USING THE INTERACTION MODEL TO IDENTIFY REPLICATION POTENTIAL BETWEEN BUSINESS UNITS

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ABSTRACT

Enterprise engineering is an enterprise design methodology that uses a process to create an *organised* whole, while mastering *complexity*. Dietz proposes an organisation theorem that reduces complexity by representing the *heterogeneous enterprise system* as a layered integration of three homogeneous aspect systems: the ontological, infological and datalogical. The ontological aspect system represents the essence of enterprise operation and a starting point for engineering a complex enterprise. This paper applies one of the key ontological models, namely the interaction model, to assess its ability to indentify replication potential due to ontological similarity. The case study environment for application of the interaction model was four departments at a tertiary education institution.

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1. INTRODUCTION

An enterprise is a heterogeneous system of which the types of problems may be classified according to two characteristics: (1) organisation, i.e. formal, non-random relationships between entities, and (2) complexity, i.e. the number of relationships between entities. According to Hoogervorst [1] the largest portion of enterprise problems falls within the area of *organised complexity*, where a high level of organisation exists and many interdependencies have formal relationships. Hoogervorst [1] further claims that the problems within *organised complexity* can neither be solved by analytical methods (due to complexity) nor statistical methods (due to the high level of organisation).

Enterprise engineering (EE) aims to comprehend enterprise complexity by guiding intentional enterprise design. Hoogervorst [1, p 8] identified two important EE pillars: enterprise ontology (EO) and enterprise architecture (EA). Whereas EO focuses on describing the essence of enterprise operation in order to reduce complexity and to assist with understanding enterprises, EA provides normative guidance for coherent and consistent enterprise design [1].

Ross et al. [2] are also concerned with guiding intentional enterprise design, but their key objective is to ensure enterprise-wide alignment between business and IT. They suggest the use of an operating model (OM) to create an enterprise-wide vision for process standardisation and data centralisation to guide decisions about how the enterprise implements processes and IT infrastructure. Although the OM provides senior management with a powerful decision-making tool about improving their current IT landscape, the selection of an appropriate OM requires additional guidance. In earlier research, we elaborated on current OM deficiencies, and requirements for enhancement [3]. We suggested the development of a *new method*, mechanisms and practices that would enable an enterprise architecture practitioner to identify the required process reuse opportunities for a specific OM. The *new method* requires selection of an appropriate process architecting language that will address a sub-set of requirements previously identified in [3]. Dietz [4] developed a process architecting language and models (ontological aspect models – OAMs) within the context of EO that could meet the *new method* requirements pertaining to *process representation* and *replication identification* as identified in [3]. One of the OAMs, the interaction model, extracts only the ontological transactions during process analysis and is thus better suited than other process architecting models to address the *replication identification* requirement that was identified in [3].

The contribution of this paper is the validation of the use of the interaction model to address the *replication identification* requirement that was identified in [3]. We demonstrate that the interaction model is suitable to identify replication potential of processes between four departments at a tertiary education institution due to the ontological similarity between the departments.

The paper is structured as follows: Section 2 provides background on different notions of a system to contextualise EO and how EO relates to the constructional notion of a system. Section 2 also contextualises EO and the OM in terms of business-IT alignment. Section 3 provides a set of requirements that could address the OM-deficiencies pertaining to process reuse opportunities and suggests validation of the interaction model in addressing the *replication identification* requirement. Section 4 discusses the research approach that was followed to validate the the use of the interaction model, whereas section 5 conveys details of the validation results. Section 6 concludes with follow-up research in validating the *new method*, mechanisms and practices.

2. BACKGROUND

Several researchers have contributed to the development of a general systems theory to provide the platform for understanding and analysing various systems, including the enterprise ([5, 6, 7]). In this article we use the notion of a *system* as a *kind of model* to extend our understanding of an enterprise [8].

In section 2.1 we introduce the concept of a system and elaborate on the distinction between a *constructional system* and a *teleological system*, and how these two notions are united during the system design process. The section concludes with the requirement for ontological construction models in engineering the construction of *any system*. Section 2.2 defines ontology and EO in providing the necessary context for discussing the ontological construction models for constructing an *enterprise* as a system. The ontological construction models that Dietz [4] suggests for an enterprise, namely the *ontological aspect models* (OAMs), are then discussed in section 2.3. One of the OAMs, the *interaction model*, is presented in section 2.4. Both EO and the operating model (OM) are contextualised in terms of business-IT alignment in sections 2.5 and 2.6.

2.1 What is a system?

Various definitions exist for describing a system; Jackson [9, p 3] defines a system as "a complex whole, a functioning of which depends on its parts and the interaction between these parts". Others extend the systems definition, stating that the parts are connected to perform a unique function that could *not be performed by the parts alone* [8, 10, 11].

In order to gain a deeper understanding of a system, Dietz [4] introduces a constructional system notion (section 2.1.1), which is required to understand the structure/construction of a system and the teleological/functional system notion, which is required to use and control the system (section 2.1.2).

2.1.1 The constructional system notion

Bunge [12] uses a constructional viewpoint when he defines the main constructs of a system (illustrated in Figure 1) with a definite:

- *Composition* (parts of some category, i.e. physical, social, biological etc.),
- *environment* (parts of the same category, but not within the boundary of the system),
- *structure* (a set of influencing bonds between the parts within the boundary, and between them and the parts in the environment).

Dietz [4] added another construct, namely that a system has a definite *production* output (the parts within the boundary produce things that are delivered to the parts in the environment).

If one considers an enterprise to be a system, the *composition* of the social system would be social individuals; the *environment* would be parts of the same category (social individuals) directly linked to the compositional parts, but outside the boundary; whereas the *structure* would be the mutual influencing relations among the system parts (i.e. individuals within the boundary and certain individuals outside the boundary). The *production* would be goods and/or services that are delivered to the environment.

White box models are used to provide a conceptualisation of the constructional notion of a system. *White-box models* are used for building or changing/maintaining a system and the dominant type of model in all engineering sciences [4]. An example of a *white box model* is the constructional decomposition model (i.e. bill-of-material) of a car (the car being the system), e.g. a car consists of a chassis, wheels, motor and lamps [4].

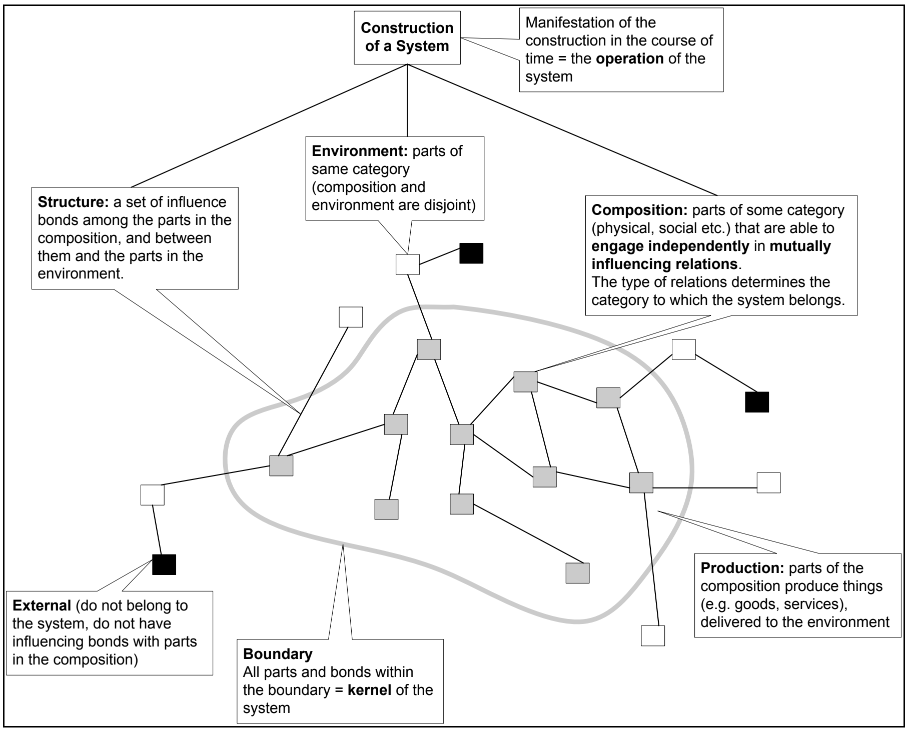


Figure 1: The structure/ontology of a system (adapted from [4])

2.1.2 *The teleological system notion*

The teleological system notion is concerned with function and behaviour and is adequate for the purpose of using or *controlling the behaviour* of the system. Management is usually concerned with the functions of an organisation and how control of the input variables has an effect on output variables [4].

Black-box models are typically used to conceptualise the functions and behaviours of the system without knowing the detail construction and operation of the system. An example of a *black box model* is the functional decomposition model of a car (the car being the system), e.g. a car consists of a lightning system, power system, steering system and brake system. *Black box models* are not useful to an engineer when maintaining the system [4]. Examples of black *box models* that describe organisational behaviour include: data flow diagrams and cause-and-effect diagrams, e.g. sistemigrams of [8].

2.1.3 *The system design process and engineering*

Dietz [4] states that every system that needs to be designed, follows a generic *design process* that incorporates two systems: the *using system* and the *object system* (see Figure 2). The object system is used by the using system. As an example, the object system could be an ICT system that needs to be designed and is used by the using system, the enterprise. The first design phase (*determining requirements* in Figure 2) involves the definition of the required function of the object system (represented by a *black box model*). The function can only be determined in terms of the construction of the using system. The second design phase (devising specifications, in Figure 2) starts with the function of the object system and concludes with the construction of the object system.

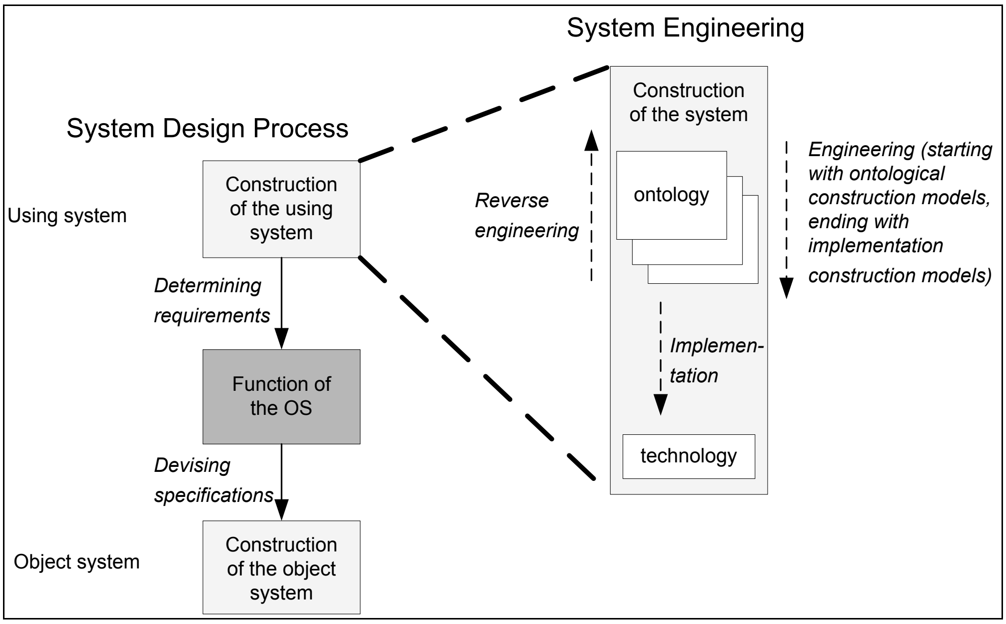


Figure 2: The basic system design and engineering processes (adapted from [4])

System engineering entails the process during which constructional models (*white box models*) are produced (see Figure 2). Engineers systematically produce a series of ontological construction models (e.g. construction models that are implementation-independent) and end with implementation construction models, i.e. models that could be linked to technology means [4]. The next section clarifies the meaning of ontology and then elaborates on ontological construction models that are relevant to an enterprise, called ontological aspect models (OAMs).

2.2 Ontology and enterprise ontology

Ontology is the study of existence and the nature of reality [13]. When the definition of ontology is used within the context of an enterprise, different viewpoints about the *nature of reality* exist. Zachman [14] uses an objectivist viewpoint when he claims that the Zachman Enterprise Framework2 (ZEF2) is an ontology: "a theory of the existence of a structured set of essential components of an object for which explicit expressions is necessary and perhaps even mandatory for creating, operating, and changing the object (the object being an enterprise, a department, a value chain, a "sliver," a solution, a project, an airplane, a building, a product, a profession or whatever or whatever)".

Contrary to the objectivist viewpoint of Zachman, Dietz [4, p 8] takes a constructivist viewpoint on ontology. He agrees with the subjectivist that there is no absolute objective reality, but that a semi-objective reality exists (called the inter-subjective reality) that is continuously adapted through negotiating and achieving social consensus among subjects. Ontology is thus "built, rebuilt and adapted in communication". The goal of *enterprise ontology* should be to understand the "essence of the construction and operation". Dietz [4] provides *five properties* for evaluating enterprise ontologies: coherence, comprehensiveness, consistency, conciseness and essence. He subsequently developed five ontological aspect models (OAMs) according to the *five properties* to communicate only the *essence of the operation* of the enterprise. Although both ZEF2 and the OAMs could be used to specify the essential components of an enterprise, Dietz provides a more practical approach and examples of the OAMs.

2.3 Ontological aspect models

Dietz [4] provides a unique way of representing the organisation as a heterogeneous system that consists of a layered integration of three homogeneous systems: the ontological, infological and datalogical aspect systems (see Figure 3). The three aspect systems are of the same category, i.e. social systems, but differ in terms of their kind of production: the ontological aspect system produces ontological acts, such as decisions and judgements; the infological aspect system produces infological acts, such as reproducing, deducing, reasoning and computing; whereas the datalogical aspect system produces datalogical acts, such as storing, transmitting, copying and destroying. The distinction between different aspect systems enables one to focus on the essential/ontological aspect system in describing the essential operation of an organisation, irrespective of its realisation (i.e. integration with the other two aspect systems) or implementations (using technology to make the organisation operational).

Figure 3 illustrates the three aspect systems and the set of OAMs to represent the ontological knowledge of an enterprise. Dietz also provided a method for creating the OAMs, called DEMO (Design and Engineering Methodology for Organisations). A method-sequence is suggested in developing the models in Figure 3 where:

1. the interaction model shows the actors and transaction types that are involved during an enterprise operation;
2. the process model is then derived from the interaction model to demonstrate the transaction patterns for each transaction type;
3. the action model details the identified steps in the process model to serve as guidelines for actors in dealing with their agenda;
4. the state model specifies the state space of the production world and is based on the action model;
5. the interstriction model finally extends the already-created interaction model by adding the passive influences (facts that were created) as detailed in the state model [4].

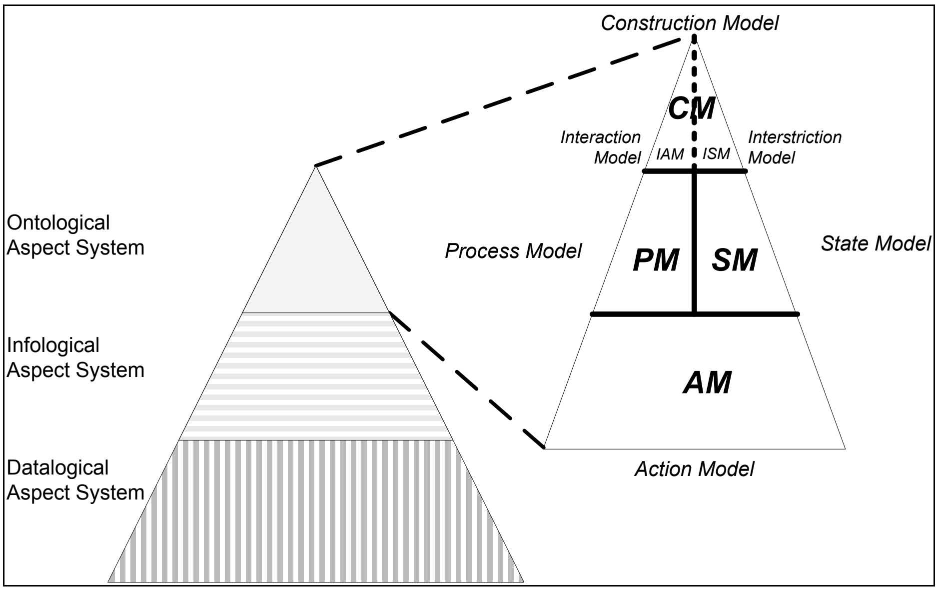


Figure 3: The three aspect systems, highlighting the OAMs (based on Dietz [4])

The following section discusses the OAM that will primarily be validated in this paper, namely the interaction model.

2.4 The interaction model

The interaction model, one of the OAMs (see Figure 3), is the most compact ontological model of an enterprise that incorporates units of logic (transaction types) that are consistent in the detail embodied in the underlying transaction patterns. The interaction model is expressed in an actor transaction diagram and a transaction result table [4]. The actor transaction diagram demonstrates interactions between actors during the execution of transactions. Figure 4 provides an example of an actor transaction diagram (modelled with the ABACUS toolset) of a hypothetical college that performs eight ontological transactions.

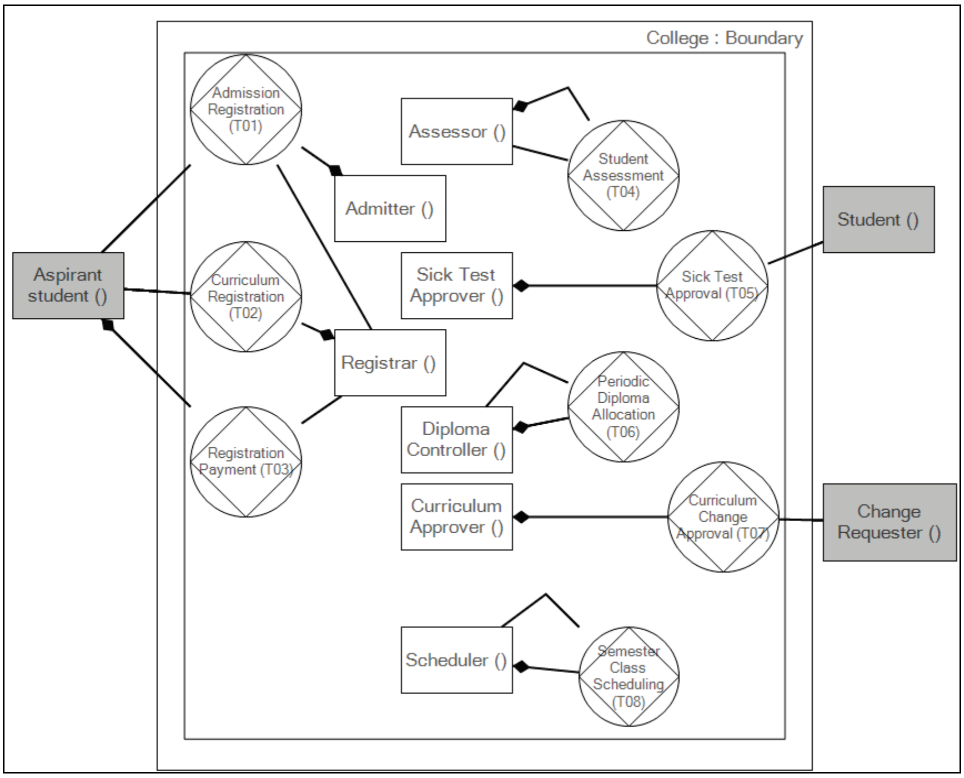


Figure 4: Actor transaction diagram for a hypothetical college (constructed using the ABACUS toolset)

The actor transaction diagram of Figure 4 consists of actors, transaction types, initiator links and executor links. The *actors* are indicated by rectangles (white rectangles represent elementary actors, whereas shaded rectangles represent composite actors). The *transaction types* are indicated by the disc-diamond combination. Each transaction type may be initiated by one or more actors and the *initiator link* is indicated by a solid line. Each transaction type is executed by only one actor and the *executor link* is indicated by a solid line with a diamond end that links to the executing actor. The transaction result table is merely an extension of the actor transaction diagram where the expected result of each transaction type is described. As an example, the result of the transaction type T01 (admission registration) in Figure 4 could be described as: admission A has been done.

Each transaction type is a concise representation of a transaction pattern that consists of a number of coordination acts and facts that come into existence when actors start coordinating around the production of a production act and fact. When actors are consenting to each other's acts, a basic transaction pattern is followed (see Figure 5). Actors may also dissent to each other's acts and/or they may try to roll back part of the transaction acts/facts. When these deviations from the basic transaction pattern are incorporated, a complete/universal pattern exists that allows for the complete description of any transaction type [4].

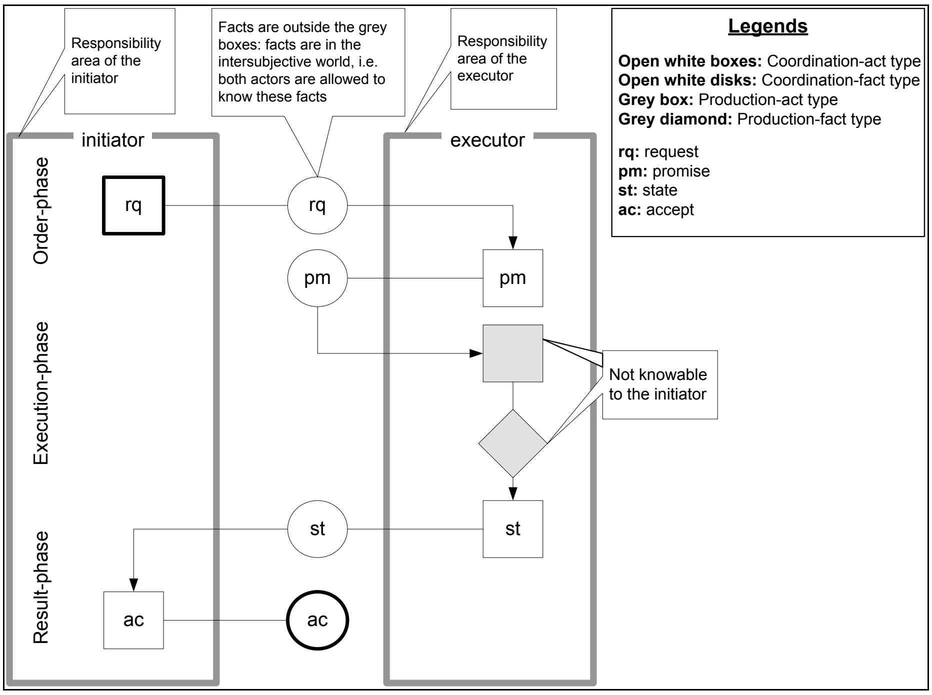


Figure 5: The basic transaction pattern [4]

2.5 Enterprise ontology in business-IT alignment and enterprise engineering

Dietz [4] initially developed the OAMs for the purpose of understanding the ontological construction of the enterprise as the using system, the object system being the supporting IT systems (see Figure 6, no.1). The ontological aspect models are thus used for business-IT alignment. Hoogervorst [1] extended the use of the OAMs, also using the ontological aspect models as constructional representations of the enterprise as the object system, while the commercial environment is the using system (see Figure 6, no.2). The OAMs are thus used to represent the EO and are used in combination with enterprise architecture (EA) as the two main pillars in enterprise engineering (EE) [1].

2.6 The business-IT alignment intent of the operating model

Ross et al. [2, p 8] suggests that a company articulates a vision (future view) of how the company will operate, called the operating model (OM). The OM is the “necessary level of business process integration and standardisation for delivering goods and services to customers”. Based on the different levels of process standardisation and process integration, as well as other characteristics, Ross et al. [2] define four stereotypical OMs: diversification, replication, coordination and unification.

Once identified by senior management, the required OM is used to guide future decisions about implementing processes and IT infrastructure. The OM is thus used as an instrument to align IT systems and infrastructure towards the process standardisation and data centralisation objectives embedded in the required OM. The OM provides a vision for business-IT alignment (see Figure 6, no.3), similar to the original intent of using EO as specified by Dietz [4].

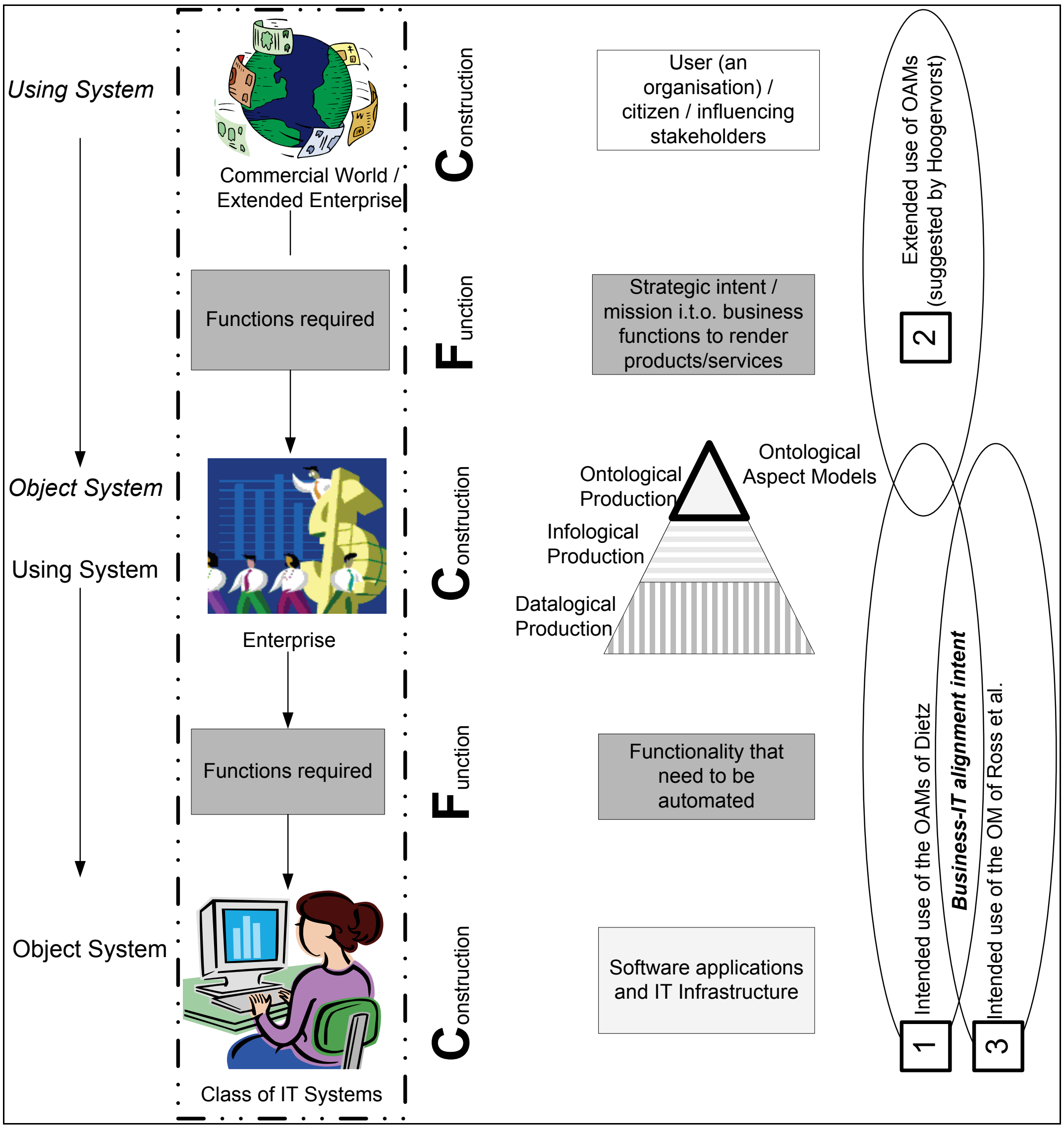


Figure 6: Enterprise ontology in business-IT alignment and EE (based on [4] and [1])

3. PROBLEM DEFINITION

In earlier research we acknowledged the use of an operating model (OM) to identify the required level of process standardisation/replication and data sharing for directing business-IT alignment in an organisation [2]. Two key deficiencies have been identified pertaining to (1) the *method* for deriving the required OM, and (2) using the OM to *elevate to a fourth level of operating maturity*. The identified deficiencies were converted into of a set of requirements (summarised in Table 1) to address the stated deficiencies, but only pertaining to the identification of *process reuse opportunities* [3]. The aim is to develop a *new method* (with supporting mechanisms and practices) that would address the requirements in Table 1. One of the key requirements in developing the *new method* is to select a suitable process representation language that would adhere to the requirement categories R5 and R6 of Table 1.

No	Category	Requirement Detail
R1	User(s) of the practices and related mechanisms	Any EA practitioner who wants to use the OM specified by [2] and needs to collaborate with other stakeholders in defining the required level of process standardisation/replication.
R2	Generality	The practices and mechanisms should be generic in their application to different types of industries. An EA practitioner should be able to apply the practices and mechanisms to either a profit-driven, not-for-profit/government organisation within any industry, in combination with the foundation for execution approach.
R3	Process categories included	The practices and mechanisms may be applied to all processes in the organisation however; practices and mechanisms will be most effective when applied to the primary activities of an organisation.
R4	Current architecture capabilities	The practices and mechanisms need to take current work in terms of Enterprise Architecture, Business Architecture and Process Architecture into account, but also need to provide sufficient detail if none of these architectures have been explicated.
R5	Process representation	The practices and mechanisms should encourage consistent process representation to ensure re-use. The extent of re-use includes the following: 1. It should be possible to add process measures if required for the purpose of performance measurement and/or process improvement. 2. The process representations should support end-to-end views of processes. 3. Process representations should not hamper the transition from the third to fourth levels of operating maturity, i.e. it should allow for modular process design. 4. The representations that are used to communicate process replication opportunities should be understandable to business users (from the contextual and conceptual viewpoints).
R6	Replication identification	The mechanisms and practices should enable the identification of operational similar organising entities.
R7	Feasibility analyses	The mechanisms and practices should not suggest the means for assessing or measuring the feasibility of process replication/rationalisation. Feasibility analysis, e.g. operational, cultural, technical, schedule, economic and legal feasibility ([15]) that may be associated with process rationalisation solutions are therefore excluded.

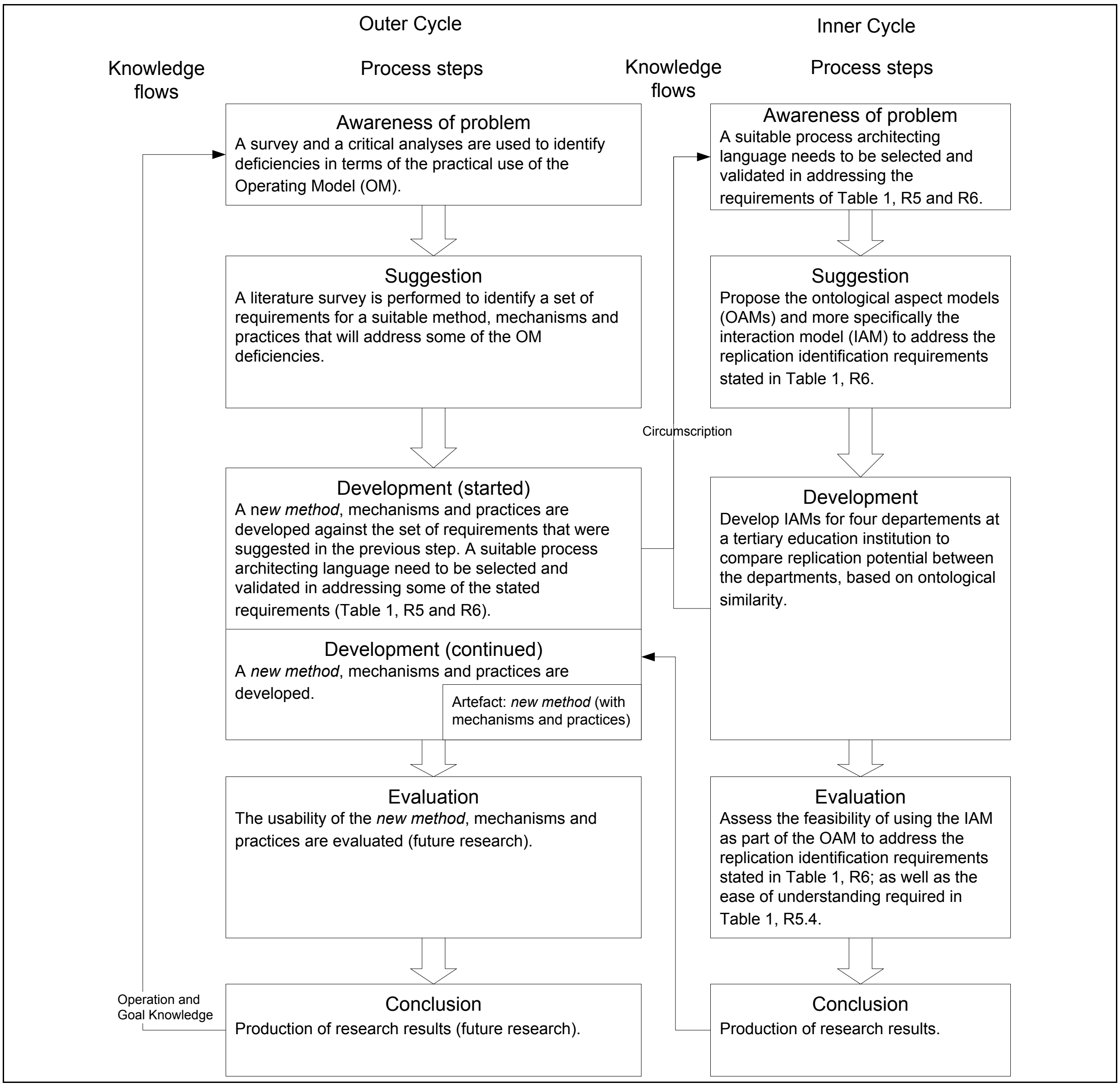
Table 1: Requirements for addressing the deficiencies highlighted in [3]

We identified two process-architecting languages as candidates for addressing the requirements of Table 1 (R5 and R6): BPMN (Business Process Modelling Notation) and the OAMs of Dietz. Whereas both BPMN and OAM complies with the requirements stated in Table 1 (R5 and R6), we favour the use of OAM primarily due to its ability of representing enterprise operation independent of its realisation and implementation. By abstracting enterprise operation from the material aspects (i.e. excluding forms and files used for communication between participants), the identification of operational similar organising entities (Table 1, R6) is enhanced. Once ontological operational similarities have been established, 'flat' techniques (e.g. flow charts, event-driven-process-chains (EPCs), Petri Nets and BPMN) may be mapped to the ontological models and extended to accommodate variations in implementation at the different organising entities [4]. Configurable process models based on BPMN could for instance be used to accommodate implementation variations between different organising entities [16, 17].

The purpose of this research is to validate the use one of the OAMs, namely the interaction model (see Figure 3), which is the most compact ontological model of an enterprise [4], to assess replication potential of processes between business units based on ontological similarity. The outcome of the validation exercise will be used as an input to complete the design of the *new method*, mechanisms and practices.

4. RESEARCH METHOD

This research forms part of a larger design research project. The design cycle method specified by Vaishnavi and Kuechler [18] was followed. The outer design cycle (Figure 7) demonstrates the iterative approach that is followed for the main research project. The inner design cycle (Figure 7) presents the research cycle that was required for the purpose of this article.



Awareness of problem
A survey and a critical analyses are used to identify deficiencies in terms of the practical use of the Operating Model (OM).

Suggestion
A literature survey is performed to identify a set of requirements for a suitable method, mechanisms and practices that will address some of the OM deficiencies.

Development (started)
A *new method*, mechanisms and practices are developed against the set of requirements that were suggested in the previous step. A suitable process architecting language need to be selected and validated in addressing some of the stated requirements (Table 1, R5 and R6).

Development (continued)
A *new method*, mechanisms and practices are developed.

Artefact: *new method* (with mechanisms and practices)

Evaluation
The usability of the *new method*, mechanisms and practices are evaluated (future research).

Conclusion
Production of research results (future research).

Awareness of problem
A suitable process architecting language needs to be selected and validated in addressing the requirements of Table 1, R5 and R6.

Suggestion
Propose the ontological aspect models (OAMs) and more specifically the interaction model (IAM) to address the replication identification requirements stated in Table 1, R6.

Development
Develop IAMs for four departements at a tertiary education institution to compare replication potential between the departments, based on ontological similarity.

Evaluation
Assess the feasibility of using the IAM as part of the OAM to address the replication identification requirements stated in Table 1, R6; as well as the ease of understanding required in Table 1, R5.4.

Conclusion
Production of research results.

Figure 7: The design cycles applied to this study

The development and evaluation strategy followed a participative approach. Four research participants (industrial engineers) received extensive training in the use of the interaction model and the underlying theory. Each participant was responsible for developing an interaction model for a different engineering department at a tertiary education institution. The purpose was to develop an initial interaction model for an engineering department (say Department 1) and to validate the contents of the interaction model consecutively at the different departments to identify replication potential.

An initial interaction model was developed by two of the engineers, working in Department 1. The initial interaction model content was based on their own knowledge about the department and analyses of the content available on the shared departmental repository. About twenty seeding transactions were identified during the first validation session. The validation sessions were structured as follows:

1. The main researcher provided an introductory presentation on using the interaction model to the head of department (HOD).
2. The interaction model of Department 1 was presented to the HOD by one of the participants.
3. The HOD suggested changes to the interaction model to reflect ontological transactions for his/her own department.
4. Changes (additions/deletions) could also be valid for other departments and were consequently verified separately.
5. The HOD was also requested to provide comments on the usability of the interaction model to identify ontological similarity between departments and the ease of understanding.
6. Each participant modelled the interaction model for their assigned department, using ABACUS (an enterprise architecture software tool).
7. The results (transaction similarity) were analysed using ABACUS.

5. RESULTS

The resulting interaction models demonstrated that the engineering departments provide process replication potential due to their ontological similarity. All departments perform the same forty-five (45) ontological transactions out of a total number of forty-six (46), i.e. only one department does not perform the transaction: “License approval for special materials”. Using ABACUS, a visual comparison (a matrix of transactions versus department) was extracted. Manual inspection of the actor transaction diagrams exposed differences regarding the initiators of the transactions (unfortunately ABACUS could not be used to highlight initiation differences, which is a limitation of the tool and not the interaction model).

The results concerning the practical use of the interaction model will be discussed from (1) a practitioner’s viewpoint; and (2) from a business user’s viewpoint, in addressing requirement Table 1, R5.4 pertaining to *ease of understanding*.

5.1 The practitioner’s viewpoint

The feedback provided in this section incorporates the reflections of the four participants as well as the observations of the main researcher during the validation sessions and the discussion sessions that followed. A few deficiencies and/or limitations pertaining to the interaction model have been identified:

1. The participants did not follow a specific order in validating the content of the actor transaction diagram. This partially contributed to some of the comments made by the Hoods that a transaction sequence is required to enhance the use of the actor transaction diagram.
2. Each transaction may only have one executor according to the actor transaction diagram rules specified by Dietz [4]. This posed a problem in the scenario where a

transaction (e.g. performance approval) could either be approved by an internal actor (an HOD) or an external actor (the dean of the faculty). The transaction pattern is exactly the same, but the executor differs. One solution is to duplicate the transaction and to assign different executors to the separate transactions. However, the problem is essentially a result of the definition of a boundary; if no boundary existed, one would simply have one executor.

3. Al participants (including the Hoods) expressed the need to express knowledge about the status of one transaction type as a prerequisite for executing another transaction type. Dietz [4] accommodates this need by expressing the required access to transaction information per actor via information links. The interaction model is then converted to an interstriction model (see Figure 3).
4. Participants (including the Hoods) expressed the need to show optional and conditional initiation and execution links on the actor transaction diagram. In its current format, all initiation and execution links seem to be mandatory. Dietz [4] accommodates conditional logic only on the next level of detail embodied in the process model (see Figure 3).

5.2 The business user's viewpoint

The comments received from the Hoods were positive. The training material used during the validation sessions was sufficient to provide the Hoods with an understanding of the purpose, use and constructional elements of the interaction model. Questions from Hoods regarding sequence and conditional execution of transaction types however emphasised the need to explain the entire set of OAMs in addressing concerns about the interaction model limitations. Three of the four Hoods provided additional comments pertaining to the use of the interaction model:

1. HOD 1 expressed the need to extend the analysis effort by analysing the implementation logic for some of the problematic transaction types and suggest improvements that could be replicated to all departments.
2. HOD 2 highlighted the importance of distinguishing between core transaction types and supporting transaction types (via colour-coding) and emphasised the need to focus on the core transaction types during improvement analyses.
3. HOD 3 expressed the value of an interaction model (and other OAMs) to her own department and their potential to capture knowledge about the operation of the department. Valuable operational knowledge is lost when Hoods are replaced every four years. Explication of operational knowledge will contribute towards continuity and customer service.

6. CONCLUSIONS / FOLLOW-UP RESEARCH

The positive validation results substantiates inclusion of the interaction model as part of the *new method* for enhancement of the OM concept of Ross et al. [2] in addressing the requirement *replication identification* (Table 1, R6). In addition, the interaction model promoted *ease of understanding* as required by Table 1, R5.4. Some of the interaction model limitations identified by the participants were due to a limited understanding of the combined us of the OAMs and the purpose/use of each OAM. Other identified interaction model limitations were used to refine the interaction model and the method used in constructing an interaction model.

Further research includes validation of the new method. The *method* will be introduced to a group of research participants who will use the method to identify process standardisation/replication opportunities at their own organisations. The research participants received extensive training on the new method and underlying theories, and will be requested to complete a survey to evaluate the ease-of-use of the *new method*, as well as the usefulness of the *new method*, mechanisms and practices to identify process reuse opportunities in their organisation. The feedback received from the survey will be used to refine the *new method*, mechanisms and practices.

7. ACKNOWLEDGEMENTS

We would like to thank all the research participants for their time, effort and contributions during the execution of the study.

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