

# Embedding Social Processes into Agent-Oriented Conceptual Models

Rodney J. Clarke<sup>1</sup> and Aneesh Krishna<sup>2</sup>

Centre for Applied Systems Research, Faculty of Commerce<sup>1</sup>

Centre for Software Engineering, Faculty of Informatics<sup>2</sup>

University of Wollongong, NSW 2522 Australia

Email: {rodney\_clarke | aneesh}@uow.edu.au

## Abstract

This paper describes how theories and methods for determining structural and functional patterns of communication in organisational settings can be applied to developing Agent-Oriented Conceptual Modelling. In particular we show how social processes in the form of genres- routine patterns of communication- can be embedded into Strategic Dependency diagrams used in the *i\** Framework. The research uses an entirely unforeseen relationship between communication theory in organisations and agent-based systems promoting agent based models that are easier to verify, more robust and portable. An example of this kind of conceptual modelling is provided and used as the basis for deriving a partial methodology.

## 1 Introduction

This research work is part of a larger project that uses theories and methods for determining recurring patterns of communication associated with social processes in work settings with the goal of developing techniques and a methodology to support Agent-Oriented Conceptual Modelling (AOCM) using the *i\** Framework (Yu 1997; Liu, and Yu 2004). The broader research project has two sets of aims relating to Agent-based artefacts and to the Conceptual Modelling process.

In terms of creating Agent-based artefacts, our aim is to develop more realistic agent-oriented models using methods based on communication patterns that specify the actual, current arrangement of agents/workers in the organisation as well as identify the main goals of the current system. We develop new agent-based Conceptual Models, by substituting existing communication patterns with new ones. We utilise Systemic Functional Linguistic (SFL) methods to identify relevant patterns of communication (see Halliday and Martin 1993; Kress 1988). These patterns may mimic existing social processes in other organisations, or they may be artificially engineered. Finally, the research project aims to make AOCM more rigorous by recognising that the dependencies between agents are often based on patterns of communication themselves. We can not only model existing system dependencies but also design new system dependencies using recurring patterns of communication in social settings.

The second set of aims involves the process of agent-based Conceptual Modelling itself. Given that this is also a social process that can be defined communicatively, we can apply these same theories and methods to, amongst other things, understand the process of requirements engineering and elicitation while developing agent-oriented models, as a series of communication patterns between clients and developers. We are also developing techniques in the form of field protocols that rely on canonical patterns of communication shared by both clients and requirements engineers (see for example Clarke 2006a), thereby making Conceptual Models (Agents and Dependencies) that are easier to describe and document, check, verify, and validate. Eventually we are aiming to develop tools to support the description of actual organisational processes as patterns of communication, and embedding them in actual agent based models, as well as to support the use of field protocols during Conceptual Modelling. These tools should support the move from domain language to requirements validation and then to directly specifying *i\** models.

This paper concentrates on the development of Agent-based artefacts and the relationship between social processes in the form of workpractices and the process of embedding them into agent-oriented conceptual models. We first describe the concept of an Agent, AOCM and the *i\** framework in §2. We then consider communication as a social process justifying our use of SFL to embed socially circumscribed workpractices in AOCMs in §3. We then describe an authentic case study involving the design of a new function for an agent-based training system developed for a state-based emergency services organisation, Australia, in §4. This illustrative case study is used to show how, by manipulating the functional staging of the workpractice structure, a social process developed for use in another system was reworked for use in a new system. We describe how the stages or elements of the workpractice structure can be mapped to *i\** notation. Using this case study we derive an approach for describing and embedding social processes into AOCMs in §5, with a view to describing a partial development methodology for creating agent-based artefacts.

## 2 Agents, Agent Oriented Conceptual Modelling and the *i\** Framework

The concept of a software *agent* is becoming more significant in the areas of Artificial Intelligence (AI) and Software Engineering (SE) and a variety of systems are developed using them. Jennings et al. (1998) identifies some characteristics of agents. They are *situated* in that they ‘sense’ the environment and perform actions that change the environment in some way. They are *autonomous* in that they control their actions and internal states without any direct intervention. Agents are also *flexible* in that they are responsive to changes in the environment and *proactive* in that they are able to exhibit opportunistic and goal-directed behaviour. Finally, agents are *social* in that they interact with other artificial and social agents to complete their tasks. Agent-orientation is becoming an increasingly popular approach to the conceptualisation and implementation of complex software systems, and provides useful modelling formalisms for requirements engineering and design. Intentional concepts such as goals, beliefs, abilities, and commitments, for example, provide a social higher-level characterisation of agent behaviour and system behaviour. Software designed with agent-oriented characteristics can sometimes provide greater functionality and higher quality when compared with object-oriented systems (Yu 2001).

AOCM uses the agent metaphor and applies it to modelling complex systems like organisations. Understanding the organisational environment as well as the rationale underlying requirements, design and process formulation decisions, is crucial to modelling and building effective computing systems (Yu 1997). Conceptual modelling notations employing knowledge representation techniques have been developed to support this understanding (Yu et al. 1993). The focus here is on early-phase requirements engineering where arguably the vast majority of critical modelling decisions are taken (Yu 1997). There are two major received AOCM approaches- AOR Modelling and *i\** framework. However, AOR Modelling is not suitable for early-phase investigations. It is also not based on the Belief, Desire and Intention (BDI) AI foundations used in the development of practical agent based systems. Many existing agent oriented modelling techniques and methodologies like Prometheus, Gaia and Roadmap are oriented towards later phases, assume completed requirements as the starting point for an investigation, tend to address late-phase requirements, and focus on completeness and consistency.

In contrast the *i\** Framework (Yu 2001) has gained considerable currency in SE because it offers high-level social and anthropomorphic abstractions like goals, tasks, softgoals and dependencies as modelling constructs and is also applicable to early-phase requirements.

Arguably it can help answer questions like what goals exist, how key actors depend on each other and what alternatives must be considered. The central concept in *i\** is that of the intentional actor. Intentional properties of an agent such as goals, beliefs, abilities and commitments are used in modelling requirements (Yu 2001). The *i\** Framework supports the analysis of strategic alternatives (in terms of possible operational processes) from the viewpoint of each actor by modelling processes in terms of intentional relationships between actors using the previously described modelling constructs, as opposed to input/output relationships typical of non-agent based modelling. The agent construct is used to identify the intentional characteristics represented as dependencies involving goals to be achieved, tasks to be performed, resources to be furnished or softgoals (optimisation objectives or preferences) to be satisfied. There are two main modelling components in the *i\** Framework. The Strategic Rationale (SR) model is used to describe stakeholder interests and concerns, and how they might be addressed by various configurations of systems and environments. The Strategic Dependency (SD) model is used to describe the dependency relationships amongst various actors in an organizational context.

The SD model consists of a set of nodes and links. Each node represents an “actor”, and each link between the two actors indicates that one actor depends on the other for something in order that the former may attain some goal. The depending actor is known as depender, while the actor depended upon is known as the dependee. The object around which the dependency relationship centres is called the dependum. The SD model represents the goals, task, resource, and soft goal dependencies between actors/agents. In a goal-dependency, the depender depends on the dependee to bring about a certain state in the world. The dependee is given the freedom to choose how to do it. In a task-dependency, the depender depends on the dependee to carry out an activity. Task- and goal-dependency may often appear interchangeable. One way to understand the distinction is to view goals as more coarse-grained, abstract entities and tasks as more fine-grained, specific entities, while recognizing that goals can always be reformulated as tasks and vice versa. Another dimension to this distinction is the relative autonomy of the dependee in deciding how a goal is achieved, while in a task the depender and dependee must coordinate in a far more tightly-coupled fashion. In a resource-dependency, one actor (the depender) depends on the other (the dependee) for the availability of a resource. In each of the above kinds of dependencies, the depender becomes vulnerable in situations where the dependee fails to achieve a goal, perform a task or make a resource available. In a softgoal-dependency, a depender depends on the dependee to perform certain goals or task that would enhance the performance. The notion of a softgoal derives from the Non-Functional Requirements (NFR) framework (Chung 1993) and is commonly used to represent optimisation objectives, preferences or specifications of desirable (but not necessarily essential) states of affairs.

The freedom afforded by the *i\** Framework can also pose difficulties when modelling practical problems in organisations. How do we know when we have identified all the relevant agents that should be included in our model? How do we know when all the dependencies have been specified? There are also difficulties in applying the *i\** Framework’s concept of dependencies. For example, sometimes the distinction between a goal and task dependency can be difficult to distinguish, and indeed in the real world these can occur simultaneously. We supplement and support the *i\** Framework by providing an approach that enables Conceptual Modelling activities to be supplemented by knowledge of social/organisational processes. These social processes are in the form of patterns of communication. In order to develop systems that meet the real needs of organisations, one should have a thorough understanding about the organisational environment and its impact on

the system. It is important to understand why organisations work as they do so that successful systems can be developed, and integrated with other systems over time (Yu 1997). These questions are difficult to answer in most AOCM approaches. In the next section, we will introduce a communicative perspective to address these organisational questions.

### **3 Communication as Social Process; Systemic Functional Linguistics**

Theories of human communication are crucial in formulating adequate accounts of how technology works in organisations and they can be extraordinarily powerful as metaphors for developing technologies as well. We use Systemic Functional Linguistics (SFL) as a foundation for our work because it is explicitly a social semiotic model of language (Halliday 1985) and therefore more appropriate to apply to organisations than other available major language paradigms- the Logical Paradigm (Carnap, Montague) and the Generative Paradigm (Chomsky). Following Andersen (1990), SFL is based on authentic language use and is well suited to field work. It views language as a social phenomenon described in functional terms. It is unique in that it addresses semantic aspects- how language users construct meanings- while possessing relatively explicit rules for relating meanings to expressions. This is necessary for conducting practical textual analysis. SFL has been successfully applied to understanding workpractices associated with systems in organisational contexts (Clarke 2000, 2001, 2002) including issues of systems use and renegotiation, system similarity and change. Recently it has been recognised that these same methods can be applied to requirements engineering and other systems development activities (Clarke 2005; Zappavigna-Lee and Patrick 2005). We can apply SFL because when we conduct work, whether we do this in the presence or absence of any technologies, the structural and functional characteristics of the work are imprinted in the communication typically associated with it. By studying communication as social processes we can understand work properties and technologies.

The basic unit of communication in SFL is called the *text* and is defined as “... a completed act of communication, in any medium...” (Kress 1988, 185). Each act of communication is an interactive social event. If we undertook shopping, what was said and done during this interactive social event could be recorded and transcribed creating a document which has an analysable structure. If we were to repeatedly record many shoppers we would end up with transcripts which would, conceptually at least, cover most of the ways in which shopping can be undertaken. We would be able to communicatively characterise this particular social process, work pattern or workpractice. Similarly, the catalogue I might browse in store is also an interactive social event. I am interacting with an idealised view of ‘customers’ created by the author of the catalogue. When technology is used to assist social processes (like shopping) it would be an advantage if it conformed to the (social) literacy and expectations that interactants already possess about these particular social occasions, otherwise its users (social agents) may consider the associated technology to be a failure! An important question is ‘What is it that social agents expect, need or utilise when engaging in completed acts of communication?’ If we can answer this question it might be easier to develop appropriate systems to support social processes. The answer lies in the fact that every completed act of communication has two types of context associated with it. The first type of context is called the Situational Context and provides the situation-specific features to the text that enable interactants to know what’s going on (called field), who is involved (called tenor), and how language (called mode) is being used. The second type of context called the Cultural Context provides interactants with information about function and structure of a communication or a social process. Both types of context can be determined using SFL methods.

The processes used in an SFL analysis that can be incorporated into the i\* Framework Agent-oriented Conceptual Modelling, include the following steps:

- *Identifying Relevant Texts*: There needs to be a decision concerning what are relevant spoken and written texts (documents) associated with work that should be modelled. Currently it is the analyst that determines this, but this process could be developed into a formal sampling strategy using the language resources that constitute the texts themselves. This will need to be the subject of further research.
  
- *Analysing the Situational Context*: Each of the previously identified texts, are analysed using three methods called field, tenor and mode, that are collectively used to describe the Situational Context associated with a text. Field describes the social activities and actions that are taking place. We know what's going on mainly from words (lexical items), specifically nouns and noun groups that are used. But as most words have many usages, we need to identify the so-called *indexical lexical items* that characterise the activities for given stakeholder groups in particular social situations. Tenor describes the social role relationships played by interactants. Examples include dyads like student/lecturer, customer/salesperson, or friend/friend. Three continua are used to determine the tenor of a text (Martin 1992). The *power continuum* is used to classify situations according to whether the roles we are playing are those in which we have equal or unequal power. In our shopping example, customers may have the power to refuse to pay the marked price for an item. The *contact continuum* is used to classify situations by whether the roles we are playing bring us into frequent or occasional contact. *Affective involvement* will be used to classify situations according to whether the roles we are playing bring us into high or low affective involvement (high or low emotional levels). Mode describes the part language itself plays in a given social occasion. Two continua are used to describe it. The *spatial/interpersonal distance* will be used to describe the possibilities of immediate feedback between interactants in terms of visual and aural contact. For example, shopping in a store occurs at the other end of this continuum does have these possibilities, shopping on the web usually does not. The *experiential distance* will be used to classify situations according to the relationship between language and the social process. At one extreme, language can be viewed as *action*- the type of situation familiar to shoppers. At the other extreme language can be viewed as *reflection*- familiar to readers of books. These methods are necessary in order to describe the situational context for agent-based model- this has never been achieved before.
  
- *Analysing the Organisational/Cultural Context- Staging of Social Processes*: Specific kinds of goal-oriented work have predictable staging. When we analyse the language associated with this work it also possesses a commensurate staging. Associated with the cultural or organisational context in which the completed act of communication takes place, this staging forms an important part of structure of a work text and is referred to as its *genre*. The functional stages of a genre are referred to as *genre elements*. Each text exhibits a particular configuration of elements, called a *genre sequence*. By analysing a number of texts of the same workpractice, we can develop a *genre digraph* that merges these genre sequences together and creates an economical notation to represent the staging of a given workpractice, see Figure 2. Generally the same kinds of texts or workpractices will have the same elements in the same order representing the typical staging of the work.

- *Determining Relationships between Texts- Intertextuality*: New concepts have been developed that show how information systems can be thought of as consisting of multiple genres. In the shopping example, we have a service encounter genre for the sales transaction and multiple genres associated with describing receipts. Literally one genre can be thought of as directly or indirectly linked to each other. Large and complex systems and workpractices have been described using these concepts, see Clarke (2002).

We are interested in analysing authentic social processes- in particular workpractices- as they are realised through texts, as well as the staging of these social processes by identifying the associated genre characteristics. We are using a model of language that is functional, socio-semantic and contextual, in order to understand the meanings associated with workpractices. These characteristics distinguish genres from the ‘narrative’-based, cognitive/psychological, and folk-linguistic approach to idealised episodic knowledge represented in Scripts and Plans (Shank and Abelson 1977). As defined in SFL’s bi-stratal theory of context (Martin 1992), recurrent genre structures are a manifest representation of the organisational/national culture of a text. As it has been described above, the genre sequence is a model or representation of the staging of the communication actually undertaken by one or more sets of interactants, and the digraph is a model of the entire genre. While genre is only one of the many resources that make up a social process, genre structure is a very important resource. It can be represented using a directed cyclical graph, and consequently the global rhetorical organisation of a text type can be represented as an executable model on a computer. As we are all too aware, executable models do construct and constrain real social actions and activities, and define or redefine social role relationships in organisations. Social processes cannot be reduced to a structure, but the staging of them (its genre) can be represented using one. Genre structure in particular is communicative, not simply because of what it is but because of how it is connected to other kinds of language resources. In SFL this is referred to as the meta-functional hook-up; how context and text resources mutually interact with each other. In a very real sense, by making a machine executable model of the generic structure of a workpractice we are engaged in ‘embedding a social process’. The staging of any executable model necessarily contributes to the mix of text-forming resources available to interactants involved in organisational communication, constraining what it is possible to do, say, mean and be in a given social setting. The two-fold nature of genre as a representation of the staging of a social process while also being an executable model is the basis for an entirely new application of communication theory to Agent-Oriented Conceptual Modelling. In the next section we use an authentic illustrative case study to exemplify this relationship.

#### **4 Illustrative Case Study**

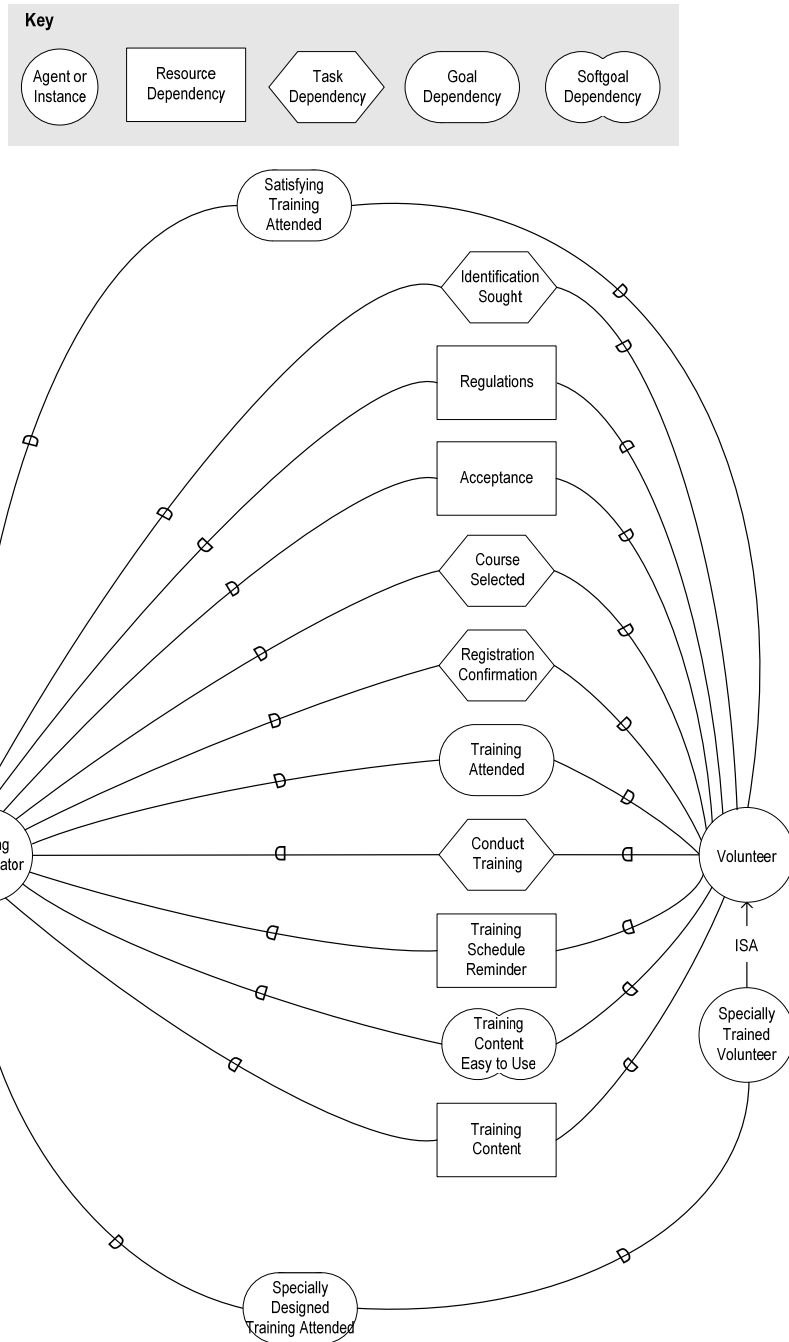
In this section, we demonstrate the utility of SFL applied to Agent-Oriented Conceptual Models by applying the category of genre to an authentic Registration System at the state-based emergency services organisation. This system was to be automated. A Strategic Dependency (SD) model for registration and training, in the absence of a computer-based system is used to illustrate the  $i^*$  notation, see Figure 1 for the model.

The modelling process begins with the identification of the actors/agents involved and their mutual dependency relationships (using the taxonomy of dependency relationships described above). The TrainingCo-ordinator agent depends on Volunteer agents to achieve its TrainingAttended goal. The class of Volunteer actors has a specialised sub-class of actors called SpeciallyTrainedVolunteers- these are volunteers who go through training programs to acquire specialised skills. The TrainingCo-ordinator depends on SpeciallyTrainedVolunteers to SpeciallyDesignedTrainingAttended, modelled as a goal dependency. The Volunteer agent

has a dependency on the TrainingCo-ordinator to provide TrainingContent, modelled as a resource dependency. The TrainingCo-ordinator has a dependency on Volunteers to achieve its SatisfyingTrainingAttended goal- a responsibility of the Training Co-ordinator that all Volunteers are trained. Volunteers depend on the TrainingCo-ordinator to perform the ConductTraining task. Observe that we have chosen not to model this as a goal-dependency since the TrainingCo-ordinator cannot autonomously decide how the corresponding goal might be achieved but must work with the depender in a tightly-coupled fashion to perform the task. Volunteers have a further dependency on the TrainingCo-ordinator to TrainingScheduleReminder modelled as resource-dependencies. Volunteers have a preference for the TrainingCo-ordinator to satisfy the softgoal TrainingContentEasyToUse. The SD model provides an important level of abstraction for describing systems in relation to their environments and in terms of their intentional relationships. This allows the modeller to consider new or existing organisational and system configurations even if the internal goals and beliefs of individual agents are not known.

Recent work by the authors (Clarke et al. 2006) has identified that Strategic Dependencies are not 'flat' but are hierarchically arranged. The dependencies could be structured if a workpractice could be embedded into a new SD model for the required computer-based system. If we examine the staging of a Student Loan genre, previously published in Clarke 2005, we can see that one subsequence or path through that genre digraph involved a student being enrolled onto a system. We recognised that this subsequence resembled (Clarke 2006b) the functionality we required in our computer-based registration and training system, but it required modification to meet our joint (client and developer) needs exactly. We were to be developing a computer-based system, so we could omit entirely the phatic elements of Greetings and Finis (leave taking), used to 'smooth the social waters' during spoken language interactions, as these are needed in computer-based systems. A Service Request element in the enrolment subsequence could be substituted with information at a new Orientation stage. The new system required users to login and so the new system retained the Identification Sought element. Similarly both workpractices required users to be acquainted with regulations, and so an RE element is evident in both Figures 2a and 2b. An explicit Enrolment stage in Figure 2a was replaced by an analogous Acceptance stage in the Figure 2b. So far we have described how similar the enrolment workpractice of Figure 2a is comparable to the registration workpractice of Figure 2b. The functional similarity of these elements is shown by the vertical columns joining elements in similar positions within their respective workpractices. The tail ends of both workpractices show different staging. The Materials Out and possible repetitions of the Service Request, together with an optional Finis stage, typify a Loan workpractice but are irrelevant to Registration. The tail end elements of the Registration feature include at least one or more Course Selections and Registrations.

**Figure 1:** Strategic Dependency model for registration and training, without computer-based system



The new Registration workpractice of Figure 2b is a pattern of communication that provides interactants with information about the functional and structure of the social process. Genres therefore provide a higher level abstraction of “how stakeholders depend on each other?” (Yu 1997). When developing the computer-based system we will see that many resource and task dependencies can be directly associated with stages in a genre. This provides a significant advantage of simplifying the SD modelling process while making it easier to validate sets of requirements.

**Figure 2:** An existing loan genre (a) with an ‘enrolment subsequence’ (Clarke 2005) is used as the source for sequencing of a canonical registration sequence in (b) that will



be used to specify a Registration task in the  $i^*$  model. The similarities between the two are described in the text.

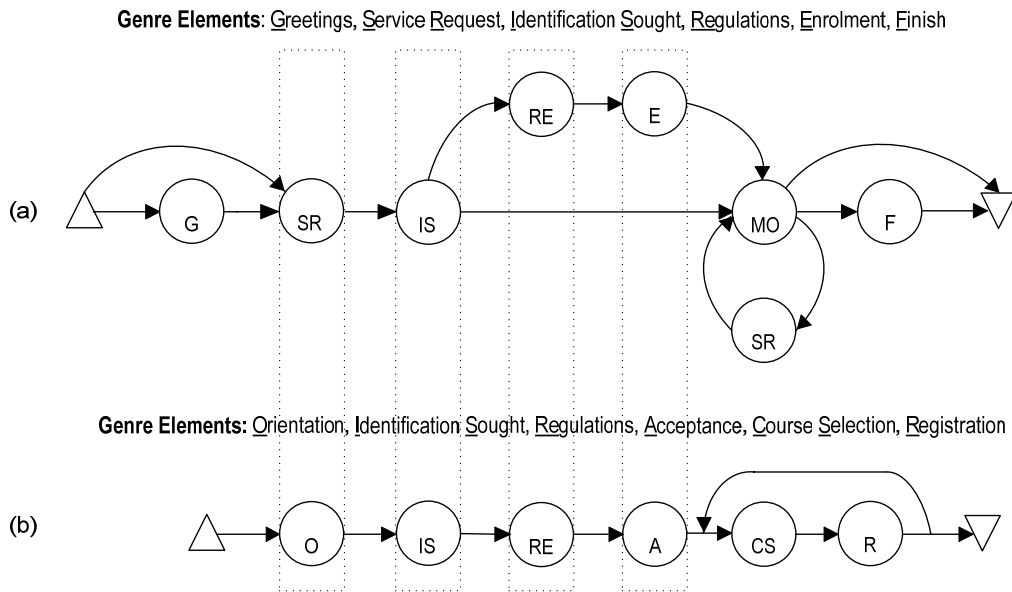
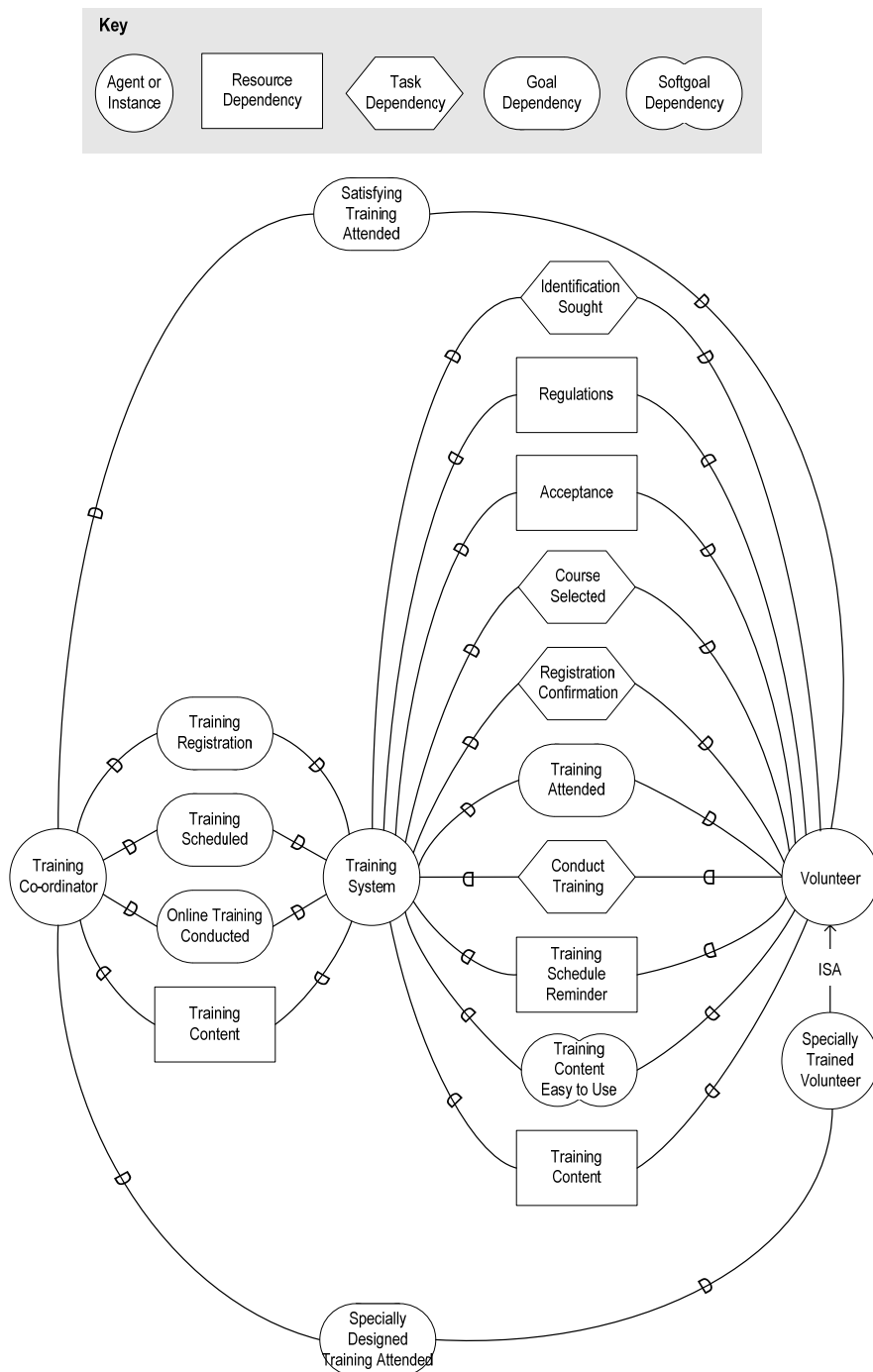


Figure 3 shows an SD model with the embedded registration process in a Computer-based training system. The TrainingCo-ordinator delegates much of the work of scheduling and conducting the online training to the TrainingSystem. The TrainingCo-ordinator is no longer bothered with scheduling of the training. One of the Yu's (1997) key questions is "Why is a computer-based system preferred?" and "Whose interests does it serve?" Again taking as our point of departure an existing manual system, we can answer the question concerning whose interests does the existing system serve, and then propose the inclusion of one or more agents to this model and explore whether a newly redesigned system offers any advantages over the existing system. Significantly, an analysis of the Situational Context can be used to answer these issues. Field, Tenor and Mode are interdependent as IT interposed between participants will influence how the communication occurs, changing what is done as well as the arrangement of participants (social agents). No existing AOCM framework can reveal these inter-dependencies.

**Figure 3:** Strategic Dependency model for computer-based training system



Reprising the key dependencies of any SD model:

- in a *Goal-dependency*, the depender depends on the dependee to bring about a certain state in the world. The dependee is free to and expected to make whatever decisions are necessary to achieve the goal (the dependum). The depender does not care how the dependee goes about achieving the goal. A goal-dependency relationship allows a depender to have a goal achieved even when it does not have the know-how and/or resources to achieve the goal. With a goal-dependency, the depender gains the ability to

assume that the condition or state of the world will hold, but becomes vulnerable since the dependee may fail to bring about that condition;

- in a *Task-dependency*, the depender depends on the dependee to carry out an activity. A task-dependency specifies how the task is to be performed, but not why. The depender makes the decision. The depender's goals are not given to the dependee. A task dependency is typically used when a desired product is not readily available (for example, easily perishable), or when no tangible product is involved (for example, go to some place). The depender has control over how the task is performed (for example, how the product is made). By using a task-dependency, the depender is able to have a task performed without engaging in it personally, but is vulnerable since the dependee may fail to perform the task;
- in a *Resource-Dependency*, the depender depends on the dependee for the availability of an entity (physical or informational). Under resource-dependency, the issue of decisions does not come up. A resource is usually the finished product of some deliberation-action process. It is assumed that there are no open issues or decisions to be addressed. The production process is not viewed as problematic by the depender in a resource dependency. There is no decision to be made. Based on this discussion, resource can be physical or informational. By establishing a resource-dependency, the depender gains the ability to use this entity as a resource. At the same time, the depender becomes vulnerable if the entity turns out to be unavailable.

Based on the above we can reason about how strategic dependencies can be related to generic staging of the Registration activity. The dependencies "IdentificationSought", "CourseSelected" and "RegistrationConfirmation" are represented as task-dependencies in the new SD model in Figure 3. This is based on the reason that depender depends on the dependee to carry out an activity. On the other hand, dependencies "Regulations", "Acceptance" are represented as resource dependencies in the new SD model in Figure 3. This is based on the reason that the depender depends on the dependee for the availability of an entity (which is physical or informational).

## 5 Deriving a Partial Methodology

In this section we describe a partial methodology for the study of social processes that may be embedded into agent oriented systems. Given that these SFL theories and methods have proved useful in modelling traditional information systems, we want to determine if they can assist Agent-oriented system developers during the AOCM process. SFL theories and methods are used to determine the structural and functional patterns of communication relevant to existing systems that can be modelled over time across a range of system types and organisational settings. Real-world challenges faced by Agent-oriented system developers include for example, the unknown and complex arrangement of social agents in workplaces, uncertain goals identifying the actual arrangement of agents and workers in the organisation, and identifying user domain knowledge in order to create new functions for Agent-oriented systems.

In order to see the largest range of communication patterns possible, a number of case studies will need to be conducted within one or more government agencies and/or large commercial organisations. These case studies will be used to develop Agent-Oriented Conceptual Modelling methods and techniques that utilise Field Analysis for determining the main system goals; Mode Analysis to determine the suitability of the system; Tenor Analysis for modelling

social/organisational structures; and Genre for modelling system dependencies and in the design and specification of new system dependencies (see Clarke et al. 2006). As we have demonstrated here, the process of determining dependencies between agents is greatly simplified if patterns of communication are used; genres can be used to describe what would otherwise seem like separate task and goal dependencies in *i\** Framework. Some case studies will be longitudinal in order to determine if the SFL techniques are sensitive enough to identify significant changes in the organisation and determine how changes to requirements over time will affect the structure of software agents and their various dependencies. Each case study will follow the same set of stages forming a partial methodology:

1. *Develop a Business/Unit Profile* from available information sources;
2. *Contact/Entry*: Individual business/units are contacted to see if they are interested in the project and potentially becoming involved in it;
3. *Site Visits*: aim is to elicit information from the business representatives about workpractices and the business/unit;
4. *Interviewing*: identify (i) existing systems and subsystems to be modelled (following Unni et al. 2003); (ii) type of workpractices (communication patterns or genres) that are evident; (iii) how these relate to other workpractices (primarily the dependencies); and (iv) an attempt to identify any knowledge or judgements associated with these workpractices. Interviews are semi-structured.
5. *Workplace Study*: photographic virtual realities (VR) are taken in order to disambiguate spoken work communication during the transcription processes;
6. *Prototyping Sessions*: the aims of these sessions are to: (i) elicit information about the actors and their interactions with inter/organisational actors (following Unni et al. 2003, Krishna et al. 2006; Clarke et al. 2006); and (ii) identify departments/units, social actions and activities ('functions' in Unni et al. 2003). The rationale and functions are revisited during the elicitation process by asking various 'why-what-how' questions (Yu 1997) until an agreement can be reached on the requirements. This stage may be iterated a number of times (see Crinnion 1991). The key tasks are to identify the agents/actors that would form the basis of the SD and SR models and their dependencies. Elicitation will be conducted using canonical genres. Versioning of requirements will be done at two different levels: (i) by analysing the language in which they are formulated; and (ii) by versioning the requirements capture templates (see Clarke et al. 2006) that are used to codify them.
7. *Revisit/Exit*: It may be necessary to negotiate return visits as required and agreed upon. As part of the study Researchers are required to communicate information about the results.

## 6 Discussion

Despite considerable progress, the domain of agent-oriented conceptual modelling still consists of a fragmented and disparate collection of tools and frameworks (Iglesias et al. 1999). There is a critical need for a comprehensive unified framework without which we find ourselves not in a position to conduct reasoning using these models, or undertake consistency and completeness checking using these models. The research significance of this project derives from its application of SFL to support agent-oriented conceptual modelling (AOCM) and development activities using the *i\** framework. An explicit functional model of communication to understand organisations and work, has never been attempted in AOCM, but it is sensible given that work routines are often accompanied by commensurate communication routines. It appears that SFL and the *i\** Framework are complementary in the respect that SFL which is a model of human communication that can be used to perform an

analysis work in organisations in great detail, while concepts in the *i\** Framework are so abstract that a mapping can be made between the two. Executable specifications however can be created from the *i\** models (see Salim et al. 2005).

There are a number of important problems in AOCM that are addressed when SFL theories and methods are also used. These include:

- *Determining the Main Goals of the System:* Yu (1997) provided a list of “why” questions that Agent Oriented Conceptual Modellers need to answer before proceeding to improve an initial set of requirements. At the top of this list was an attempt to determine ‘What are the main goals of the system?’ SFL methods can provide a user verifiable way to describe current systems that in turn can act as models for new systems. Significantly, a field analysis can be used to determine the actual social actions and activities that are taking place- no guessing is required.
- *Modelling Complex Social/Organisational Structures:* Current frameworks offer little support to model complex organisational/social structures. Social structures, especially team structures, have been the subject of considerable study by multi-agent systems researchers, see for instance Singh (1998). However, little has been done to support the representation of social structures within modelling frameworks. A recent attempt by Parunak and Odell (2001) falls short because while an explicit group construct is presented, it does not capture the semantics of a wide array of other social entities. We can use SFL methods to directly identify candidate agents from communication in work settings (for example Tenor). In those cases where no pre-existing social arrangements can be found within the organisation, one can be specified from experiences gained outside of the organisation in question or from the experience of the client base. This innovation is non-trivial given the complexity of goal relationships between agents (these can be adversarial or cooperative) and inter-agent communication.
- *Suitability of a New/Computer-based System:* Another of Yu’s (1997) key questions is “Why is a computer-based system preferred?” and “Whose interests does it serve?” Again taking as our point of departure an existing manual system, we can answer the question concerning whose interests does the existing system serve, and then propose the inclusion of one or more agents to this model and explore whether a newly redesigned system offers any advantages over the existing system. We illustrated the interdependency of Field, Tenor and Mode in our example.
- *Modelling System Dependencies using Genre:* Recent work by the authors has identified that Strategic Dependencies are not ‘flat’ but are hierarchically arranged. We also demonstrated in our example that Strategic Dependencies are not flat but hierarchically arranged revealing how genres can be used to identify “how stakeholders depend on each other?” (Yu 1997). This has the significant advantage of simplifying the modelling while simultaneously making it easier to validate sets of requirements.
- *Design of New System Dependencies using Genre:* In this paper we developed a new system feature for an Agent based system where one had not previously existed. This illustrates the possibility of using genre as the basis for the description of multiple dependencies- typically only one can be specified at a time.

In communicative approaches to IS- including SFL, social semiotics and systemic semiotics- the normal situation has been to modify and apply these methods to early phase concerns;

requirements engineering and systems analysis. The problem has always been that these theories do not directly map to late-phase concerns; design and implementation. In several necessary ways, the selection of agent-oriented technologies is an appropriate form of late-phase representation for communicative approaches. It enables our work to have greater visibility in mainstream IS and CS. For example, *i\** representations can be converted into UML sequence diagrams (Krishna et al. 2006), and therefore social processes embedded into them may also be represented in this way. Analysis work using communicative approaches is often conducted manually, but environments used for supporting the development of *i\** representations may be adapted to support systemic semiotic uses. Perhaps most importantly agent-oriented technologies provide us with the means of creating executable models; for example *i\** models transformed into agent based executable models in Agent Speak (L), see Salim et al. (2005). In related work we have been able to develop executable specifications of *i\** models that include embedded social processes (Clarke et al. 2006) and this provides systemic semiotics with a mechanism for developing completed working systems.

## Acknowledgements

This research work has been supported by the Australian Research Council (ARC) Linkage Project Grant LP0230453 awarded to Aditya K. Ghose, Rodney J. Clarke, and Peter Hyland (2002) entitled “Practical methodologies for Agent-oriented Conceptual Modelling” combining for the first time agent-oriented conceptual modeling and semiotic analysis.

## Bibliography

- Chung, L. (1993) "Representing and Using Non-Functional Requirements for Information System Development: A Process-Oriented Approach" Graduate Department of Computer Science Toronto, University of Toronto
- Clarke, R. J. (2000) “An Information System in its Organisational Contexts: A Systemic Semiotic Longitudinal Case Study” *Unpublished PhD Dissertation* Department of Information Systems, University of Wollongong
- Clarke, R. J. (2001) “Social Semiotic Contributions to the Systemic Semiotic Workpractice Framework” *Sign Systems Studies* 29 (2) pp. 587-605
- Clarke, R. J. (2002) “Intertextuality at Work: Large-Scale Structure of Information Systems” in Clarke, R. J.; Liu, K.; Andersen, P. B. and R. K. Stamper eds/ (2001) *Organising Signs: Studies in Organisational Semiotics 2*, Information, Organisation and Design Series, Kluwer Academic Press, pp.
- Clarke, R. J. (2005) “Systems Resemblance and Workpractice Evolution: Implications for Work Activity (Re)design” in Goldkuhl, G., Clarke, R. J. and K. Axelsson eds/ *Proceedings of the International Workshop, Communication and Coordination in Business Processes* June 22, 2005 Kiruna, Sweden, pp. 45-61
- Clarke, R. J. (2006a) “The Work that Analysts Do: A Systemic Functional Approach to Elicitation” in Nilsson, A. G.; Gustas, R.; Wojtkowski, W.; Wojtkowski, W. G.; Wrycza, S. and J. Zupančič (2006) *Advances in Information Systems Development: Proceedings of the 14<sup>th</sup> International Conference on Information Systems- Development Bridging the Gap between Academia and Industry* Volume 1 NY: Springer Science + Business Media ISBN-10: 0-387-30834-2, pp. 325-336
- Clarke, R. J. (2006b) “Systems Resemblance and Recognition” in Clarke, R. J. and G. Goldkuhl eds/ “Special Issue in Communication and Coordination in Business Processes (CCBP)” *Systems, Signs and Actions (SYSIAC): An International Journal on Communication, Information Technology and Work* **in press**
- Clarke, R. J.; Dong, D. and P. Windridge (2003) “Application Architecture for Spoken Language Resources in Organisational Settings” *International Business Information Management Conference (IBIMC 2003) CD-ROM Proceedings* Cairo, Egypt, 14<sup>th</sup>-18<sup>th</sup> December 2003, 8pp.

- Clarke, R. J.; Ghose, A. K. and A. Krishna (2007) "Systemic Semiotics as a basis for an Agent-Oriented conceptual Modelling Methodology" in Gudwin, R. and J. Queiroz eds/ (2005) *Semiotics and Intelligent Systems Development* Hershey, PA: Idea Group Inc., Chapter 9, pp. 256-285 ISSN: 1-59904-063-8
- Crinnion, J. (1991) *Evolutionary Systems Development: a practical guide to the use of prototyping within a structured systems methodology* London: Pitman Publishing
- Halliday, M. A. K. (1985) *An Introduction to Functional Grammar* London: Edward Arnold
- Halliday, M. A. K. and J. R. Martin (1993) *Writing Science: Literacy and Discursive Power*, Critical Perspectives on Literacy and Education, London and Washington: The Falmer Press
- Iglesias, C.; Garrijo, M. and J. Gonzalez (1999) "A Survey of Agent-Oriented Methodologies" in Muller, J.; Singh, M. P. and A. S. Rao eds/ (1999) *Proceedings of the 5th International Workshop on Intelligent Agents(V): Agent Theories, Architectures, and Languages ATAL-98*, Volume 1555, Springer-Verlag: Heidelberg, Germany, pp. 317-330
- Jennings, N. R.; Sycara, K. and M. Wooldridge (1998) "A Roadmap of Agent Research and Development" *Journal of Autonomous Agents and Multi-Agent Systems* Vol. 1, pp. 7-38
- Kress, G. (1988) "Language as Social Practice" in Kress, G. ed/ (1988) *Communication and Culture: An Introduction* Kensington: UNSW Press
- Krishna, A.; Clarke, R. J. and A. K. Ghose (2006) "Genre-based approach to Requirements Elicitation" *Proceedings of the Eighteenth International Conference on Software Engineering and Knowledge Engineering (SEKE-2006)*, San Francisco, California, July 5-7 2006 ISBN1-891706-18-7, pp. 682-687
- Krishna, A.; Ghose, A. K. and A. Vranesevic (2006) "Agent-Oriented Conceptual Models to UML Sequence Diagrams via Effect Annotations" *Special issue on Agent-Oriented Software Development Methodologies-International Journal of Multi-Agent and Grid Systems*, **in press**
- Liu, L. and E. Yu (2004) "Designing Information Systems in Social Context: A Goal and Scenario Modelling Approach" *Information Systems* 29(2), pp 187-203
- Martin, J. R. (1992) *English Text: System and Structure* Philadelphia/Amsterdam: John Benjamins Publishing Company
- MacWhinney, B. (2003) *CHAT Transcription System Manual* <http://chilides.psy.cmu.edu/manuals/CHAT.pdf>
- Parunak, V. D. and J. Odell (2001) "Representing social structures in UML" *Proceedings of the 2001 Autonomous Agents Conference*
- Salim, F.; Chang, C.; Krishna, A. and A. K. Ghose (2005) "Towards Executable Specifications: Combining i\* and AgentSpeak (L)" *Proceedings of 17th International Conference on Software Engineering and Knowledge Engineering (SEKE-2005)*, Taipei, Taiwan, Republic of China, July, 4 pp.
- Shank, R. and R. Abelson (1977) *Scripts, Plans, Goals and Understanding* Hillsdale, N.J.: Erlbaum
- Singh, M. (1998) "The intentions of teams: Team structure, endodeixis and exodeixis" *Proceedings of the 1998 European Conference on Artificial Intelligence* Wiley pp. 303-307
- Unni, A.; Krishna, A.; Ghose, A. K. and P. Hyland (2003) "Practical Early Phase Requirements Engineering via Agent-oriented Conceptual Modelling" *Proceedings of 14th Australasian Conference on Information Systems (ACIS-2003)*, Perth, Australia, November, 2003
- Yu, E. (1997) "Towards Modelling and Reasoning Support for Early-Phase Requirements Engineering" *Proceedings of the 3rd IEEE International Symposium on Requirements Engineering (RE'97)*, January 6-8, Washington D.C., USA. pp. 226-235
- Yu, E. (2001a) "Agent Orientation as a Modelling Paradigm" *Wirtschaftsinformatik* 43 (2) pp. 123-132
- Yu, E. and J. Mylopoulos (1993) "An Actor Dependency Model of Organizational Work- with Application to Business Process Reengineering" in Kaplan, S. (1993) ed/ *Proceedings of Conference on Organizational Computing Systems*, November 1-4, Milpitas, California, USA, ACM Press, pp. 258-268
- Zappavigna-Lee, M. and J. Patrick (2005) "Explicating Tacit Knowledge Embedded in Nominalisation" *ACIS 2005 Socialising IT: Thinking About the People*, Wednesday 30<sup>th</sup> November 2005 CD-ROM Proceedings