REQUIREMENTS ENGINEERING FOR ORGANISATIONAL MODELLING

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Keywords: Requirements Engineering, Semiotics, Organisation Modelling, Norms, Semantics, Agents

Abstract: This paper explores a semiotic perspective to information systems engineering, using organisational modelling techniques rooted in organisational semiotics. The components and relationships of large corporations are highly complex, volatile and unstructured. Semiotic modelling techniques are therefore introduced to address these challenges posed by large enterprises. MEASUR, a suite of methods based on organisational semiotics, are used to address the IT and organisational requirements, needed to encapsulate behavioural patterns and to formalise the convoluted relationships. A case study illustrating the applicability of MEASUR is presented, to evaluate a crime reporting system from the Police Information Technology Organisation (PITO) in UK, and to examine its application and significance in the modelling of organisations. We focus on two key fundamental issues. Firstly we investigate the agent behaviour within the organisation. Secondly, we analyse the semantics of the relationships between these patterns of behaviour in building a normative model of a large organisation.

1 INTRODUCTION

In the last decade great advances in technology and the exponential growth of multinational corporations have led business managers, practitioners and academics to develop a growing interest in the field of organisational modelling. Organisational modelling is interdisciplinary, and as such incorporates a variety of methods, techniques and tools. It encompasses social, technical, business and organisational domain. Modern enterprises are highly complex, multifaceted and fluid. Traditional systems, as such are overwhelmed, and unable to address the social and technical roles of organisation (Joaquim *et al.* 1999). Liu *et al.* (1999) observed that due to this disparity, systems requirements and organisational semantics have over the years evolved separately.

This research employs semiotic methods for organisational modelling, to improve the design of business and IT systems. MEASUR (Stamper *et al.* 1988) proposes a set of methods comprising of Problem Articulation Method (PAM), Semantic Analysis Method (SAM), and Norm Analysis Method (NAM), which we shall discuss and illustrate using the Police Information Technology Organisation (PITO) case study.

MEASUR offers a viable alternative, which until now has not been fully exploited. This approach contributes towards the overall usability and coherence of organisational models. The need to elicit business rules and norms are widely recognised, it is however represented using modelling languages that are ill-equipped to handle organisational behaviours.

Key trait in representing an organisational model lies in the representation and interpretation of business rules and norms. These intricate relationships have to be embedded during organisational design phase. The weakness with many information systems is largely attributed to the inability of requirement engineering to determine systems requirements based on complex organisational behaviour. Most information systems specifications are crudely mapped directly from business requirements, without due consideration to factors as norms, semantics and agents. There have been numerous failed attempts to model organisational semantics, which were based on entity-relationships (Peckham & Mryanski 1988, Wand *et al.* 1999).

PAM will enable us to identify the organisational context and define the problem domain, while SAM will help to study the agents and their behaviour. NAM will analyse and extend this further by identifying agent's responsibility and norms that control agents behaviour. This paper will offer an alternative approach to business modelling to

Tan S. and Liu K. (2004).
REQUIREMENTS ENGINEERING FOR ORGANISATIONAL MODELLING.
In *Proceedings of the Sixth International Conference on Enterprise Information Systems*, pages 383-388
DOI: 10.5220/0002653003830388

supplement modelling languages such as Role Activity Diagram (Ould 1995), and Unified Modelling Language (Martin & Ken 1999).

This paper is structured as follows: Section 2 illustrates with a case study of a crime reporting system, using modelling techniques to derive a conceptual model of PITO crime reporting process. In section 3, we briefly describe the application of the PAM method, and the significance of each technique, to articulate complex organisational issues, followed by Section 4 using Semantic Analysis method to derive the semantics of crime validation process. In Section 5 we highlight the Norm Analysis method. Using a norm analysis template we formulate norms from the crime reporting process. Section 6 will draw conclusions and discuss future work.

2 CASE STUDY: POLICE CRIME-REPORTING

This section introduces a case study which will be used for further illustration of the MEASUR methods. This case study was based on a project of designing a crime management system for the police force. An excerpt of this project, "crime-reporting" was highlighted to reflect the actual research conducted by our research team, which is still ongoing. For the sake of brevity the detailed workings and complexity of the model have not been fully reproduced here.

The Crime Reporting Unit in the Police Force is the contact point between members of the public and the police departments. It is charged with the responsibility of collecting, maintaining, analysing, and reporting crime data for the nation-wide crime management.

In the following sections, MEAUR methods will be introduced. The application of the methods will demonstrate how the problem domain, organisational behaviour (in terms of agents and affordance) and organisations dynamics (norms) are dealt with in these methods.

3 MEASUR – REQUIREMENT ENGINEERING METHODS

Organisational semiotics is a sub-discipline of semiotics that studies the problems of how information and human communication work in organisational contexts (Liu *et al*. 2001).

MEASUR is a set of methods for organisational modelling stemming from organisational semiotic. This method aims to address business problems that are ambiguous, and to define requirements of organisational and IT systems domains. It seeks to analyse the existing infrastructure in two aspects: Organisational Infrastructure and IT Infrastructure. Thereby it identifies relevant components and their inter-relationship.

3.1 Problem Articulation Method

Problem Articulation Methodology (PAM) was first conceived as one of the three methods of MEASUR by Stamper (Stamper *et al.* 1988) and his researchers (e.g. Kolkman 1993). PAM addresses infrastructural analysis as an initial investigation for organisational study and information systems design. This method consists of a suite of five techniques. In the course of our research, we have made extensions to the various techniques. This paper will provide a brief description and objectives of (1) Unit Definition, (2) Stakeholders Identification, (3) Organisational Containment, (4) Valuation Framing, and (5) Collateral Structuring.

These techniques take the infrastructure and social problem domain as input, and deliver outcomes in the five categories. These outcomes can be further seen as input for other semiotic methods e.g. semantic analysis, norm analysis and the co-design of business and IT systems.

Units Definition

Unit definition identifies courses of action and lists interdependent sub-actions needed to accomplish the lists of objectives. An organisation is composed of the units systems, the problem situation is then analysed as a constellation of different sets of tasks, each providing a brief description. Each activity can be taken to represent the focal system. In the case of PITO, the activity of crime-reporting represents the focal system.

Stakeholders Identification

Stakeholders identification, lists key stakeholders and their roles within the domain, categorising and defining stakeholders responsibilities (Table 1).

Table 1: Stakeholder Identification Template.

Unit System	Stakeholders	Roles	Category	Responsibility
Unit 1: Crime reporting system	SH 1: Witness	Actor	Contribution interdependency	Providing statements, assists investigation
	SH 2: Crime Assessor	Principal	Source interdependency	Verify incident, refer cases, issue case code

This phase is concerned with identification of all parties and actors involved or interested in the business of the organisation.

Collateral Structuring

Collateral structuring (Fig. 1) assists in building a given situation into a number of named unit systems - a kernel course of action surrounded by activities which stand beside it. This phase is concerned with the definition of units that are interrelated and form an infrastructure for the focal system. In the PITO crime reporting case study, the crime reporting system takes to represent the focal system.

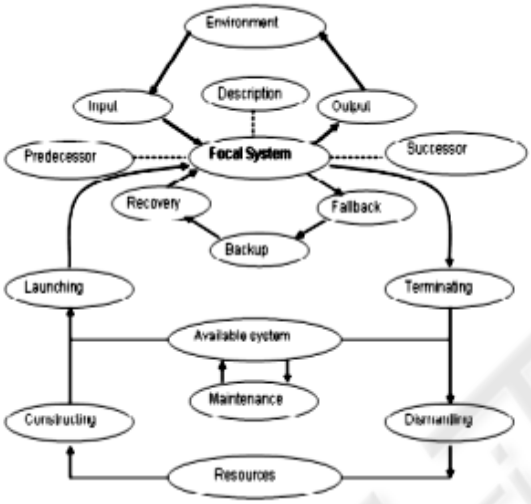


Figure 1: Collateral System (Kolkman 1993)

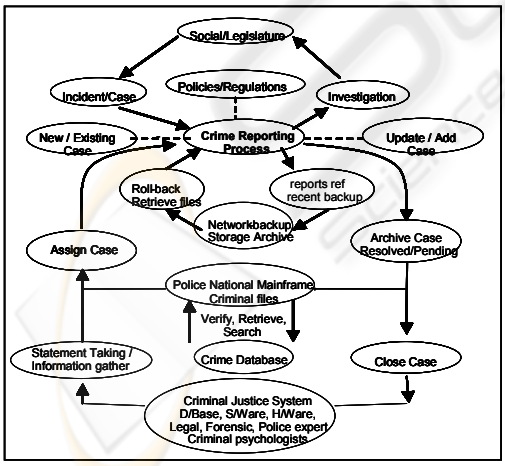


Figure 2: Collateral Structuring – Crime Validation

A focal system addresses the need and solves problems with a host of supporting processes, in a given domain (Stamper & Kolkman 1991).

Collateral structuring studies the focal activity; in this instance the crime validation process and other related activities (Fig. 2). The *collateral* units are systems that surround and support the focal system needed to establish its logical structure. This technique is equipped to elicit organisational semantics and identify inter-relationship between processes. The semantic analysis to be conducted in the next phase associates interprets and validates these ontological dependency relationships.

Modelling the Processes

In the crime reporting case study, Role Activity Diagram (Ould 1995) was used to capture the overview of the systems outline of crime reporting department (Fig. 3) Roles have been seen as effective for modelling the authority, responsibility, functions, and interactions, associated with agents within an organisation. However, these are ideal for an initial mapping, but insufficient to establish detailed relationships between agents and the targets they manage. Crime validation activity diagram (Fig. 4) and scenario diagram (Fig. 5) provide simplified workflow diagrams; however it is not equipped to fully reflect the norms, dependency relations and the agents behaviour which have been omitted. This has, nevertheless, provided a schema mapping of inter-processes within the crime validation process, supported by collateral structuring. Collateral structuring assists in identifying the infrastructural and organisational entities and requirements to initiate systems intervention and analyse the business processes.

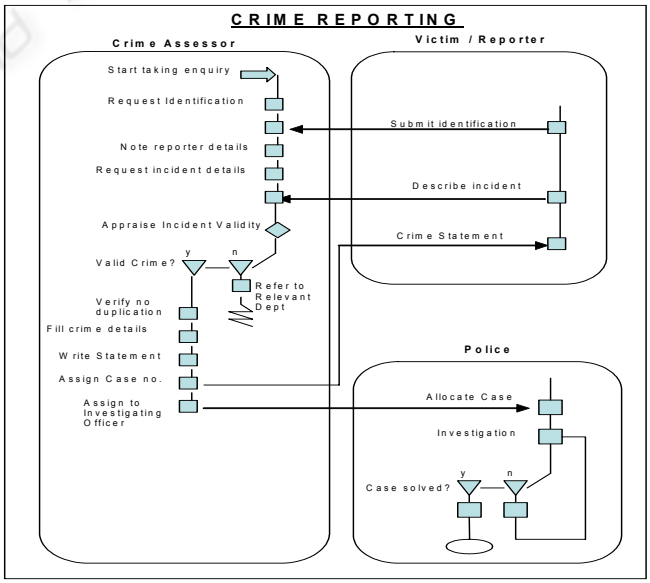


Figure 3: Crime Reporting Process

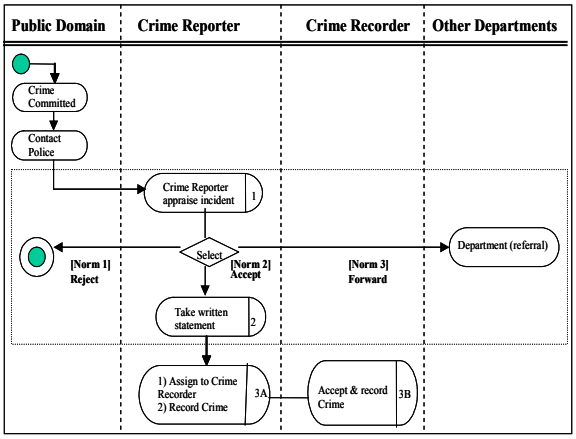


Figure 4: Activity Diagram – Crime Validation

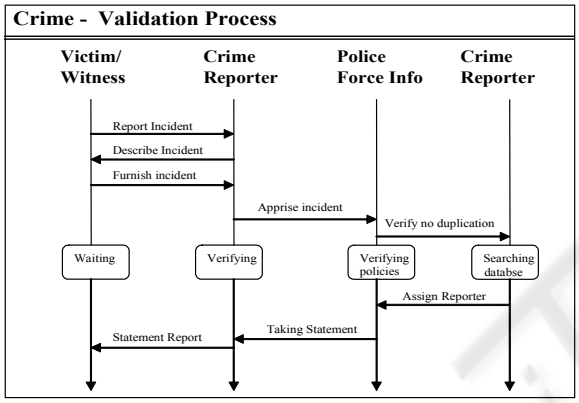


Figure 5: Scenario Diagram – Crime validation

4 SEMANTIC ANALYSIS

Semantic analysis involves interpreting the meaning of agents, affordances and its relationships within the focal system in the organisation, thereby offering a much richer interpretation than lexical or syntactic analysis.

Wand (1999) uses entity relations to establish logical dependencies. This approach was however, not designed to capture complex organisational relationships. A technically, logically or syntactically sound representation, will not guarantee a correct semantic relationship. Semantic analysis thus plays a crucial role to identify and address these problems to establish a semantically valid system, to determine what they explicitly mean. This relationship is termed as ontological dependency, with the antecedents on the left and the dependencies on the right. Three key components need to be present in the ontology-chart (Fig. 6) namely:

1) An *agent* is the responsible person or organisation involved in the focal systems. An agent is represented with an oval.

2) *Affordances* are the things involved and the behaviours afforded by the agent. Affordance is indicated by a rectangle.

3) Ontological *dependencies*, represents how these agents and their behaviours are interrelated in existence. Role name are represented between agent and affordance with an arch.

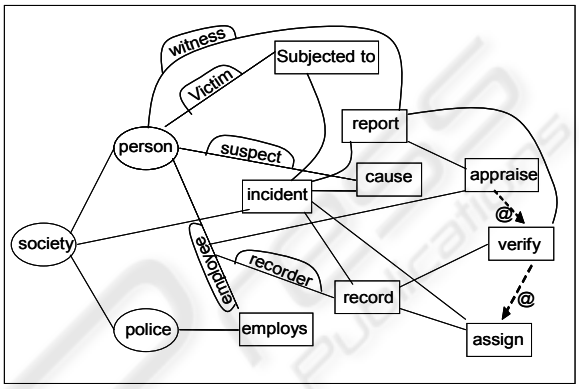


Figure 6. Crime validation ontology-chart

A *person (agent)* may be classified as a *victim (role name)* when he is *subjected to* an *incident (affordance)*. A *report* is generated when an *incident* occurs, with information provided by a *witness*. The i*ncident* in this case is the *antecedent,* it thus should be positioned to the left of the *report, a dependency*, else the *report* would cease to exist. The *report* must be available before the crime reporter can *appraise* the *incident.* The *verification* of an incident cannot take place before appraisal which is indicated by a dotted-line attached with a "@" standing for "authority" – a permission for starting the activity of verifying the crime record. Likewise to *assign* an *incident* to an investigator; it first needs to be *verified* before it can acquire the *authority* to delegate, the investigation to an investigator. Having established an ontology chart it will greatly facilitate the modelling of organisational norms using norm analysis methods describe in the next section.

5 NORM ANALYSIS

Norms are a set of rules and regulations, an underlying protocol governing the agent communications network. Norms revolves around agents, which influences the agents to execute a series of concerted actions to achieve a particular goal. In this respect, it can specify to a limited extent how an agent should or should not behave, under a prescribe sets of triggers. They represent procedures,

constraints and policies on the way an organisation should conduct its business (Liu & Ong 1999). Norm Analysis formulates a systematic approach to elicited norms, agents behaviour and defines pre/post conditions of event triggers. The analysis is carried out in 4 stages to provide each process with a tabular normative unit of information. The NA table (Table 2.) is designed to capture a series of norm "instance". This modular design enables a clear and well-defined norm structure, representative of each characteristics pertaining to a specific norm.

Table 2: The Method of Norm Analysis (Adapted from Liu 2000 and Liu & Salter 2002)

stages	tasks	outcome
1	Responsibilities Analysis	Identify responsible agents for the Start/finish of "*an instance*"
2	Information Identification	Select type of key information required by "an instance"
3	Triggers Analysis	Activities/actions effecting the Start/finish of "*an instance*"
		Pre-conditions: The conditions for acting and invoking norm
		post-conditions: The resultant after the successful execution of norm
4	Norm Specification	Norms specified in the standard construct.

Norm Analysis formulates an approach to elicit organisational knowledge. A norm subscribes to the following construct (Stamper *et al.* 2000):

Norms Constructs:
whenever <condition>
if <state>
then <agent>
is <deontic operator>
to do<action>

Responsibility Analysis (Stage 1 - Analyse)

Responsibility analysis identifies state association of entities and agents that are responsible for the start and finish of "an instance". The incident starts immediately from the instance a case number is issued but not prior to it being classified as a crime. It is therefore more evocative to link processes, which are time-bounded and responsibility linked, as compared to establishing links based exclusively on process that trigger a subsequent or concurrent process.

Information Identification (Stage 2 - Identify)

"An instance" needs key source information for the preceding action. The investigating officer would need to know information such as, details of the victims, location/time of crime committed and description of incident to proceed with the investigation. These affordance and agents define in the NA tables, are elicited after semantic analysis, based on the ontology chart drafted.

Trigger Analysis (Stage 3 - Associate)

Triggers act as a mechanism to activate associated processes based on the pre-post conditions of existing social norm define in Stage 1; it could either take the form of Temporal, Substantive or Semiological to control or delay the trigger procedure.

Norm Specification (Stage 4 – Course of Action)

Norm specification is the final stage, where the earlier 3 stages of information are collated, decimated, formalised and structured to facilitate prudent behaviour decisions based on conditional norm presented. The complexity here is to deal with formalise norm when instances of violation or contention occurs.

Norm Analysis information table clearly helps to state and structure responsible agents, key data, pre-post triggers and detailed behaviour norms.

An example of possible norms is given below, after the validation of an incident (Table 3.)

Norm Analysis – Algorithm
[Norm 1] Reject : (Sub-Norm 1.1, 1.2, 1.3..)
[Norm 2] Accept : (Sub-Norm 2.1, 2.2, 2.3..)
[Norm 3] Forward : (Sub-Norm 3.1, 3.2, 3.3..)

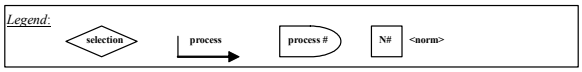
[Norm 1] *Sub-Norm - 1.2*:
IF the (incident does not constitute to a crime);
a case of customer/consumer disagreement.
THEN Crime Reporter
Is Obliged
To forward it to the consumer association organisation
Sub-Norm3:…..

Norm Analysis, present an unambiguous detailed description of the interrelated entities and its possible behaviour, which is structured on information modelled from collateral structuring, high level RAD and Activity diagram.

Norms are used in organisational systems modelling e.g. by Sergot (2001) and Ivan (2000), with varying degrees of systems complexities. The roles and norms are identified to further capture high-level normative elements. An activity diagram (Fig. 4) is only sufficed to model at a surface level. A scenario diagram shows the existence of objects, their relationships in a logical view, and how they execute a particular scenario or use case. Norm analysis offers an extension to capture norms, which may appear obscure but present.

Table 3: Norm Analysis (Crime Statement - Accepts)

Crime Statement : Selection (Accepts)		N2
Responsibility	Crime Reporter	
Info. Identification	Type of crime, category, urgency	
Trigger	Determine Incident	
(Conditions Pre/Post)	Valid Crime	Statement report
Detailed Norm	**WHEN** a crime is confirmed **IF** it is urgent that it will be assign immediately **THEN** the officer in contact is to investigate	



The results attained are comprehensive in its procedural logic, which considers entities behaviour, norms and agents (Table 3). This allows the flexibility to model the very essences of complex organisation systems. Equipped with this information the modeller will have an invaluable glimpse of a significant insight in the communication network of the organisation (Tan & Liu 2003).

6 CONCLUSION

The above case study illustrated the significance of ontological dependencies, affordances and normative agents in a business domain. The next phase of systems study is to define and model norms, as well as to develop the interoperability of agents. This approach would structure on behavioural norms for systems optimisation and reuse. It is with the aim of bringing requirement engineering a step closer to realising the above objective with the advent of tools such as semantic analysis 'SAM' and norm analysis 'NAM'; more effort however, needs to be done in the following areas, (1) Elicitation and abstraction of organisational norms/patterns for reuses, (2) Develop the interoperability of agents structured on norms, (3) Develop a case tool to formulise organisational norms and (4) Validation of organisational norms

Equipped with these sets of semiotic tools, we aim to improve future work and formulise the current requirement system technique, unifying systems design with MEASUR methods, with further enhancement.

Acknowledgement

This research is partly supported by EPSRC – SEDITA project GR/S04840/01.

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