# Comparative Analysis of Computational Models of Multi Agent System Based on Interaction and Coordination

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## Abstract

The aim of our study is to compare the Multi-Agent Models. The purpose of this study is also to find out which model is comparatively better for multi-Agent System on the bases of factors i-e Performance, Fast, Time Efficient, Cost and Learning. Under positivism paradigm, descriptive research design has been used in this study. It compares the Computational model of multi agent system to find the best model out of these for specific situations and to build better interaction and coordination between Agents. In addition to that, the environmental factors that affecting the multi-Agents also addressed. The models used in this study are Trust Model, Selection Model, Meta Model, Synchronous execution Model and Interleaved Execution Model. Findings of this study indicated that Synchronous execution Model is fast and better model out of these models. Results also indicated that Synchronous execution Model help to build better interaction and coordination between multi Agents Systems.

## 1. Introduction

In the dynamic era different types of Computational models of Multi-Agent System and check this model to how much they fast? How much they Efficient? How much they quick? How much they learn? With interaction and coordination between multi-Agent. The other thing we check is which model less costly as compared to other. Different types of Approaches used In it to check interaction and coordination between models, e.g. fuzzy sets, sending messages/receiving, Select the trustable Agent, Quick Learning between Agents. Models are also checking on the continuous interaction between Agents. Agent plays different roles in different groups. The study also builds Trust and Reputation between Agents. Study deal with Different types of Problem means two Agents not interact with each other at the same; Agents aren't defining its initial state for the ease of the Agent. Study

has no Particular criteria of Selection of Agents to overcome this problem we provide a better Solution in terms of find the best model out of these Model. In the bellow Figure 1 we show the components of Multi-Agent System.
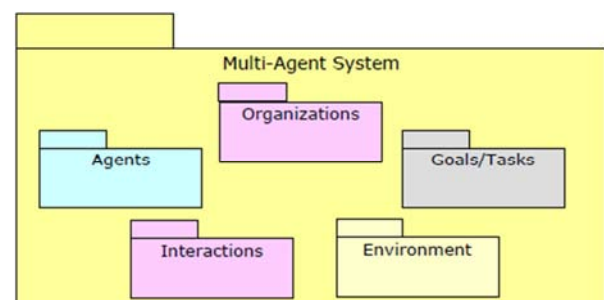


**Figure 1.** Multi-Agent System.

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## A. Meta Model.

The Meta model we select is AALAADIN that describe the two main concepts negotiation and coordination between Agents of Systems. It also defines the concept such as groups, roles and organization are used in a casual way. The Group Structure method describes a group at level. It identifies all the roles and interaction that can appear within a group. AALAADIN is able to resolve that Problem by allowing a designer of Multi-Agent System to describe the main concept of an Organization such as groups, roles and Agents

## B. Trust Model.

The trust model that based on reputation and confidence and using the approach of fuzzy set for the better interaction between Agents to establish new contracts between them. Agent mostly commit to each other to perform a particular task. The Confidence and reputation, build between agents by reliable interaction. For Strong reputation you need a large number of interactions. We discuss two types of interaction in it direct or indirect multi-Agent interaction. The model help agent to (i) choose an interaction partner. (II) Develop the set of negotiable issues and (iii) Determine the interval of negotiation. The work on coordination of (Jennings 1993; Dufee 1999), on collaboration (Cohen & Levesque, 1990; (Pynadath & Tambe, 2002), and negotiation (Rosenschein & Zoltkin, 1994; Jennings et al 2001; Kraus, 2001)

## C. Selection Model.

The Replicator Dynamics used by the Selection –Mutation Model for Q-learning in games. In the evolutionary process usually combine two major concept Selection and Mutation. The selection prefers some variety and while mutation provides variation in the population. The mostly Player are Q-learner in this paper. Learning is a Time Consuming Activity.

## D. Synchronous Execution Model.

The aim of this Execution model for multi-Agent System to build better cooperation and interaction between groups of the Agent with Structure. In this model Agent interact by sending and Receive Messages. The Interaction is based on defining the states

## E. Interleaved Execution Model.

The interleaved not allow the Agent to communicate at the same time. In which Agent didn't define its Initial state at interact with each other that's why agent between the Agent is weak
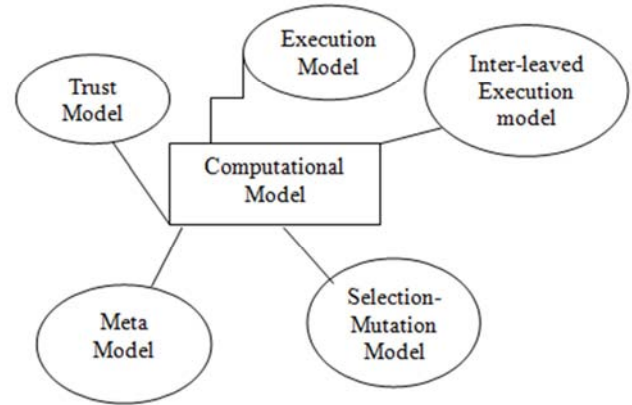


**Figure 2.** Computational Models.

# 2. Literature Review

1. Meta Model

The Meta model for the Multi-Agent system best to use in it is a generic model of multi agent system based on three major concept groups, roles and structures called AALAADIN. AALAADIN describe the negotiation and coordination between Agents that called Agent oriented. To reduce the language discrepancies with other Agents standardize the language KQML. The Agent able to part of any group and play different roles in different types of groups. The Agent is supposed to interact with any other Agent in the system Agent able to support multiple platforms. Each Agent performs a specific role rather than all activities. [1]

We also used the different Software development models. For the integrating the different types of objects The URM (unified resource model) we used in. It is a specialized model to for the Software system, Agents and for the Development process. The URM model provides the Knowledge foundation for the best interaction and association between different objects. It is a powerful model to find the impact between different system and objects [2]
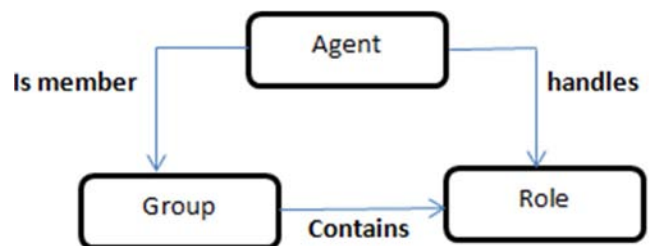


**Figure 3.** Meta Model Structure.

2. Trust Model

The interaction based on three phases (i) negotiation between

agents (ii) task execution by the agent (iii) The outcome generates from this Execution. The Trust high means contractions between the Agents are strong and reliable. To identify the trustworthiness check the Confidence by analyses the previous interaction result with that agent and Reputation acquired from previous experience with the other agent in the community by analyses signals sent by another agent. Before interaction defines the context of that interaction for the better interaction each agent must define its initial state for better interaction. Our objective is to minimize the uncertainty in interaction. [3]

Trust is the belief of an Agent has that the other Agent will do task what it says. The two methods to build the trust between multi-Agent system (i) Allow Agents to trust each other (ii) Allow Agents to measure the amount of trust they can place in their interaction partner. The Trust concern the design of a protocol and mechanism of interaction. [4]
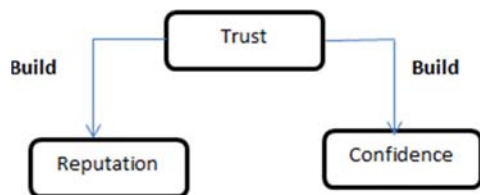


**Figure 4.** Trust Model Structure.

### 3. Selection Model

In EGT (Evolution games Theory) first defines the context of each player in the games that called genotype. It refers the particular behaviour to measure the Payoff of the Player. For the Quick learning in games continuous time limit is apply on Model. To overcome the trade-off between exploration and exploitation we used selection-mutation model for the better selection of Action for the agent. Learning is the time Consuming activity but the Selection mutation help to initialize that activity. [6]

In which we use the evolutionary Approach that is strongly concerned with the Environment in which behavsiour is determined. The process of learning of Agent in games is specific to environment. The learning process fast if the context of learning already defined. Good Selection build trust between different Players on the base of previous interaction. For the purpose of Q-learning we used the Replicator dynamics. [9]

### 4. Synchronous Execution Model

In the Synchronous model each agent defines its initial state means initial belief to interact with each other. An Agent action is called move in it. Both the Agent interacts at same time. Agent able to change state any time. In synchronous multiple transition take place. We can also make nil transition between two agents for the better selection of Action for the

agent. Learning is the time Consuming activity but the Selection mutation help to initialize that activity.

$$State = Agid \rightarrow Belset$$

The state is equal to Agent id implies to believe Set

### 5. Interleaved Execution Model

In the interleaved model each agent not defines its initial state to interact with each other. An Agent action move in it is irrespective. Both the Agent no able to interacts at same time. Agent able to change state any time. In interleaved multiple transition take place. Not All message send in a sing cycle. Keep track all those messages that not received.

$$State = (Agid \rightarrow Belset) \times Pool.$$

The state is equal to Agent id implies to believe Set and the pool of jobs

In the Study define which model fulfils the Research variables that we define below. Research variables we used is learning, Performance, Time, Space and Security. We Compare this models on the bases of previous study and Stats. The representation of Models is also shown in the bellow Figures. The variation between the models are based upon their performance and mapping on the research variables. There are no single criteria to judge these models of Multi-Agents. Study Check different constraint on this models on the bases of these we declare result and plot them into the Graph. However, moving from agent models to implementation is not fully addressed by most of the Agents-oriented methodologies is an systematic way.
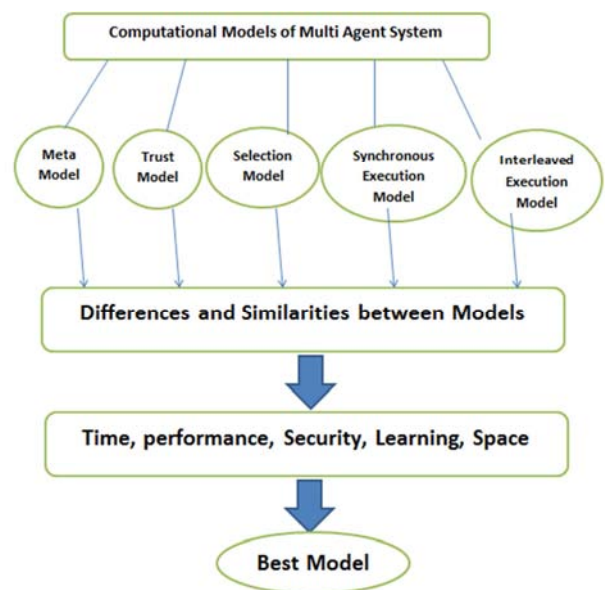


**Figure 5.** Computational Models Hierarchy.

## A. Learning

Fastest learning model is selection model. Because it Initially define context of Learning. Learning is the time Consuming activity but the Selection mutation help to initialize that activity. The selection favours some variety and while mutation provide different types of variety in the population. The Selection also famous for Q-Learning using Replicator Dynamics. In which we also construct Time Limit in the Learning Process.
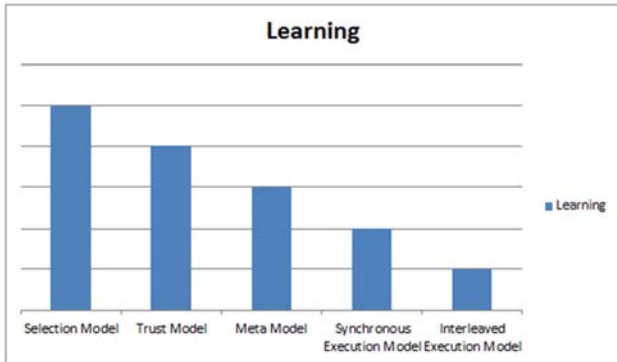


**Figure 6.** Learning Graph.

## B. Performance

The best model for performance wise is synchronous Execution model because it interacts and coordinates fast as compare to other model. Because Each Agent knows about the state of other Agent. It takes minimum time to interact with other Agent. Each Agent interact with multiple Agent at a time.
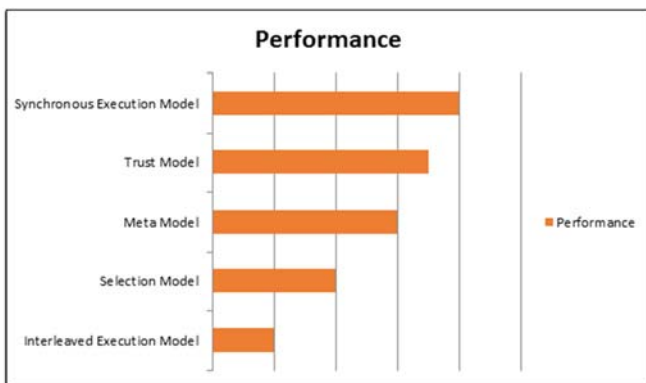


**Figure 7.** Performance Graph.

## C. Space

The Trust model used less space as compare to other model. Because it shrink the memory for new model. It Trust value was too low that's why number of issue negotiate. Trust model also resolve the negotiate issue. The negotiable issues expand due to less trust conversely and trading off the length of dialogues with better expected utility than otherwise. [3]
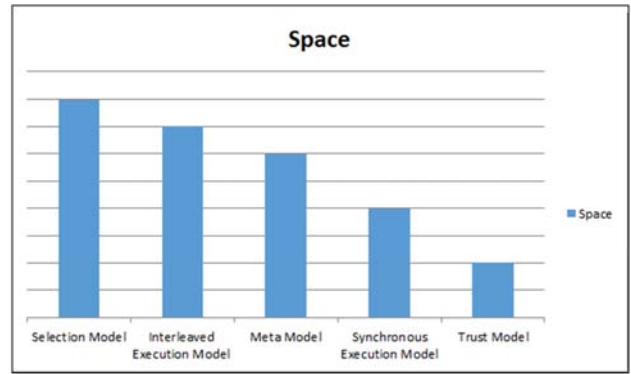


**Figure 8.** Space Graph.

## D. Security

The Meta model is most secured than other model because it is agent oriented and difficult to design complex system. It only interact with those Agents that fulfil three condition

- _Heterogeneity of language.s

- _Multiple applications and architectures

- Security.

That's why it auto maintain its security. Security in sense of interaction between Agents must be secure for the good coordination between them.

## E. Time

The Synchronous Execution model takes least time to interact with other Agent. Because in which each Agent define its initial State that's why Agents interact and coordinate. The initial state means initial belief that closed under deduction rule.
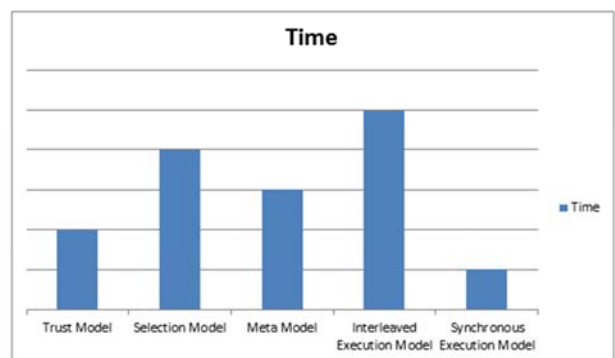


**Figure 9.** Time Graph.

The approach that used by Synchronous Execution model is sending message and receiving Message. If you know that the other Agent is Receiver than you send message otherwise not. You also identify the move of other Agent from its state. [7]
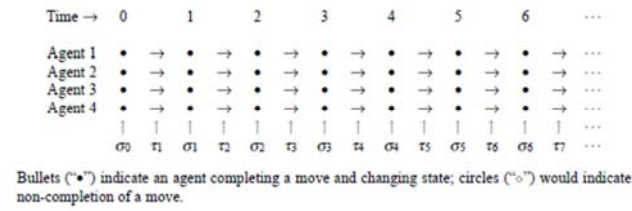
| Time → | 0 | 1 | 2 | 3 | 4 | 5 | 6 | ··· |

**Figure 10.** Synchronous Execution.

# 3. Conclusions and Results

In this paper, we concluded that the best Model for the interaction and Coordination is synchronous execution model. Because it takes least time to interact with other Agent on the bases of define its initial state. The good Coordination based on the Trust between Agent means Larger the Trust = Larger the belief. Before the interaction study need to define the context of interaction and coordination. Select the Agent on the bases of previous interaction with this Agent. Each Agent interacts with Multiple Agent at a time in synchronous Execution Model. The other model may also play different role in different context and different constraints that apply on it. Interleaved follow the sequential method means one after other Agent. The Agent act well in proper structure. The Meta Model and Synchronous Execution Model help a lot to build better coordination between Agents. Each Model used different Approach of doing task e.g. Trust Model used the Fuzzy logic to build Trust between models. In the Meta model make group of Agent for the better interaction and coordination. Different roles are assigning to different Agent. The study also distinguishes between direct or indirect interaction. Study concluded that the direct interaction is faster than the indirect interaction.

# 4. Discussion on Results

The purpose of the discussion is to interpret and describe the significance of our findings. We also understand from the research is that the coordination is depend on Trust between Agents [4]. Stronger the Trust means Strong Coordination and the Reputation is built of each of them. Selection of Agents based on the previous experience of Interaction and Context Based. [6] Need to work more on heterogeneity in language due to inappropriate standard of language [1].

Difficult to Map the Model on the selected Research variables. The benefits of this study we determine that that synchronous model take least time out of these models for better and fast interaction with other agent at same time and no need to worry about the selection of Computational Model for the Multi-Agent System. Selection totally depends on the previous interaction experience. Every Agent learn with their experience The Learning Process in our Model is Slow but Continuous [6].

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