

Applying NOMIS - Modelling Information Systems Using a Human Centred Approach

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Abstract. NOMIS is an innovative human centred information systems modelling approach that is based on human *observable* actions. It seeks to deliver the desired objectivity and precision required in information systems development. From a theoretical perspective, NOMIS offers a vision into an Information System (IS) using different views that are complimentary, comprehensive and consistent. 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. From a practical perspective, NOMIS proposes a modelling notation that uses a set of tables and diagrams to represent NOMIS vision and views.

In this paper, we will provide an overview of NOMIS and we will describe NOMIS modelling elements and notation. A case study of a course system is used to show a practical example of modelling with NOMIS that includes a real system created using the NOMIS approach.

Keywords: Information Systems · Information systems modelling · Human-Centred information systems · Human relativism · Organisational Semiotics · Theory of Organized Activity · Enterprise Ontology · NOMIS · NOMIS vision · NOMIS models · NOMIS modelling notation · NOMIS metamodel

1 Introduction

In spite, many years of research and practice, Information Systems (IS) are still created with a loose understanding of information and how computers relate to human activities. From an information perspective, data as *information*, is stored in databases per schemas developed by technical people without sufficient business people contribution and, without objective guidelines for its design. Often, schema elements are reproduced as user interface terms, that are inadequately or not properly understood under the business context. Regarding human activities, it is also common that the computer application does not allow a human user for certain actions required or useful for a specific activity, or does not provide the required action information.

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 [1], the Theory of Organized Activity [2] and, Enterprise Ontology [3], and (2) its visual representation composed by different models shown as a set of diagrams and tables. For this representation NOMIS provides its own modelling notation.

This paper extends and complements the work presented in [4]. In this previous paper, NOMIS vision was described and, an empirical case study of a library system was presented to highlight some modelling aspects and to show a practical application of NOMIS modelling approach. In that paper, an empirical library system was modelled via a set of diagrams using UML profiles adapted from [5, 6] that are not fully suitable to express NOMIS modelling elements and their relationships.

In this paper the NOMIS metamodel and a 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: Sect. 2 gives a brief overview of NOMIS vision, Sect. 3 presents NOMIS elements metamodel and describes NOMIS modelling notation, Sect. 4 presents a case study and part of its model, Sect. 5 introduces the e-learning platform and the developed e-learning prototype and, Sect. 6 concludes and points some future research directions.

2 NOMIS Vision

2.1 Introduction

NOMIS – **N**ormative **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” [7]. Nevertheless, its main goal is the development of computerized systems suited for human use within organisations.

NOMIS kernel elements are *human actions* and *information*, both associated 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 [8]), based on language-acts as (human) actions, or the Activity Theory approach [9] based on human collective actions, which are, both, in the roots of NOMIS.

Human actions utilized in NOMIS are human *observable* actions, those perceived by the human sensory system. This focus comes from its foundational philosophical stance – Human Relativism [10] – 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, [11]). 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, [12]) where signs can be understood 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) [3], the Theory of Organized Activity (TOA) [2], and Organisational Semiotics (OS) [1]. 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 [13] 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 [13], where people tend to behave in a certain, expected and controlled way. Examples of IF are an organisation, a department, a team or even a family. IF and Norms are a *glue* connecting human actions and information.

An overall NOMIS Vision is sketched in Fig. 1.

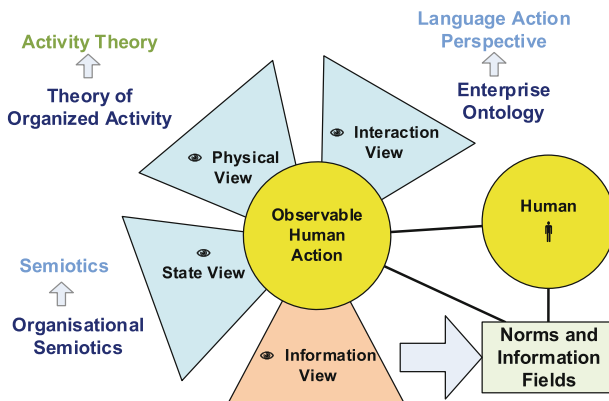


Fig. 1. NOMIS Vision – its views and foundational theories

2.2 NOMIS Views

NOMIS Vision is the way NOMIS sees and understands IS. Its central element is the human and, 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.

The Interaction View. The Interaction View covers the communicational dimension. It is expected to model all forms of human communication and human interaction within an IS. From this perspective, it addresses communication channels and interacting people and their actions including language-acts as seen by EO. Effectively, Language-acts as many other types of interaction acts are represented under this view as interactional patterns that can be reused in different contexts.

The State View. The state view uncovers and considers 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 (known as *bodies*) and/or information elements (which are *information items* referred by its physical representation). The notion of ES is a NOMIS interpretation and adaptation of the *affordance* concept ([14] and, in OS, [13]).

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

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

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.

3 NOMIS Models

3.1 Models

Models are used to represent simplified views of reality, capturing its essential elements peranontology. 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 [15] NOMIS vision is a concept, a form of seeing and understanding an IS, and NOMIS Models one of its possible representations as it is shown in Fig. 2.

Modelling, in general, may be expressed by using natural languages, analytical or mathematical formal languages, visual means such as diagrams and schemes, or even

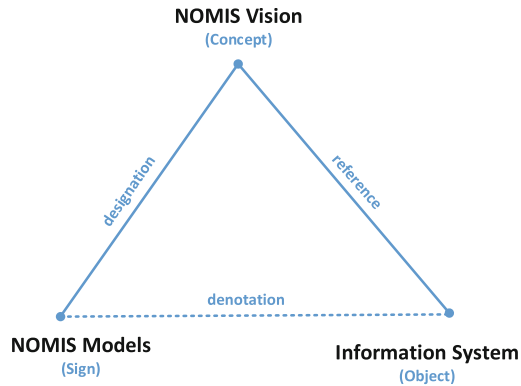


Fig. 2. The NOMIS Modelling Approach

simulations. NOMIS models can be expressed by diagrams showing its *essential elements* and their relationships, although they can be complemented by auxiliary tables and/or textual rules. This section will focus in NOMIS Model diagrams and its notation.

3.2 NOMIS Metamodel

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

- Human Actions – *observable* human actions
- Actors – human performers
- Bodies – physical things
- Information Items – information without a physical support
- Language Actions (or Coordination-acts) – speech actions
- Environmental States – context for actions

It is also possible to have composites of these elements: a group of human actions as activities, a group of actors representing a team or organisation, or a group of bodies or information items.

A complete Metamodel of NOMIS showing its *essential elements* was presented in [4] and is reproduced in Fig. 3. This metamodel conveys the NOMIS modelling language abstract syntax.

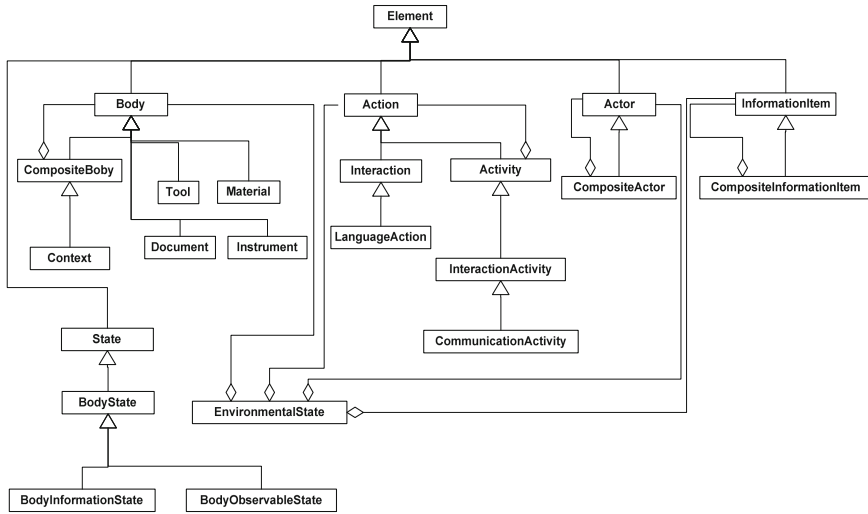


Fig. 3. NOMIS Metamodel

3.3 NOMIS Modelling Notation

An important purpose of models, as with any language, is to communicate. From this viewpoint, they can be used informally as a sketch to communicate system aspects or, otherwise, models can be used formally as blueprints for system development and in this last case, be subjected to creation rules following a formal specified syntax.

To facilitate communication, understanding and ease of writing, NOMIS modelling language concrete syntax or notation, provides different ways of writing model diagrams using NOMIS model elements and their relationships. This differentiation is inspired in the ways Semiotics recognises a representation refers to an object (see, e.g., [12]):

- Symbolic** – the representation does not resemble the object being represented and is fundamentally arbitrary or purely conventional. This is the case of textual languages
- Iconic** – the representation is perceived as resembling the object by being similar in possessing some of its qualities. For example, it could be a typical computer icon used for applications, a portrait or a scale-model
- Indexical** – the representation is not arbitrary, but is connected in some way to the object. Usually indicates something. An example from [12] is a clock indicating the time of day










Thus, NOMIS notation defines three ways or three concrete syntaxes for writing NOMIS Model elements, namely:

- (1) A simple geometric form with a *symbolic annotation* for the element type. In this case, all elements are rectangles with a small letter representing the element type that is shown inside a circle positioned close to rectangle' upper-right corner.

- (2) A *symbolic geometric form* related to its type per a convention. In this case, each element type will have a different form.
- (3) An *iconic form* that represents its type. In this case a simple icon is suggested for each element type being represented.






The symbols used in (1) and the representation for each element used in (2) are shown in Table 1 for each element type. The form and presentation aspect of icons used in (3) will be left for a tool to define them.

Table 1. NOMIS elements notation

Element	Description	Symbolic annotation	Symbolic form
Actor	The human actor element	A	
Action	The human action element	AC	
Interaction	An interaction between two actors	IA	
Language Action	A language action involving actors	LA	
Information Item	An atomic information item	I	
Body	A simple body. Includes its specialised types namely document, material, instrument, tool or context	B Also DOC, MAT, INST, TOOL, CTX	 May include a circled letter —B, D, M, I, T or C
Body State	A conceptual body state. Not used for showing a body, only its state	BS	
Composite element	A composite element may be any of the above that is composed by one or more elements of the same type.	C Initial letter	 Added inside the element
Environmental State	Represent a composite of bodies, information items, actor and actions	ES	

NOMIS model elements are represented as nodes in diagrams. Nodes are connected by lines that represent relationships between those elements. There are different types of lines depending on the relationship. Lines may also be directed for clarifying the role each element plays in the relationship. The meaning of a line connecting two elements may depend on context such as the type of elements being connected. In Table 2 there is a list of the different line types used to relate nodes in NOMIS models and their description.

Table 2. Line types used to connect NOMIS model elements

Line format	Linking...	Description
	A body and an action	Defines an involvement relationship.
	An action and an actor	Human performer of an action. When there is only one actor linked to a specific action
	A body and an information item	Information carried by a body
	An action and an information item	Information related to the action context
	Two actions	Indicates a sequence of actions.
	From actor to action	The actor initiating the action
	From action to actor	The addressee of an action. Usually in the context of communicative actions
	Two actors	For specifying a communication link
	From actor to information item	Information created by an actor
	From information item to actor	Information consumed by an actor
	Two body states	A transaction between two states. It happens when a certain human action occurs.
	From body to action	A body which state will be changed by an action.
	From action to body	A body created or which state was changed by an action
	From body to information item	An information item created by a body
	From information item to body	An information item registered in a body
	Two model elements	An existential dependency between two elements
	Two model elements	Usually applies to model elements of the same type to refer a composite element. It can also be used by an environmental state to indicate its elements.
	From action or activity to environmental state	The beginning process of an environmental state
	From environmental state to action or activity	The ending process of an environmental state

Besides nodes and lines, it is also possible to define areas grouping different elements. Information fields may be represented using these areas.

Finally, special adornments are defined to add specific element information. The following types of adornments are available:

- **{ }** – Curly brackets – to show the state of a body or the role of a person. The state or role name appear inside the brackets below the body or person name. If different nested states apply they are shown separated by commas.
- **< >** - Angle brackets – a placeholder for a concrete NOMIS element. Instead of providing a concrete element, an abstract element is given that can be instantiated by elements of the same type. It should appear inside angle brackets. For example, '`<action 1>`'. Used in templates for actions.
- **[]** – Square brackets – to provide additional information for a relationship. For example, in the case of a decision where two or more sequences of future actions are possible, helps to clarify the decision taken for each outgoing line.
- **()** – Parentheses – for notes and commentaries. The text inside should not be considered as part of the model.

- « » – Guillemets – to specialise meaning of an element. For example, an existential dependency may include the word ‘legal’ to mean a *legal* dependency between elements.

4 Modelling Information Systems Using NOMIS: A Course System Case Study

This section presents a case study of a course IS and shows a few models using the NOMIS modelling notation described in the previous section. There is no intent to provide the complete case study model but just a few aspects not covered in [4] and an illustration of some other aspects of the NOMIS modelling approach.

4.1 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 h and 2 h. 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 where 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.

4.2 Applying NOMIS – First Steps

Although NOMIS Modelling approach does not propose a methodology a first step is to find its kernel elements in the problem domain: human actions and their performers. These elements are 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 3 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 3. Initial human action table of a typical 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			

4.3 Interaction and Physical Views

This system does not have 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 kinds of interaction using *business patterns* ([16]) understood as the fundamental building block for modelling any organisation at the ontological level. NOMIS can express these type of interaction patterns using Human Interaction Diagram (HID) from the interaction view. In Fig. 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 Fig. 5 where *<work>* is a general action and can be replaced with different concrete actions such as exercise, examination or even projects.

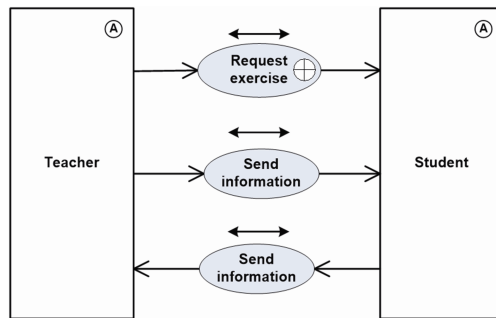


Fig. 4. HID showing interactions

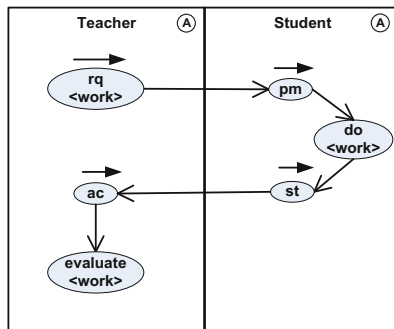


Fig. 5. An ASD showing the request work pattern

4.4 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 Table 4 some information items, required in thee-learning case study, are shown.

Table 4. Some course information items

	Information item	Information	
		Content	Related supporting bodies
1.	Enrolment Information	Student information	
	Description	<ul style="list-style-type: none">• Student’s name• Student number• Sex, date of birth• Contact	
2.	Teacher Information	Teacher information	
	Description	<ul style="list-style-type: none">• Teacher’s name• Category• Title• Contact	
3.	Course Information	Course information	
	Description	<ul style="list-style-type: none">• Course name• Course• Semester	

4.5 State View

NOMIS course state view is an important system view. It shows 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 Fig. 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).

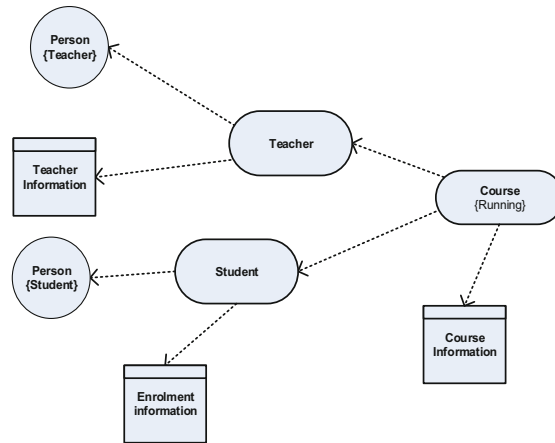


Fig. 6. Course system EDD

4.6 Norms and Information Fields

A last and important element to be modelled per 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 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 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 rules. For example, a student may not attend a course unless it is a registered student per 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.

5 Implementing an Information System Per 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 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 human actions modelled using NOMIS. Its simple use will be as a repository for class materials such as texts, documents, presentation slides, etc. and 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 as an example. In this case, 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 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.

5.1 NOMIS Platform Architecture

For implementing the e-learning system a basic Client-Server based architecture using the Internet was chosen (see Fig. 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 reused by any other NOMIS application.

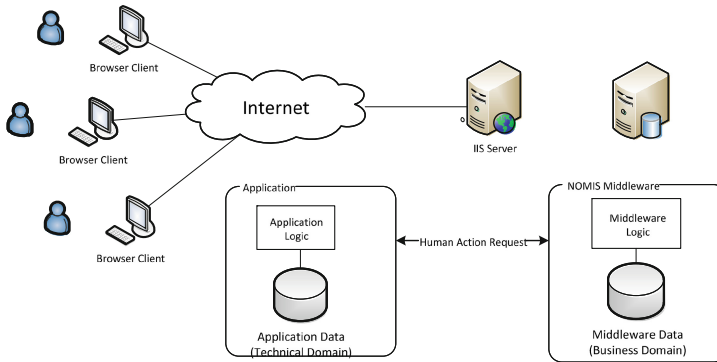


Fig. 7. The e-learning platform architecture

5.2 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 (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
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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 ([1]). 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. Thus, the person information will be relative to its existing period.

Figure 8 shows the kernel tables of NOMIS MW DB that are divided in 3 groups: meta-elements, elements and relationships. The first group just contains the *Element* table. This table stores a list of all tables stored in the database managed by NOMIS MW. The *Element* table allows to identify and to find any table by its GUID (table GUID field) plus its name (tableName). This is because tables stored as business domain tables have a name that results from the concatenation of its regular name with its GUID. This allows duplicated table names.

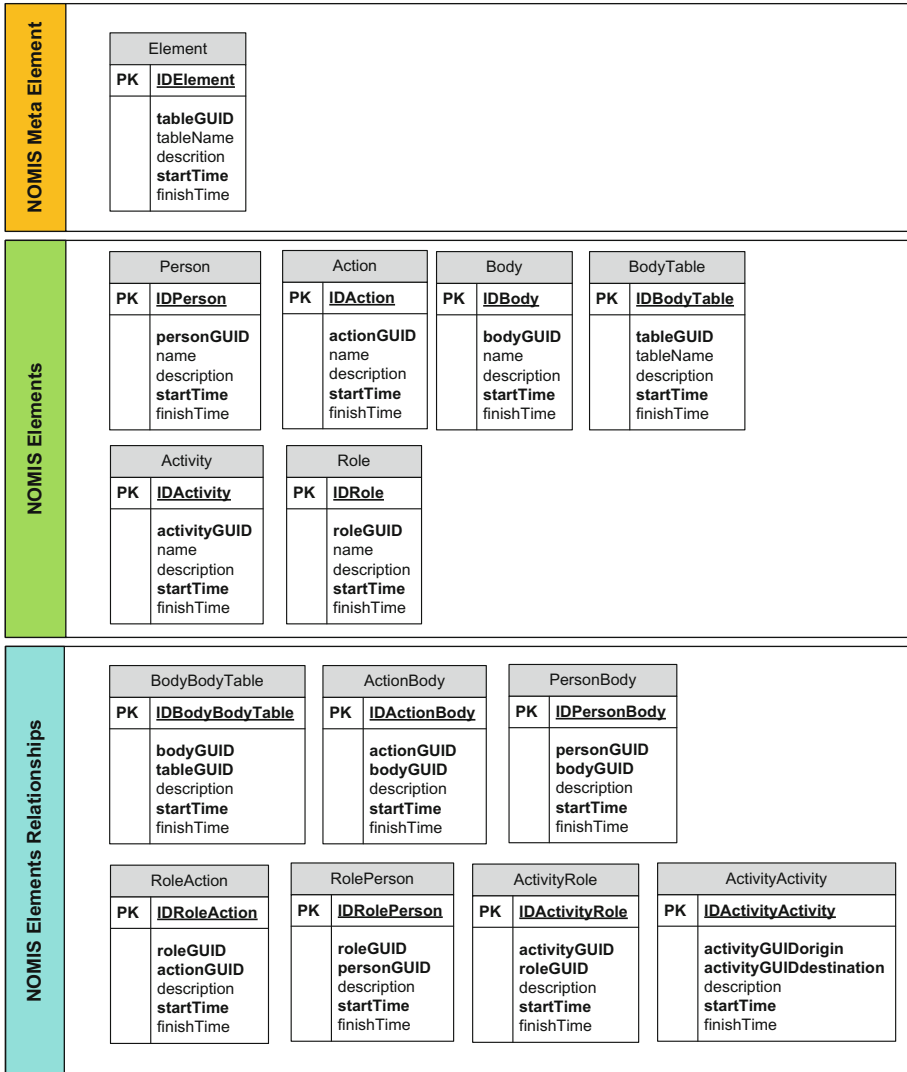


Fig. 8. NOMIS Middleware database kernel tables

The second group consists of tables for registering information regarding NOMIS basic elements that includes *persons*, *actions*, *bodies*, *activities* and *roles* and third group contains tables for storing relationships between NOMIS basic elements.

To show the flexibility of this schema, as an example, it is possible to have a person's name and birth date registered in the NOMIS MW DB. In this case the person will have an entry in the *Person* table that will serve to identify him/her, but the actual name and birth date will be registered separately in a *PersonInformation* table. The *PersonInformation* table name and its GUID will be registered as an element in the *Element* table, the *tableGUID* will also appear in the *BodyTable* as a separate record. The specific name

and birth date will be a record in this *PersonInformation* table identified by a unique GUID. This GUID identifying that information will be registered in the *Body* table. From this approach, any GUID should refer a record or a table. In the case of a table it will appear in the *Element* table and may refer to any NOMIS kernel tables, or, otherwise to an application specific *body* table. The strategy behind this implementation choice is that it is possible to change any application element without having it constrained by the technical implementation. In the last example if it was necessary to change person information by having also information about his/her sex, this could be achieved by creating a new *PersonInformation* table with an extra field for the sex added information. The GUID referring to the person information just needs to stay the same, but the information record is now in a different table with new information. The flexibility introduced allows NOMIS MW to cope with business changes although it makes the system more complicated technically. Nevertheless, it is the author believes that most technical problems can be treated rigorously and scientifically, and a solution provided no matter how complicated they are if there are no business domain aspects embedded.

5.3 The E-Learning Prototype

A prototype using NOMIS Platform architecture was developed using the Microsoft.NET platform, a screen shot is shown in Fig. 9. Some notes regarding this implementation:

1. The school, each course and each class is defined as an activity giving a context for actions.
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, considering its user, associated role, any applicable norm and all contextual information stored on bodies. This separation helps keeping the design independent of application technical details.

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

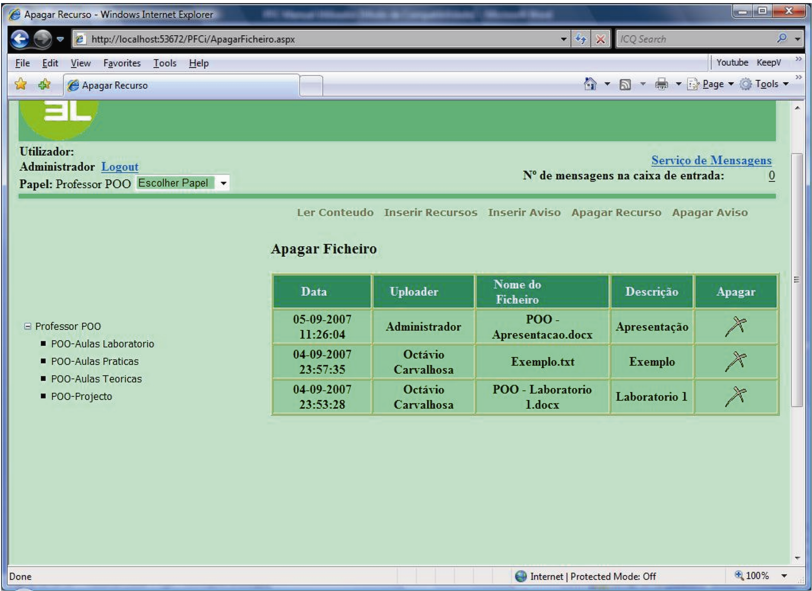


Fig. 9. Screen shot of the e-learning application prototype

6 Conclusions and Future Work

This paper presented an overview of NOMIS Vision and its modelling aspects including NOMIS elements metamodel and NOMIS modelling 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 [17].

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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