Real-timeliness of Multi-agent System (AADL Simulation Latency Analysis)

Here, we illustrate that the proposed MAS architecture with dependency lists has enhanced real-timeliness compared to the standard MAS. In our proposed MAS, each agent maintains a dependency list with a list of agents it has to cooperate with for achieving the desired behavior. In a standard MAS, we assume that each agent has to cooperate with all other agents to achieve a consistent view of the environment before taking the desired action.

We simulated a miniature version of the system with 3 agents in AADL using OSATE tool and analyzed the system end-to-end latency requirements. The actions of each agent include detecting the event, updating its event list, synchronizing this event with other events, updating the event list again and finally taking the decision. We map all these sequences as separate threads in AADL. For the analysis, we assume periodic sampling for the sensors every 20 sec and all the communication occurs via two buses - Bluetooth and Internet with Bluetooth (Latency: 150 to 200 ms) and Internet (Latency: 50 to 100 ms).
In this system model, we analyze the cumulative decision-making time taking into account the agent synchronization and communication delays.

Case 1: With dependency list

Here we assume that Agent 1 (say fire agent) has only 1 dependency with Agent 2 and has no dependency with Agent 3, then the AADL model of the fire agent process has the following threads as defined below.

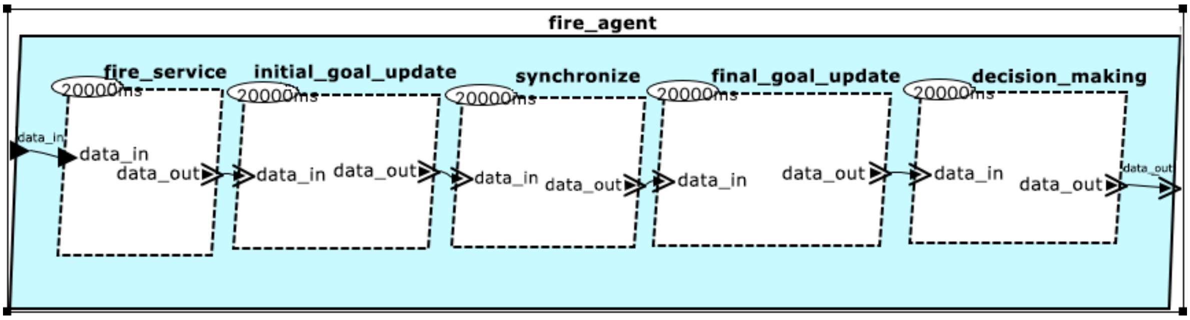

Fig.1 AADL model of the fire agent thread (illustrating Flow1)

All the threads are assumed periodic with a period of 20000 ms. For simplicity, we assume that period = execution time. Note that the ‘synchronize’ thread is the thread dealing with communication with other agents. We assume that synchronization with 1 agent takes a time of 20000 ms.

End-to-end-Flow	Latency
Flow 1	100,500 ms

Case 2: Without dependency list

In this case, we assume that the Agent 1 (fire agent) needs to synchronize with other 2 agents in the system to make a collective decision making. The threads are same as that of AADL model, however the 'synchronize' thread takes 40,000ms as it needs to synchronize with 2 other agents, hence the end-to-end flow latency analysis of the system are as depicted in table.

End-to-end-Flow	Latency
Flow 1	120,500 ms