Artefact-oriented Business Process Modelling
An Ontological Dependency Approach

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Abstract: Business process modelling can help an organisation better understand and improve its business processes. Most business process modelling methods adopt a task- or activity-based approach to identifying business processes. Within our work, we use activity theory to categorise elements within organisations as being either human beings, activities or artefacts. Due to the direct relationship between these three elements, an artefact-oriented approach to organisation analysis emerges. Organisational semiotics highlights the ontological dependency between affordances within an organisation. We analyse the ontological dependency between organisational elements, and therefore produce the ontology chart for artefact-oriented business process modelling in order to clarify the relationship between the elements of an organisation. Furthermore, we adopt the techniques from semantic analysis and norm analysis, of organisational semiotics, to develop the artefact-oriented method for business process modelling. The proposed method provides a novel perspective for identifying and analysing business processes, as well as agents and artefacts, as the artefact-oriented perspective demonstrates the fundamental flow of an organisation. The modelling results enable an organisation to understand and model its processes from an artefact perspective, viewing an organisation as a network of artefacts. The information and practice captured and stored in artefact can also be shared and reused between organisations that produce similar artefacts.

1 INTRODUCTION

An organisation can be seen as a system that has inputs, processes, and outputs, and also contains various parts integrated to accomplish the shared goal (Senge, 1990). The system view enables management to view the organisation in flows, processes and relationships, to achieve optimal results (Seddon, 2008). The flows, processes and relationships in a system are usually defined by the sequence of activities and tasks. Hammer and Champy (1993) defined a business process as a collection of activities with a goal that takes one or more types of input to create a valuable output to the customer. Eriksson and Penker (2000) argued that a business process focuses on addressing how work is performed rather than describing the output of a process. Business process therefore contains a sequence of work activities that together contribute to the customers' desired outcome.

Business process modelling provides a shared understanding and analysis of business processes (Aguilar-Savén, 2004). It captures how the activities are being performed, the sequence of activities involved, and the presence of the business process in a chosen approach. Business process modelling helps an organisation conceptually structure the architecture of its business process. The results of business process modelling can therefore be used for software development and for business process restructuring (Phalp and Shepperd, 2000).

There are numerous methods and techniques for business process modelling, which were all developed for different purposes and needs (Aguilar-Savén, 2004). The majority of business process modelling methods capture the sequence and details of activities, and then represent an organisation by visualising or grouping the captured activities via various techniques. Various attributes are used in different methods for defining business process, such as human roles (Holt et al., 1983), data and information (Gane and Sarson, 1977, Yourdon and Constantine, 1979), actions (Lakin et al., 1996), data objects (Douglass, 2000), and duration (Aguilar-Savén, 2004). Despite the numerous attributes used, activities are still normally the starting point for

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business process modelling. However, by reviewing and analysing the elements within an organisation, we identify the three elements as human agents, artefacts and activities, and the interdependent relationship between them. Due to the direct link between these three elements, an instance of any type of elements can be used as a basis to identify the relevant instances of the other two elements. In order to gather artefact-oriented information about activities and human agents, a business process modelling method that captures the business flow from an artefact perspective has been developed.

In order to develop an artefact-oriented method for business process modelling, we first adopted activity theory to understand the relationship between human beings, activities and artefacts. Organisational semiotics was chosen as the theoretical basis for the artefact-oriented method development. The ontology chart for artefact-oriented business process modelling was then produced, however we extended the ontology chart by applying the techniques from semantic analysis and norm analysis in order to develop the artefact-oriented business process modelling method, and allow us to identify the artefact and agent's activities. Each step of the above method will be explained and demonstrated in more details, via use of a supporting example.

2 BACKGROUND

2.1 Activity Theory and Organisations

Business process modelling has been an important topic in the study of business, because it facilitates organisations to understand and improve their business processes, therefore working towards better performance. In order to model a business process, it is essential to understand the structure, components and workflows of an organisation. We used activity theory (AT) (Engestrom et al., 1999) to define the elements of organisations. AT identifies each goal driven activity as an analysis unit. An activity model contains object, subject and artefact. An object is both something given and something projected or anticipated. Object is the thing being modified to fit the purpose. Subject is the human being that is being motivated by the object to perform tasks to reach a goal. Artefact refers to the mediating tools that can either be physical or mental. Additionally, AT states that activity model is artefact-mediated and object-oriented, and the context has to be considered while analysing human activities. The outcome of one activity model can be the object or artefact of another activity model. An AT model can therefore operate independently, or cooperate with other activity models. An organisation can be seen as a network of activities. The interaction between the object and the human subject is through the mediation of tools. AT has been applied to understand business process (Larkin, 2003, Rozycki et al., 2012), and the process deconsolidation is based on different perspectives of agents. According to AT, subject modifies objects to generate outcome (Barthelmess and Anderson, 2002). Activities are therefore significantly related to human beings, objects and tools. Both tools and objects are the artefacts that are being modified or utilised by human beings when performing activities. The object of an activity can be reused as a tool by another activity model. Hence, the tools and objects can be categorised together by nature, whilst also being viewed as a set of activities, since any form of organisation requires the collaboration of human beings performing sets of activities or tasks. Hence, we define three major elements in an organisation as being human, activities and artefacts. These three elements construct to form an organisation through intertwined relationships. An organisation can be seen as a network of artefacts that are linked to human beings and activities. Hence, artefacts, as well as activities, can also be seen as the linkages in a system, as artefacts within a system can normally be defined at the input and output of the systems and sub-systems. The sub-systems pass artefacts from one sub-system to another; with the output of one sub-system acting as the input of its succeeding sub-system. By focusing on the input and outputs between sub-systems, a more artefact-oriented perspective for examining organisations emerges. As artefacts are often directly involved with human activity, the relationship between artefact instances can further reveal the relationship between artefacts and human beings; i.e. artefacts can be used as the base for stakeholder mapping (Pan et al., 2013).

2.2 Organisational Semiotics

Organisational semiotics (OS) is a discipline that applies semiotics to organisational study. It focuses on the nature, function and effect of information and communication within organisations (Liu, 2000). Semantic Analysis Method (SAM) and Norm Analysis Method (NAM) of OS are selected for this research. SAM is a set of methods to elicit and specify user's requirements in a formal and precise format, and the building blocks of SAM include

affordances, agents and ontological dependency (Liu, 2000, Bonacin et al., 2004). Gibson (1986) defined affordances as patterns of behaviours that are meaningful in the context of society. Affordance is the perceived and actual properties of the thing, and the properties determines the possible use of the thing (Norman, 1988). Stamper (1985) explained that a physical object can also be defined as an affordance given the object's ability to enable patterns of behaviours. Hence, the entities, objects or artefacts that can be utilised by human beings in an organisation are all affordances. Agents are also affordance, which distinguish themselves from other affordances by being able to take responsibilities for their own and others' actions (Salter and Liu, 2002). Agents can be individuals, groups or organisations, as long as the agent takes responsibility for their actions. Furthermore, affordances defined in a given context are not isolated from each other. There are relationships between affordances. The ontological dependency means that the existence of an affordance relies on its antecedents. The relationships between affordances can therefore be shown in an ontology chart where the nodes normally represent universal affordances rather than particular affordance instances.

Based on the results from SAM, NAM further identifies and analyses rules and patterns of artefact behaviour. NAM contains four steps, namely responsibility analysis, proto-norm analysis, trigger analysis and detailed norm specification (Liu, 2000). The results of norm analysis can help the organisation understand and potentially improve its processes. These steps can be utilised to analyse and model the activities related to the artefacts within the organisation, once the ontological dependency within the organisation has been clarified.

3 METHODS

By reviewing the literature in AT, OS and business process modelling, we have identified the potential use of artefacts as an approach to business process modelling. AT and OS provide the theoretical foundation for understanding the elements within organisation and the ontological dependency among them, which is used to develop the ontology chart for artefact-oriented business process modelling. Artefact orientation and ontological dependency within organisation will be discussed in section 4.

The ontology chart for artefact-oriented business process modelling demonstrates how agents and afforded acts can be identified and linked through artefacts in a defined environment. We also adopted the concepts and analysis techniques from SAM and NAM. The semantic analysis techniques helped identify the affordances in the defined environment and to examine the relationship between them. Once the affordances and the relationship amongst them are clarified, the techniques from NAM were used to assign responsible agents to the identified afforded acts and to further analyse the rules for the afforded acts. The details of each step will be addressed in section 5, with an example to demonstrate each step of the artefact-oriented business process modelling.

4 ARTEFACT AND ONTOLOGICAL DEPENDENCY

Developed from AT, artefacts, human agents and activities have been identified as the three major elements within an organisation. Organisations would not be able to function with the absence of any of the three elements. Artefacts are being processed or produced by human agents performing activities; and therefore they are the three co-dependent corners of a triangle that explains how organisation functions.

In order to understand the overall picture of an organisation, any of the three major elements can be used as the focal perspective to gather information of the relevant occurrences of the other two elements. By using artefact (affordance) as the analysis unit, we aim to capture the associated activities (afforded acts) and human subjects (agents). Hence, our next step is to produce an ontology chart for artefact-oriented business process modelling. Each organisation as a system is composed of many affordances and agents that are related to, and have an effect on, each other through their ontological dependency. The artefacts in the system are the affordances of the system. The artefacts are the linkage between sub-systems as the input and output of the sub-systems. The artefacts within a system can represent the components, which refer to raw materials, services, or parts that are required to deliver an output that is desired by the end customers of a system (Pan et al., 2012).

The stakeholders are those who are involved with the organisation, either actively or passively (Vos and Achterkamp, 2006). The role-name indicates that an agent has a specific role. The agent's afforded acts are the activities of the system. Based on the semiotic analysis of stakeholders and components, an ontology chart (Figure 1) is

produced. The business environment is the root to all affordances, since all of the affordances are dependent on the business environment. Therefore, the affordances would not exist if there was no business environment. All of the items in the ontology chart are affordances, with the affordances on the right of the ontologically being dependent on the affordances to its left; i.e. its ontological antecedent. The names attached to the lines between the agents and afforded acts refer to the roles of the agents. Determiners are a special type of affordances that represent the measurement standards, which are marked with a # symbol. The outputs are dependents on the components, as the components are assembled to produce the output. The oval shapes represent the agents and standard affordances (artefacts). The agents include the organisation and stakeholders, and the artefacts cover both the output and components. The rectangular boxes refer to the afforded acts performed by agents. The ontology chart reveals the ontological relationship between the artefacts, human agents, and activities. Hence, an organisation can be analysed and modelled accordingly.

5 ARTEFACT-ORIENTED BUSINESS PROCESS MODELLING

Based on the concept of artefact orientation and the ontology chart for artefact-oriented modelling, an artefact-oriented method for business process modelling is proposed. The modelling method contains five steps, which will be explained and demonstrated with a case study example in the following sections.

5.1 Unit System Scoping

The scope of any system needs to be defined before the analysis can be conducted. Scoping the unit system sets the boundary, which ensures that the analysis covers all of the essential parts and excludes the elements beyond the scope.

A university's programme support team is selected for the case study. Since the programme support team supports all of the postgraduate programmes across the faculty, instead of any specific school, the faculty is considered as the business environment. Other schools and departments are within the faculty; however they are not the part of the defined organisation for process modelling, yet might fall into the stakeholder category as agents that interact with the unit system.

5.2 Artefact Identification

The modelling unit for this method is based on the artefact instances, and therefore the artefacts need to be identified first, once the scope has been defined. Artefacts include the outputs and the components in the defined organisation. Common data collection methods, such as observation, interview and document review (Sapsford and Jupp, 1996), can be applied to identify the artefacts. The outputs are the artefacts produced by the defined organisation for its customers. The artefacts can be either tangible or intangible, depending upon the nature of the defined organisation. An output is the final product of the organisation, and it can be the end result of either routine manufacturing or an ad hoc project. Once the outputs are identified, the analyst can further break down the outputs into components.

The components of an output are the raw material, parts, information and/or services that are required to produce the output. Human agents perform a set of activities to modify and process a group of components to deliver a specific output. Identifying the components of each output requires the analyst to produce a component-based structure (Pan et al., 2012) for each identified output, which reveals the relationship between the output, components, and sub-components.

There can be numerous outputs in a defined organisation. For each identified output, the output name, output ID, required components and the specification have to be decided. The output ID should be unique and readable by a machine, as this ID can be used as a tag to identify the information related to a specific output. The output name is the term that human agents use to describe the output. The 'required components' column lists all component IDs for components that are required to produce the output. The specification column provides a brief description of the output, which should include the functions, purposes, uses, limitations, etc. In addition, more columns can be added, as deemed necessary. In the context of the programme support team example, we observed their processes and conducted semi-structured interviewed with two team members in order to identify the organisation outputs, and their related components, as shown in Table 1 and Table 2.

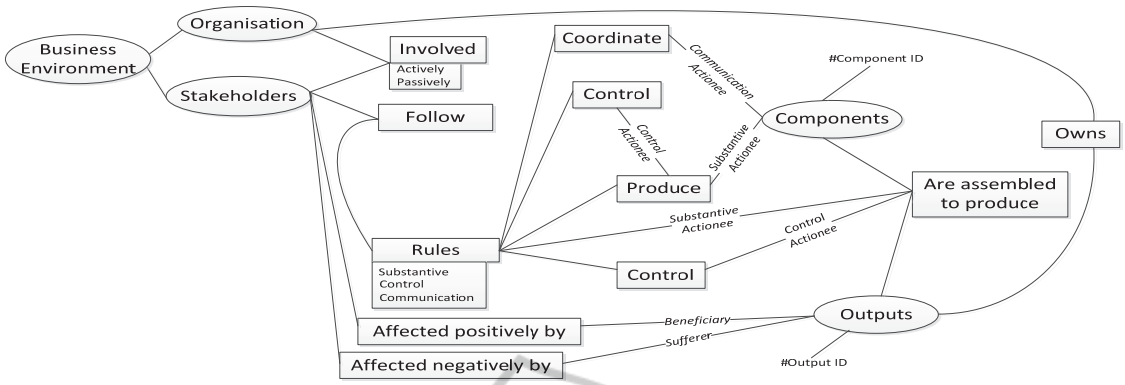

Figure 1: Ontology chart for Artefact-oriented business process modelling.

Table 1: Output list.

System	Programme Support Team
Outputs	Programme Summary Report (PGT001) Student Transcripts (PGT002) Module Distribution Statistics (PGT003)

Table 2: Output description.

Output ID	PGT001
Output Name	Programme Summary Report
Required Components	Student Information (PGT101) Module Marks (PGT102) Degree Classification (PGT103)
Specifications	To be produced before the exam board

5.3 Activity Analysis

Activities are the afforded acts performed by agents. The activities enable the artefacts to achieve their defined purpose. For each output, the related activities are divided into two categories, namely assembling activities and post-assembling activities. Assembling activities are the activities that transform the components into the output. Not only does an assembling activity apply to the physical assembling of parts in a manufacturing domain, but also apply to the collation of intangible services and information. The assembling activities include substantive activities and control activities that ensure the substantive activities complying with the rules. Post-assembling activities refer to the activities that happen between the output and the agents who are affected by the output.

OS classified activities into substantive activities, communication activities and control activities (Liu, 2000). Substantive activities refer to the tasks and activities that fulfil the main purpose of the action. Communication activities enable the right sub-components available at the right time at the right place. Control activities ensure that all coordination and production activities are conducted according to the relevant regulations. The rules and regulations are enforced by the conduction of control activities. Hence, we identify that there are substantive activities, communication activities and control activities for each component.

Hence, there are five groups of activities associated to identified output and components. Each artefact should have a table listing all of the associated activities. Each identified activity is then assigned an activity ID, activity name, activity type, and description. In the example of programme support team, once the tables of activities that are related to the output and components are produced, the activity description can be generated for each activity. Table 3 is an example of activity description.

Table 3: Activity description.

Activity ID	PGTAC1023
Activity Name	Checking the final mark
Associated Artefact	PGT001, PGT102
Activity Type	Control
Activity Description	Ensuring that the final mark was decided according to the regulations

5.4 Agent Identification

In the ontology chart for artefact-oriented business process modelling, agents include the organisation and the individuals. The organisation owns the outputs, yet outputs are essentially dependent on stakeholder components. All of the components are ontologically dependent on agents who enable components by performing their afforded acts. Based on the afforded acts performed by the agents, the agents can be categorised by their roles. For each output, there are five types of roles, namely owner, substantive actionee, control actionee, beneficiary

and sufferer. For each identified component, there should be substantive actionee, control actionee and communication actionee. Each agent is linked to a certain set of activities, and the agent's role name should reflect its afforded acts directly.

For the example, one output and one component have been chosen to identify the related agents. Once the relevant agents have been identified, an agent description is then produced for each identified agent. Table 4 and Table 5 are the examples of the agent identification and description.

Table 4: Output-agent identification.

Output ID	PGT001
Owner	Programme Support Team
Substantive Actionee	Administrator (PGTAG002) Senior Administrator (PGTAF003)
Control Actionee	Team Manager (PGTAG001)
Beneficiary	Exam Board (PGTAG201)
Sufferer	N/A

Table 5: Agent description.

Agent ID	PGTAG002
Agent Name	Administrator
Agent Type	Substantive, Communication
Contact	Admin@example.ac.uk
Location	Room 105, Admin Building

5.5 Rule Specification

The techniques from trigger analysis and detailed norm specification of NAM (Liu, 2000) are adopted to conduct rule specification. In order to formalise the activities, it is essential to identify and specify the norms that realise the activities. Hence, for each identified activity, the analyst should specify the activity type, time, associated artefacts, associated agents and rule specification. The format of behavioural norm (Liu and Dix, 1997) is considered suitable for the rule specification, because most rules and regulations in the business environment fall into the category of behavioural norms. The format is constructed as follows (Liu and Dix, 1997).

Whenever <condition> If <state> Then <agent> Is <deontic operator> To <action>

This format is selected to present the rule specification for each identified activity. All rules within each identified activity need to be scripted and listed to allow activity analysis. Table 6 is an example of activity rule specification.

5.6 Modelling Result

Each step of the artefact-oriented business process modelling method provides a set of information respectively. Once all of the steps are completed, the component-based structures of identified outputs can be used to reveal the organisation's fundamental processes from an artefact perspective. By using the tables produced in artefact identification, activity analysis, agent identification and rule specification, all of the activities and agents within the organisation can be explicitly linked to the output and component to which they are related. Hence, the practices and information can be encapsulated into the artefact analysis unit. A component might be associated to more than one output, and accordingly the practice and knowledge embedded in the component can be shared between outputs.

Table 6: Activity rule specification.

Activity ID	PGTAC1023
Act Type	Control
Rule Specification	*Rule 1:* Whenever <the resit box is ticked> If <the resit mark is greater than 50%> Then <administrator> Is <obliged> To <record the final mark at 50%>
	Rule 2: Whenever <the resit box is ticked> If <the resit mark is less than 50%> and <the resit mark is greater than the calculated final mark> Then <administrator> Is <obliged> To <keep resit mark as the final mark>

6 DISCUSSION AND CONCLUSIONS

This paper developed the ontology chart for artefact-oriented business process modelling based on AT and OS and then further proposed the artefact-oriented method for business process modelling. An artefact-oriented approach is different to a functional flow, as it aims to treat the organisation as a system, and place focus on the inputs and outputs of an organisation. As a system, constructed of sub-systems, an organisation can be modelled by considering the outputs that it produces. The outputs themselves can also be broken down and modelled; with each artefact systematically used as an analysis unit to extract activity and agent information. Based on the ontology chart that defines the relationships between agents, afforded acts and artefacts, we propose an artefact-oriented method for business process modelling. The method contains five steps that identify the artefacts within the defined

organisation and analyse the agents and activities around the artefacts. The modelling results show the organisation's outputs and their component-based structures, which view an organisation as a network of artefacts. For each identified artefact, there will be relevant agents and activities identified.

The term 'artefact' in the proposed artefact-oriented approach is not to be confused with the term 'artifact' in artifact-centric business process model (Bhattacharya et al., 2007). In artifact-centric business process model, artifacts are the moving business-relevant objects/data that are created, evolved and normally archived as they pass through a business (Cohn and Hull, 2009), which contains both the attributes and states describing the identity of the artifact and its current stage in its lifecycle (Bhattacharya et al., 2009). The term 'artefact' is our approach does not refer to the data, but the things actually being modified or produced.

The artefact-oriented approach focuses on an organisation's conceptual structure based on artefacts. The artefacts are ontologically interdependent. Unlike activity-focused modelling, artefact-oriented modelling does not rely on the sequence of activities, but the ontological interdependency of artefacts. When the relationship between artefacts is output-component relationship, the component will need to be sourced or produced before the production of the output can take place. However, the existence of the component does not necessarily lead to the production of the output, and the relationship between them is not sequential. Between the artefacts, as components, required by the same artefact (output) there is also no sequential relationship at all. There is no specific order in which the components need to be sourced for the production of the output. As long as the required components are sourced, the production of the output can be done, and the sequence of components is irrelevant. Therefore, the artefacts can be viewed and modified independently without affecting other artefacts, while they are still ontologically interdependent, which enables the flexibility of artefacts as a base for process modelling.

Additionally, because the artefact-oriented modelling method records the agent and activity information linked to the artefact, the recorded relationship between artefacts, agents and activities can then be used in the event of an emergency, or in the case of business process redesign, to identify those agents involved and activities that will be affected. If a specific agent or activity becomes unavailable or faulty, the organisation can quickly identify which outputs and components will be affected. The component-based structure also gives the organisation a clear view of which artefacts are being to produce specific artefacts. The organisation can use this information to consider which artefacts can be replaced or reused across the whole organisation. The activity of similar artefacts can be reviewed and potentially improved by using benchmarking criteria. The proposed method is predominantly designed to capture and analyse the formal and technical part of the organisation. Some of the informal norms in the organisation might still be captured and recorded, but some might not necessarily be captured; if the informal activities do not have a direct involvement with an artefact. However, this issue can be resolved by incorporating techniques that focus on informal norms.

Moreover, the modelling results can also be used to design and configure Information System (IS). In the example of programme support team, the different IDs can all be used as the primary keys in the database. The rule specifications can help programmers or enterprise consultants compute the business processes. The modelled business processes than can be coded or implemented within software systems. By formalising the information around the artefacts, each artefact can then be considered as a software component; with each artefact-based software component truly reflecting its counterpart in real world; and the practice of information sharing can be conducted on the basis of artefacts. In conclusion, the artefact-oriented method for process modelling provides a novel perspective for identifying and analysing business processes, as well as agents and artefacts, as the artefact-oriented perspective demonstrates the fundamental flow of an organisation; with the information and practices embedded in artefact allowing reuse across both the organisation and/or the industry. Since the artefact analysis unit consider the drill-down detail of multiple level sub-components, the basis of information and practices sharing can be scaled. This scaling allows organisations to use the same modelling approaches, irrelevant of the complexity of the artefact; as additional levels can be added as required in areas of complexity to allow scope of modelling to be manageable.

Not only does the artefact-oriented approach lay the groundwork for business process modelling, but it paves the foundation for IS design and configuration. The modelling results provide an alternative basis for IS design, with the rule specifications enabling the automation of process in IS. The software component of information system can be constructed based on the artefacts, instead of

the conventional functional processes. The development of artefact-oriented approach to business process modelling is at an early stage. Extension of this concept needs to be applied in more scenarios, where task-centric methods currently apply, in order to further refine the concept and develop related methods or techniques.

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