Evaluating Multi Agent based Service Architectures for Call Admission Control

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Abstract—Multi Agent Systems find their use in various diverse domains where interaction, collaboration, cooperation, or negotiation with other agents and with the environment is required to solve a particular problem. In this paper we model call admission control as a multi agent system and attempt to evaluate the impact that the degree of distribution of agents and interaction models of multi agent architectures have on the call admission control performance attributes such as reactivity, responsiveness, message overhead, utility and resource utilization, as well as general quality attributes such as robustness, modifiability, and scalability. This knowledge becomes essential while choosing the correct MAS architecture to meet the specified service level agreement.

Keywords—Multi Agent Architecture, Call Admission Control, Cellular Networks

I. EVALUATING MULTI AGENT ARCHITECTURES

The degree of distribution of agents in multi agent based architectures affects performance characteristics according to the domain of implementation [1]. The work presented in this paper demonstrates this effect for the domain of MAS based Call Admission Control (CAC) for Service Level Agreement (SLA) guarantee [2, 3, 4]. The degree of distribution categorizes the architectures into Centralized Service Architecture (CSA) and Distributed Service Architecture (DSA) as presented in [4]. Network Provider Resource Agent (NPRA) acts as the controller agent for CSA that controls Network Provider Cell Agents (NPCA), whereas in DSA peer-to-peer communication takes place between NPCA-NPCA. [5]

The following sections presents the theoretical, or qualitative analysis of the influence, the degree of distribution of agents and the interaction models of these two multi agent based service architectures have on the performance related attributes for Dynamic-Call Admission Control [6]. The later section presents the experimental results of these qualitative analyses. The attributes can be defined as:

1) Reactivity ($T_{RVTY}$): It is a measure of how promptly the Multi agent architecture reacts to the event of call arrival at a particular NPCA cell and assigns the call. It can be defined as the sum of the times taken by the agents to interact ($T_{RES}$) (which is also called responsiveness), make a decision about call admission/rejection by calculating dynamic threshold ($T_{Thresh}$), and finally allocate a channel to the call ($T_{ALLOC}$), from the time of call arrival ($T_{ARRV}$).

$$T_{RVTY} = (T_{RES} + T_{Thresh} + T_{ALLOC}) \cdot T_{ARRV}$$

2) Responsiveness ($T_{RES}$): This is defined as the time for which the agents are involved in message passing. These interactions, which are in the form of request and reply, enable the requester agent to calculate the dynamic threshold according to D-CAC. Thus the responsiveness of this multi agent interaction is defined as the time elapsed from the sending of the first request message (performative) by an agent till the arrival of a response message from all its neighboring agents.

$$T_{RES} = \sum_{i=1}^{C} T_{INFORM} - T_{PROPOSE}$$

3) Communication Overhead: Communication overhead can be measured either by the number of messages exchanged,
during agent interaction or by the bandwidth required for allocation. Communication tends to be concentrated in smaller areas (localised) in DSA as compared to CSA.

4) Sustainability under high traffic conditions: This parameter is a measure of the ability of the architecture to sustain a higher traffic intensity while still maintaining the utility of the system. The user utility function is defined as the measure of the satisfaction level of the user with respect to a perceived quality of service. The higher the utility, higher the user satisfaction.

5) Utilization of resources: It is a measure of the efficiency of cell agents with respect to available resource utilization. It can be measured by the ratio of carried load to offered load at any point of time.

\[ U_T = \frac{L_{\text{Carried}}}{L_{\text{Offered}}} \]  

\[ L_{\text{Offered}} = (\text{New call arrival rate / cell}) \times \text{mean call hold time}. \]
\[ L_{\text{Carried}} = \text{Average no. of ongoing calls in each cell at any time} \]

6) Modifiability: It is the ease with which a system can be changed after it has been implemented or deployed. This is measured in terms of two parameters- first is the ease with which agents can be added/removed from the service architecture which depends on the of modularity i.e. coupling and cohesive nature of agents and second is the ease with which the CAC policies can be changed and congestion control be implemented. CSA scores over DSA in both the above mentioned parameters.

When new agents are added to a CSA system, the change is reflected only at the NPRA, whereas in DSA, addition of an agent changes the cluster dimensions, i.e. the number of clusters to handle or the size of the cluster for D-CAC threshold calculations. These changes need to be reflected at the every NPCA. Moreover, since the call admission decision-making is entirely with the NPRA in case of centralized architecture, NPRA can pass CAC schemes down to the NPCAs as policies. Since these policies change dynamically at the NPRA, each NPCA needs to change its local CAC strategies according to the NPRA's suggestions. The global view of the network, at the NPRA, makes manageability easier.

7) Scalability: Scalability can be measured by the change in performance parameters with increase in the number of NPCA agents. Scalability seems to be better supported by distributed architecture than centralized architecture. This is because the computational load of call assignment is divided between a number of NPCAs in a distributed architecture. Also, there remains no possibility of a communication bottleneck at the NPRA, thus responsiveness of the system is maintained.

8) Robustness: Robustness is defined by the vulnerability of the system to agent failures. Regarding robustness we conclude that more centralized the control is, the more vulnerable the system gets. This is because the system cannot perform call assignment, if the NPRA agent, responsible for centralized control fails. In a more distributed architecture, the assignment may function partially even though some NPCA agents have failed.
As seen in Figure 3 the time $T_{RVTY}$ by both the architectures increased almost linearly with increase in the number of cells. The CSA could not scale in terms of reactivity as time taken by it to react with increase in number of cell agents beyond 115 was very high. This was due to the bottleneck at NPRA whereas DSA performed relatively well.

Communication overhead in terms of number of messages per call remained constant at 9 messages for DSA as compared to only 12 messages for centralized architecture. It depended on various factors such as periodicity, round trip time of the communication that depended on the distance between the agents. As the NPCA cluster was a cluster of peer agents, they were present in the same container and thus, this localized nature of agents in DSA resulted in better reactivity.

The sustainability of the two architectures under high traffic conditions was tested by increasing traffic. The handoff call blocking probability was chosen as 0.055 towards QoS. It was observed that the DSA could sustain more traffic load as compared to CSA for the same handoff call blocking probability.

IV. CONCLUSION AND FUTURE WORK

MAS based NPCA cells are self-contained. The autonomous feature of these cells increases scalability and also robustness of the system. The results presented here point out the impact of each of the Multi Agent architectures on different types of QoS parameters. DSA reduces the response time, which in turn increases service availability, guarantee timely QoS and increase utility, whereas simplicity, modularity, and modifiability are achieved by using centralized service architecture. Thus the work highlights the effect of degree of distribution of agent in MAS service architecture on the system performance parameters for call admission control for cellular system.

Integrating congestion control schemes for cellular networks will further explore the full benefit of Multi Agent Systems. The multi agent interaction is of coordination type, since all the cell agents agree on distributed cooperation for D-CAC. One could explore QoS based negotiations amongst the agents.

REFERENCES


