

# Foundation of Intelligent Agents

## Assignment #2

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### 1. Describe briefly the layered model of Agent Communications

Agents require to communicate with each other and as well as with the environment into which it is deployed. In order to communicate and function in determined fashion, agent systems require to follow a specific communication model. This will ensure interoperability between communicating parties. The Figure 1 below depicts a Layered Agent Communication model. The communication parties must be inter-operable at each of the layers in order to communicate successfully with each other and the environment in which it functions.



**Figure 1: Layered Agent Communication Model**

Agents can negotiate with each other on the specific protocols to utilise to successfully communicate with each other. The various layers of the communication model are as defined below:

**Network Infrastructure:** This layer provides the network connectivity and allows agents to be distributed over the Network. This is the basic network infrastructure that is involved.

**Transport & Signal:** The Agent communication is transported using TCP, UDP protocols. This layer of the communication model ensures the delivery and the reception of agent messages over a distributed networks. This layer in some cases is also responsible to guaranteed and reliable delivery of messages across the network.

**Message Transport:** The message transport protocols utilised in this layered model are based on IIOP, HTTP or RMI, in the case of wireless networks this can be based on WAP.

**Message Envelope:** Since it is possible to utilise any message transport protocol, the agents in order to interpret the message sent via any transport protocol, has isolated the actual contents of a

communication message into the so called Message Envelope. This enables the transport independent handling of messages in agent systems and allows any future bindings to transport protocols. The contents of the Message Envelope are tightly coupled to the transport protocols (in the case when IIOP is used for transport) while at times loosely coupled (XML over HTTP)

**Agent Communication Language:** This layer contains the communication language the communicating agent complies with. The ACL would contain the agent messages complying with both semantics and syntaxes of a specific agent communication language (such as FIPA ACL). The messages can also be encoded by three different means: ASCII, XML and bit-efficient syntaxes.

**Content Language:** This layer of the communication model is responsible to define the action that the message contained in the ACL layer depicts. The Content Language layer is responsible to ensure a common understanding of the message being exchanged between agents. The common understanding is established by sharing the common ontology. This layer is used to contain the ontological expressions that are exchanged and communicated between the agents in order to explicitly mean and communication the same thing across agents.

**Conversation:** The agents typically engage in exchange of a set of messages resulting in interactions between one or more agents. The agents indulge in interactions with each other, basically forming a conversation to achieve a specific task. All the agents engaged in such interactions need to comply to a specific conversation protocol, namely Interaction Protocol.

## 2. A Short Article about FIPA ACL

Agent based systems are intelligent, in the sense that they can perform their set objectives autonomously, without human intervention, when necessary, at the same time intelligent enough to adapt to the situations and correspondingly communicate with other entities within a specific environment (with other Agents, systems or environment elements when necessary).

Agents need to communicate with each other in order to achieve agent's goals, specifically if the agent by itself can not achieve the goal.

There are three aspects that the participating agents need to address prior to communicating:

- a. Agree upon a specific agent communication language to utilise for communication
- b. Have common understanding of the knowledge exchanged, this is related to content language and Ontology used. If they are different then atleast they need to be mapped to represent the same meaning of the reality.
- c. Establish a common means of exchanges communication messages, this could be some sport of transport protocols such as HTTP, etc.

Once the above three aspects are addressed the Agents then need to communication using specific interaction protocols to establish a specific conversation in order to exchange services and accordingly achieve their goals correspondingly.

Foundation of Intelligent Physical Agents (FIPA)[6] provides a set of specifications that can be utilised agent system developers to incorporate into their solutions. This helps agent systems to inter-operate with each other.

The FIPA specifications addresses the following in order to enable the develop a complete Agent based system:

- **Agent Management:** This defines the Agent Platform reference Model containing functionality such as white and yellow pages, message routing and life-cycle management
- **Agent Communication Language:** This contains a mechanism is expressing and sending messages or actions which are communicative acts which are intended to perform some act by virtue being sent by an originator to a target agent.
- **Agent/Software Integration:** This defines a means of integrating an Agent system to non-agent based software systems. As part of which an Agent Resource Broker has been specified which is responsible to advertise the services provided by Non-Agent systems which are intended to be consumed by Agent systems in a specific agent based domain.

- **Personal Travel Assistant:** This provides a set of building blocks for the travel industry related application. The agent systems can be built using the specification available, which can perform actions on behalf of a Human, representing a Personal Travel Agent.
- **Personal Assistant:** This is an Agent systems which can act in a semi-autonomous manner representing and acting on behalf of an Human, basically modelling the interests and preferences of the human and in turn providing services to another user or similar Personal Assistant of another user.
- **Audio / Video Entertainment and Broadcasting:** This allows end users to receive rich information and multi-media services in a more personalised manner specifically of interest of end user in a simple and enjoyable interface with the system. This is made possible by applying several techniques of negotiation, filtering and applying user preferences and choices.
- **Network Management and Provisioning:** This is used for management and provisioning of underlying network for the services. This is achieved by three different agent systems namely: Personal Communications Agent, Service Provider Agent and Network Provider Agent. These three agents need to communicate and negotiate in order to establish optimal network services.

Agent Communication Language (ACL) enables communication between FIPA Agents. This language is based on Speech Act Theory (SAT), which is a pragmatic theory of language dealing with syntax and semantics. The SAT is based on the following acts of speech:

- Locutionary Act: Which specifies the utterance of a syntactically acceptable sentence
  - Illocutionary Act: Communication of the speakers intention to the target listener
  - Perlocutionary Act: The act of bringing out effect on target listener of the utterance of sentence
- The SAT was originally developed for modelling human communication, which was later applied into Agent Communication Languages as in FIPA-ACL [4].

The SAT is classified [5] into the following categories:

**Representative:** This represents some state of affairs, such as assertions, claims, descriptive, informative

**Commissive:** This commits the communication message originator to some future actions, such as: Promising, Agreeing, Threading, Inviting, Offering, Attesting, Volunteering

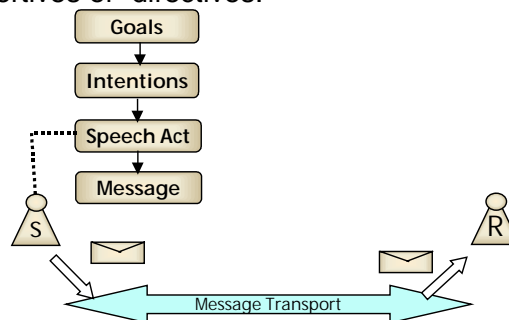
**Directive:** This is communication message originator's intention to direct the target message receipt to carry out some specified action, examples such as: Commanding, Requesting, Daring, Asking, Begging, Forbidding, Restricting, Advising.

**Declarative:** Bringing about a specific state, for example: Arresting, Naming,

**Expressive:** Indicating message originators psychological state or mental attitude, such as: Greeting, Congratulating, Thanking, Apologising.

The syntax of the language is not as important as semantics of a language. If two agents follow different syntaxes, a mediator agent can be used to still enable the communication between the two agents; the complexity of the approach is lot simpler as the semantics of the communication remains the same, when compared to different semantics.

The FIPA-ACL is developed from language called ARCOL (France Telecom), which had a small set of primitives which were all as assertives or directives.



**Figure 2: Agent Communication**

The Figure 2 depicts the communication between two Agents S and R. The Agent S which intends to achieve a specific goal communicates with the Agent R with the help of messages which are built using the Speech Act theory.

FIPA-ACL, based on Speech Act, provides formal semantics and several concrete syntaxes. The Semantic Language is the formal language used to define the semantics of the FIPA-ACL. The communication language specifies :

- Communicative acts and semantic model behind the language
- Abstract structure of the messages and the
- Encoding schemes

The Semantic Languages is expressed using Notation to express concepts and few of them as listed here below :

Iip - i has an Intention to bring about p

Bip - i believes p

Cip - i desires that p currently holds

Done (a, p) - a has just taken place and p was true just before that

Feasible(a, p) - a can take place and if it does p will be true just after that

Possible ( $\bigcirc$ ) - Feasible(a,  $\bigcirc$ )

Agent(I,a) - I denotes the only agent that ever performs the actions which appear in action expression a.

RE - Rational effects

FP - Feasibility precondition

I =  $\bigcirc$  ,  $\bigcirc$  is valid

FIPA-ACL specifies five different properties of which 3 of them are related to the reasoning process, used for the communicative acts while 2 of them are for consuming communicative acts.

### Reasoning Process:

- a. An Agents intention to achieve a given goal generates an intention that one of the acts known to the agent be done. The act is such that its rational effect corresponds to the agent's goal and the agent has no reason for not doing it
- b. Whenever an agent chooses to perform some act the agent intends to seek the feasibility and if it can satisfy such an act.
- c. If the agent has the intention that a communicative act be performed, it necessarily has the intention to bring about the rational effect of the act.

### Consuming Process:

- a. When an agent receives(observes) a message it should believe that the sender of the message has the intention to achieve the rational effect of the act.
- b. When a agent receives a message(communicative act) it is allowed to believe that the persistent feasibility preconditions hold, it means that the agent persistence after performing the communicative act, though it is not a mandatory for the receiving agent.

FIPA-ACL specifications defines 22 predetermined communication acts, which are used by Agents to communicate with each other within the messages that they exchange. Each of the message also has a mandatory field which is the communication act, the message could have other information such as Sender, Receiver and the message content following a specific content language(depict Ontology based description). The Figure 3 depicts FIPA-ACL based text encoded message, the Figure 4 shows an example, which is a ASCII based representation of the FIPA-ACL message. It could also be based on XML or then bit-efficient syntax.

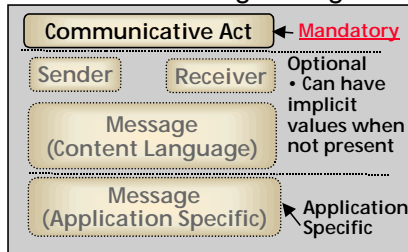


Figure 3: FIPA-ACL Message

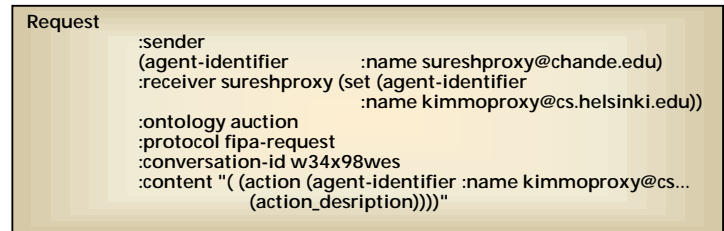


Figure 4: FIPA-ACL example message[4]

The Figure 4 shows an example for the Request Communication Act. The communicative acts are of two types, namely primitive acts and composite acts. Composite acts are composed from primitive acts either by substitution or by sequencing.

**Primitive:** Request, Confirm, Disconfirm, and Inform

**Composite:** Accept-proposal, Agree, Cancel, Cfp, Failure, Inform-If, Inform-ref, Not-understood, Propagate, Propose, Proxy, Query-if, Query-ref, Refuse, Reject-proposal, Request-when, Request-whenever and Subscribe.

The relationship between the primitive and composite can be seen in the Figure 5.

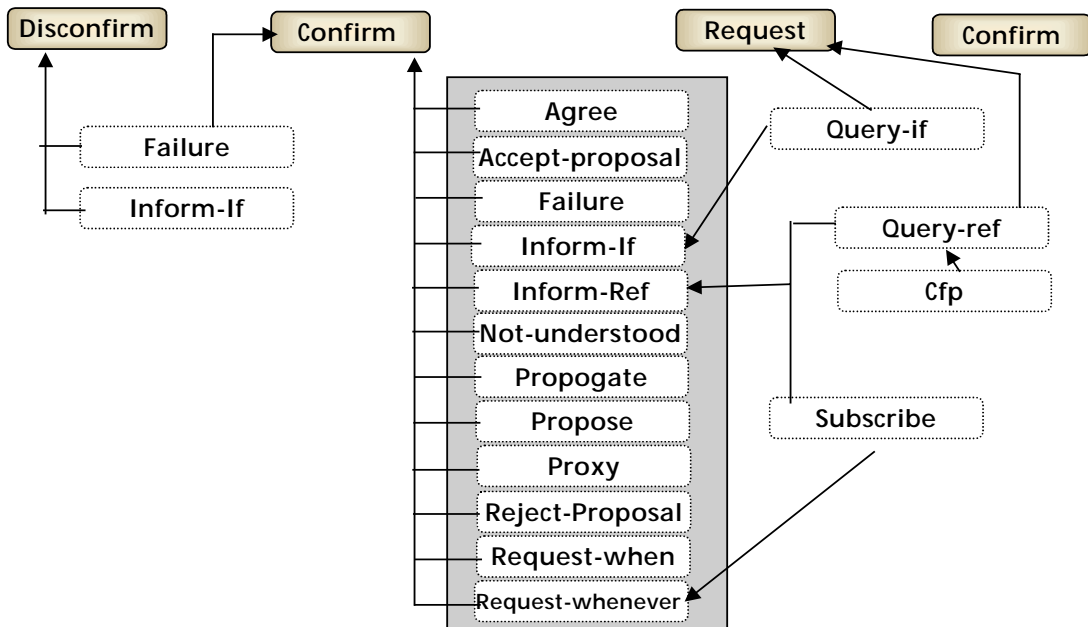


Figure 5: Relationship between primitive and composite Communicative Acts

Out of these acts only four of them are primitive, namely: Inform, Request, Confirm and Disconfirm, the rest of them are composite communicative acts.

Each of the communicative Act has a meaning and formal semantics which can be expressed using the Semantic Language(SL). A Communicative act model is presented as follows :

<s, act(r,C)>

FP:  $\phi^1$

RE :  $\phi^2$

Where "s" is an agent of the act, r is the recipient, act is the name of the act, C stands for the semantic content or propositional content, and  $\phi^1$  and  $\phi^2$  are the propositions. FP denotes the feasibility precondition of a communicative act, basically the conditions that needs to be true for the execution of the communicative act. The RE denotes the rational effects of a communicative act, basically the reasons for doing the act.

An example of semantics expressed for a **Inform** communicative act[4] :

<s, inform(r, $\phi$ )>

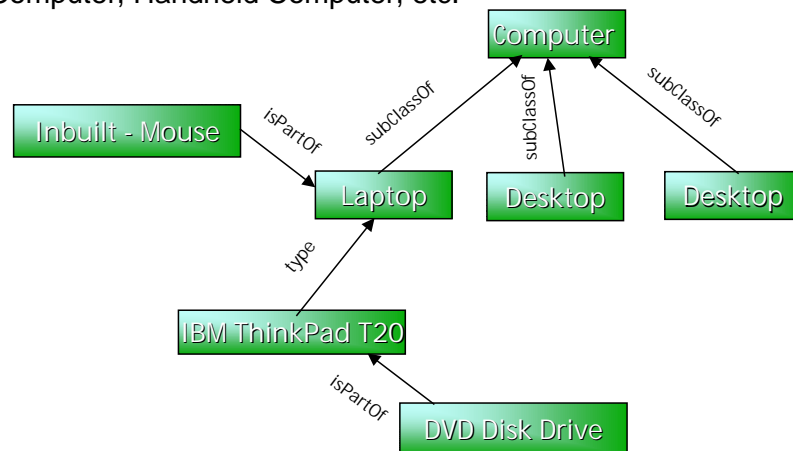
The agent  $s$  tells another agent  $r$  that some proposition is true. The reason for telling this fact to agent  $r$  is that the agent  $s$  wants agent  $r$  to believe that  $\phi$  is true and that the agent  $s$  does not already believe that the agent  $r$  believes  $\phi$  is true or not.

### 3. What is an Ontology ?

An ontology is a mechanism of representing knowledge or description of concepts and the various relationships that exists between them in an unambiguous manner, in short. it is specification of conceptualisation. The roots of the word "ontology" lies in the domain of philosophy, where it means systematic account of existence[3]

An ontology consists of a set of terms used to describe and represent an area of knowledge[2]. An Ontology with the usage of concept forms a vocabulary used to describe a specific reality along with the explicit assumption of the meaning that comprises with the utilisation of the vocabulary elements(words). The ontology forms a logical and mental representations of reality. Concepts are elements of a vocabulary utilised to define a specific reality, where concepts are basically a logical or mental representation of reality. A Concept has an Intention, meaning describing a specific instance of reality, while the Extension is a set of elements to which a specific concept refers to. Ontology is mainly related to Intentions(meaning).

For example : Intention: for example a Computer, while Extension could be Laptop Computer, Palmtop Computer, Desktop Computer, Handheld Computer, etc.



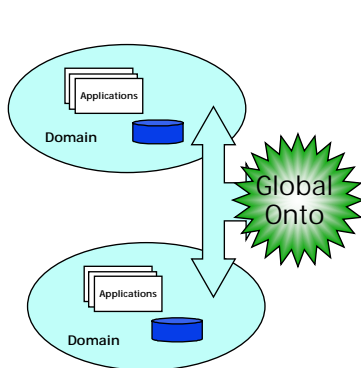
The Figure above depicts concepts and the relations between the concepts..

A set of concepts together can represent knowledge about a reality in a specific domain. This Domain specific ontology can be utilised by applications, systems, humans or databases that are required to share or exchange information about a specific reality in relation to that domain. Ontology enable systems, computers to communicate with each other and the environment by exchanging information based on the knowledge they contain about the environment or concepts locally or then based on globally shared ontology, which explicitly expresses the intentions of the communicating party. Ontology can be organised into global domain, which encompasses all the domains, or then be more specific to particular domain, there are both pros and cons in these approaches.

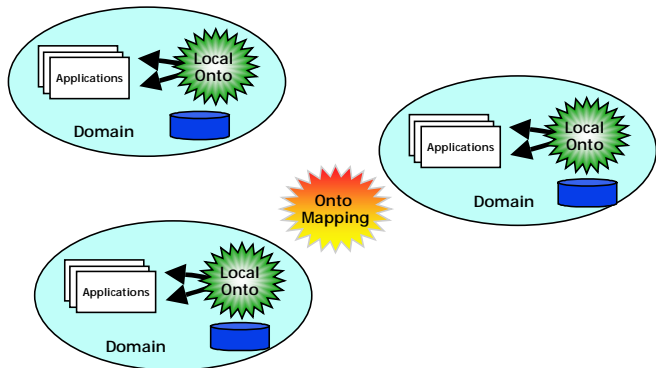
When considering Global ontology, as depicted in Figure 6, they reduce the possibilities of inconsistencies and make it earlier for application developers to find the relevant concepts relatively easily. It also ensures less overlapping ontology and allow reduce redundancy. The approach has practical problems such as :

- who will host and maintain the global ontology.
- How do we introduce new ontology into the global
- Since this contains the whole set of ontology representing the whole world of domains this could get heavy from the processing and inferencing point of view.
- Not all requirements can be satisfied in such global ontology mechanism.

Where as in locally maintained Ontology, as depicted in Figure 7, specific to a particular domain, it ensures that the ontology fully support the application domain serving custom needs. Since it is small and light weight the processing and inferencing for application will be lot faster and efficient. This approach also has disadvantages, such as : there will higher level of overlapping ontology between domains, incompatibilities between different domains, specifically when applications need to utilise services across domains. Introduces requirements for sophisticated onto mapping software entity, in turn reducing the computation efficiency.



**Figure 6:Global Ontology**



**Figure 7: Domain specific Local Ontology**

The description of Ontology are developed using logic-based languages, so as to make it unambiguous, accurate, consistent, and specific distinctions can be made between the concepts and elements utilised to define a specific domain.

The benefits[2] that ontology brings into the computing world are that the

- "Tools can perform automated reasoning using the ontology, and thus provide advanced services to intelligent applications such as: conceptual/semantic search and retrieval, software agents, decision support, speech and natural language understanding, knowledge management, intelligent databases, and electronic commerce"[2].
- Ontology provide means of defining the semantics of information of a specific application or Web resource and this in turn will enable such information to be utilised by web applications and intelligent agents, as the meaning and the assumption are explicitly declared through a predetermined vocabulary(part of (global or domain specific) ontology).
- Ontology give a explicit means of defining metadata about a specific application or resource, which could be utilised by applications that can in an automated manner represent human level of computation or processing to some extent.

## 4. References

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