

# DIALOGUE ACT MODELLING FOR ANALYSIS AND SPECIFICATION OF WEB-BASED INFORMATION SYSTEMS

Ying Liang

School of Computing, University of Paisley, Paisley PA1 2BE, U.K.

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Abstract: Web-based information systems aim to enable people to live and do things in society with help of computer systems on internet. User interfaces and navigation structures of these systems become more important and critical than the ones of traditional information systems to the user because of the nature and specific characteristics of these systems. The experiences on requirements analysis and specification of these systems have shown the need of gathering and specifying communicational requirements for these systems in the analysis model as a basis for designing user interfaces and navigation structures. This paper addressed this issue and proposes a dialogue act modelling approach that has focus on communicational requirements with pragmatic and descriptive views in terms of the Speech Theory in social science and the object modelling techniques in Software Engineering.

## 1 INTRODUCTION

Web-based information systems (WBIS) are a new type of IS based on technology and standards of the World Wide Web Consortium (W3C) and there are many differences between them and traditional IS (Deshpande et al., 2002). For example, WBIS must address ethical, social and legal issues but this was unnecessary to traditional IS. Deshpande et al. also noticed that traditional IS dealt with largely data transactions in predominantly numerical form with a bit of textual information, but WBIS contain text and multimedia in addition. Experiences of developing WBIS have convinced that they have their own characteristics in comparison with traditional IS such as:

- *They include web pages.* Developing web pages with consultation with customers is vital to web site success and, ideally, customers are consulted repeatedly in order to understand their needs over time (Lawrance et al., 1998).
- *They have an unlimited number of varied users.* Traditional IS are used by a fixed number of users working in organization and well trained for use of systems. But WBIS are used by an unlimited number of users (e.g., online customers) anywhere in the world (Conallen, 2003). They cannot be well trained in advance. Thus it is critical to provide user-friendly systems to such users.

- *Their development process is volatile.* This makes requirements specification difficult (Baskerville and Pries-Heye, 2001).

These specific characteristics increase difficulty of developing WBIS in general. It has been found that traditional information system development methods and techniques are not really proper or adequate to WBIS development because of dynamic and evolving nature of WBIS (Lang, 2002; Zelnick, 1998). Experts in this field thus intend to set up a new discipline *Web Engineering* for research and to establish sound scientific, engineering and management principles and systematic approaches to successful development and maintenance of high quality WBIS (Murugesan et al., 2001). Engineering a web application is to diverse problems to application domain analysis, navigational structures, and user interface design (Conallen, 2003). Application domain analysis is done at the analysis stage with focus of problems and navigation structures and user interfaces are constructed at the design stage with focus of solutions in software process. Modelling approaches for traditional IS such as use case modelling, object modelling, and behaviour modelling in UML (Booch et al., 1999) have been used in application domain analysis for web applications (Conallen, 2003). Requirements of traditional IS often include *functional requirements* that tell what the system should do and *non-functional requirements* that specify constraints (e.g.,

performance and security) on functions of the system. They are elicited and specified in requirements analysis and specification of the software process (Sommerville, 2004). However observation on WBIS showed that online users were often concerned with what are displayed on the computer screen for them to communicate with the system and how they can do this correctly and efficiently. These concerns can become new requirements on communications between users and WBIS, apart of other types of requirements. We call them *communicational requirements* in this paper. It is important to elicit them as they have impact on use of WBIS and can affect its navigation structures and user interfaces significantly. Also elicitation of them can help understand and clarify system obligations and user responsibilities/commitments within the business context. But current modelling approaches (e.g., Conallen, 2003) do not support analysis and specification of communicational requirements as they focus on functional and non-functional requirements only. Change of WBIS may be inevitable later using these approaches as users' concerns with communications are not considered in analysis but at the late stages of WBIS development. This paper addresses this issue and proposes a dialogue act modelling approach that has focus on communicational requirements in WBIS analysis. The next section will describe communicational requirements. The third section will explain pragmatic view and descriptive view used in IS analysis. The fourth section will show the approach and the fifth section will describe the dialogue act model. The final section will conclude the work.

## 2 COMMUNICATIONAL REQUIREMENTS

We observe the following concerns of WBIS users as communicational requirements of WBIS:

- *Business contexts* required to display on the computer screen. They are business activities such as "Car search" or business indexes such as "Cars". The business contexts may include same things if users are concerned with the things in different ranges, e.g., a car company wants business context "Car for sale"; while its customers want business context "Cars" including car for sale. "Car for sale" is concerned in different ranges in WBIS.
- *Dialogues* required to display on the screen while users and WBIS communicate interactively. They are the preference of users in collaborations with system within a business context. For example, in the business context "Cars", car buyers want "car list" to be displayed on screen for searching or

finding a car. User responsibilities/ commitments and system obligations are elicited and specified along the dialogues (see Figure 3).

We found that the Speech Act Theory (Austin, 1962) in the social science can help elicit communicational requirements as communications mean speech to act. According to it, a dialogue between a user and a system means one or more acts in an e-business society. Therefore communications are useful to find roles of users and their responsibilities/commitments and roles of the system and its obligations. System obligations mean system functions, and user responsibilities/commitments are preconditions of the functions. Navigation structures and user interfaces must be designed and validated based on communicational requirements. We hope that focus on these requirements can help reduce changes in system maintenance because of failure of elicitation of communicational requirements.

## 3 DESCRIPTIVE VIEW AND PRAGMATIC VIEW

There are two modelling views in requirements analysis and specification of traditional IS:

- *Descriptive view* used for observing the semantic aspects of IS as image of reality. Examples using this view are data modelling (Chen, 1976), process modelling (DeMacro, 1978), and object modelling (Booch, 1991; Coad, 1991; Rumbaugh, 1991; Jacobson, 1992). In general this view has much focus on business processes but little focus on other business properties such as customers and their responsibilities/commitments (pragmatic concepts) in the business context. Thus the analysis model built with this view does not emphasize users' responsibilities/commitments in the business context.
- *Pragmatic view* used for observing the pragmatic aspects of IS as part of reality within the business context. Action workflow approach (Denning and Medina-Mora, 1995) is an example using this view. This view has much focus on pragmatic concepts (Agerfalk, 2002; Erickson and Kellogg, 2000; Eriksen, 2002; Holm and Ljungberg, 1996). Thus the analysis model built with this view covers users' responsibilities and commitments in the business context. But it cover little semantics of the system.

We regard both of these two views equally important in requirements analysis and specification of WBIS as WBIS need focus of both of semantic and pragmatic aspects in order to create a complete analysis model covering all concerns of WBIS users and WBIS developers. We thus created a new

modelling approach, for this need, that integrates the two views using dialogue act modelling and object modelling techniques in WBIS analysis.

#### 4 DIALOGUE ACT MODELLING AND SPEECH ACT THEORY

The speech theory was initially defined by Austin in 1962 (Austin, 1962) for describing the phenomenon in a social society that people use speech to act such as demanding or promising something. Then in 1969 Searle specifically defined a speech act with four different sub-acts: *utterance acts* with uttering words, *prepositional acts* with referring and predicating, *illocutionary acts* with stating, questioning, commanding, promising, and *perlocutionary acts* with causing an effect on hearers (Searle, 1969). This theory explains how people in a society use a language for talk about events in the external world as observers, and also for communication act within the world as actors in the society (Agerfalk and Erisson, 2004). In computer society, IS were even defined as language systems in general used to perform communication acts (Goldkuhl and Lyytinen, 1982). IS Modelling approaches based on this theory also include COMMODIOUS (Holm and Ljungberg, 1996), conversion-for-action schema (Winograd and Flores, 1987), DEMO (Dietz, 2001), and action-oriented conceptual modelling (Agerfalk and Erisson, 2004). The applications of these approaches in IS analysis have shown the significance of understanding of the pragmatic aspects of IS using this theory. This encouraged us to use it in WBIS analysis as WBIS also use a language for communication and other things such as demands and promises (i.e., dialogue to act). The current approaches observe communications between users and IS as data flows and acts as data transformations through different medias such as a computer screen. However WBIS not only deal with data transformations but also provide textual information and customer services. We thus observe

communications between users and WBIS as wider than data flows as they can be *information flows* (e.g., car list), *organization flows* (e.g., sales department), and *service flows* (e.g., buy car). In our approach all these kinds of communications are termed '*dialogue*'. A sequence of dialogues is termed '*dialogue flow*' and a speech act is termed '*dialogue act*'. They cause different acts in WBIS:

- (a) Utterance act is production and communication of physical written message such as "Buy car" displayed on the computer screen or printed on paper.
- (b) Prepositional act is performed by an object such as a Car and its attributes.
- (c) Illocutionary act is performed by a business service (activity) such as sell car.
- (d) Perlocutionary act such as buy car is performed by the hearer. It has the effect on the business context.

The new dialogue act modelling approach was created as described below based on the definitions.

#### 5 DIALOGUE ACT MODELLING, OBJECT MODELLING AND BEHAVIOUR MODELLING

The new approach builds a dialogue act model using dialogue act modelling, an object model and a behaviour model using object modelling:

- *Dialogue act modelling*: It focuses on the pragmatic aspects of WBIS and interactive communications and collaborations between users and the system within business contexts.
- *Object modelling*: It focuses on business entities involved in collaborations and structure of the system.
- *Behaviour modelling*: It focuses on behaviour of business entities and interactions between them.

The modelling process defined by Sommerville (Sommerville, 2004) is then used iteratively along with these modelling in the approach as illustrated in Figure 1.

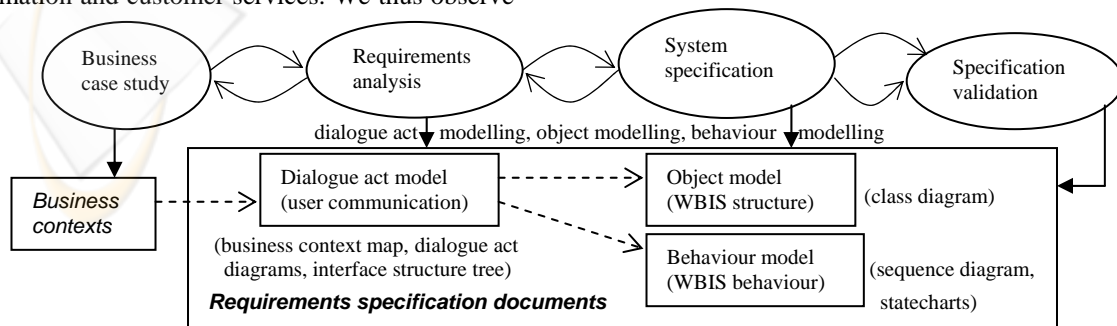


Figure 1: Dialogue act modelling approach for WBIS requirements analysis and specification

### 5.1 Dialogue Act Modelling

The pragmatic aspects of WBIS concern business properties such as customers (e.g., Car Buyer) within the business context (e.g., Cars). Dialogue act modelling describes such properties as speakers and hearers of dialogues, performers of dialogue acts, and seekers of business data in the dialogue act model. Dialogue act modelling aims to generate a dialogue act model for WBIS with following steps:

- i) Elicit business contexts required by stakeholders of business based on business case study.
- ii) For each of the required business contexts,
  - (i) Identify business people/department (e.g., sales person/department) and stakeholders (e.g., car buyer) who will communicate with the system within the business context. They are represented as actors of the business context in the diagrams.
  - (ii) Identify dialogues between the system and actors by asking actors:
    - What things/terms/keywords do they want to see/display on the computer screen?

- What conversations do they wish make with the system?
- What conversations do they expect the system to make with them?

Dialogues are linked by dialogue flows. Actors involved in conversations are shown as the speakers/hearers of the dialogues.

- (iii) Identify dialogue acts by asking actors:
  - What are actions of hearers?
  - What do they promise/demand to do through conversations?
- (iv) Describe states of the business context (i.e., effects of performance of dialogue acts).

Hearers are performers of the dialogue acts. We create a *business context map* (see Figure 2) for WBIS to show business contexts (black rectangle boxes) and connections (solid lines) with actors (figures) requiring them, and a *dialogue act diagram* (see notation and definition in Table 1) for each of business contexts (e.g., Cars in Figure 3 as explained by Table 2). Hierarchy of business contexts with dialogues in WBIS can be illustrated as shown in Figure 4, as a basis for designing user interface and navigation structures in WIS development.

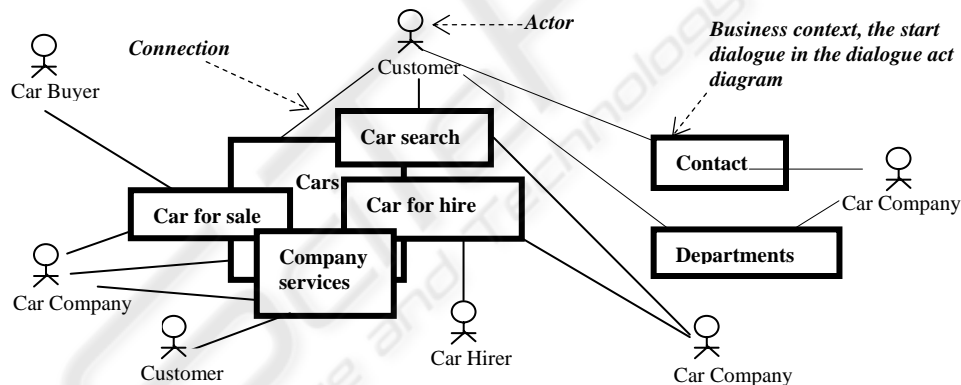


Figure 2: Business context map

Table 1: Notation and definition of dialogue act diagram

Element	Diagrammatic Notation	Definition
Start dialogue		First directed communication from speaker to hearer(s). It must be displayed on computer screen for getting into a business context in WBIS.
Following dialogue		Directed communication from speaker to hearer(s). It can be displayed on the computer screen to mean a demand/promise for information/service.
Actor (speaker/hearer)		Speaker/hearer of a dialogue. A performer of a dialogue act.
Dialogue flow		Connection of communications within the business context.
Dialogue act		Activity performed by hearer(s) as a consequence of a dialogue. It is regarded as a precondition of the next dialogue.

Element	Diagrammatic Notation	Definition
Resource flow		Resource sent through actors within the business context.
State of business context		Effect on the business context.

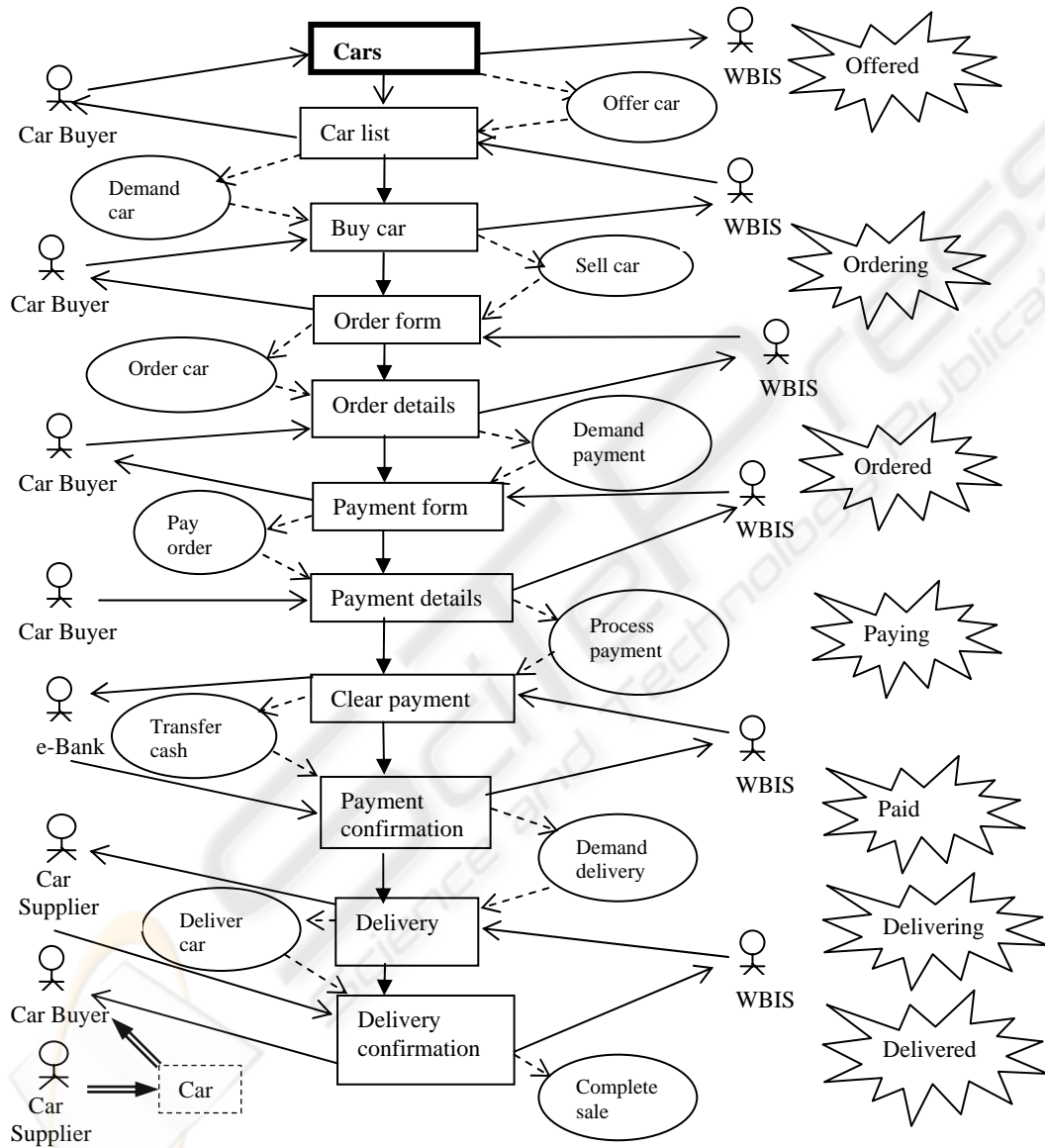


Figure 3: Dialogue act diagram for the business context "Cars"

Table 2: *Cars* business context

{precondition} Dialogue (meaning)	Speaker-Hearer	Dialogue act performed by hearer	Re-source	State of business context
{ } <b>Cars</b> (want to find a car)	Car Buyer-WBIS	Offer car		Offered
{Offer car} Car list(promise to offer cars)	WBIS-Buyer	Demand car		
{Demand car}Buy car(want to own a car)	Car Buyer-WBIS	Sell car		Ordering
{Sell car}Order form (demand order details)	WBIS- Car Buyer	Order car		Ordered
{Order car} Order details (promise to buy car)	Car Buyer-WBIS	Demand payment		
{Demand payment} Payment form (want to get pay)	WBIS- Car Buyer	Pay order		Paying
{Pay order} Payment details (promise to pay)	Car Buyer-WBIS	Process payment		
{Process payment} Clear payment (want to get cash)	WBIS-e-Bank	Transfer money		
{Transfer cash} Payment confirmation (state pay accepted)	e-Bank-WBIS	Demand delivery		Paid
{Demand delivery}Delivery(want to deliver car)	WBIS-Car Supplier	Deliver car		Delivering
{Deliver car} Delivery confirmation (state delivery done)	WBIS	Complete car sale	Car	Delivered

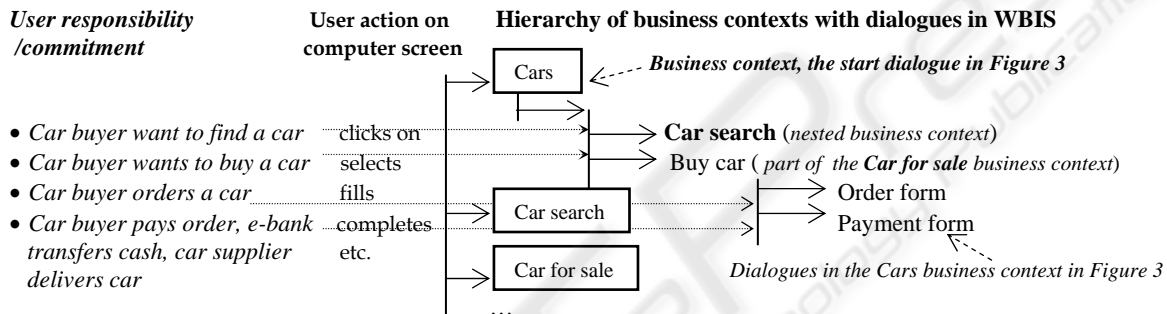


Figure 4: Hierarchy of business contexts and dialogues

## 5.2 Object Modelling

WBIS is currently designed and implemented using object-oriented technology in WBIS development. Once the dialogue act model is created, object modelling technique like UML class diagram (Booch et al., 1999) is used to describe business entities (classes) such as cars and orders involved in the dialogues and dialogue acts. Some objects such as *Customer* may be found from actors such as Car Buyer if they need to play roles within the system. Dialogues in the model are specified as user interface (UI) classes in the diagram (see Figure 5). Dialogue acts and properties of business entities such as car details and order details are specified as operations and attributes of the classes in this model.

the objects in WBIS. They are represented using statecharts (Harel, 1987) as shown in Figure 7.

## 5.3 Behaviour Modelling

Communications between objects of classes in WBIS for a business context are abstracted from the dialogue act model and represented using UML sequence diagrams (Booch et al., 1999) as shown in Figure 6. Dialogue acts and states of business contexts are used to identify states and behaviour of

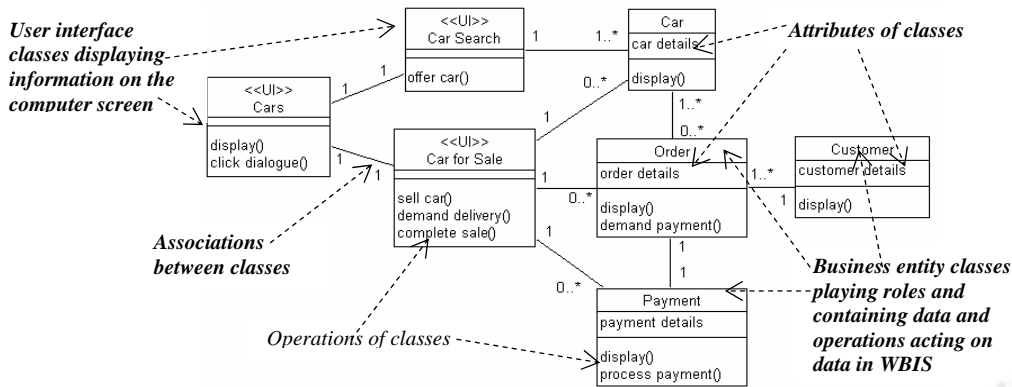


Figure 5: A class diagram for the Cars business context

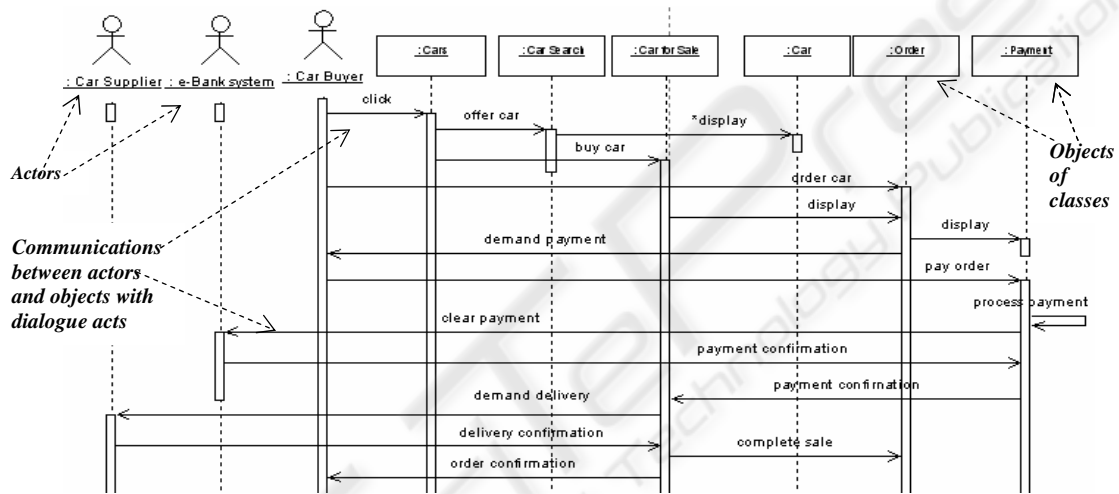


Figure 6: Sequence diagram for the business context Cars

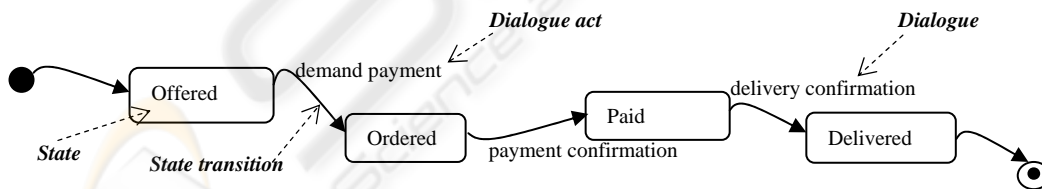


Figure 7: Statechart for objects of the class "Car"

## 6 CONCLUSIONS

By research we have found that WBIS have their own characteristics that make them different from traditional IS. Unlike traditional IS whose users are limited employees working in the organization, WBIS users are an unlimited number of varied users such as online customers on internet. Therefore it is impossible to train users of WBIS face-to-face in the reality. This means that many users have to learn use of these systems on their own with help facilities and

to understand system obligations and their own responsibilities/commitments based on dialogues (communications) displayed on the computer screen. In this situation user interfaces of WBIS becomes much more critical in WBIS development than in traditional IS development as an important place where users learn and find what and how they can communicate and collaborate interactively with the system correctly and efficiently. It is thus probably inevitable for such users to make requirements on this part of the system in WBIS analysis. This requires a specific focus on this type of requirements

Table 3: Dialogue act modelling approach for WBIS requirements analysis and specification

Observation	Pragmatic view	Descriptive view	
Model	Dialogue act model	Object model	Behaviour model
Requirements analysis	Pragmatic aspect of WBIS within the business context	Semantic aspects of WBIS	Semantic aspects of WBIS
System specification	Actors and their responsibilities/commitments within the business context. Interactive communications and collaborations of actors and WBIS. Dialogue to act in the e-business society States of business contexts.	Classes (business entities). Attributes of classes. Relationships between classes.	Operations of classes (business processes). Interactions between objects. Object behaviour.
Support of characteristics of WBIS	Help make a user-friendly WBIS. Help gather user requirements in a view possibly consistent with varied users. Help evolution of WBIS based on communicational requirements.	Help change and maintain WBIS.	

and to model them as communicational requirements during WBIS analysis, apart of functional and non-functional requirements.

There are two modelling views in traditional IS analysis: *descriptive view* and *pragmatic view*. It has been observed that, when using one of the two views only, traditional IS modelling approaches either have too much focus on the semantic aspects (i.e. system semantics) and too little focus on the pragmatic aspects (i.e. business contexts) of the systems, or vice versa. Then analysis models built using these approaches either do not show enough business context concerns or do not include sufficient system semantics. This paper has addressed this issue and presented a dialogue act modelling approach that aims to balance the focus of the two aspects in analysis and specification of WBIS. This approach focuses on pragmatic aspects with the pragmatic view and semantic aspects with the descriptive view in WBIS analysis. Specifically it provides a dialogue act modelling for observing the pragmatic aspects of the system in terms of the speech theory in the social science, and it uses object modelling techniques in Software Engineering for observing the semantic aspects of the system in WBIS analysis, as outlined in Table 3.

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