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7-3-2008

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UML-BASED DEMO PROFILES AS METACONCEPTS FOR INTERLOCKING INSTITUTIONAL WORLDS

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Abstract

An information system supporting an organisation is based on concepts from the organisation's institutional world. An institutional world consists of a collection of "speech acts" and "institutional facts". For a group of information systems to interoperate, the organizations responsible for these systems must first agree on what the words mean in the interoperation. This agreement is called an ontology. The ontology is generally defined as an explicit "specification" of a "conceptualization". One of the major uses of ontology is to support interoperation of information systems. Many institutions whose systems are to interoperate are not fully autonomous; they do sometimes cooperate with each other, so that their "institutional worlds" will interlock therefore "interlocking ontologies". Modeling interlocking institutional worlds (IWs) requires a dedicated representation system that gives a formal model which is the "specification of institutional facts" as well as the "specification of speech acts". The ontology is the specification of institutional facts. However, we do not have a system that can give a formal model for the speech acts. Therefore, this paper adopts a synthesis approach to propose the UML extension for modeling speech acts in the context of interlocking institutional worlds. DEMO is one of the most popular Language Action Paradigms (LAP)-based methodologies based on speech act theory so is close to the concept of IWs. The UML is a standard modelling language in the world of information system development and currently there is a growing interest in its adoption as a language for conceptual modeling and business process representation. Taking advantage of the fact that UML is an OMG standard and its use is growing quickly, this paper proposes UML-based DEMO profiles purposely for modelling IWs.

Keywords: ontology, DEMO, UML, interlocking institutional worlds, business process.

1 MOTIVATION

Nowadays, almost all businesses or organizations are supported by information systems. As described by Colomb (2007); *"…companies in the finance, insurance and real estate industry group are very little more than information systems. Mines and farms use information systems to keep track of production and assets. Manufacturers, wholesalers and retailers use information systems to manage their production, sales and employees. Construction firms use information systems to bid for and manage projects. Transportation firms use them to schedule services. The health sector is served by thousands of systems assisting in the operation of various departments in hospitals, doctors' surgeries, and the flow of payments through the system. Universities use information systems to keep track of students, courses, libraries and staff. Government use them to record births, deaths and marriages,* *and in the provision of all sorts of services…"* Therefore, there are millions of information systems. Colomb (2007) further explains that; *"…Anyone who does anything in this world will typically interact with several business or organizations supported by information systems, sometimes very many. A shopper will visit several stores comparing products, availability and price. All but the simplest medical conditions involve several doctors, pharmacies, pathology laboratories and other services. A trip can involve airlines, hotels, car hire companies, travel insurance and tours, mediated by travel agents, facilitated by credit card companies and bank automatic teller machines. A manufacturer will interact with many suppliers, customers, transportation services, banks, stock exchanges and governments at many levels in order to carry on its business…"* In another part of the text, Colomb (2007) states that; *"…if doing something involves interaction with many business and organizations, each supported by information systems, it is reasonable to expect that the information systems themselves will interoperate to support the interaction…"*. He then continues to state that; *"…for a group of systems (information systems) to interoperate, the organizations responsible for the systems must first agree on what the words mean in the interoperation. This agreement is called an* ***ontology****, a description of the world shared by the participants…*"

The statement above illustrates the situation for the *"Dream of Interoperability"*. In the last paragraph, we are interested in his claim about the *ontology.* According to Gruber (1993), the ontology is defined as an explicit *specification* of a *conceptualization*. One of the major uses of ontology is to support *interoperation of information systems* (Hart et al. 2004). In this purpose, we have extended Gruber's definition by revealing what *"sorts of things"* are specified in the conceptualization as discussed in (Colomb & Ahmad 2007). We use Searle's theory of institutional facts (Searle 1995) to reveal these *"sorts of things"*. As a result, we submit that *in the context of interoperation of information systems*, instead of ontology being a kind of model specification it is actually *"a specification of a coordinated system of institutional facts"* or an institutional world.

Much ontology research concentrates on developing *foundations* of ontology modelling language (e.g., meta-models, language constructs) which gives a *formal model* of the conceptualization, which is a *specification of institutional facts*. Those works generally describe *heavyweight ontologies* (e.g., Weber 1997; Guizzardi 2005; Guarino & Welty 2004; Wand & Weber 1999; Opdahl & Henderson-Sellers 2001).

Institutional facts are created in ***speech acts*** made by certain players (e.g., users or information systems). Therefore, we need a dedicated representation system which gives a *formal model* of the conceptualization, which is a specification of the business system or so-called the ***"specification of speech acts"***. By having this business representation system, we can use it to develop a *business model* tailored to the context of ontology-based interoperation of information systems. From here, it can serve as *basis* for developing a kind of information system such as an *ontology server* to support ontology-based interoperation of information systems. For this purpose of ontology usage, the ontology to be hosted by the server is a representation of *interlocking institutional worlds (IWs)*. Having some understanding of how players make use this ***"specification of institutional facts"*** (ontology) may help *software developers* systematically develop an ontology server using a standard approach (e.g., UML) to software systems development. Hence, the purpose of this paper is to provide an *extension* of UML as a standard modelling language for modelling IWs. Before proceeding, we introduce some *fundamental* concepts that ground the concept of IWs: *brute facts*, *institutional facts* and *speech acts* (section 2.1). Section 2.2 uses these concepts to briefly introduce the notion of IWs by making sense what "*sort of things"* exist in the environment of the *interoperating systems*. Section 2.3 links the importance of modeling IWs to the context of ontology server development. Section 2.4 defines several *meta-concepts* for IWs using a case study of the Olympics. Section 3 and 4 generally provide some information about DEMO (Dynamic Essential Modeling of Organizations) and UML (Unified Modeling Language) respectively, and further provide our approach to ***synthesis*** of the UML with the DEMO concepts for modeling IWs. Section 5 demonstrates our approach for modeling IWs using an Olympics case study. We discuss our approach in the conclusion section (section 6).

2 INTERLOCKING INSTITUTIONAL WORLDS

2.1 Brute Facts, Speech Acts and Institutional Facts

Searle distinguishes two types of facts, *brute facts* and *institutional facts*. A *brute fact* is about something in the physical world that is *independent* of human society, while an *institutional fact* is *dependent* on human society. Suppose a truck turns up one morning and dumps *10 tones of mushroom compost* in your driveway. This is a *brute fact*. The driveway would be there and so would the pile of mushroom compost, even if suddenly all human beings disappeared. Suppose further that on the previous day, you had sent a message to the landscape supply company ordering 10 tones of mushroom compost. In this circumstance, the pile of compost constitutes the delivery of your order. The *delivery of an order* is an *institutional fact*. Without human society, there would be no landscape supply company, nor would you for that matter, and the truck never have arrived and deposited the compost. Further, part of the meaning of the delivery of your order is that you are now obligated to pay the landscape supply company an amount of money in exchange for the compost and its delivery. Without human society, an obligation to pay has no meaning. Searle uses a formula *"(brute fact) X counts as (institutional fact) Y in context C"* to organize the relationship. In our example, the *context C* in this case is your previously having placed an order for that amount of compost.

Your *placing the order* is called a ***speech act***. A *speech act* is something that is said which changes how the world is. The term *"said"* is used in a very *general sense* – you could have called by the landscape supply company and placed the order by speaking to a clerk, or telephoned, or sent a message to their web site as in the previous chapter. You can see how you are placing an order changes the world by considering what would happen if you had not placed an order, but still a truck arrived and left 10 tonnes of compost in your driveway. In this case, instead of you having an obligation to pay for the compost, the landscape supply company has an obligation to return, clean up the pile, and possibly compensate you for any damage caused. When you make the speech act of placing an order, the institutional fact of your having placed the order becomes true, which constitutes a change in how the world is. In next section, we will use these concepts; speech acts and institutional facts to make sense what "*sorts of things"* exist in the environment of the *interoperating systems*.

2.2 Interoperating Systems: Interlocking Institutional Worlds (IWs) is the "*Conceptualization"* and Interlocking Ontologies is the *"Specification"*

The concept of institutional world and interlocking institutional worlds are defined in (Colomb & Ahmad 2007). Our world is full of *institutional facts*. One's name is an institutional fact. Being given a name is an *act*, called a *speech act*, performed by one's parents and government department acting in cooperation. The speech act is recorded in some way, such as on a birth certificate or passport. The record of the speech act is actually an institutional fact. Likewise, information systems are almost exclusively concerned with storing institutional facts. Most messages between information systems are speech acts. The fact that someone is a customer (stored in the *Customer* table) is an institutional fact. The customer's name is an institutional fact (created in a speech act by the person's parents). The customer's credit rating is an institutional fact created in a speech act by the company's accounting department. The information systems' business rules enforce the context rules determining the validity of the speech acts, and the systems themselves keep track of how the world changes as a result. Once an interoperating community is established, it can generate a large number of institutional facts. This collection of integrated speech acts and consequent institutional facts made by a particular institution as that institution's *institutional world.* This institutional world is basically the *conceptualization* of which the ontology is the *specification*. Even though institutions are generally more or less autonomous, they do sometimes cooperate with each other, so that their *institutional worlds* will interlock thus *interlocking ontologies*. If we think of there are many institutions interoperate, hence, they may generate a large number of institutional facts. We can therefore think of the *overall* conceptualization is a result of IWS, forming a larger IW and consequently a single *large* and *complex* ontology.

The semantic heterogeneity always arise at the conceptualization, so must always be resolved amongst two or more players in order to interoperate. Keep in mind that, the interlocking ontologies is the specification. Since many players are involved to form a larger institutional world (consequently a larger ontology), thus, we generally turn to an information system technology to help players to commit to the ontology. In next section, we will link the need for a kind of *information system* so-called *ontology server* to support the domain IWS.

2.3 The Importance of Modelling IWS: In the Context of Ontology Server for Supporting IWs

We have made the distinction between the conceptualization and the specification. To keep in mind, what have been specified in the conceptualization are a collection of institutional facts created in the speech acts made by a certain players, while the ontology is the specification for this system of institutional facts.

When we want to manage a large and complex object, we generally turn to information systems technology. An *ontology server (OS)* is a kind of information system intended to manage ontologies. It is built around a database core. One of the main purposes for developing OS is to support ontology-based interoperation of information systems (Ahmad et al. 2007). In this context, we can therefore think how we can specify *software server* which performs *operations* (e.g., extracting, merge) on this ontology. The operations on ontology reflect to what have been specified at the conceptualization which is the *"...speech acts creates the consequent institutional facts made by a certain players…"* Therefore, we need to get familiar with the *business process* that the server will support for and can aid us to define the user requirements and also aids in developing use cases for example. Developing a business process model can give us a better understanding of what sort of activities is performed in the domain IWS that the server can support. In fact, currently many software methods start with modelling the business domain (e.g., IWS) that has to be supported by the information system (e.g., ontology server) (Dietz 2006b; Bahrami 1999; Jacobson et al. 1999). To make sense the need for modelling IWS in the context of ontology server development, we quote some excerpt of (Colomb & Ahmad 2007) as follows: "*…Notice that the institutional facts in the various conceptualizations are actually created by their respective institutions in speech acts. Only one body determines what an Olympic gold medal means, or how a Madison cycling event works. The participants in the interlocking institutional world see the institutional facts created by the other participants as fixed reality. These institutional facts are created by what are called **performative speech acts**. Because they are human creations, they can be changed. When an element of an institutional world changes, the other participants need to know about it, which they do by either an announcement being made or by means of a query. Both announcements and queries are also speech acts, called informative. The decisions made which allow the various institutional worlds to interlock are also performative speech acts. The interlocking institutional world is created by performative speech acts and held together by **informative speech acts**. The performative speech acts are reflected in the specification (ontology) by the **creation** of classes, properties, individuals and statements. The informative speech acts are reflected in **queries** and, if the server software supports a **publish/subscribe facility, notifications of change**. In other words, the informative and performative speech acts specified at the conceptualization are sorts of actions or operations on the specification of institutional facts (ontology)…"*

In other words, the operations on ontology (which is the specification) provided by the server are held together by performative and informative speech acts specified in the conceptualization. However, as aforementioned, we do not have a system can give a formal model for modelling speech acts which is the specification of the business system. Therefore, we can extend a standard UML modelling language in order to represent some modelling concepts of IWS. Before proceed, in next section, we first need to identify some modelling concepts in IWS that make sense for our purpose.

2.4 Modelling concepts in IWs

We need to define some modelling concepts (meta-concepts) of IWs. The Olympics is a good example of an institutional world formed by the interlocking of many institutional worlds because it is large and complex, well-established, familiar and very well published, primarily in its sporting dimension, but also in its business dimension due to the requirement for accountability to all the stakeholders. There are some useful examples proposed by Colomb (2007) in his hypothetical Olympics**.** However, a reader could add details based on general knowledge or the results of research into the Olympics. The following excerpt is taken from (Colomb 2007) and subsequently identified modelling concepts for IWs are itemised in **Table 1**.

There are sports, including swimming and athletics. Each sport has an international sporting federation. Swimming has FINA, athletics IAAF. At the Olympics, each sport organizes a number of events drawn from the events recognized by the corresponding federation. Events are open to either men or women competitors. Some events in Swimming are 100 metres butterfly, 400 metres freestyle, 1500 metres freestyle, and 400 metres medley relay. Some events in Athletics are 100 metres, 400 metres, 1500 metres and 400 metres relay. In some cases competitors are individual persons, while in others (the relays in this case) competitors are teams of individual persons. Competitors are organized into national teams, each organized by the country's national Olympic committee (NOC). A national team consists of a number of competitors and a number of officials. A particular Olympic games is organized by a Local Organizing Committee (LOC), under the auspices of the International Olympic Committee (IOC). An event is organized into a number of sub-events (heats, semi-finals) intended to reduce the number of competitors in the final sub-event. For the two sports considered, we can call these sub-events races. Each race includes a number of competitors complete in a time and achieves a finishing position. In the final race, the first three finishing position competitors are awarded medals: gold, silver, and bronze. There are Olympic records for times of races in each event, and also world records. Olympic records are recorded by the IOC and world records by the respective sporting federations. It is usual to aggregate results in events by national team, so that during the Olympics a record is kept of the number of medals won by competitors of each national team, with subtotals for gold, silver and bronze. Each NOC maintains its own totals on advice from the LOC of results in events.

MODELLING CONCEPTS	DESCRIPTIONS
PLAYER	In domain IWs, it is used in a very *general sense.* It can be an individual (e.g., swimming official) who can play one or more different *roles* and interoperate at business or organization level (B-Level). More general, it can be an institution (e.g., IBF, IOC) whose systems are to interoperate. At information system level (IS-level), it can be an individual (e.g., system analyst, database designer) who is responsible for their defining application to commit to the ontology. In principle, it must be a *human*. **EXAMPLES:** a swimmer, a swimming official, LOC, IOC, FINA, system analyst, database designer, etc
ROLE	It is a kind of *obligation* taken by a certain player in the interoperation. **EXAMPLES:** competes in races by competitor, selects local organizing committee by IOC, etc
USER	User is a kind of *agent* who performs a kind of *operations*. **EXAMPLES:** a user extracts relevant ontology elements about competitor.
ROLE-OWNER	Role-owner is the *player* responsible for the definition of the speech act and its framing rules. **EXAMPLES:** FINA updates relevant ontology elements about swimming rules and concepts.
SPEECH ACT	It is a concrete *action* for doing things made by players in a certain *context* and is recorded as institutional fact. **EXAMPLES:** IOC decides city for an Olympics, establishes rules and procedures for specific events, keeps world records.
PERFORMATIVE	A kind of speech acts performed by players to create the respective institutional fact. This

ACT	institutional fact seen by other players as *fixed* reality. **EXAMPLES:** a competitor winning a gold medal in an event, assignment of a heat/lane to a competitor.
INFORMATIVE ACT	A kind of speech acts performed by players to create the respective institutional fact in order to *notify* or make a *query* about changes in element of institutional worlds. **EXAMPLES:** publication of the fact, telling the competitor to which heat/lane they have been assigned, assignment of a heat/lane to a competitor.
ACTIVITY	It is an integrated (unity) of speech acts constitute a non-atomic execution of speech act or so called *activity* or *transaction*. It is ultimately result in some action. **EXAMPLES:** register competitor, conduct competition, publish results, heat/lane assignment
INSTITUTIONAL FACT	It is a recorded of speech act. It is created in a respective speech act. It can be single (one element) and complex (part and whole elements). **EXAMPLES:** a heat/final has been conducted, a competitor competed in a heat/final, a competitor won a gold medal in an event, competitor's name.
CONTEXT	It is any information that can be used to *characterize* a particular speech act to be made. The relevant context will include *who* the players are, *when* and *where* the act is performed, *background* behaviours and *practices* underpinning the operation of the systems involved and possibly other factors. **EXAMPLES:** person was a competitor, heat/final was a final, person was not declared by an official to have behaved inappropriately, IOC constrains all events in the Olympics to award gold, silver and bronze medals, a constraint on the rules of the events created by the sporting federations.

Table 1. Modelling concepts in interlocking institutional worlds

3 DYNAMIC ESSENTIAL MODELING OF ORGANIZATIONS (DEMO)

3.1 In brief of DEMO

Dietz (2006b) has developed the Dynamic Essential Modeling of Organizations (DEMO) which is an experimental method with associated terminology for the description of business process and the development of information systems. The method is based on the *conversations-for-action theory* which is originally grounded by the *theory of speech acts* (Austin 1962). DEMO provides at least four types of model; *interaction model, business process model, action model* and *fact model*. However, for our purpose, we are only interested to discuss some important DEMO concepts that very close to the modeling concepts of IWS. We can therefore have a strong foundation in developing profiles for the IWS.

DEMO describes each organization as a social system consisting of a network of *actors* with specific *tasks* and *responsibility*. An actor is an individual or collective subject that performs essential actions. An essential action causes changes in the object of business, either now (by making a new observation or intervention) or in the future (by taking a decision). Actors coordinate their activities by seeking *commitments*. To reach a commitment they have to engage in conversation, which is a *commucative action* instead of an essential action. By a conversation, actors commit themselves to an essential action. The combination of *order conversation* (O-phase for short), *essential action* (E-phase for short), and *result conversation* (R-phase for short) is called a *transaction*. A transaction is the elementary business process in the organization, in which two actors reach one commitment. In the O-phase, the initiator and the executor negotiate for achieving consensus about the *production act* (P-act for short) that the executor is going to bring about. The main *coordination act* (C-act for short) in the O-phase are the REQUEST and the PROMISE. The result of successfully performing a C-act is a *coordination fact* (C-fact for short). In the execution phase, the P-act is brought about by the executor (the result of successfully performing a P-act is a *production fact* (P-fact for short). In the R-phase, the initiator and the executor negotiate for achieving concensus about the P-fact that is actually produced (which may differ from the requested one). The main C-acts in the R-phase are the STATE and the corresponding ACCEPT. There are also some other C-acts (in case of failure) such as DECLINE, QUIT, REJECT and STOP. All transactions of a business system together can be presented in an interaction diagram (refer to Dietz 2006a; Dietz 2006b). In next section, we will make sense the modeling concepts of IWS in the context of DEMO.

3.2 Making sense IWs with DEMO

Table 2 depicts a mapping between modelling concepts for IWs in the context of DEMO. Noted that, our aim is *"to find which DEMO concepts could be used to represent IWs concepts*". DEMO provides many concepts however not all that we need. Also, not all IWs concepts can be mapped to DEMO. However, some *key* concepts such as *performative* and *informative acts* (DEMO C-act and P-act), *institutional facts* (DEMO P-fact and C-fact) show us that in this sense, DEMO fits well to the domain of IWs.

MODELLING CONCEPTS IN IWS	MODELLING CONCEPTS IN DEMO	DESCRIPTIONS
PLAYER	In DEMO, *actor-role* is a job function, role or task.	The concept of player similar to the notion of actor-roles in DEMO. The same as DEMO, players in IWs can play multiple roles.
ROLE	No direct concepts. In DEMO, an actor-role basically represents role or job function.	Role is a responsibility, a job function or a task.
USER	It is an intelligent agent (human). No direct concepts in DEMO. However, the DEMO's actor-role represents a job function which basically performed by a particular agent.	One particular user or agent can perform one or more actor-roles or players.
ROLE-OWNER	N/A	The user who is the player as the owner. In domain IWs, the notion of owner is important since only a player who is the owner can specify the definition of speech acts and its framing rules. DEMO does not provide this requirement.
SPEECH ACT	C-act and P-act	In general, the notion of speech act in IWs fits well to the notion of C-act and P-act in DEMO.
PERFORMATIVE ACT	C-act and P-act	In particular, both C-act and P-act in DEMO are performative. The P-act is bigger, and is the result of the *transaction*. The C-acts are also performative, made necessary by the fact that there is more than one player in the transaction. The C-acts collected into a transaction result in the performance of a P-act. They are all parts of the P-act.
INFORMATIVE ACT	I-act	In particular, the informative speech acts are called *infological acts (I-act for short)* in DEMO.
ACTIVITY	Transaction	In domain IWs, a collection of speech acts (held together by performative and informative speech acts) may constitute an elementary business process. This is similar to the notion of *transaction* in DEMO.
INSTITUTIONAL FACT	C-fact and P-fact and I-fact.	By making a C-act and a P-act can create a consequent institutional fact which corresponds to the notion of *C-fact* and *P-fact* respectively in DEMO. While, a I-act can create a *I-fact*.
CONTEXT	N/A	In domain IWs, some other information needed to describe the creation of speech acts. DEMO does not support this.

Table 2. Modelling concepts of IWs and corresponding DEMO modelling concepts

Since DEMO provides a well-developed systematic method of modelling speech acts in information systems, we decide to adopt DEMO concepts for modeling IWs. However, we retain the concept of *activity* instead of using DEMO concept of *transaction* because the term activity most *common* in a standard modelling language such as UML. For some other concepts which DEMO does not provide, such as the notion of *context* and *role-owner* we will retain the IW concept.

4 UNIFIED MODELING LANGUAGE (UML)

4.1 In brief of UML

The UML has been originally designed to support software design and implementation. It is now an *industry standard* for modelling information system therefore has a large number of tools, code generators, communities and books. Due to its *extensibility* and *expressiveness* through its UML extension mechanism, the UML has been adopted in various modeling fields such as in the areas of conceptual modelling, ontology representation (e.g., Guizzardi 2005; OMG 2007), web application design (e.g., Conallen 2000), knowledge-based system (e.g., Syazwan 2005), design a real-time system, database design, technology implementation (e.g., OMG 2002), business process modelling (e.g., Eriksson & Penker 2000) and so forth. It is fact that some of them have been adopted as OMG standard such as UML CORBA (OMG 2002) and UML ODM (OMG 2007). The specification of the UML or what OMG refers to as the UML's superstructure (OMG, 2004) is divided into two parts: *semantics* and *notation*. The first part introduces the concepts of UML with the help of metamodels and natural language. It is organized in packages. See **Figure 1** for an overview of the relevant packages. For example, the UML activity diagram relates to the ACTIONS GRAPHS and ACTIONS packages. The second part (notation) provides a number of *diagrams* that define how the elements of the semantics packages can be represented *graphically*. For the purposes of this paper we are only interested in relevant diagrams (and the primary packages they refer to) are: Activity Diagram (ACTIVITY GRAPHS AND ACTIONS) and PROFILE (FOUNDATION). For a detailed description of these diagrams refer to OMG (2004).

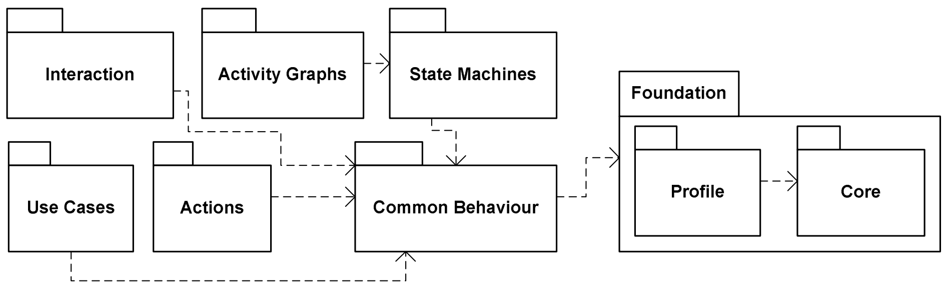

Figure 1. Architecture of UML (simplified)

4.2 UML extension mechanism

The OMG (2004) has defined two extension mechanisms for UML: *profiles* and *meta-model* extensions. The FOUNDATION package or what OMG refers to as UML's infrastructure owns the CORE and PROFILES packages (see **Figure 1**). Focused to PROFILE package, it contains a predefined set of *Stereotypes, TaggedValues, Constraints,* and *notation icons* that collectively specialize and tailor the UML for a specific domain or process. Profiles extension are sometimes referred to as the *"lightweight"* extension mechanism of UML (OMG 1999). The main construct in the profile is the stereotype that is purely an extension mechanism. In the model, it is marked as <<*stereotype*>> and has the same structure (attributes, associations, operations) defined by the meta-model that describes it. However, the usage of stereotypes is restricted, as changes to the semantics, UML structure and the introduction of new elements to the meta-model are not permitted (Perez-Martinez 2003). The stereotype is a *specialization* of UML metaclass and in principle, the UML does not allow us to stereotype a stereotype. A stereotype can have its own notation, e.g., *a special icon*. The *"heavyweight"* mechanism for extending UML is known as the meta-model extension which is defined through the Meta-Object Facility (MOF) specification (OMG 2003) and which involves the process of defining a new meta-model. Using this extension, new metaclasses and meta-constructors can be added to the UML meta-model. This extension is a more flexible approach as new concepts may be represented at the meta-model level. The difference between the profile and meta-model extensions comes from the restrictions on profiles in extending the UML meta-model. These restrictions impose that profile based extensions must comply with the standard semantics of the UML meta-model. However, this restriction is not applicable to the MOF based extensions, which can define a new meta-model. The meta-model approach however, is also called a profile. Empirically, the usage of UML mechanism such as stereotype is proven to improve UML comprehension primarily when UML is used in modeling of a specific application domain (Staron & Kuzniarz & Wohlin 2006).

4.3 UML-based DEMO profiles for IWs

We are concerned to extend the UML activity diagram for modeling IWs. Activity diagram emphasizes the sequence of parameterized behaviour that is expressed as a flow of execution through the sequencing of subordinate units (whose primitive elements are individual actions) (OMG 2004). An action represents a single step within an activity, thus being the fundamental unit of behaviour specification. To represent all IWs concepts, it is necessary to extend the activity diagram with new stereotypes related to multi-agent system in IWs. **Figure 2** illustrates a part of UML 2 metamodel related to meta-concepts of IWs (Note: for the sake of clarity, not all concepts are included in the figure)

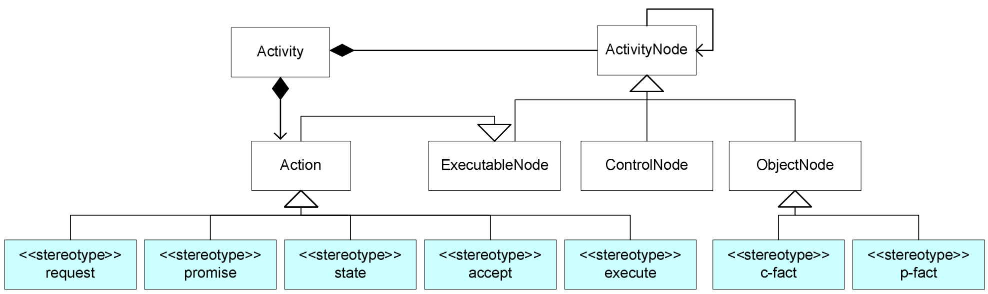

Figure 2. Extending the UML 2 meta-model with stereotypes for IWs (simplified)

While, as a result, the following **Table 3** we define several stereotypes which some of them are adopted from DEMO as modelling concepts for IWs and profiling them as UML profile.

MODELLING CONCEPTS OF IWS	UML STEREOTYPES	UML BASE CLASS	DESCRIPTION
ACTOR-ROLE	No stereotypes	N/A	Using *swimlanes or partition* to model actor-role. An alternate is to place the actor-role name in *parenthesis* above the activity or action name.
ROLE	No stereotypes	N/A	A series of performative and informative acts represent roles involved.

USER	No stereotypes	N/A	Implicitly represented by the actor-role
ROLE-OWNER	*<<roleOwner>>*	Partition	An actor-role can be labeled with the stereotype *<<roleOwner>>*
SPEECH ACT	*<<speech act>>*	UML action node	It is a stereotype of UML action node with the general properties of a speech act. Thus, the specific speech acts are specializations of this *<<speech act>>* in the profile definition.
C- ACT AND P-ACT	*<<request>>, <<promise>>, <<state>>, <<accept>>, <<decline>>, <<quit>>, <<reject>>, <<stop>>, <<P-act>>, etc.*	UML action node	All represent performative speech acts. C-acts stereotyped *<<promise>>*, *<<state>>*, etc made necessary by the fact that there are more than one *actor-role* in the *activity*. The P-act stereotyped as *<<P-act>>* is bigger, and is the result of the *activity.*
I-ACT	*<<query>> or <<notify>>*	UML action node	It represents informative speech act and stereotyped either a *<<query>>* or a *<<notify>>*
ACTIVITY	No stereotypes	N/A	All speech acts collected that serve the same *purpose* are collected in an *activity*. We use a standard UML (activity node) to represent activity.
INSTITUTIONAL FACT	*<<institutional fact>>*	UML object node	It is a stereotype of UML object node with the general the general properties of a institutional fact. Thus, the specific institutional facts are specializations of this *<<institutional fact>>* in the profile definition.
C-FACT AND P-FACT	*<<c-Fact>> and <<p-Fact>>*	UML object node	Both represent an institutional fact which is a record of speech acts made by a certain *actor-role*.
CONTEXT	*<<context>>*	UML constraint	It represents some information that characterizes the speech acts.

Table 3. UML-based DEMO profiles for IWs

5 A SIMPLE CASE STUDY OF MODELING IWS

Again, the case study is based on the Olympics. Due to limited space, not all stereotypes given in **Table 3** are included. We present a small part of application in *managing a swimming event by FINA rules* as depicted in **Figure 3.** Four activities are shown; *GetAthleteSequence, RunHeats, RunSemiFinals and RunFinals*. For example, see an activity *GetAthleteSequence*; this activity has at least two collected speech acts stereotyped as <<*promise*>> and <<*state*>> that serve the same purpose as to get *an athlete sequence*. In DEMO sense, *RaceOrganizer* may promise to register athletes and as a result creates *a list of registered athletes* stereotyped as <<*c-Fact*>> which is an institutional fact. Next, with that list of registered athletes, a *RaceOrganizer* states that a sequence of athletes has been created for a particular swimming event. Once this is accepted by a *RaceOfficial,* that *sequence of athlete* stereotyped as <<*p-Fact*>> is a result of activity (or called as transaction in DEMO) which is an institutional fact or what DEMO calls a production fact. We can assume the p-fact (a sequence of athlete) to be used in other activities such as a *RunHeats.* Notice that, we can include some information which characterizes the creation of speech act such as the context for RegisterAthlete as illustrated using UML constraint labelled with a stereotype <<*context*>>.

Deleted: *P*

Deleted: *fact*

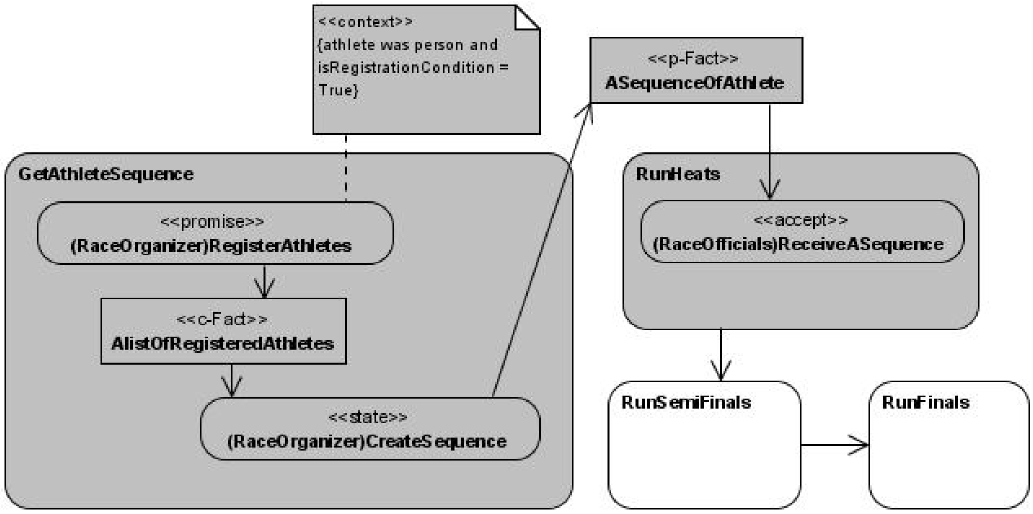

Figure 3. An example of modelling IWs using UML-based DEMO profiles (simplified)

6 CONCLUSION

Modelling IWs closely relates to business process modelling, and the methods for business process modelling are relatively immature. Stemming from our position on IWs detailed in (Colomb & Ahmad 2007), this paper addresses the need for modelling IWs by developing an *extension* of the UML activity diagram. DEMO is close to the notion of IWs because both are grounded with the theory of *speech acts*. So the major concepts of DEMO fit well to the concepts of IWs. The DEMO is a prominent LAP-based methodology for information systems development. It is a well-developed systematic method of modelling speech acts in information systems (Dietz 2006b). We adopt a *synthesis approach* to extend UML with the DEMO profiles (e.g., modelling speech acts). In fact, DEMO has a good position to differ from typical business process modelling methods as extensively argued in (Dietz 2006b). In addition, DEMO is proven to work well in *action-view* oriented to information systems development (Rittgen 2006). Unlike UML, DEMO does not provide extensibility mechanism. In this light, instead of using native DEMO, we suggest to have a sort of UML-based DEMO profiles for IWs. So, some *metaconcepts* of IWs are adapted from DEMO and represented as UML-based profiles. The UML is *extensible* and *expressive* and there are many UML-based resources and tools to assist an ontology engineer in modelling IWs.

The work described in this paper is closely related to that of (Agerfalk & Eriksson 2004; Rittgen 2006). However, they differ from us in terms of *goal* and *purpose*. For example, Agerfalk & Eriksson (2004) focus primarily on static target models (class diagrams or entity-relationship diagrams) with the ultimate aim of database design whereas our approach targets only dynamic UML models (e.g., UML activity diagram) with ultimate goal to model IWs. In term of DEMO models, Rittgen (2006) focus mainly on mapping both static and dynamic DEMO models to UML static and dynamic models respectively. Our approach is more *specific* and *aims* only to synthesize UML with DEMO purposely for modelling IWs. In other words, our work can be seen as one example of adapting DEMO profiles for IWs and profiling DEMO into the mainstream of UML. For future work, we will use the proposed UML profiles here to model IWs linked to the development of *conceptual models* of ontology server supporting the IWs.

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