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Insuring Halal Food Interlocking Institutional Worlds Integrity Using an Ontology Server

Abdelrahman Abbas Ibrahim[1], Robert M. Colomb[2] and Abdelgaffar Hamid Ahmed[3]

[1]Software Engineering Dept., Faculty of Computer Science, Sudan University of Science and Technology
[2]School of IT & Electrical Engineering, The University of Queensland, Queensland, Australia
[3]Faculty of Computer Science, Sudan University of Science and Technology

***Abstract*– Ontology servers are used to manage ontologies; is an information system that provides a number of functionalities during design, commit, and run time. Ontologies are widely used to overcome the problem of interoperability and assist in simplify interoperability among participants. Interlocking institutional worlds (IWS) are a collection of organizations interact together in order to achieve some business goals. Ontologies are consisting of two types of entities, the first for describing data of specific domain (classes, subclasses, Attributes etc), and the second for describing actions that will take place within an specific domain and resulting in changing the first one status. To insure that all (Actions) transactions within the IWs are valid and done in legal way, all transactions must be recorded and make it available for all participants, but current ontology case tools do not nearly provide representation of Instances of these transactions. Furthermore, both endurants and perdurants of the ontology need to be managed in order to be stored, retrieved and inferred. This paper is reporting on this problem using Halal Food supply Chain as an instance of IWs.**

***Index Terms*– Perdurant Ontology, Information Systems Interoperability, Interlocking Institutional Worlds and Ontology Server**

I. INTRODUCTION

NEARLY, every organization or business is supported by an information system, in every aspect of our life, in finance, education, government, manufacture farms and mines, the list is endless. Most of these information systems are accessible via the World Wide Web and large rapidly increasing fractions of systems have indeed been made available via the web. A collection of organizations and businesses interact together to achieve some business goals, a service to some beneficiary in return for profit. For example, Amazon.com provides many services such as online shopping for electronics, Apparels and bookstore. To exchange information organizations need to interoperate, they must have a pre-defined terms in order to understand each other.

Insuring Halal food integrity becoming very important issue due to the internationalization of food trading and due to the increasingly number of Muslims around the world, for Muslims before start consuming food, they should check whether the food is Halal (permissible to consume) or not. However, the food now goes thought long processes and stages since producing by some company to storing in different places and circumstances, distributing and selling until it reach customer hand. There are a number of suppliers included in this series of stages, they need to interoperate and exchange information, and they need a consensus vocabulary to use in the interoperation. Ontologies are widely used to provide this vocabulary; but current ontology development tools are only representing static data, entities that exist in timeless (which are called endurants), and ignoring the representation of occurrence entities (perdurants), the proposed ontology for halal food interlocking institutional world represents both perdurants and Endurants. In this study, we will present ontology for Halal Food interlocking institutional worlds contain both endurant and perdurant entities. We will make use of web ontology language, which endorsed by the World Wide Web Consortium (W3C), and *ODM profile* by *OMG* to represent Halal food ontology, and will use *OWL-S* to represent perdurant ontology. Finally, we will present the framework of Halal Food ontology server (*HFOS*) to manage halal food ontology in order to resolve the problem of halal food integrity.

II. MATERIALS AND METHODS

A) Speech act and Institutional facts

According to Searle and Colomb [1], [14] there are 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, for example a coin is a piece of metal in a round shape; this is a brute fact, but in human society it's something used in selling and buying goods. Speech acts are something said that affects and changes the world, when you placing an order you submit a speech acts. An institutional fact is a record of a speech act having been made, for example, a drive certificate is a record of the speech act of authorizing someone to drive a motor vehicle on public roads after passing a series of driving tests.

Institutions are Information systems that creates a collection of instances of institutional facts which are created by speech acts, these institutions are called institutional world for example in Halal food supply chain farmers, Butcheries, wholesalers and retailers are institutional worlds. When two or more institutional worlds share their systems of institutional facts, then they called interlocking institutional worlds and abbreviated IWs.

B) Ontology and Upper Ontologies

According to Tom Gruber ontology is "an explicit specification of conceptualization" [2], [17], this is the most concise definition; conceptualization means an abstract, simplified view of the world. Every conceptualization based on concept, object, and other entities that are assumed to exist in an area of interest, and the relation that exist among them, specification means a formal and declarative representation which implies that an ontology should be machine-readable. Ontologies provide a number of features including facilitating interoperability.

Ontology-Based Interlocking institutional worlds *IWs*, that exchanging institutional fact and perform speech acts depend on both endurant and perdurant ontologies, endurant ontology describe entities in a hierarchy and relationships between them and perdurant to represent events and actions that could be taken to perform speech act during interoperation. For instance in Amazon supply Chain buying an element is a speech act, which involves number of processes will be performed by different institutions, such as paying through American Express, Diners Club, Discover, JCB, MasterCard, Eurocard, Visa, or Visa Check Cards. Each process of payment through one of these institutions is an instance of paying speech act.

C) Ontology of Perdurants

Ontologies are actually data models, these data models are not just taxonomic hierarchies of entities (classes) and relationships (associations) among them, but also should involve actions (events and processes) which represents entities that happens in time. according to Claudio Masolo e*t al*. [4] DOLCE, Descriptive Ontology for Linguistic and Cognitive Engineering - upper ontology in its ontology data model it distinguished between two type of entities, An endurant which is an entity that exists in a timeless way. All of its parts exist at the same time. A perdurant is an entity that happens in time, the perdurant entity has sub-entities, event and stative, event represents accomplishment and achievement, and stative represents states and processes. Both event and stative not concretely specified although event has many attempts. Another prominent upper ontology, BBW, Bunge–Wand–Weber (BWW) [2] system, also recognizes actions according to [2] a world is composed of things, things have properties, and the collection of property values at a point in time is the state of a thing. An event is a change of state of a thing. The history of a thing is a record of the events involving that thing. The two systems are different, but compatible. Clearly, a BWW event is a DOLCE perdurant. One conclusion Ahmed, M. Nazir et al [3] had draw from the combination is that every endurant comes into existence and goes out of existence via a perdurant. A second conclusion is that every perdurant must involve some endurants.

DOLCE divides perdurants into two kinds, events and stative. A DOLCE event is the same as a BWW event. It is an essential whole. All of its parts are necessary. A stative is not an essential whole. The BWW system does not explicitly recognize the concept of stative, although stative are covered by the system.

General Formal Ontology (GFO) also is an upper ontology for conceptual modeling has recognized the above actions using the term occurrence [6], [10], [11]; GFO distinguishes between persistence through time and being wholly present at a time-boundary. This has produced two GFO categories instead of endurant alone: persistents and presentials. GFO persistent refers to the idea of persistence through time as attributed to DOLCE's endurant, although persistent are not considered in GFO as individuals but as universals . GFO presentials can be generally interpreted as DOLCE endurants, but without temporal extension. Intuitively, DOLCE notion of perdurant corresponds to GFO notion of occurrent. Moreover, it seems that the GFO notions of process, state and change can be interpreted in DOLCE as stative, state and event, respectively. Finally, the GFO categories that concern properties and their values correspond rather well to DOLCE qualities, qualia and quality spaces.

Robert M. Colomb and Mohammad N. Ahmad [3], present a formal ontology for perdurants suitable for representing interlocking institutional worlds IWs in the general area of interoperating information systems. Their formal ontology is specialization of the perdurant elements of DOLCE and Bunge-Wand-Weber universal formal ontologies using an abstract material ontology based on the theory of speech acts embedded in the DEMO method of information system design. In addition, their formal ontology is represented as a UML profile, enabling them to reuse vast structure of the UML. However, in DOLCE upper ontology perdurant entity has sub-element i.e. event and stative, they only discussed event and not touch stative leaving it for future work, furthermore they discovered that the process is more complex than importing objects from one ontology in another.

D) Ontology server

As mentioned earlier in previous sections, the ontology is a complex information object consists of many entities in taxonomy with a complicated relationship between them. In order to manage this kind of information object we need appropriate information system which intended to manage large amount of information within an enterprise, this information system is the ontology Server. Thus ontology server is an information system that responsible for managing ontologies. This server provides some tools to achieve essential tasks such as developing and editing the ontology.

Ontology servers are closely related to Computer-Aided Software Engineering (CASE) tools, which are a relatively mature technology. CASE tools are generally used to support the design of a system. Ontology servers are mainly in three lifecycle stages, in each lifecycle it provides some tasks requirements, the following Table 1 shows these requirements.

Table 1: Ontology server requirements

Lifecycle Stage	Requirements
At design-time	An ontology server should provide tools such as editing tools to enable ontology engineers to enter, modify, and browse a developing ontology., certify an ontology, Manage Imported Ontology Modules, Abstract Data Types and Metaproperties, Version Control, Publishing,
At commit-time	A player wishing to join an exchange needs to commit to the ontology, integrating part of their local conceptual model with at least part of the ontology. It provides: Browsing Services, Find Relevant Fragments of the Ontology, Subscription Services, and Multiple Natural Languages.
At run-time	An ontology server can perform tasks like Maintain Directories of Players, Roles and Objects. Validate Messages, Broker services, and Archive Services

E) Halal food Integrity problem

"*60 percent of the meat which is being sold with halal certificate in New York and New Jersey is not halal,*"

Ali Kucukkarca, the owner of the biggest halal slaughter facility in the east of the US[1] said.

One of the most important questions for Muslims in multicultural and multi-religion countries is "halal meat" certificate and how they can trust it. Meat products before reaching consumer's hand, travel through a number of suppliers and distributors, and during this travel there are specific processes should be followed to conceder these products as permissible (Halal) such as slaughter process, packaging and coating, distribution and storing conditions. The main question should be answered is that*: how can we insure that these products are Halal?* For instance, when we buy a package of meat from butchery or meat retailer, how can we trust *halality* of that product? To answer this question we need to follow and trace back the product within the supply network and verify that any supplier in the supply network has achieved all processes according Halal and food safety. To accomplish this verification we need to collect all information regarding the product since producing to specific position in the supply chain, two more questions arise there, *who can perform this process for the customer or supply chain's participant, in other words, who will provide a service that can check food halality?* Obviously all suppliers (participants) are making use of this service. Therefore, we need a third party independent of Halal food interlocking institutional world participants' and hence independent of their information systems to achieve that service. The second question is that, *how can we collect needed information since it might be private to some participants*? Moreover, *how to make sure that this information is genuine and could be trusted?* We can go more in depth, actually this information are institutional fact result from performing some speech acts, *how can we record both records of institutional fact and the status of each speech act in order to provide accurate information*? This study tries to answer all these questions. Fig. 1 represents a simple Halal food interlocking institutional world consisting of some participants – a concise view. It is obvious that there are many problems regarding the process of query information from previous participant directly or via another supplier in the interlocking institutional world. Moreover, if the supply chain is long enough this process will be too tedious, for example if a retailer needs information about a farm, then it either go directly, or through wholesaler and process plant. Both are difficult, for the first state there may not be a direct interoperation, for example pre-established EDI sessions between the retailer and the farm and thus it is difficult for them to understand each other. In the second situation, a retailer must query wholesalers, and wholesaler queries process-plant, and finally process-plant will query farms and send the result to the end retailer and at the end, we might have uncertain information. Furthermore, if the supply network very long then query process will be inconceivable.

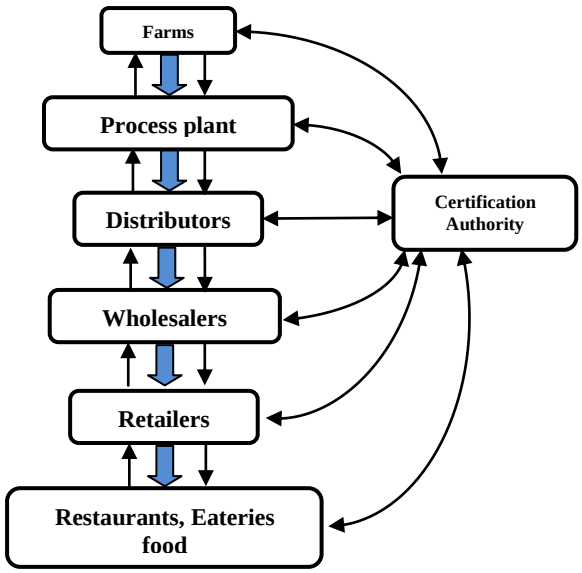

Fig. 1: A concise Halal Interlocking Institutional world

F) Non-Ontological Halal food tracking and tracing approaches

In halal food industry there are three different types of tracking and tracing halal product within the Halal food interlocking institutional worlds (*HFIWs*) depicted in Fig. 2, the first type is *cascade traceability systems* (denoted with CTS) in this approach each link in the production chain gets its relevant information about the former participant from the former links. For instance, if a retailer queries for information about a farm four level above then it must get this information through a wholesaler, the wholesaler will get information

[1]Halal focus daily Halal market news at: http://halalfocus.net/usa-muslims-having-problem-in-halal-meat-in-us accessed 21-11-2013:10:00

from the above link and send it down to the retailer and so forth. One advantage of this approach is that the amount of information per transaction remains small and hence reduces transaction costs. But a considerable drawback of this approach is that it is largely based on trust, each link has to trust the former link on the quantity and quality of information. Another noticeable point is that if the supply chain is highly complicated and interlocked, retrieving information would be so complicated too, and there would misunderstand of terms and messages used in interoperation, and hence there must be a standard way for interoperation between participants in order to interchange information and documents such as Electronic Data Interchange (EDI).

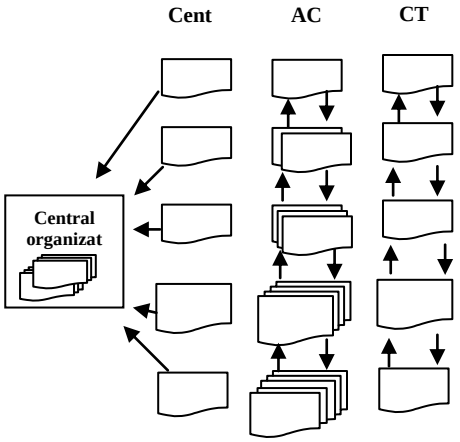

Fig. 2: Halal Food IWs tracking approaches

The second approach accumulative cascade traceability system (denoted by ACTS), in this approach each link gets the relevant information about all former participant in the supply chain. This approach also depends on trust but it differs from CTS in the step for fetching information. Because each link in the chain receive all other former participant's information, the amount of data and document increases per link. Also there should be a pre-defined framework for interoperation.

The third approach uses a central organization for hosting and storing information and document. In this approach each link provides relevant information to the central organization which combines the information of all other link in whole supply chain, this can overcome trust matter. Also if the supply chain complicated and interlocked the interoperation between participants and the central organization would be inextricable due to different participants with different way of doing business. There would be a semantic heterogeneity.

Ontology-based study by Yan-ye *et al.* [12] present an approach to developing ontologies of supply chain management (Onto-SCM) as a common semantic model of the SCM domain, their model constructed in a modular way in order to enhance reusability and maintainability. This study focused mainly in providing supply chains with semantics via SCM ontology. This might help in interoperation between supply network partners and help in exchanging information. However, not clearly discussed the problem of how to record, store, and retrieve instances of transactions, its only help in recording institutional facts ignoring recording the speech acts that generate these institutional facts. The study does not extend to cover all interlocking institutional worlds' to be more common model.

Ali Ahmad and others in [13] have presented a methodology for constructing a general-purpose ontology for supply chain management along with the resulting ontology. Their general-purpose supply chain management ontology can then be extended into various application areas including supply chain specification, supply chain knowledge management systems, various supply chain models and applications. Also this study focusing mainly on endurant ontology for supply chain management, and ignoring the perdurant ontology, which from our point of view is the most important to all supply network partners, and of course all interlocking institutional worlds in the same domain.

None Ontology-based study by Suhaiza Zailnai *et al*. in [15] have discussed the conceptual architecture on Halal traceability and Halal tracking system for Halal food product in Malaysia. Halal food supply chain is an example of interlocking institutional worlds. Their conceptual architecture built around central database with an interface for suppliers and consumers this interface is called traceability system front-end, through the internet suppliers can access all partners' information specifically shared information. In this system there are many issues arise: the conceptual architecture does not built around ontology, this means that the interoperation between supply network partners and therefore the Interlocking institutional worlds lacks of semantics and will include semantic heterogeneity, on addition, each supplier in the supply chain will keep its information as private data, and this will affect information sharing. Another thing is that all instances of speech acts will not obviously recorded.

G) Insuring HFIWs integrity using ontology server

The proposed approach (Fig. 3) is somewhat looks as the third approach discussed above, refer to Fig. 2, but it provides a consensus vocabulary between all participants i.e. ontology (perdurant & endurant). All participants should conform to this ontology in order to contribute to the Halal food interlocking institutional world. In addition, this approach provides an information system to manage this ontology, store and retrieve, query, and inference data.

The proposed approach requires ontology to which all HFIWs' participants should conform to; this ontology should contain both endurant and perdurant entities, as well as an information system (ontology server) for managing all HFIWs data and processes; it should provide services during design-time, commit-time and run-time. The ontology server supported with a repository. Fig. 3 shows HFIWs' participants and the Halal Food ontology server (HFOS) with the repository.

H) Halal Food Ontology of Endurants

There are many representation languages are being used for modeling ontology of endurants; among these languages is web ontology language (OWL) which is one of OMG

specification for representing ontologies. UML is the most widely used in modeling these days; One of UML features in the ability to be extended; The Ontology Definition Meta-Model (*ODM*) which is an Object Management Group (OMG) specification makes the concepts of Model-Driven Architecture applicable to the engineering of ontologies. Thus providing a UML profile can be used to model the meta-model of endurant ontology. Figures below show a fragment of Halal Food Ontology model using both OWL and ODM UML profile, the former developed using *Eclipse Luna* with *papyrus* plug-in. and the latter developed using *protégé* case tool

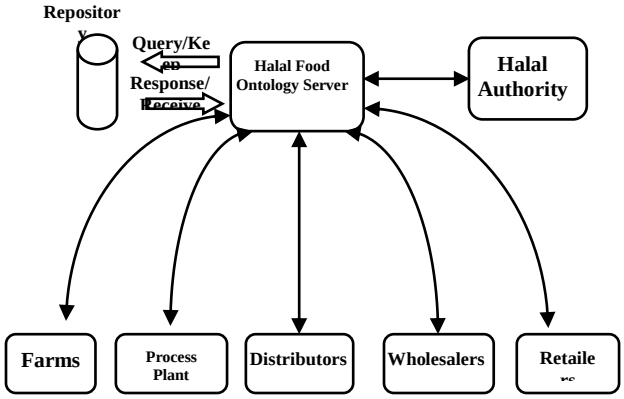

Fig. 3: HFIWs with the ontology server

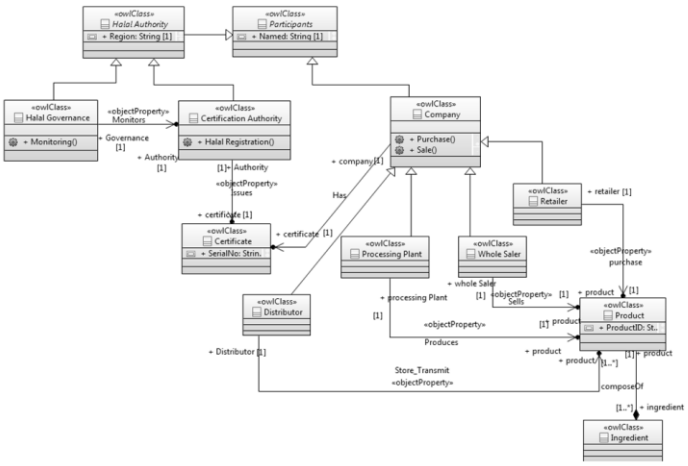

Fig. 4: UML model for Halal Food Ontology of Endurants

The model shows that the owlClass stereotype which extends UML *meta-class* class. There is abstract owl-class *Participant* with sub-owl-classes, Company and Halal Authority respectively. Each of which is a parent owl-class of other owl-classes. However, the profile was not able to represent actions that might happen in Halal interlocking institutional worlds although UML provides activity diagram for representing processes and events because it does not provide model instances. In our framework, we used only OWL ontology because it has XML/RDF format that helps in using more semantic web paradigms such as *Jena* and *Pallet* to infer new information from existing.

I) Halal Food Ontology of Perdurants

Fig. 4 shows classes, their properties and operations, as well as relationship between classes themselves. It does not show details about processes and operations, For instance, *Halal-Registration, slaughtering, Monitoring* and *purchasing;* UML uses activity diagrams to describe dynamic aspects of the system. In this section will present the behavioral view of the HFIWs using UML activity diagrams. Now we are going to look carefully to our two services Halal Registration Process and Purchasing Process, Because owl doesn't support developing ontology of perdurant, and so UML we will borrow OWL-S ontology (*an ontology, built on top of Web Ontology Language - OWL, for describing Semantic Web Services*) terms to describe these scenarios. OWL-S organizes a service description into four conceptual areas: the *process model*, *the profile*, *the grounding*, and *the service*, in our case study we will concentrate only on process models.

Consider the two services shown in Fig. 4, Halal registration Process and Purchasing Process. Each of which will has a process model which describes how a service performs its tasks. It includes information about inputs, outputs, preconditions, and results. In addition, they have profiles, which provide a general description of these services. Moreover, they have a grounding, which specifies how a service is invoked.

OWL-s process model distinguishes between three types of processes: *atomic*, *simple* and *composite*. For a *composite* process, the process model shows how it breaks down into simpler component processes, and the flow of control and data between them. *Atomic* processes are essentially ``black boxes" of functionality, and *simple* processes are abstract process descriptions that can relate to other composite or atomic processes. The first service (Halal Registration) is an atomic process, suppose it receives, three inputs namely company name, list of product to be certified, and support documents to issue Halal certificate as an output, Fig. 5 shows this service with its I/O.

J) Halal Food Ontology server (the framework)

Ontology servers are used to manage ontologies; it provides a number of functionalities during design, commit, and run time. In our case study Halal food ontology server (HFOS) intended to provide functionalities to halal food domain at commit and run time, we will try to achieve one of these functionalities; *Insuring Integrity*, the rest of functionalities are open for studying in the future.

The proposed ontology server composed of semantic web related technologies see Fig. 6, triple store for storing ontology data supported with Mysql Database, API for accessing and manipulating ontology data, a reasoner to inferring new information from exiting triples. In the next paragraphs, we will describe these technologies in details.

Fig. 5: Atomic process Halal Registration Service showing its input and output

Jena API is an open source Semantic Web framework for Java. It provides an API to extract data from and write to RDF graphs, an ontology API for handling OWL and RDFS ontologies. We can use it as a way for manipulating Halal food Ontology's data during running our case study. We need it to add instances of the ontology classes and processes. Jena SDB library is a component of Jena server for storing RDF, and query specifically to support SPARQL. The storage is provided by an SQL database and many databases are supported, both Open Source and proprietary. An SDB store can be accessed and managed with the provided command line scripts and via the Jena API. For Reasoning and extracting new data from ontology Pellet library has been added, Pellet is an open-source Java based OWL 2 reasoner. It can be used in conjunction with both Jena and OWL API libraries. It incorporates optimizations for nominal, conjunctive query answering, and incremental reasoning.

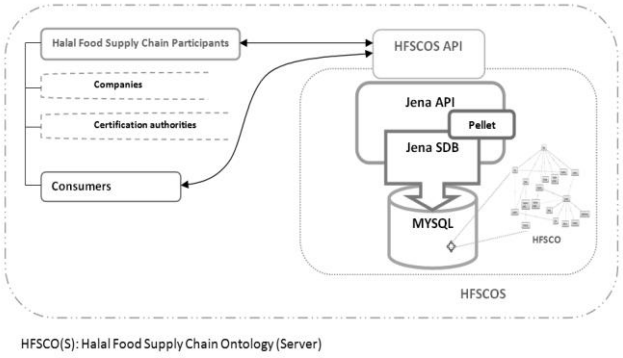

Fig. 6: Halal Food Ontology server with some semantic plug-ins

III. RESULTS AND DISCUSSION

During running Halal food case study, we have observed some important following notes: Owl-s does not support representation of instances of services. In its conceptual model there is no specification for instance for services, and hence, how can we record an instance of specific process for example instance of Halal registration process, such as registration of (*VKS*) company by Halal authority (*HA*). Another note is that, OWL-s represents services as black box without showing service tasks, for example, owl-s *Process Model* does not show *Halal registration service* details – speech acts and task status, it treat it as black box specifying its input and output and pre-conditions. In our case study, we have found that a participant can easily query the status of this kind of processes, but it will fail to represent this in our OWL-s ontology. Last point, OWL-S takes a service point of view to describe service activities, so we think that it works better for agents than humans.

IV. CONCLUSIONS AND FUTURE WORK

This study presents a frame work for insuring halal food interlocking institutional world integrity by using a new technology; the ontology server, this frame work provides interlocking institutional worlds' participants with a consensus vocabulary to enable them to interoperate semantically on one hand and provide halal food consumers with an API to query the ontology server for halal food product on the other hand. The ontology server manages both ontology of endurant and ontology of perdurant to store and retrieve both structural and behavioral data. The study used the OWL language to represent the ontology of endurants and owl-s to represent ontology of perdurant, but owl-s does not have model instance and hence not able to represent perdurant ontology thus more research should be done to overcome this drawback.

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