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Application of Markov Process under Multi-agent System

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Abstract- *Multi-agent systems become popular across multiple areas. Coordination and cooperation among agents should be accurate for completing specific task. Making consensus is quite challenging under multiagent system. In this situation markov process plays important role for predicting next state. This paper studies markov decision process and its application in multiagent system. Also introduce intrusion detection mechanism under multiagent system using markov decision process.*

Keywords: Multiagent System, Markov Decision Process, intrusion detection system, Security.

1. INTRODUCTION

Multi Agent Systems (MAS) is a technology comprising of one or more agents or intelligent agents. Each agent has specific goals and its actions are driven towards the completion of those goals. However, agent's actions depend, in some cases, on the actions of other nearby agents, for which nearby agents need to communicate with each other. Presently, MAS technology is finding wide range of applications in the field of control engineering. MAS has been used in distributed control, hybrid control, automation, congestion control, system restoration, network control, online medical system [2]. Consensus has been taken for coordination among multiple agent. Consensus means that all the states of a multiagent system can dynamically reach certain agreement. The states in the agreement could be some physical variables such as position, velocity, attitude, angle, temperature, activity and so on. In [1], consensus problem under multiagent system is studied. Agents are distributed, and autonomous, so Markov process is use to describe each agent's state space and actions space.

2. DEFINITION

In MAS, each agent can only sees a partial view of the whole system, by which an agent only observes part of the global system state [7]. Although agents do have the ability to communicate with each other, it is usually unrealistic for the agents to communicate their local state information to all agents at all times, because communication actions are usually associated with a certain cost. Yet, communication is crucial for the agents to coordinate properly. Therefore, the optimal policy for each agent must balance the amount of communication such that the information is sufficient for proper coordination but the cost for communication does not outweigh the expected gain.

As mention in [3, 4], Markov process can be define as follows
Definition 1: A stochastic process is a sequence of events in which the outcome at any stage depends on some probability [3].

Definition 2: A Markov process is a stochastic process with the following properties: (a.)The number of possible outcomes or states is finite. (b.) The outcome at any stage depends only on the outcome of the previous stage. (c.) The probabilities are constant over time [3].

Definition 3: Markov Decision Process (MDP). MDP model contains

(a.) A set of possible world state S.
(b.) A set of possible actions A.
(c.) A real value reward function R (a, s).
(d.) A description T of each action's effects in each state [4].

MDP's are used to do Reinforcement Learning, to find patterns which need unsupervised learning and which cannot handle an infinite amount of data. Actually the complexity of finding a policy grows exponentially with the number of states |S|.

3. ADVANTAGE OF MARKOV PROCESS

(a.) Global convergence.
(b.) Building the policy taking into account the delay of rewards.
(c.) Simple methods of calculating policy.
(d.) Using MDP for dynamically optimizing the network operation to fit the physical condition result in significantly improved resource utilization.
(e.) MDP Model allows a balance design of different objective.

4. DISADVANTAGE OF MARKOV PROCESS

(a.) The prior knowledge of system model are needed
(b.) The complexity of method implementing in non-Markov systems.

5. APPLICAION OF MARKOV DECISION PROCESS

White, D.J. (1993) mentions a large list of applications:

(a.) Harvesting: how much members of a population have to be left for breeding.

(b.) Agriculture: how much to plant based on weather and soil state.
(c.) Water resources: keep the correct water level at reservoirs.
(d.) Purchase and production: how much to produce based on demand.
(e.) Queues: reduce waiting time.
(f.) Finance: deciding how much to invest in stock.
(g.) Robotics:

i. A dialogue system to interact with people
ii. Robot bartender.
iii. Robot exploration for navigation

(h.) Wireless Sensor Network (WSN): As mention in research[5,6], following are application of MDP

I. Data exchange and topology formulation

a. Data aggregation and routing: MDP models are used to obtain the most energy efficient sensor alternative for data exchange and gathering in cooperative multi-hop communications in WSNs. Different parameter can be included in the decision making for i.e. transmission delay, energy consumption, and expected network congestion.
b. Opportunistic transmission strategy: MDP model determine next transmission level, hence the MDP model help to select the minimum transmit power for the sensors to reach the destination. The effects of MDP are energy consumption and the interference among nodes.
c. Relay selection: When the location and distance information is available at the source node, a relay selection decision can be optimized by using simple MDP-based techniques to reduce the energy consumption of the relay and source nodes.

II. Resource and Power Optimization

a. Energy Control:
For the energy charging of sensors, an MDP is used to decide on the optimal time and order of sensor charging.
b. Dynamic Optimization:
A sensor node should optimize its operation at all protocol stack. E.g. data link and physical layer.
c. Duty Cycling & Channel Access Scheduling:
MDP based Methods predicts the optimal wakeup and sleep pattern of the sensors.

6. SECURITY AND INTRUSION DETECTION SYSTEM IN MAS USING MDP

One method for the detection of intrusion vulnerable node is based on MDP. This is done by analysing the correlation among sample collected from the node. Thus the intrusion and instruction free samples are traced by an Intrusion Detection System (IDS).MDP based security methods are develop to analyse the attacking entity behaviour to select the optimal security configuration. Markov Decision Making Model for IDS contains.

State(S): {Attack Types}
Action (A): Select Protecting Action
Reword(R): Attack Detection

Algorithm 1. Intrusion Detector Mechanism using Markov Process

1. Start
2. Execute Markov process
3. Check Event type (Active, Inactive)
4. If (event Request = Active && assign task execute) then no intrusion under multiagent system
5. If (event Request = Active &&Attack executes) then select protection action
6. End if
7. End if

To check whether agent is in active state or not first markov process is execute. Output of Markov process is agent state prediction, which is either active or not. If current agent is active then is returns 1, or if agent is inactive then it returns -1. If agent is active and doing his own task means agent is not misbehaving within multiagent system. If agent is not doing his task and doing strategic attack under multiagent system then using markov decision policy attack detection and protection action is made. As per algorithm 1, following Fig 1.shows execution of Markov Process under MAS. Here Agent1, Agent2, Agent3 are get initialized. At the time of initializing agent, Markov process is also executed, which shows state of agent. In following Fig 1. Each agent is in active state. Hence, message is displayed on console" Agent is Active". Here agent is active means it return 1,

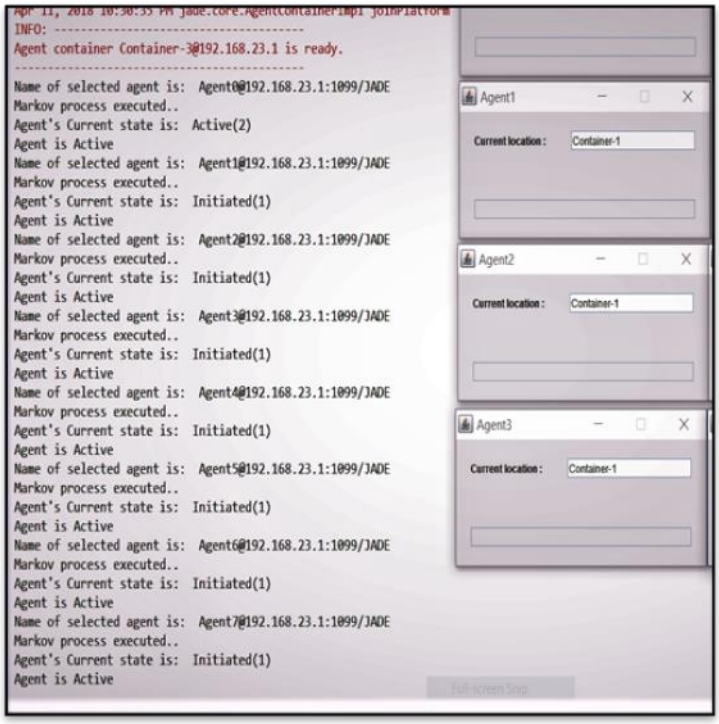

Fig 1. Execution of Markov Process under MAS

7. FUTURE WORK

The output of markov process will be used as input for stability analysis under multiagent system. Stability analysis will determine whether the multiagent system is under attack or not.

CONCLUSION

In this paper, markov process and its parameter like state, action and reword for decision making model is studied. It also highlighted application of markov process in various area such as agriculture, robotic and wireless sensor network which can be control by multiagent system. Finally, it define intrusion detection mechanism using markov process for maintain security under multiagent system.

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