# Approaches to Hospital Process Management

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**Abstract**. According to the World Health Organization (WHO) health care systems worldwide are faced with the challenge of responding to the needs of people with chronic conditions such as diabetes, heart failure and mental illness. Chronic disease management (CDM) is a systematic approach to improve health care for people with chronic disease. This paper studies two different approaches to the management of two of the various processes involved. In particular, we specify chronic disease management and purchasing processes both with Electronic Institutions and Metastorm.

**Keywords**. Business Process Management, Health, Electronic Institutions, Metastorm.

## Introduction

In recent years there has been an increasing interest in integrating organisational concepts into different computational systems. On the one hand, within the area of Multi-Agent Systems (MAS), it has been done with the purpose of considering organisation-centred designs of multi-agent systems [1]. One the other hand, commercial software has been developed with the aim of aiding in Business Process Management (BPM) [2]. Using computational systems in medical and health-care domains has recently amplified [3]. This paper uses this same domain to apply and compare two examples of computational systems: Electronic Institutions (EI) [4] -in the MAS area- and Metastorm [5], a commercial BMP tool. Both systems allow to specify interaction conventions in the associated processes. Within this research line, our previous work [6] focused on applying Electronic Institutions to a hospital scenario. In this paper, the resulting specification is compared with an analogous specification in terms of BPM, thus allowing a hands-on comparison of MAS research approaches with BPM commercial tools.

The considered domain is hospitals chronic disease management and purchasing system (HCDMP). Chronic diseases are those that can only be controlled and not, at present, cured [7]. They include diabetes, asthma, arthritis, heart failure, chronic obstructive pulmonary disease, dementia and a range of disabling neurological conditions. Living with a chronic disease has a significant impact on a person's quality of life and on their family. The life of a person with a chronic condition is forever

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altered. Chronic conditions have a profound effect on the physical, emotional and mental well-being of individuals, often making it difficult to carry on with daily routines and relationships. However, in many cases, deterioration in health can be minimized by good care. Chronic disease management (CDM) [8] is an approach to health care that emphasizes helping individuals maintain independence and keep as healthy as possible through prevention, early detection, and management of chronic conditions

Additionally, the frequency of such diseases increases with age. Many older people are living with more than one chronic condition and this means that they face particular challenges, both medical and social. The care of people with chronic conditions also consumes a large proportion of health and social care resources. People with chronic conditions are significantly more likely to see their GP (General Practitioner), accounting for about 80% of GP consultations, to be admitted as inpatients, and to use more inpatient days than those without such conditions. The World Health Organisation (WHO) has identified that such conditions will be the leading cause of disability by 2020 and that, if not successfully managed, will become the most expensive problem for health care systems [7, 9]. This confirms the global importance of chronic disease management (CDM).

The rest of this paper is structured in four sections. Section 1 explains Electronic Institutions and includes a description of the HCDMP system. Section 2 introduces BPM, Metastorm Manager's Edition Designer and how it can be used to specify our HCDMP system. Section 3 presents some related work. Finally, section 4 discuses about the comparison of these alternative approaches and future work.

## 1. Electronic Institutions

Within the area of Multi-Agent Systems (MAS), Electronic Institutions (EI) [4] are a system approach to implement interaction conventions for the agents who can establish commitments on an open environment. These agents can be either humans or computer software. The proposed EI in this paper for hospitals chronic disease management and purchasing system, HCDMP, is a good example of such efforts to tackle medical situations using agent technology and electronic institutions.

In general, an EI regulates multiple, distinct, concurrent, interrelated, dialogic activities, each one involving different groups of agents playing different roles. For each activity, interactions between agents are articulated through agent group meetings, the so-called scenes, that follow well-defined interaction protocols whose participating agents may change over time (agents may enter or leave). More complex activities can be specified by establishing networks of scenes (activities), the so-called performative structures. These define how agents can legally move among different scenes (from activity to activity) depending on their role.

According to [3] an EI is solely composed of: a dialogic framework (DF) establishing the common language and ontology to be employed by participating agents; a performative structure (PS) defining its activities along with their relationships; and a set of norms (N) defining the consequences of agents' actions. Therefore, we have that EI=<DF, PS, N>.

The Dialogical Framework (DF) defines the valid illocutions that agents can exchange as well as the language and ontology they use. Moreover, it defines the participant roles within the EI and their relationships. Any participant agent is required

to adopt some of them. In the context of an EI there are two types of roles, internal and external roles. The internal roles can only be played by what are called staff agents which are those related to the institution. Accordingly, external roles are played by the agents that join and leave the institution but do not belong to it.

For each activity, interactions between agents are articulated through scenes, using well-defined communication protocols. The protocol of each scene models the possible dialogues among roles (or agents). One of the features of the scenes is that they allow agents either to enter or to leave a scene at certain particular states of an ongoing conversation depending on their role. A scene protocol is specified by a directed graph, where nodes represent the different conversation states and arcs are labelled with illocution schemes or timeouts that allow the conversation state evolve. Hence, at each point of the conversation, electronic institution defines what can be said, by whom and to whom.

As a scene models a particular multi-agent dialogic activity, more complex activities can be specified by establishing relationships among them in the Performative Structure (PS). In other words, the activities represented by PS can be shown as a collection of multiple, concurrent scenes. In a PS agents move from scene to scene. Moreover a PS can be thought as a network of scenes in which, the initial and final scenes determine the entry and exit points of the institution respectively.

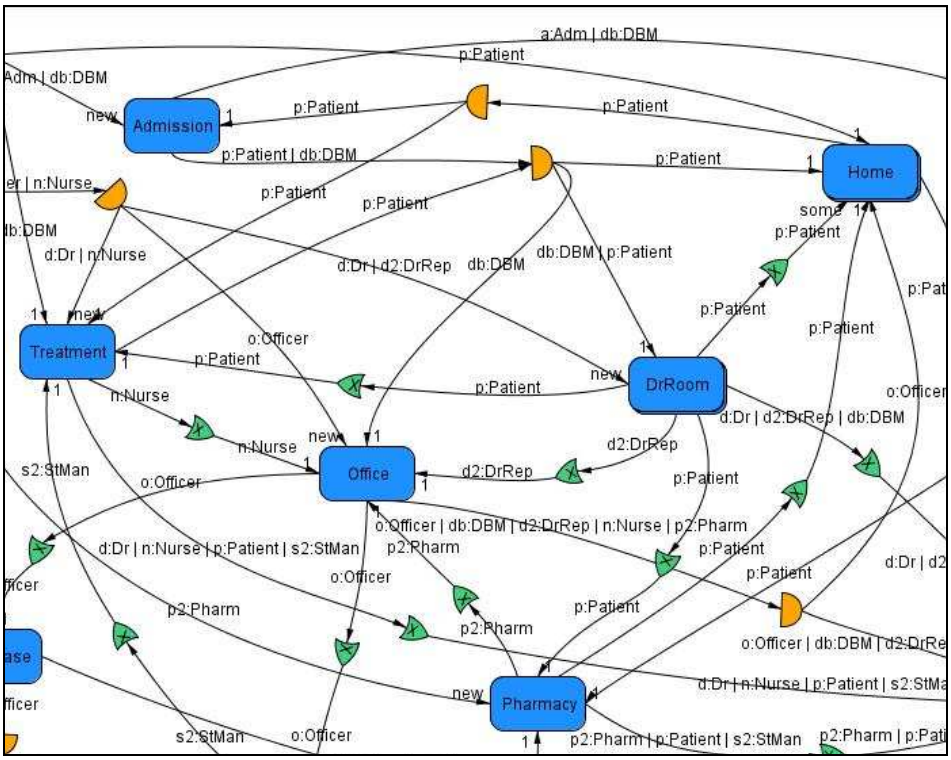
### *1.1. Hospital process management with Electronic Institutions*

Hospitals Chronic Disease Management and Purchasing (HCDMP) System is an Electronic Institution in a hospital environment for helping chronic patients. It provides guidebooks, prompts and reminders to the patient home address. Additionally, in order to offer support from knowledgeable patients, it introduces them to other patients (with their consent).

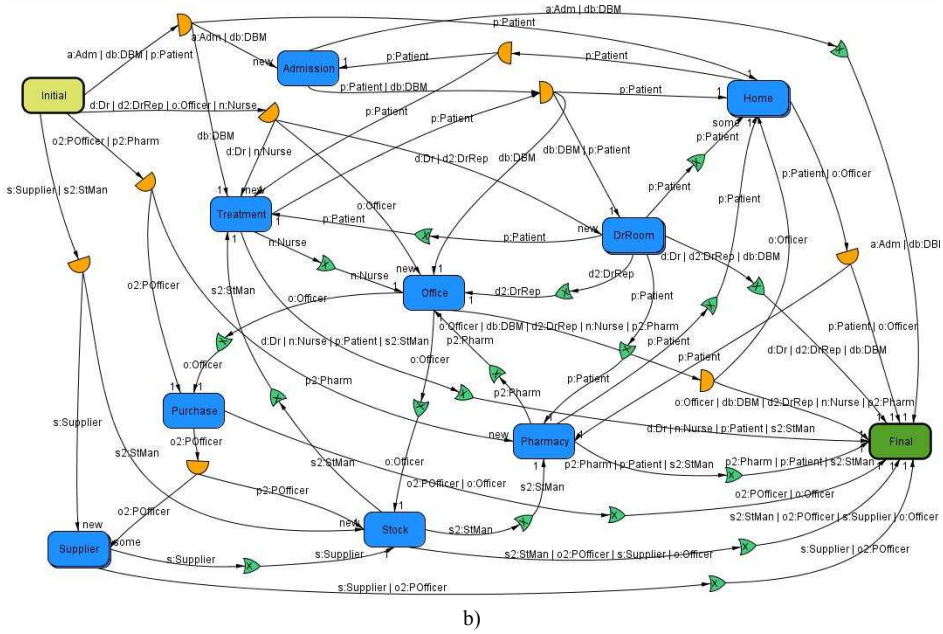
Figure 1 shows the performative structure of the HCDMP system. There are a total of eleven scenes, six of them are devoted to the disease management: Admission, Home, DrRoom (which stands for doctor room), Office, Treatment, and Pharmacy. Three of them correspond to the purchasing system: Purchase, Stock, and Supplier. Finally, the Initial and Final scenes are common to both systems and allow the EI to start and finish. Scenes are connected through transitions that help synchronizing agents. Thus for example, before a patient can join the Admission scene, an admitter agent must have created and entered it.

Regarding roles, they can also be distinguished according to the system where they take part on. Chronic disease management: Adm (admitter), DBM (data base manager), Dr (doctor), DrRep (doctor representative), Nurse, Patient, and Pharm (pharmacist). As for the purchasing system, we have Officer, POfficer (purchase department officer), StMan (stock manager), and Supplier.

Following Figure 1, it can be seen that agents enrol to the Institution at the “Initial” scene and they move between the scenes depending on their roles. Initially the Patient, after enrolment, goes to the “Home” scene where all the patients, as external roles, are assumed to stay. From Home patient moves to the “Admission” to register and requests the Adm (Admitter) an appointment to visit a doctor. If it is accepted, then, an appointment will be issued for the patient to visit his/her doctor and he moves to “DrRoom” scene. Otherwise the patient is informed that he/she is notAccepted and returns to the Home scene.




a)




b)

Figure 1: HCDMP System Performative Structure: a) zoom of the six disease management scenes; and b) the complete performative structure representation.

In the “DrRoom” scene, the doctor (Dr), in order to know the patient, requests for the patientFile from DBM (DataBaseManager). Then, Dr requests the patient howCanIHelp and patient informs the Dr from his/her problems/disease. There are two different protocols for this scene, one for current hospital patients and another for new patients to the hospital. The protocol is chosen by the system and depending on its type (that is, if for new or current patients), Dr asks different questions to patients (i.e., about new patients’ diseaseHistory, or if current patient useMedicationOnTime, contactOtherPatients and happyWithServices). Dr then informs the patient with the DrInstruction4P (doctor instruction for patient) and also provides DrInstruction4O (doctor instruction for Office) to the DrRep (doctor representative). Afterwards, depending on DrInstruction4P, patient moves either to “Home”, “Pharmacy” or “Treatment” scenes. The patient goes to the “Treatment” scene to stay in the hospital until he/she either fully recovers and leaves the hospital to Home, or dies. Additionally, DrRep moves to “Office” scene to inform the Officer about the DrInstruction4O.

In Office scene DrRep informs the Officer of the DrInstruction4O including: PatientID, PatientName and recommendedServices for the patient. Then officer requests the patientFile from DBM in order to process the doctor recommendations and provide services to the patient including: guidebooks, reminders, recommendedOrganizations (able to provide extra help such as psychiatrists) and similarAreaPatients (patients with the same disease and condition that are willing to help other patients). Officer then moves to the Home scene to inform the patient about the services he/she will receive. Specifically, similarAreaPatients is highly recommended service because it allows patients to contact each other, discuss their problems and help each other (this includes Consultation and information such as DrInstructions).

Simultaneously, Officer also moves to the “Purchase” scene to inform the POfficer (purchase department officer) about the purchaseList (a list of requested products by the Pharmacy and Treatment departments). POfficer then answers back with the purchaseDetails (including requested items, price, productInfo, deliveryTime and quantity). Afterwards, POfficer moves to the “Supplier” scene and requests the purchaseList to the Supplier so that he/she informs back with the purchaseDetails. If the POfficer accepts them, then the purchasing process is completed. Otherwise, the POfficer informs the Supplier of the failure and requests a modified proposal (i.e. purchaseDetails). Finally, Officer also moves to the “Stock” scene to inform the StMan (stock manager) of the requested products (mainly medicine) for Pharmacy and Treatment scenes. These products will be delivered later by the StMan to the Pharmacy and Treatment scenes.

## 2. Business Process Management

Business process management (BPM) [2] is a field of management focused on improving business processes in organizations. A business process is a collection of related, structured activities that produce a service or product that meet the needs of a client. BPM can be used to understand organizations through expanded views that would not otherwise be available to organize and present. These views include the relationships of processes to each other which, when included in the process model, provide for advanced reporting and analysis that would not otherwise be available. BPM is closely related to the concept of Workflow [10]. A workflow is a pattern of

activity enabled by a systematic organization of resources, defined roles and mass, energy and information flows, into a *work process* that can be documented and learned. Workflows are designed to achieve processing intents of some sort, such as physical transformation, service provision, or information processing.

Metastorm [5] offers market-leading software for Business Process Management (BPM). Metastorm Manager's Edition Designer is the main tool used to create the components required to define, implement and automate business processes. Main components are:

- Procedure: Metastorm BPM views the information, activities, and instructions required to automate a business process as a procedure. In Designer, the main component of a procedure is one or more maps, but it may also contain other components such as forms or roles.
- Map: it illustrates the various steps required to complete a specific business process (the lifecycle of a folder). Each instance of the business process is called a folder, and the steps are called stages and actions.
- Folder: A new folder is created each time a new instance of the business process is initiated. A folder contains one or more tabs/forms of information relating to that instance of the process. This information may come from users (through forms), databases or other applications
- Stage: a specific state of the business process. When a folder reaches a user's desktop, Metastorm BPM views the folder as having reached a stage in the procedure. A map may also contain various system stages that do not require human interaction to move the folder to the next stage.
- Action: the step or activity necessary to modify data and/or move a folder from one stage to the next one. Actions may include activities such as: filling out a form, logging a telephone call, reviewing an attached file, or approving or denying a request. Nevertheless, some actions do not require human intervention. Some examples are determining the routing for a folder based on information available in a folder or in a database, launching an external application, or moving a folder after a timed event
- Form: forms are used to gather and display information necessary to perform a business process.
- Role: Participants in a procedure have specific roles assigned to them based on either their individual or group responsibilities. Assignments within a procedure are made based on these role designations.

### *2.1. Hospital process management with Metastorm*

When modelling the HCDMP system described in previous section, we identify two main business processes, and thus, we have defined them in two distinct main maps: one for the chronic disease management, and another one for the purchasing process.

Each business process definition includes in fact several maps. The basic main map allows the information to be transferred along the whole process and includes some submaps. These submaps correspond to sub-processes that are specified by means of the so-called "sub-procedure stage" relational components. In this manner, in the chronic disease management process (see Figure 2), the following submaps have been used: Admission in Figure 2 (and further specified in Figure 3 for illustration pourposes), Dr Room, Nursery (which in turn is a subprocess of Dr Room), Pharmacy,

Treatment, and Home. Initially, patients enter the hospital and ask for an appointment in the admission. If everything goes right, it will be assigned and so the patient will move to the doctor's room. From this subprocess, the flow returns to the main map and, if required, the patient will move to the pharmacy to buy some medicines or to the treatment sub-process (which ends when the nurse finishes treating the patient). In any case the flow will return to the main flow. All subprocesses end with an action that corresponds to the storage of the patient's file.

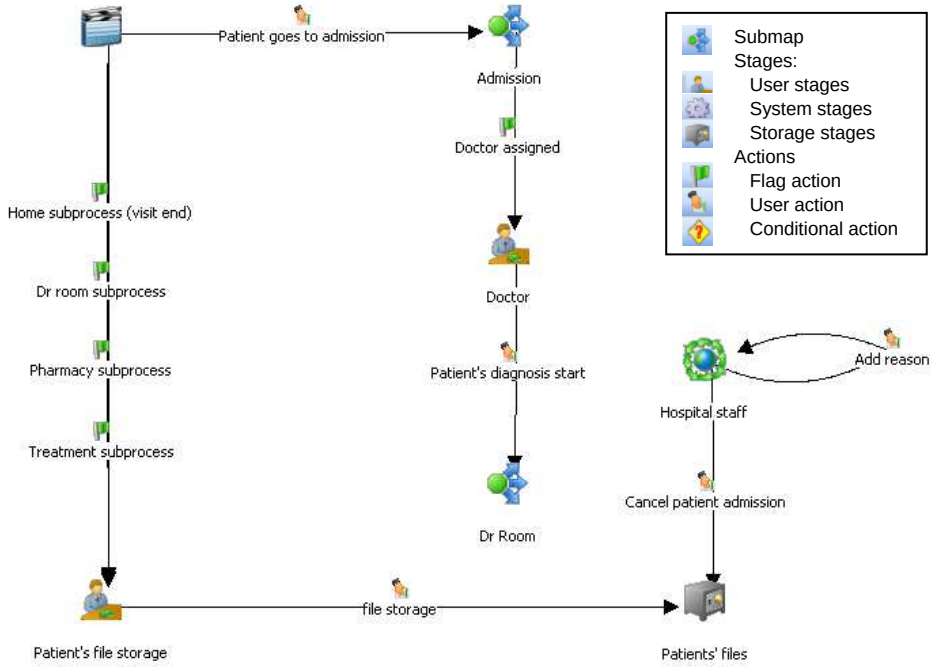



Figure 2: Chronic disease management process specification

## 3. Related work

Research in both MAS and BPM areas has been active, and therefore, other products exist as alternatives to Electronic Institutions or Metastorm. Regarding MAS, Moise [11] or Ingenias [12] are mostly related, although they have task oriented specifications. As for BPM, Aura Portal BPMS [13], QPR Process Guide [14], or Sgaim [15] are just a few examples of commercial solutions. Most of them have in common their SOA (Service Oriented Architecture) approach.

Regarding health care approaches, there are a number of commercial solutions that help in the management of hospital-related processes. As an example, we can mention Cielo MedSolutions [16] which is based on software developed by physicians at the University of Michigan Health System (UMHS). It comprises a chronic disease management information system that is based on a complete patient registry. In fact, information supports clinicians' decision making along the entire chronic disease

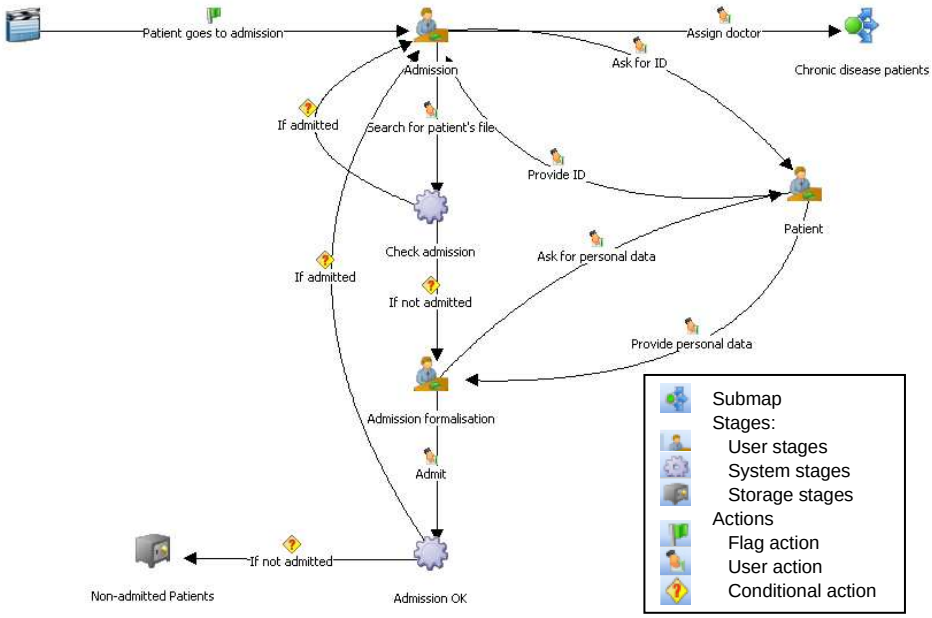



Figure 3: Admission protocol. Upon patient arrival to admission, the admitter needs to check if the patient was registered before and so it requests its ID (DNI) to the patient. If there is a record of this patient, the admitter assigns an appointment and the workflow moves to the main map. Otherwise, the patient fills in the personal data form in order to establish his/her record at the hospital.

workflow: prevention, screening, and management. A different approach is the one by MEDecision [17], which provides collaborative health care management solutions. They allow both internal and external collaboration on patient care for health care stakeholders —physicians, hospitals, laboratories, and even patients themselves. The main objective is to improve the quality and affordability of health care, which is reached through cost maintenance, operational optimization, and stakeholder relationship strengthening. Following this same criterion, SAP –the general BPM purpose company–, customizes its solutions for healthcare and provides the so called SAP for Healthcare portfolio [18]. Briefly, its approach focuses in providing tools to reduce costs so to increase the amount of time spent on patient care. The proposed solution integrates components that cover all administrative and clinical processes. Some of these components are: resource and supply chain planning; personnel administration; and collaborative care support modules. Finally, it is worth mentioning a specialized on-line tool provided by TCS Healthcare Technologies [19]. Their solution in care management includes: patient care plans –such as care taking, nutrition, or smoke cessation– and their management –with goals, interventions, and outcomes –; conduct and score assessments; and automatic tailoring of care plans based on assessments.

## 4. Discussion and future work

As we have seen so far, both Multi-agent institutions and workflows in BPM try to model the processes of an organization. Modelling can be participant centred or

information centred. Due to its nature, multi-agent systems take the former approach, whereas flows are more naturally related to the information that is processed along the process. As a result, this basic difference yields to alternative models, where most suited elements are more naturally reflected.

In this sense, we have seen how Electronic Institutions do model in a very natural way participants' interaction such as the dialogue between a patient and the admitter or the doctor or between an officer and a supplier. In the information centred approach, this has to be modelled through the piece of information they are exchanging. Therefore, following previous examples, participants act upon an admission form, a diagnosis form, or a purchase list.

On the other hand, if we require electronic institutions to transmit information from scene to scene, then we need an agent to carry it, acting as a messenger. For example, this is the case for the doctor representative agent moving from Dr Room scene to the Office scene in our HCDMP system.

As for the provided specification in this paper, it has the aim of been general enough so to be applied to any kind of chronic disease –i.e., from diabetes to asthma or arthritis, including heart failure or other disabling neurological conditions. It represents an approach to health care that emphasizes helping individuals to systematize the monitoring and treatment of their condition. And, since these activities are continuously repeated in the management of chronic diseases, they become especially suitable for this approach. Thus, although the general management of any disease could potentially be done through the proposed specification, those diseases requiring single interventions would take less profit from this systematization and long term action.

Chronic diseases can also be characterised for their suitability for having standard patient care plans. Thus, protocols are particularly convenient to enforce their execution. Nevertheless, in case of exceptions, they need to be incorporated in the specification, since, by now, there is no way to adapt on run-time to violations.

Regarding deployment as the natural step to follow after specification, an initial implementation has been developed for the Electronic Institutions framework. There, some agents (Admitter and Patient) have been programmed with the aid of the Agent Builder tool inside the EIDE development environment [20]. They follow the protocol in the Admission scene in accordance with the general chronic disease management specification. On the contrary, participants in Metastorm are supposed to be human users, so the deployment of the system involves the intervention of users in the workflow. Nevertheless, deployment requires licensing and thus it has not been tested. In this manner, empirical comparison is by no means a straightforward task, since the actual execution of experiments relay in really different settings. A first step would require a modelisation of human users that could be conducted by what-if experiments in participatory simulations [21].

As a final remark, we can conclude that both Electronic Institutions in MAS area and Metastorm in BPM provide a means to specify, deploy and monitor business processes. The selection of the most appropriated solution mostly depends on the perspective that we think it is more suited: participant centred (Electronic Institutions) or information centred (Metastorm). Nevertheless, other approaches can be further studied. Therefore, we take this comparison extension as our immediate future work. As for long term future work, we plan to enrich the system with the capability of adapting to improvements in the process, exceptions, or changes in the environment.

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