Information View

Although it is possible to show connections between human actions or *bodies* and information in specific NOMIS diagrams, e.g. (1) show all information required, auxiliary or produced by a human action or (2) show connections between human information interpreters and respective body information carriers, here the emphasis is on how information is collected and represented. In this case, NOMIS uses an Information Items Table (IIT) where information items and its supporting bodies are described.

In Tabl some information items, required in the e-learning case study, are shown.

Table 3: Some course information items.

	Information Item	Information	
		Content	Related supporting bodies
1.	Enrolment Information	Student information	
	Description	• Student's name • Student number • Sex, date of birth • Contact	
2.	Teacher Information	Teacher information	
	Description	• Teacher's name • Category • Title • Contact	
3.	Course Information	Course information	
	Description	• Course name • Course • Semester	

3.5 State View

NOMIS course state view is a key system view. It shows its fundamental environmental states (ES) providing an overall system perspective. Business processes are just *paths* between ES or *paths* to achieve an ES. Some ES may be understood as *goals* as they correspond to desired states such as "to complete a course". ES are shown in NOMIS using Environmental State Diagrams (ESD) where links between the different action states represent existential dependencies. In Figure 6 it is depicted a course system EDD where a running course (an ES) is dependent on teacher and student ES. These ES on the other hand are dependent, respectively, on teacher information (an information item) and person (a person *body* as teacher) and enrolment information and person (as student).

3.6 Norms and Information Fields

A last and important element to be modelled according to NOMIS is *norms*. Many of these norms can be extracted from NOMIS diagrams such as some norms regarding action sequences, existential dependencies, and information required or auxiliary

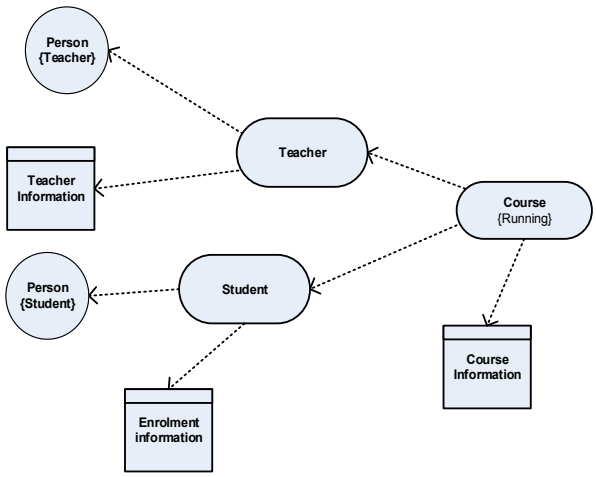

Figure 6: Course system EDD.

To actions among others. A small list of course system norms for illustrative purposes are:

- Classes Scheduling;
- Semester Calendar;
- Teacher attending hours;
- Teachers responsibility to create class summary, course evaluation rules, bibliography and theoretical contents;
- Teachers responsibility to produce course reports, and to send evaluation information to the school;
- General school evaluation rules

Some of these norms may just be used as information in the context of particular human actions or, for example, be incorporated in the model.

In the course system context there are different norm systems or information fields (IF). These are the school, the department and the course. Each of them may use its proper terms and have some particular rules. For example a student may not attend a course unless it is a registered student according to the school norms but, sometimes due to a possible delayed registration process it is authorized within the course scope (IF) to attend it without being legally registered.

4 IMPLEMENTING AN E-LEARNING SYSTEM ACCORDING TO NOMIS

The previous section provided a short and simple analysis and modelling of a course system. In this section, our goal is to present a simple implementation of an e-learning system to support that (*human*) course system. This application should be seen as one practical application of NOMIS, still many other forms of using NOMIS in practice are possible.

The implemented e-learning system is a computer system that will be used to support some of the course human actions modelled using NOMIS. Its simple use will be as a repository for class materials such as texts, documents, presentation slides, etc. and also as a communication tool that will enable information exchange among participants. A consequence of using this supporting system is that human actions will change, for example “to request an exercise”, a physical action of giving a piece of paper to a student will be replaced by a menu entrance that supports this action by sending an electronic document to that student. This change is often neglected when implementing business processes for example. Therefore, there will be new human actions for the e-learning system such as to store a document, to send a document, to retrieve a document, to send a message, to retrieve a message, to send and store a document, to view a document, etc. An advantage of designing a system from this perspective is that each relevant human action can be individually analysed from a business oriented view and its computer support can be furnished appropriately. Also, effective user needs can be fulfilled accordingly. Besides furnishing support for specific human actions the system can also help by giving useful information related to those actions such as how to execute them, norms affecting those actions, or available tools. A separate awareness system may be designed and implemented with this purpose.

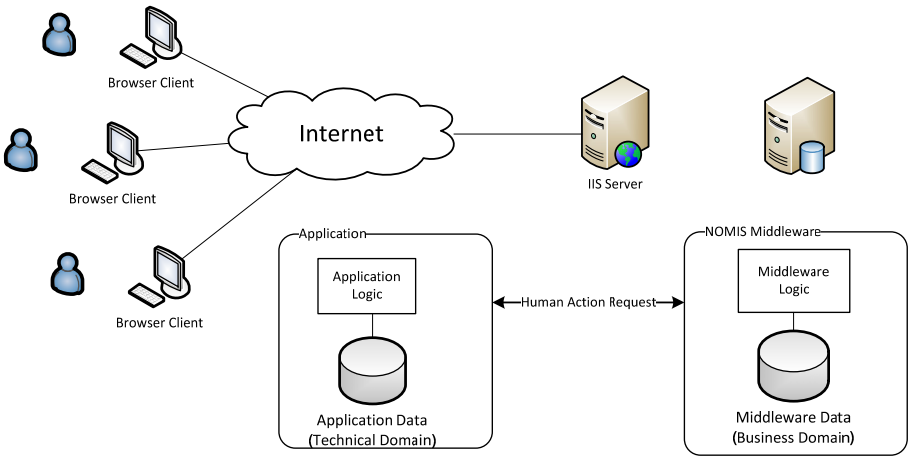

Figure 7: The e-learning platform architecture.

4.1 NOMIS Platform Architecture

For implementing the e-learning system a basic Client-Server based architecture using the Internet was chosen (see Figure 7). However, this architecture was further adapted to be aligned with NOMIS concepts. Accordingly, there are two separate modules: (1) to handle application specific aspects and (2) to handle NOMIS related features. The last one is a kernel middleware – NOMIS middleware – used to provide support for user actions, user information and user communication functionalities. NOMIS middleware includes a relational database to support business data and a logic layer responsible to handle requests from applications. The application module, on the other hand, handles most technical aspects, including presentation logic, interaction with NOMIS middleware, technical parts of application logic and may include its own database of technical data. Separation of technical and business aspects is an essential characteristic of this platform and its based applications. This separation is accomplished by assigning to NOMIS middleware the management of any element seen as part of the business domain.

This architecture is not specific of the e-learning application and can be used by any other NOMIS application.

4.2 NOMIS Middleware

NOMIS middleware (NOMIS MW) is an independent layer responsible for connecting an application to general business information and human action supporting features. Basically it consists of a database composed by a group of tables that store all important business related information and a logic layer responsible for managing access to it. NOMIS MW tables store NOMIS elements and relationships between them. There is a table per each element: Person, Action, Body, Activity and Role. Role in this case represents a "person state" and for each valid relationship between elements: Action-Body, Person-Body, Body-Body, Role-Action, Role-Person, Activity-Role and Activity-Activity.

A distinctive feature of NOMIS MW tables is that all tables, except for relationship tables, contain a group of similar columns having the following structure:

ID	**GUID**	Name	Description	**StartTime**	FinishTime	.....

Bold column fields represent required data and cannot be empty.

This table structure is partially inspired by the Semantic Temporal Database (STDB) proposed by OS (Liu, 2000). In fact, it keeps its temporal dimension by having a start and finish time for each element, allowing it to change.

The GUID field stores a global unique identifier that is attached to each record and table. It is possible using this strategy to change completely the information about a person, for instance using a different information table, as the GUID will stay the same the person information will be relative to its existing time period.

4.3 The e-Learning Prototype

A prototype using NOMIS Platform architecture was developed using Microsoft .NET platform, a screen shot is shown in Figure 8. Some notes regarding this implementation:

1. The school, each course and each class is defined as an activity giving a context for actions.

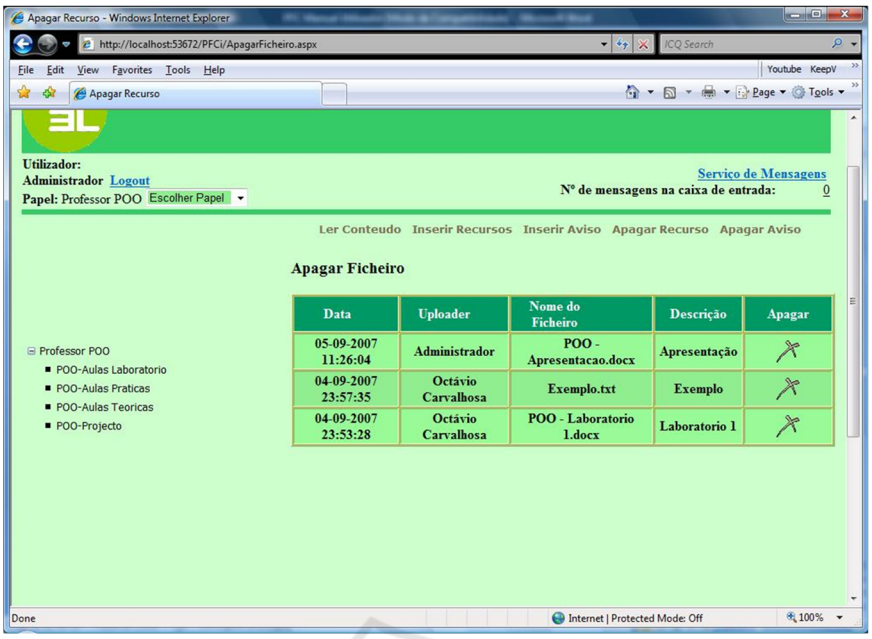

Figure 8: Screen shot of the e-learning application prototype.

2. Information Items are supported and created as tables and records in the database, or otherwise as documents referred also by records in the database.
3. Three roles were created, namely administrator, professor and student.
4. Actions correspond to ASP.NET pages triggered by menu selections, buttons or hyperlinks.

NOMIS MW does not deal with visualisation and interaction aspects; those can be designed by a designer and implemented using application specific visualisation controls. From an application point of view, NOMIS MW can furnish all actions available for a certain activity, taking into account its user, associated role, any applicable norm and all contextual information stored on bodies. This separation helps keeping the design independent of many application technical details.

All the necessary information about available activities, action, and bodies is provided through NOMIS MW.

5 CONCLUSION AND FUTURE WORK

This paper presented a brief overview of NOMIS and its modelling aspects including NOMIS elements metamodel and part of NOMIS notation. A case study of a course system was used to show some practical examples of NOMIS notation application and also to deliver a real system according to NOMIS approach as one possible implementation. The e-learning prototype implemented took advantage of a NOMIS specific infrastructure that could be used for other NOMIS applications.

NOMIS modelling approach is fully described in (Cordeiro, 2011).

Regarding future work there is much to do to validate and test NOMIS modelling approach. A new prototype is necessary to uncover additional modelling and practical aspects. One possibility is the use of Model-Driven Engineering to produce different applications using some ideas from the created prototype infrastructure. In this respect, NOMIS metamodel and the modelling notation can be used to create, respectively, the abstract and the concrete syntax of a Model-Driven approach.

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