Virtual Process Modelling Informed by Organisational Semiotics: A Case of Higher Education Admission

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Abstract. The purpose of this study is to explore virtual process modelling based on organisational semiotics and WebML. The Internet and the Web afford opportunities to virtualize physical processes. Research on process virtualization has so far focused on theorizing or testing which activities can or cannot be virtualized. However, studies on virtual process modelling remains limited. This study therefore uses a university's admission process as a case to explore virtual process modelling in a higher education environment.

Keywords: Process virtualization, Virtual process modelling, Web application modelling, Higher education, Organisational semiotics, WebML.

1 Introduction

Drawing from organisational semiotics and WebML, this study explores virtual process and web application modelling. Physical processes have traditionally been conducted through direct human-to-human contacts. However, the Internet and the Web afford the opportunity to virtualize such processes [1]. Process virtualization has begun to attract research attention [e.g.2, 3, 4]. However, the focus so far has been on theorizing or testing which activities can or cannot be virtualized. Research on virtual process modelling thus remains limited. This study therefore focuses on virtual process modelling to extend the existing limited research focus.

The study employs organisational semiotics [5, 6] as the theoretical foundation and WebML [7, 8] as the web interface modelling language to explore virtual admission process modelling in a higher education context. Organisational semiotics was selected for its useful information systems modelling and specification techniques [9], while WebML was chosen for its useful hypertext notations for web interface modelling [8, 10].

The rest of the paper is structured as follows. Section 2 reviews related works on organisational processes, higher education admission and WebML. Section 3 presents organisational semiotics as the theoretical foundation of the study. Section 4 illustrates the modelling of a virtualized postgraduate admission process. Section 6 concludes the paper and offers direction for future research.

2 Related Works

2.1 Physical versus Virtualized Processes

Organisational processes comprise network of activities and their dependencies [11]. Processes can be physical or virtual. Physical processes occur through direct human-to-human contacts. Conversely, virtual processes are conducted via the Internet and the Web. Physical processes can therefore be virtualized by making them Internet and Web enabled [12].

Fig. 1 illustrates a generic process with activities and dependencies.

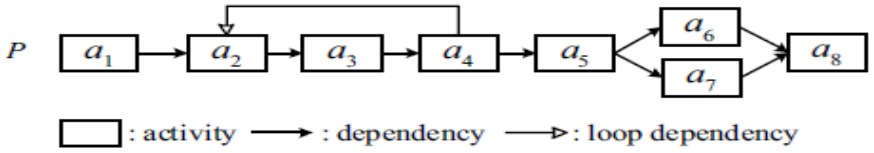


Fig. 1. Basic structure of a process [11]

The dependencies, which can be sequential, loop, split or joint [11], determine the directions between activities.

2.2 Higher Education Admission Process

A fundamental challenge for higher education admission is how to provide quality processes based on effective information systems [14] in order to attract highly qualified applicants. Following Harman [15] as well as McClea and Yen [16], this study views the admission process a composition of five main activities as shown in Fig. 2, namely, programmes advertisement, application, selection of qualified applicants, admission offer, and finally offer acceptance by satisfied applicants.

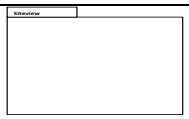
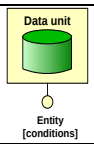
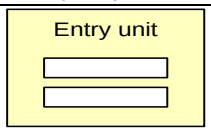
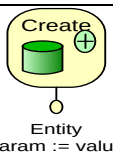
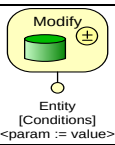
Fig. 2. Higher education admission process

The admission process is one of the major areas in need of computerization [14]. Computerizing the admission process can help to reduce printing and postage costs, improve efficiency and effectiveness, and provide real-time information access to stakeholders [16, 17]. Moreover, the Internet and the Web offer opportunities to virtualize admission processes [19]. However, such virtualization would require appropriate modelling techniques.

2.3 WebML

WebML [7, 8] is a visual web modelling language that is considered usefulness for designing data-, service-, and process-intensive web applications [20-22]. WebML supports both data and hypertext modelling. Its data model is used for designing back-end data structures, while the hypertext model is for web interface design. This study focuses on the hypertext model for the virtual admission web interface. Table 1 presents the relevant hypertext notations used in this study under their respective categories.

Table 1. Relevant WebML hypertext notations

Category	Notation	Name and description
Content units: components for entering and publishing content.		Site view: container for web pages, links, and operation units.
		Web page: container for published data, input forms and other components.
		Data units: entity instance for published data.
		Entry unit: web form for entering and accepting data.
Link units: links between web pages and other components.		Normal link: user activated hypertext link between web pages and other components
		Automatic link: system activated hypertext link between pages and other components.
Operation units: functionalities for data creation and manipulation subject to constraints.		Create operation: functionality for creating new instance of an entity in a base table.
		Modify operation: functionality for modifying or updating data in an entity instance.

In Section 4.3, the relevant hypertext notations are used to model the virtual admission web interface. The complete list of WebML notations with detailed explanations can be found in Ceri et al. [7, 8] as well as on the model's website: http://www.webml.org.

3 Organisational Semiotics

Organisational semiotics theorizes information systems as a collection of signs and symbols [23] created and consumed by actions and interactions of agents [24]. This study draws on two of its frameworks, organisational morphology and norm specification, as the theoretical foundation for the virtual admission modelling.

3.1 Organisational Morphology

Organisational morphology [25], also called organisational onion [5], views activities as norms and classifies them into three layers: informal, formal and technical, as shown in Fig. 3. Organisational norms are rules that regulate and govern how activities are performed [26].

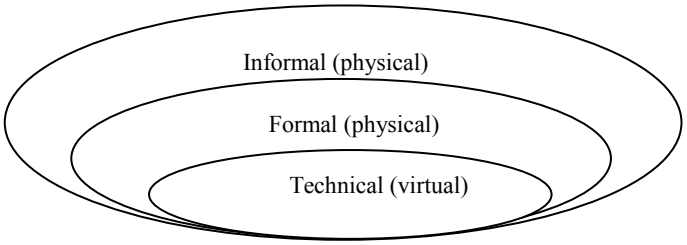


Fig. 3. The organisational onion [5]

The informal layer comprises activities that are based on implicit norms such as culture, customs and values that reflect people's beliefs, habits and practices. The formal layer consists of activities that are based explicit norms that define organisational rules and procedures. Finally, the technical layer encompasses activities that are structured and therefore are or can be computerized.

The three layers are however interrelated such that the technical layer is contained in the formal lay, which in turn is contained in the informal layer [26]. In addition, activities can be transformed from one layer to another. For example, an informal activity can be formalized, while a formal activity can computerised to become part of the technical [5].

In relation to process virtualization, the informal and formal activities constitute physical processes while the technical (computerized) form virtual processes. Virtualization therefore involves transforming physical activities (formal and informal norms) into virtual processes. According to Liu [5], transforming informal and formal

activities into technical (computerised) activities require formal norm analysis and specifications. The next section discusses the formal behavioural norm specification.

3.2 Behavioural Norm Specification

Behavioural norms constitute rules that define conditions under which organisational activities should or may be performed by responsible agents [5]. Behavioural norm analysis investigates norm-based activities and specifies them in a formal structure [27]. Fig. 4 presents the generic structure for behavioural norm specification in the form of condition, state trigger, responsible agent, deontic operator and action [5].

WHENEVER *<condition>*
IF *<state>*
THEN *<agent>*
IS *<deontic operator: should, may or should not>*
TO *<action>*

Fig. 4. Basic behavioural norm specification [23]

The WHENEVER <condition> and the IF <state> together define the necessary pre-conditions before an activity can start. The <agent> specifies the responsible actor for the activity. In general, an agent is an individual, a group, an organisation, a software or a physical artefact [25]. In relation to virtual processes, the agent is either physical (human or object) or virtual (internet service or web function). Deontic operator specifies whether an action is obligatory (should), optional (may) or prohibited (should not) [27].

Behavioural norms are classified into substantive, communication and control activities [25]. Substantive activities are direct operational activities; communication activities generate messages to support substantive activities; while control activities enforce rules and regulations to maintain standards for substantive and communication activities. As this study is at the exploratory stage, the current focus is on substantive norm specification.

To specify dependencies in substantive activities, the basic behavioural norm specification in Table 1 is extended to include predecessor and successor activities, as shown in Table 2. This structure is used to define the norm specifications for the virtual admission process in Section 4.2.

Table 2. Substantive behavioural norm specification for a processes

Activity ID	<activity name>
Specification	***WHENEVER*** *<condition>* ***IF*** *<state>* ***THEN*** *<agent>* ***IS*** *<may>* ***TO*** *<online action >*
Predecessor	*<predecessor activity>*
Successor	*<successor activity>*

4. Virtual Admission Process Modelling

The study used the postgraduate admission process of University of Ghana as a case to explore virtual admission process modelling. Established in 1948, University of Ghana is one of the oldest and leading universities in Africa. In addition to undergraduate programmes, the university offers postgraduate programmes for the award of masters and doctoral degrees to both local and international students. In 2011, the first author initiated an action case research project involving himself, the university's ICT unit and the postgraduate admission office to virtualize the admission process.

Action research has a dual purpose to address an immediate practical problem in an organisation and contribute to research at the same time [28]. The study therefore aimed to improve the university's postgraduate admission by reducing processing time, data errors and data loss as well as increase online access to information for various stakeholders. It also aimed to contribute to research on virtual process modelling and organisational semiotics. Data for the study emerged from the first author's participant observation and interviews with project members and users, project and corporate documents, prototyping as well as focus group discussions with users and development team members.

4.1 Virtual Admission Process

In general, the study identified substantive, communication and control norm-based activities. However, as noted earlier, the current paper's focus is on the substantive norms. Communication norms such as advertisement, inquiries and message communication as well as control procedures are therefore not included in the current virtual process specification. This limited focus was adopted so as to first establish the substantive model before communication and control norms can be added at a later stage.

From the norm analysis involving informal and formal norms, five substantive activities were identified in the university's postgraduate admission process as shown in Fig. 5.

Fig. 5. Admission Process

The application process involves applicants completing online forms and uploading supporting documents. The web application then transfers the online data to the responsible teaching department for assessment and selection. The department reviews the application data and documents such as transcripts, certificates, research proposal, referees' reports, and selects qualified applicants. The admission office officially admits the selected applicants and those satisfied complete an online acceptance form.

4.2 Substantive Norm Specification for Virtual Admission Process

Following the norm analysis, the substantive activities were presented in a formal the extended behavioural norms specification for processes to enable their virtualization into technical norms in the university's organisational onion. As shown in Table 3, the predecessor and successor activities were added to the norm specification to account for activity dependences.

Table 3. Substantive norm specification for virtual admission process

Activity	Specification	Predecessor	Successor
Application	***WHENEVER*** *<admission is open>* ***IF*** *<applicant likes programme>* ***THEN*** *<applicant>* ***IS*** *<may>* ***TO*** *<submit application>*	<open admission>	Transfer
Transfer	***WHENEVER*** *<application is submitted>* ***IF*** *<application is complete>* ***THEN*** *<Website>* ***IS*** *<should>* ***TO*** *<transfer application to department>*	application	selection
Selection	***WHENEVER*** *<application is received>* ***IF*** *<applicant is qualified and vacancy exists>* ***THEN*** *<Department>* ***IS*** *<should>* ***TO*** *<select applicant>*	transfer	admission
admission	***WHENEVER*** *<department selects applicant>* ***IF*** *<applicant meets all requirements >* ***THEN*** *<Admission officer>* ***IS*** *<should>* ***TO*** *<offer admission through website>*	selection	acceptance
acceptance	***WHENEVER*** *<admission is offered>* ***IF*** *<applicant likes the offer >* ***THEN*** *<applicant>* ***IS*** *<may>* ***TO*** *<accept offer through the website>*	admission	<enrolment>

In order to maintain dependencies, each activity has a predecessor and a successor. The emergent problem was how to get a predecessor and successor for the first and the last activity respectively. The issue was addressed by ensuring that the preceding and successive processes respectively served as the predecessor and successor for the first and last activities as shown in Table 3 with <open admission> and <enrolment>.

4.3 Hypertext Model

Following the formal substantive norm specification, WebML was used to design the hypertext architecture as the web interface to help virtualize the process activities. Fig. 6 shows a high level web interface model for the virtual admission application.

The process begins with the applicant accessing the admission website and proceeding to the application page to view information on available programmes. If the applicant identifies a programme he/she likes, the applicant completes and

submits the online application form. The application is automatically transferred to the relevant department for assessment and selection. After the selection, an admission officer officially admits the applicant to the chosen programme. Finally, if the selected candidate likes the programme, he/she completes an online acceptance form for enrolment.

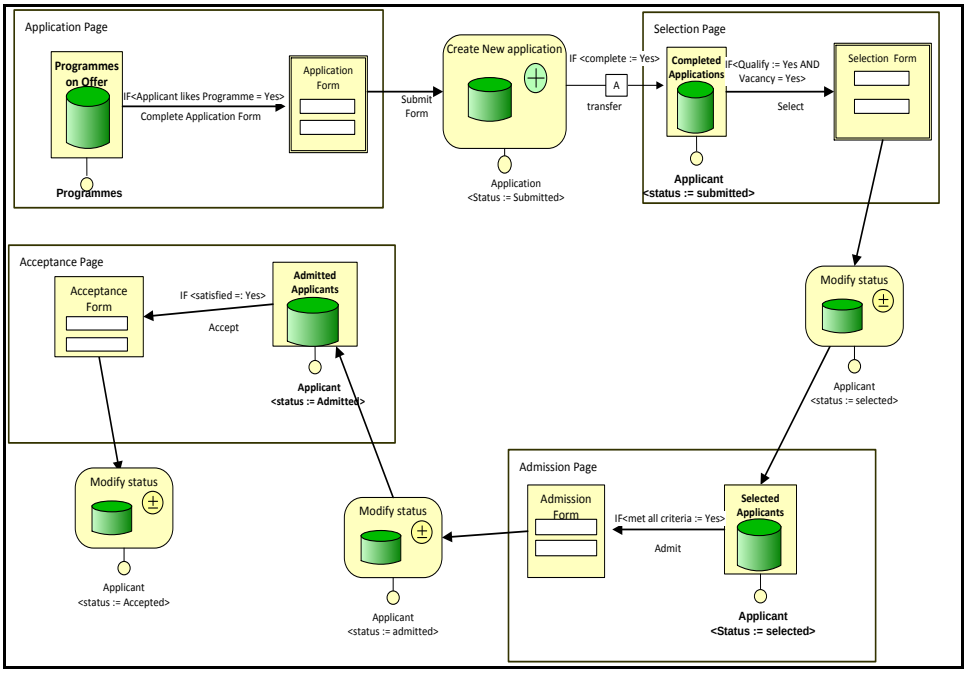


Fig. 6. Hypertext model for virtual admission

Following the implementation of the virtual admission process of the university, the post-graduate admission process has become more efficient. Reported benefits by the admission office include reduction in time, costs, human resource requirements, data errors and data losses. Other benefits include increased access to online information for all stakeholders as well as a virtual tracking facility for the applicants. Reported challenges however include frequent power failures and slow internet access during peak periods when admission is open.

5 Conclusion

This study employed organisational semiotics and WebML to explore virtual process and web application modelling with a university's postgraduate admission process as a case study. The study contributes to both organisational semiotics and process virtualization research. Based on the notion that processes consist of activities and

dependencies, the study contributes to organisational semiotics research by extending the basic behavioural norm specification to include predecessor and successor activities.

The study also demonstrates the applicability of WebML to extend behavioural norm specification into Web interface modelling. By this, process modelling under organisational semiotics can be extended with WebML hypertext for web interface design. In terms of process virtualization, the study extends the existing limited research focus on theorization and testing of process to virtual process modelling and web interface design. In terms of contribution to practice, the findings demonstrate improved efficiency and reduction in time, effort, human resource, cost as well as data errors and losses as potential benefits from virtualized processes.

The limitation of the study stems from its exploratory nature and high level focus on substantive activities without communicative and control activities. Future research can therefore benefit from extending the virtual process model and the web interface design to include communication and control norms.

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