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An Ontology in OWL for Case based Reasoning to support the Decision Process in SCM

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〈목 차〉

Ⅰ. Introduction

Ubiquitous computing becomes a popular research field with the progress of automatic identification techniques, sensor network and so on(Attiya, H. 1998; Stephen S. 2006). The most important topics in ubiquitous computing are context awareness, situation awareness(Zixue Cheng 2006) and the services based on them. Although a lot of research work has been done in context awareness based services, there is still exists a big challenge to identify the situation in a dynamic system. Using ontology to model situations enables multiple entities to have common understanding of the situation during collaboration. We present our work on logistics situation modeling and the facilitation of decision processes in SCM by using CBR based on our logistics Ontology.

Logistics is the art and science of managing and

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controlling the flows of resources, information and goods like products or services from the source of production to the destination. It is difficult or nearly impossible to accomplish any international trading, global export/import processes, and international repositioning of products without professional logistical support. So we aim to develop a logistics ontology in OWL which based on situation semantics to boost the logistical support research. Knowing the current situation of the products allows the decision support system to better target what should do next. As you know, logistics involves processes such as transportation, inventory, warehousing, maintenance, purchasing, packing, and so on.

Because the traditional database lacks the ability to describe the relationship between each entity(C. Kobryn2001). In this paper we utilize meta-data method and focus on the definition of the logistics situations of products and the corresponding events on these situations that are essential as a semantic base for the creation of logistics ontology which will be used as a reference for creating a semantic CBR library. So when the defined situations really happen, the defined events would be triggered to achieve certain results according to the case based reasoning technique. These events and situations are based on logistics processes that model the transit of products, most of these definitions come from "supply chain and logistics terms and glossary" which are compiled by supply chain vision. And we introduce a semantic situation model based on semantic to specify the situations of products and define corresponding events on these situations. This research aims to construct a decision support system to facilitate the decision processes in SCM by designing a logistics Ontology for semantic representation of situation in logistics processes. In order to make the logistics process safer and more economical.

A lot of research work has been done in context awareness based services, such as location awareness, identification awareness, and so on. However, the values of context variables maybe slightly change from time to time(Attiya, H. and Welch, J. 1998) (e.g. from context to context). We could not say that a slight movement of a product within the warehouse really affects the current situation. So there is still a hard challenge to identify the logistics situation of products to provide valuable information and corresponding actions adapted to the situations of products in a dynamic system such as CBR logistics system. Even though the notions such as process, event, action, context, situation motioned above have been studied in the past few years, we are not aware of any model that encompasses all these notions in a unified logistics framework. The situation has been studied in different fields of computer science such as computational linguistics, situation theory(Deerwester, S.1990) and robotics situation calculus. Although these researches have similarities to our situation modeling, the scope of application of these approaches is different. Our situation model complements the area of business logistics by a formal description of the products' environment and states. the definition of our situation model is based on definitions that had been established in the fields of AI and context awareness(Stephen S.2002;J.R. Quinlan.1986;Ted Selker 2000).

This paper presents a research work on the application of case based reasoning based on our logistics ontology which built according to the semantic techniques and theories. Case based reasoning is a analogical reasoning technique that solves the problem based on the adaptation of the solutions of similar problems, which already solved and stored in a CBR logistics library.

Case based reasoning is a problem solving technique by reusing past logistics cases to find a solution to new problems. The central tasks involved in our research are to identify the current logistics situation, find a past case similar to the new one, use that case to suggest a solution to the current logistics problem, and update the decision support system by learning from this experience(J. Barwise1999). So our research consists of several steps. First of all, it needs to design a situation model(C. J. Matheus2003) based on semantic to specify the logistics situations of products and define corresponding logistics events on these logistics situations. Second, it needs to construct a logistics Ontology which would be used substitute the traditional database as the CBR library, since the traditional database can not satisfy the project of the logistics decision support system since they lack the capability to express entity semantic and the relationships to other entities. The logistics Ontology contains the definitions of a set of logistics actions, logistics events, logistics processes, logistics situations, and the relationships between these definitions. Third, it needs to design a case based reasoning System which can utilize the developed logistics Ontology, analyze the collected data of the products and find the current logistics situation of them by using the decentralized case based reasoning technique. And according to the current logistics situation of the products the decision support system can make the decision of what should do next, by taking the actions which can bring safer and more economical logistics processes.

This paper is organized as follows. Section 2 gives an introduction to the related works. Section 3 describes the requirements of logistics case modeling. The meta-data situation model is strengthened in Section 4. Section 5 introduces the concepts and properties that constitute the logistics ontology. In section 6 we give the introduction about CBR within OWL. In Section 6 we give the logistics scenario based on events and situations. Finally Section 7 gives the conclusion and our anticipated future work directions.

Ⅱ. Related Works

In this section, we give the introduction on the related works that has been well studied in recent years, and the introduction on the advantages and disadvantages of each one in these works which involve Ontology, Case based reasoning and situation semantics. Researches done in the filed of semantic and ontologies play important roles in our research, in order to interpret real situations during the logistics processes.

2.1. Ontology

The term Ontology has a long history in philosophy, in which it refers to the subject of existence. With recent development of Semantic Web(김하균2004), ontology has been widely used to facilitate knowledge sharing and reusing. For pervasive computing environments, using ontology to model context and situation enables multiple entities to have common understanding of the context and situation during collaboration.

Ontology is at the heart of semantic web technologies and OWL is the standard language for representing the concepts of all objects and the relationship between each two concepts(Bechhoer, S.2004). An ontology is used for the knowledge exchange in a particular domain. The OWL language allows the use of deductive reasoning such as classification, consistency checking, subsumption reasoning, and implicit knowledge inference.

The Core SAW Ontology has been developed by Christopher J. Matheus, Mieczyslaw M. Kokar and Kenneth Baclawski from Northeastern University, USA in 2001. This situation awareness Ontology focus on the attributes of situation objects and the relationships with other objects as they evolve over time, but this Ontology lacks the ability to describe the transition between situation and event. The ABC Ontology has been developed by Carl Lagoze and Jane Hunter in 2001, this situation awareness Ontology focus on the creation, evolution and transition of objects overtime, but it lacks the ability to describe the mede-date of the situation(Frank, A. U.;2003 Carl Lagoze).

2.2. Case Based Reasoning

Case based reasoning (CBR) is a problem solving technique that is fundamentally different from other major artificial intelligence (AI) approaches. Instead of relying on making associations along generalized relationships between problem descriptors and conclusions, CBR benefits from utilizing case specific knowledge of previously experienced problem situations(Kyung shik Shin2001, C.K Riesbeck1989). A new problem is solved by finding the similar past logistics situations and reusing it in the new problem situation. A wide range of application of CBR has been reported, including business classification for decision making such as bond rating, bankruptcy, and supply chain management prediction.

2.3. Situation Semantics

Situation semantics is a theory natural language semantic based on mathematics. This theory is introduced by the mathematician Jon Barwise in 1980, and developed jointly by Barwise and the philosopher John Perry throughout the 1980'(C. J. Matheus2003).

Situation semantic refers to the extension of situation through the embedding of additional semantic meta-data. In this paper, logistics situation is a collective condition at the scene of interaction that is composed of context variables and relations among variables of conditions such as products states, device states and environment states according to above situation semantics theory. In situation semantics, events and situations are reified as objects, once a situation is made into a concrete object, various properties of the ubiquitous computing environment such as time, location, temperature could be associated with this situation. All of these properties are the semantic bases of Ontology based situation modeling and play important roles in situation modeling.

In this paper, logistics situation is a collective condition at the scene of interaction that is composed of context variables and states variables such as product state, device state, and environment state according to above situation semantics theory.

Ⅲ. Requirements of Case Modeling

The main tasks of CBR are to identify the current problem situation, find a past case from the case library which is similar to the new one, then we use the found case to suggest a solution to the current problem, and update the system by learning from this process. In doing tasks, one of the critical issues is to build a useful case library(T.P. Liang1990;S. Slade.1991;노태협, 유명환2005).

A case is a piece of knowledge representing an experience. It comprises of:

- The problem that describes the situation of the world before certain logistics event occurred.
- The derived solution to that problem, such as take some actions.
- The outcome which describes the situation of the world after certain event occurred.

When trying to model the situations about logistics, the situation modeling approach must satisfy the following requirements:

- Machine interpretable: The modeled logistics situation must be easily recognized by pervasive computing systems.
- Semantic-based: The modeled logistics situation must have well-defined semantics so that multiple entities in different environments can understand and inter-operate with each other correctly.
- Reusable: The modeled logistics situation should be reusable to reduce the information needed to be transferred and processed.
- Extensible: In different period of logistics, situation will associate with different contexts

of environment and characteristic features of these contexts. The modeling approach must support extension of such domain specific knowledge.

- Logic inference: The modeled logistics situation should support formal logic based reasoning.

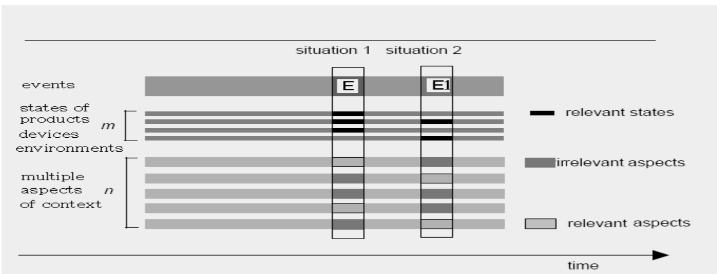
Ⅳ. Logistics Situation Modeling

4.1. Describing Situation

In doing the major tasks of CBR, one of the major issues lies in the retrieval of appropriate logistics situations. An index used to retrieve logistics situations from logistics ontology may fail even if there is a relevant logistics situation in our logistics ontology. For this reason, the integration of general domain knowledge in logistics situation indexing and retrieving processes is highly recommended in building the logistics situation modeling and a successful CBR based decision support system(S. Slade.1991).

A situation is the general states of objects exist for a period of time and the combination of the circumstances. Every situation is generated by exactly one event. This section is concerned with our ontology which based logistics situation model. It is not an easy task to describe the situations of the objects in logistics process, since a situation of the situation object is related with various factors and relations among these factors. Logistics situation is a collective condition that is composed of variables of conditions such as context and relations among variables of conditions such as states. Therefore the representation of logistics situation needs to include description of a set of descriptors as listed above and the relations among them.

Some aspects of context and state take significant roles in forming situation for current event. On the contrary, the other aspects become irrelevant. So we call former relevant aspects of context and later irrelevant aspects of context. Figure 1 shows how relevant aspects of context and state form the logistics situation of certain event. As the result of the event, some of the aspects of context change and evolve over time.



<Figure 1> Model of Situation with contexts and states

4.2. Situation Model

We adopt the situation theory(J. Barwise1991) as a basis for specification of situation, basic elements to compose a logistics situation contain:

- A set of context such as time, location and so forth. All values of context usually observed by sensors.
- A set of states such as products state, device state and environment state. Each of which belongs to a predetermined set of possibilities.

The model of the situation is shown as follow:

◇S: = { <Context>, [States]}

= {<Time; date time>, <Location; sting>, <Temperature; float>, Format; string>, <Quantity; int >, [Product state; Boolean], [Environment state; Boolean], [Device state; Boolean]};

A situation is composed of contexts and states. Both of contexts classes and states classes are composed of a series of elements formed like <name; value>. Location and Format have string type value. Time and temperature have the date time type and float type value respectively. Product state, device state and environment state have the Boolean type value that is true or false.

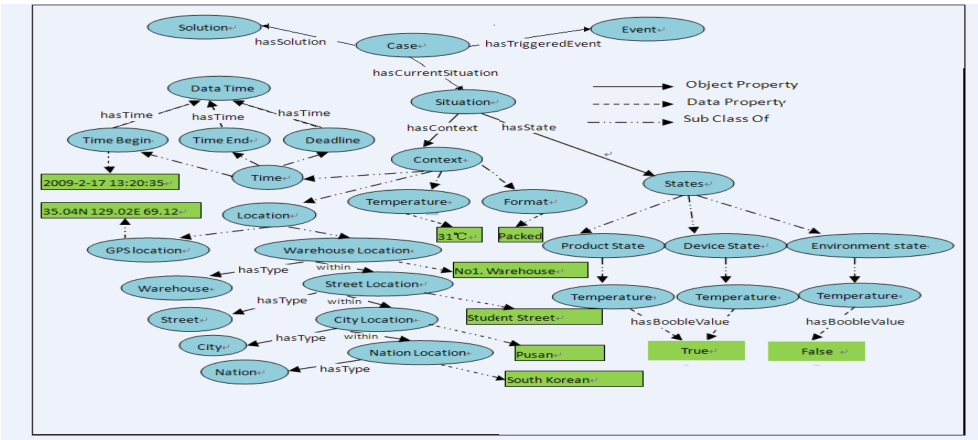
Situation evolves over time, some aspects of condition change fast, others change slowly. So when defining a logistics situation, we give 'true' to the relevant states, and 'false' to the irrelevant states. So some aspects of context and condition take significant roles in forming situation for the current event.

Figure 2 shows a sample ontology describing a past logistics case, and this case contains a situation that "state of vehicle is empty, state of products in number 1 warehouse is packed, location is Kim street Pusan of South Korea, and the temperature in the warehouse is 25 centigrade."

The situation ontology is structured as a tree. At the root of the tree in Figure 2 is the situation class which associates with other two subclasses context class and condition class. The context class is composed of time (2009.02.17 12:20:35), location (Student street Pusan of South Korea), format (e.g. packed) and temperature (e.g. 31 centigrade) in this sample. The condition class consists of products states, devices states and environment states. And each state carries a Boolean type value.

In Figure 2 time consists of Time Begin, Time End and Deadline. Each of them has a Date Time type value such as the time of day, day of week, date of month, etc. Also we can infer the time duration about a situation according to begin time and end time of the situation. And the event notification systems can take appropriate action to avoid back order of the products according the deadline.

To represent location, a symbolic, hierarchical model is used. As you can see in Figure 2, location class divides into GPS location subclass and geographical location subclass which involves address number, street name, city name and state name. Geographical locations are referred to by name, and may be spatially contained in other



<Figure 2> The Situation tree

locations. GPS location is the unique property of an entity, and it consists of longitude, latitude and altitude which have the float number values. In this sample, as Figure 2 shows. 'Number 1 Warehouse' has the GPS location such as (35.04N, 129.02E, 69.12). For geographical perspectives, this warehouse is contained in 'Kim Street' which is a named street in Pusan city, and 'Student Street' is contained in 'Pusan' which is a named city in South Korea. Each location is associated with a class that represents the type of location. For example, the city name 'Pusan' has a type as 'City' which is the subclass of abstract geographical location class.

Condition class involves a set of states class in Figure 2 , each state class is associated with a special type which returns a Boolean value. And all the subclasses of condition class belong to a predetermined set of possibilities. We will represent these classes in our logistics ontology. Subclass of Environment State class which named as 'In Warehouse', subclass of Product state which named as 'Products Packed' and subclass of device state which named as 'Vehicle Available' in this sample have 'true' value. Subclass of environment state which named as 'Temperature >= 28 Centigrade' has 'false' value. According to our opinion, the logistics situations and corresponding relative sates which we use product state (PS), Device state (DS) and Environment State (ES) for short are defined and shown in Table 1 and we labeled the situations.

If we take the ontology based situation model as foundation, we can construct the entire ontology of logistics. And we will concretely discuss how to make it in section 5.

Ⅴ. OWL Logistics Ontology

In this section we describe the elements of logistics ontology which involves a set of classes and properties. And in order to support the requirement of logic inference, the notion such as subclass of, domain, range, type are used in the manner of OWL to represent the construction of logistics ontology. And we will illustrate the ontology in Figure 4 at the end of this section.

5.1. Classes

The following paragraphs that follow discuss the highlights of some of this research. We represent the hierarchical relationships between the logistics ontology classes which are described below.

Entity: subclass of thing

All instances of any class are an instance of this class. The primitive category has no upper class.

Abstract: subclass of Entity

The abstract category encompasses entities that are pure information or concepts. They can not

<Table 1> Logistics Situations

label	Situation	Context/ State
S1	Nothing exist	--
S2	Material exits in workplace ready for manufacture	Material in workplace(ES) Ready for Manufacture(PS) Location: workplace
S3	Specific time products exist in workplace	Products in workplace(ES) Location: workplace
S4	Specific time products exist in warehouse	Products in warehouse(ES) Location: warehouse
S5	Products maintain in warehouse ready for order	Products ready for order(PS) Location: warehouse
S6	Temperature in warehouse <= lowest limit	Temperature<= lowest(ES) Temperature Context
S7	Temperature in warehouse >= highest limit	Temperature>= highest(ES) Temperature Context
S8	Quantity able to fill order, ready for packing	Products ready for picking(PS) Quantity Context
S9	Below order point turn to Situation 2	Below order point(PS) Quantity Context
S10	Vehicle empty, Packed products ready for load	Vehicle available(DS) Products packed(PS)
S11	Vehicle unavailable Packed products under maintenance	Products under maintenance(PS) Vehicle unavailable(DS)
S12	Vehicle full Loaded product ready for transport	Packed Products ready for transport(PS) Vehicle available(DS)
S13	Products under transportation Kind of products transportation	Products under transportation(PS) Products in vehicle(ES) Land transit way(PS)
S14	Products arrive at the customer	Products in destination(ES)
S15	Products arrive at the distribution center	Products in distribution center(PS)
S16	Products not arrive at the destination	--
S17	Products exist in destination ready for use	Products in destination(ES) Products unpacked(PS)
S18	Products under distribution	Products under distribution(PS)
S19	Returned products exist in the source place	Products in source(ES)

exist at a particular place and time without some physical embodiment. This class will divide into two subclasses Time Duration and Condition. Time durations are used to stamp the interval of the situations. The Condition class will be discussed later.

Physical: subclass of Entity

An entity has a location in space-time.

Situation Object: subclass of Physical

Situation objects are entities which participate in logistics situations such as products and device being used in logistics process.

Temporality: subclass of Physical

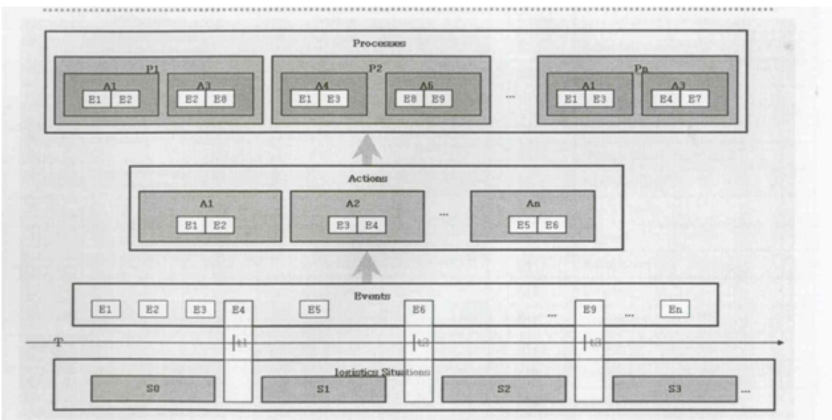
The primitive ontology category explicitly models time and the way in which properties of objects are transformed over time. All classes associate with time are the subclass of it, e.g. Process, Action, Event and Situation.

Logistic_Processes: subclass of Temporality

Process is a particular course of a set of actions intended to achieve a certain result. This definition comes from WordNet. We propose the modeling of logistics processes using a bottom-up strategy, in which logistics Processes are composed of logistics actions, which in turn are composed of logistics events. Logistics processes are defined through the composition of logistics events each of which belongs to a predetermined set of possibilities, and we have discussed it in previous section. In Figure 3, we give the relationship among processes, actions, events and logistics situations.

Logistics_Actions: subclass of Temporality

An action is defined as the collection of events that are carried out by some "doer" according to the definition from OpenCyc Ontology(Ted Selker, Winslow Burleson.2000). When a logistics process takes place in order to achieve the prospective result, it will trigger a series of logistics actions which in turn will trigger a set of events. Following this theory, the Logistics processes and corresponding logistics actions are shown in table 2.



<Figure 3> The relationship among process, action, event and situation

<Table 2> Logistics processes and actions

	Logistics Process	Logistics Action
1	Outsourcing	Purchasing_The_Material
		Convey_The_Material
2	Manufacture	Parts_Making
		Assemble_The_Parts
3	Warehouse	Moving_The_Products
		Pile_The_Products
4	Inventory	Sorting_The_Products
		Record_The_Products
5	Maintenance	Store
		Heating
		Cooling
6	Order	Accept_The_Order
7	Packing	Order_Picking
		Moving_The_Products
		Pack_The_Picked_Products
8	Load	Moving_Packed _Products
		Pile_The_Packed_Products
9	Transportation	Convey_The_Products
		Processing_During_Convey
10	Unload	Moving_The_Products
		Pile_The_Arrived_Products
11	Distribution	Sorting_The_Products
		Convey_The_Products
12	Reverse Logistics	Convey_The_Products
		Return_The_Products

Logistics_Events: subclass of Temporality

An event occurs at a point in time. It has no other role than to cause the end of some situations, and the start of new situations. The event here marks a transition between situations(Carl Lagoze, Jane Hunter.). A situation may generate a set of N alternative events, and only one of them will occur. Using events, steps in the development of logistics process can be specified in an adequate temporal order, so that changes in the satiation of products can be recorded. We just concern about the transition of products in the logistics process. So we just collect the events that can affect the transition of products. We call them logistics events and in Table 3 we given each logistics event a label.

Logistics_Case: subclass of Temporality

A case is a piece of knowledge representing an experience. It comprises of the problem that describes the situation of the world before the logistics event occurred, the derived solution to that problem, such as take some actions, and the outcome which describes the situation of the world after the event occurred.

<Table 3> Logistics Events

Label	Logistics Event
E1	Material_Arrived
E2	Products Exist
E3	Warehoused
E4	Inventoried
E5	Temperature_Regulated
E6	Maintaining
E7	Stock Check
E8	Packed
E9	Back Order
E10	Loaded
E11	Transport
E12	Products_Arrived
E13	Unload
E14	Distributing
E15	Back Out

Problem: subclass of Temporality

A problem is the description of the situation of the world before certain logistics event occurred.

Solution: subclass of Temporality

A derived solution to that problem, such as take some actions.

Logistics_Situation: subclass of Temporality

A situation is the general states of objects exist for a period of time and the combination of circumstances(Scheurer, T.2000). A situation provides the contexts for framing time-dependent properties of entities. Entities may have properties that exist only in the context of a situation and other properties that are constant. Logistics Situation is a collective condition that is composed of relations among variables of conditions such as contexts, product state, device sate and environment state.

Condition: subclass of Abstract

Condition is defined as a series of characteristic features of context such as product state, device state and environment state which are invariant during certain time intervals(Paolo Bouquet, Luciano Srafini.2001).

Context: subclass of Physical

Context ontology category encompasses entities of any instantaneous, detectable, and relevant property of the pervasive computing environment. A context can be defined as a collection of values usually observed by sensors.

Time_Duration: subclass of Abstract

This class gives the measure of length of time, with or without respect to the universal timeline. Due to process, action and situation associate with a period of time.

Time: subclass of Context

Time class divides into three subclasses. Time_Begin and Time_End are used to represent the begin time and the end time of a situation. And the Deadline gives the deadline when a certain situation must be satisfied.

Location: subclass of Context

Location class can be used to specify the location of situation objects.

5.2. Properties

We have introduced all the concepts we are going to use in our logistics ontology. In this section we illustrate the relationship among these concepts through a set of properties which will be used in the construction of Logistics ontology.

Name: **hasContext**

Domain: Situation; Range:Context

This notion establishes a contain relationship between a situation and context.

Name: **hasState**

Domain: Situation; Range:State

This notion establishes a contain relationship between a situation and a set of general states of logistics objects.

Name: **consistOf**

Domain: Process, Action; Range:Action,Event

A Process can have one or more Actions, which in turn can consist of one or more Events. This notion expresses the involvement of Events in the representation of an Action or a Process.

Name: **hasAction**

Domain: Event; Range: Action

This notion binds a Event, a Situation and its solution by take some actions.

Name: **triggerBy**

Domain: Event; Range:Situation

This notion binds a Situation and an Event within the pervasive computing environment. When a certain situation takes place, it may cause one or more certain events which belong to a predetermined set of possibilities.

Name: **satisfies**

Domain: Situation_Object; Range: Logistics_Situation

This property establishes the relationship between the objects that participate in the situation and the corresponding situations.

Name: **inTimePeriod**

Domain: Situation; Range:Time_Duration

This property binds a situation with the time period it lasts. The Time_Duration class can associate with the begin time and the end time of a situation through 'begin' and 'end' properties.

Name: **begin**

Domain: Time_Duration; Range:Context

This property establishes the relationship between a time period and the date time value.

Name: **end**

Domain: Time_Duration;Range:Context

The end property establishes the relationship between a time period and the date time value.

Name: **hasType**

Domain: Location ; Range:Abstract

Use this property we can establish the relationship among the process, action and event classes.

Name: **withIn**

Domain: Location; Range: Location

Location are referred to by name, and may be spatially contained in other locations. For example, 'Pusan' is contained in 'South_Korea'.

Name: **hasCurrentSituation**

Domain: Logistics_Case; Range: Logistics_Situation

Name: **hasTraggeredEvent**

Domain: Logistics_Case; Range: Logistics_Event

Name: **hasSolution**

Domain: Logistics_Case; Range: Logistics_Action

5.3. Construction of Logistics Ontology

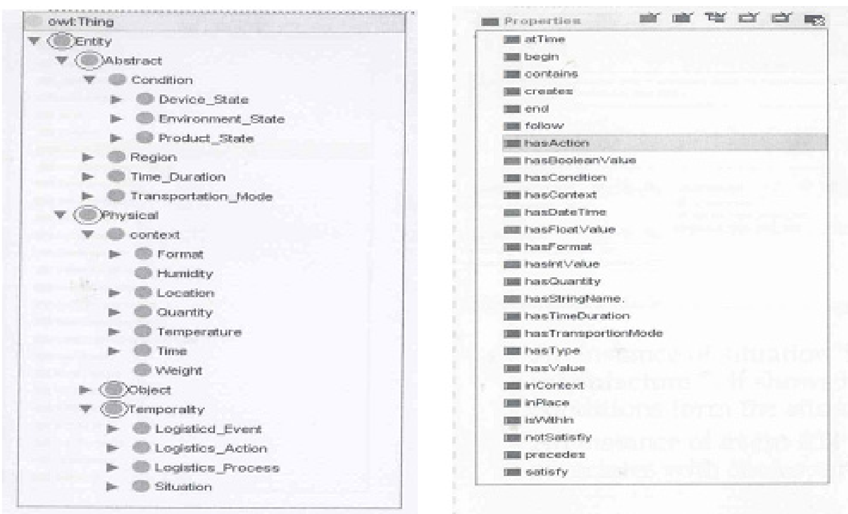
Due to the complexity of ubiquitous computing environments, it is impossible to enumerate all possible contexts and situations in a single ontology. Our logistics ontology models context and situation by defining a set of core classes and relations using OWL DL since. The use of OWL DL combine with CBR technique to support formal logical reasoning over the logistics ontology for consistency checking, subsumption reasoning, and implicit knowledge inference. Our logistics ontology has 175 classes and 29 properties.

Using the defined concepts and relationships among them we can construct out logistics Ontology. Considering the reusing and sharing, we construct Ontology of Logistics according to the construction rules of Suggested Upper Merged Ontology(SUMO)(Ian Niles, Adam Pease.2001) by using the same upper classes with SUMO which you can see in the Figure 4 marked with the circles.

Ⅵ. Case Based Reasoning with OWL

6.1. A Brief Introduction to OWL

OWL is the standard language for the representation of ontologies for the semantic web. In OWL, the domain knowledge is represented within an ontology such as our logistics ontology. An OWL ontology contains definitions of classes, properties and instance from the related domain such as supply chain management. An instance corresponds to an object and a property denotes a binary relation between those objects. A class represents a set of objects such as process, event, action and situation. An OWL ontology is defined by a set of axioms and a set of assertions.



<Figure 4> Classes and properties of logistics Ontology

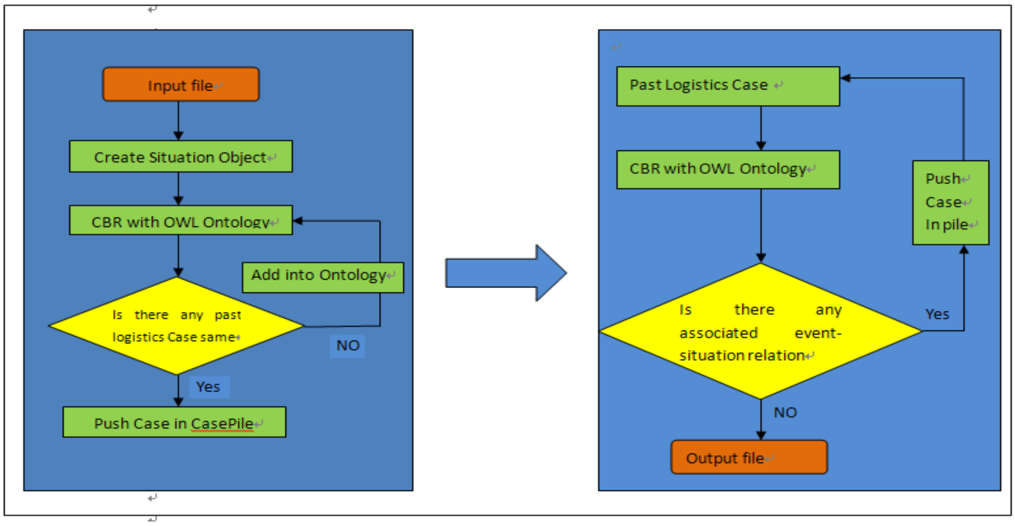
6.2. CBR Within OWL Ontology

This paper introduces our research on the application of case based reasoning within the semantic web technologies and principles. CBR is a type of reasoning in which problem solving is based on the adaption of the solutions of similar problems that already solved and stored in a case library such as our logistics Ontology. And we want to show the classical deductive reasoning made in the semantic web technologies could be completed and enhanced with CBR that may take advantage of domain ontologies and provide an operation for reasoning by analogy. The representation of the knowledge used for adaptation in CBR must be integrated within ontology.

OWL axioms are used to relate situation and solution to classes of the domain knowledge, classification organizes the classes of the logistics ontology in a hierarchy. Regarding CBR, the class hierarchy is used as a structure for the case library, where a class represents an index for a source situation, and every index is considered as an abstraction of a source logistics situation, containing the relevant part of the information leading to a particular solution to this situation. And a case is a problem solving episode represented by a situation and a solution which consist of a set of actions. The classical CBR process consists of two steps, retrieval and adaptation. Retrieval aims at finding a source logistics situation in the CBR case library which is similar to the new situation. The role of adaption task is to adapt the solution of source, in order to build a solution of target, then the solution is tested, repaired and if necessary, memorized for future reuse.

In our logistics Ontology, the event, situation and solutions are represented as instances of the Logistics_Event, Logistics_Situation and Logistics_Action classes. The links a situation triggered event and its solution is materialized by a property called hasAction. The Situation and Action classes correspond respectively to the Problem and Solution classes, so there are two axioms Situation $\in$ Problem and Action $\in$ Solution are added to the Ontology. Then the hasAction property relates current situations to the recommended treatments.

We give algorithm of CBR within OWL Ontology shows in Figure 5. In the left part, the input file contains the context values from sensors. We create logistics situation object according to the input file, then we minning the constructed logistics Ontology to find is there any past situation same with the new one. This part implement the first step of CBR process which called retrieval. In the right part, once we found the similar past situation with current situation, we also need to minning the constructed logistics Ontology to find is there any associated event - situation relation, and the problem solution by minning the hasAction property. This part implement the second step of CBR process which called adaptation.



<Figure 5> Algorithm of CBR within OWL Ontology

Ⅶ. A Scenario of application to SCM

The conceptual model we introduced in previous sections provides a good starting point for developing a simulation of logistics. One of the key powers of simulation is the ability to model the behaviors of a dynamic system as time progresses. And the results can then be used to provide insight into the whole system.

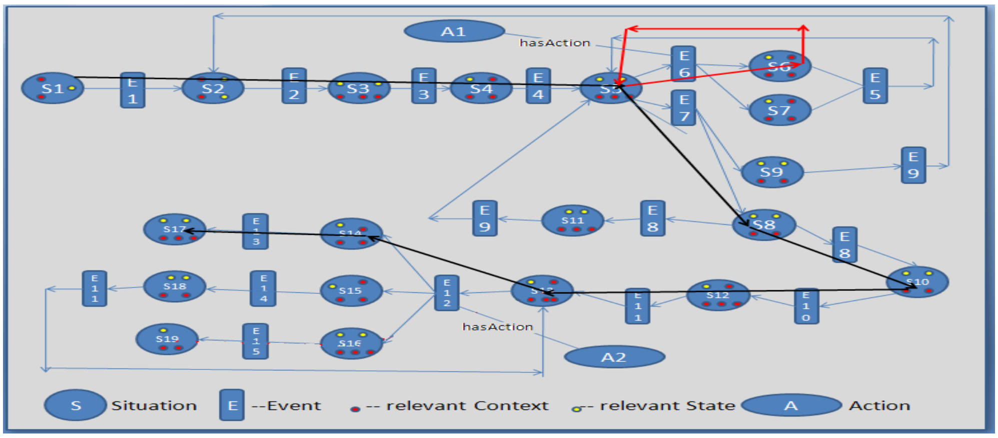
Here we will give the transition scenario of the logistics process according to Petri Net theory (W.M.P. van der Aalst.1995), it has a set of place nodes symbolize situations (circular node in Figure 6) and a set of transition nodes symbolize events (rectangle node in Figure 6) which play the transition role, and directed arcs connecting situations with events. The Logistics scenario consists of all labeled events and situations describing in prior sections (see Table 2 and Table 3). Places contain tokens symbolize the contexts and states from situations, these tokens draw as red and yellow dots. When an event takes place, it consumes some tokens in current situation and product some new tokens which consist of new situation. The graphical representation corresponding to the logistics process model is shown in Figure6.

We suppose that we have an original transit plan as you can see in Figure 6 follows the black line (S1 -> S2 -> S3-> S4 -> S5 -> S8-> S10 ->S12 -> S13 -> S14 ->S17). During the transition process of the products, we get the data of contexts and states from a series of sensors. According to these data we could retrieve the past situation and event similar to the new one, and use it to suggest a solution for current problem by change the original plan to a new transition plan (S1 -> S2 -> S3-> S4 -> S5 -> S6 -> S5’ -> S8-> S10 ->S12 -> S13 -> S14 ->S17). Through this process we can deliver relevant products at the right time to the right place, the event notification systems need to be aware of the products' correct situation by spent little human resource, money, and time.

About the original plan, first of all there is no product exist in logistics process so we have situation S1 'Nothing exist', then event E1 'Material prepared' takes place. E1 has no other role than cause the end of S1, and the start of a new situation S2 'Material exist in workplace ready for manufacture'. E1 causes the situation transition from S1 to S2. S2 triggers Event E2 'Products exist' so 'products are manufactured and exist at the workplace'. Now we must store all of these products in warehouse, event E3 'Warehoused' occurs and situation transits from S3 to S4 'Products exist in the specific warehouse at the specific time'. Then we have to sort and record the products, so E4 'Inventoried' occurs, and it triggers situation S5 'Products under maintenance'.

In Figure 6 S5 generates event E7 'Check stock' occurs, it causes situation S8. The situation transits from S5 to S8 'If the quantity able to fill products ready for packing'. When situation S8 takes place, it triggers event E8 'Packed', E8 also causes two alternative situations. If vehicle available, S10 'Packed products ready for load' occurs. Event E10 'Loaded' causes situation transition from S10 to S12, then situation S12 'loaded products ready for transport' triggers the transportation of loaded products, E11 'transport' occurs and causes the situation transition from S12 to S13 'Product under distribution'. After transportation, event E12 'Arrived' occurs and if products arrive at the customers situation S14 occurs and event E13 'unloaded' will take place, situation transits from S14 to S17 'Products exist in destination ready for use'.

Support there is a new problem occurs, and we need to recognize the current situation. In accordance with our CBR with in OWL Ontology algorithm, we have to get the context values from



<Figure 6> Logistics Scenario

<Figure 7> Logistics Scenario

sensors, and use these context values we create a situation object correspond to the new problem, so we have to find the if there any past situation same with the current situation in our CBR case library, if the temperature in warehouse is too high situation S5 transits to S6 which found from our logistics Ontology, thus we must take some action such as regulate the temperature in the warehouse to keep the products which as the solution of our found case by using CBR technique. So event E5 occurs and a new situation S5' is triggered by it. You can see the input file and output file of our program in Figure 7.

According to the method described in this section, we can implement the facilitation of decision process in SCM by four steps: First, we create the new situation instance by using the context data from the sensors. Second, we find the most similar past situation in our logistics Ontology. Third, we find the event which is triggered by this situation. Fourth, we find the associated actions to the found event, and decide what to do next.

Ⅷ. Conclusion

In this paper, we proposed a logistics situation model which satisfied all the requirements in Section 3 to specify the situations of the products. With the model, one can specify a situation of a product and attach the event that is triggered by this situation. Following this method, we constructed the scenario of logistics process based on events and situation semantics to address the implication of our study, and we have constructed the OWL based Ontology as the CBR case library of logistics process, it contributes to understanding the relationship between modeling CBR and modeling cases. The limitation of our research is how to find the similar past logistics situations exactly, so in future work, we will focus on the case indexing process for logistics situation classification tasks, in order to combine the general domain knowledge with case specific knowledge. And design a logistics decision support system based on the research before.

References

Supply Chain and Logistics Terms and Glossary, Updated October 2006, Definitions compiled by: Supply Chain Vision, Bellevue, Washington, www.scvisions.com.

Frank, A. U., Operation Based Semantics – A process oriented ontology, Tutorial notes for the ISCI Summer School in Bad Zwischenahn, Sept 2003.

Riesbeck, C. K. and Schank, R.C., Inside Case Based Reasoning, Lawrence Erlbaum Associates, Hillsdale, NJ, 1989.

Attiya, H., and Welch, J. Distributed Computing, McGraw Hill, 1998.

Barwise, J., and Perry, J., Situations and Attitudes, CSLI Publications, California, 1999.

Aalst, W. M. P., "Business Process Redesign: A Petri net based Approach," Computing in Industry, Vol..25, No.1, pp.36-45.

Bechhofer, S., Harmelen, F., Hendler, J., Horrocks, I., and McGuinness, D., "OWL Web Ontology Langurge Reference". W3C Recommendation 2004

Bouquet, P. and Srafini, L., "Comparing Formal Theories of Context in AI," Artificial Intelligence, Vol. 155, No.1, 2004, pp.41-67.

Cheng, Z and Huang, T., "A Situation-aware Support Model and its implementation", FCST 2006, pp. 172-177.

Deerwester, S., Dumais, S. T., Furnas, G. W., Landauer, T., and Harshman, R., "Indexing by latent semantic analysis," Journal of the American Society for Information Science, Vol. 41, No. 6, 1990, pp. 391-407.

Kim, H. K., "A Study on Designing the XBC(XML Based Catalog)," The Journal of Information Systems, Vol. 13, No. 1, 2004, pp. 161-177.

Kobryn, C., "UML 2001: A Standardization Odyssey," CACM, Vol. 42, No. 10, 1999, pp. 29-37.

Kim, T. W., Yang, S. M., and Seo, D. H., "Multiagent Enabled Modeling and Implementation of SCM," The Journal of Information Systmes, Vol. 12, No.2, 2003, pp. 57-72.

Lagoze, C. and Hunter, J., "The ABC Ontology and Model," Proceeding of the International Conference on Dublin Core and Metadata Application, 2001, pp. 160-176.

Liang, T. P., Chandler, J. S., Han, I., "Integrating statistical and inductive learning methods for knowledge acquisition," Expert Systems with Applications Vol. 1, 1990, pp. 391-401.

Matheus, C. J., Kokar, M. M, and Baclawski, K., "A Core Ontology for Situation Awareness", Proceedings 6th International Conference on Information Fusion, 2003, pp. 545 – 552.

Niles, I. and Pease, A., "Towards a Standard Upper Ontology", Proceedings of the

International Conference of Formal Ontology in Information System, 2001, pp. 2-9.

Quinlan, J. R., "Induction of decision trees." Machine Learning Vol. 1, 1986, pp. 81-106.

Roh, T. H, Yoo, M. H. and Han, I. G., "Integrating rough set theory and case-based reasoning for the corporate credit evaluation," The Journal of Information Systems, Vol. 14, No. 1, 2005, pp. 41-65.

Scheurer, T, "An Application of Situation Theory" Proceeding of IEEE System, Man, and Cybernetics, 2000, pp. 358-363.

Selker, T. and Burleson, W., "Context-aware design and interaction in computer systems," IBM Systems Journal, Vol. 39, No. 3, 2000, pp. 880-891.

Shin, K. S. and Han. I. G., "A case based approach using inductive indexing for corporate bond rating," Decision Support System, Vol. 32, No. 1, 2001, pp. 41-52.

Slade, S., "Case based reasoning: a research paradigm," AI Magazine, Vol. 12, No. 1, 1991, pp 42-55.

Stephen, S. Y. and Liu, J., "Hierarchical Situation Modeling and Reasoning for Pervasive Computing", Proceeding of the 4th IEEE Workshop on Software Technologies for Future Embedded and Ubiquitous System, Vol. 1, 2006, pp. 5-10..

Stephen, S. Yau, Wang, Y., and Karim, F., "Development of Situation-Aware Application Software for Ubiquitous Computing Environment," Proceeding of the 26th Annual International Computer Software and Applications Conference (COMPSAC'02), IEEE, 2002, pp.233-238.

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<한글 초록>

SCM 결정과정을 지원하기 위한 물류 온토로지 디자인

옥석재 · 염 붕

물류 프로세스내의 상황결정은 전문적인 물류지원 연구의 중요한 목표이다. CBR(Case Based Reasoning)는 기존의 사건이나 경험으로 현재 발생한 문제의 해결책을 발견하기 위한 기술이다. CBR의 주요 역할은 현재 사건에 있는 문제의 상태를 인식하며 이 사건과 유사한 기존 사건 중의 하나를 통하여 현재 사건의 해결책을 추론함으로써 기존 시스템을 업데이트하는 것이다. 이러한 과정에서 가장 중요한 이슈는 유용한 사례베이스를 구축하는 것이다. 온토로지를 이용하여 상황을 모델화하면, 여러 개체들이 협업하에서 상황에 대한 인식을 공유할 수 있게 된다. 본 논문에서는 CBR 사례베이스 구축을 위한 참조로서 물류 온토로지를 디자인하였다.

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