Review on IMS-4G-cloud networks maintaining service continuity using distributed multi agent scheme

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Abstract: In the current networking field, research works are going on with the aim of providing user's desired QoS everywhere. This paper discusses the distributed multi agent scheme (DMAS) scheme used in the IMS-4G-cloud networks to support session (service) continuity. It explains the role of different agents which make use of knowledge sources in solving the problem and performing tasks. A Q-learning awareness algorithm is used to estimate the QoS by calculating cost function with the help of mathematical formulae comprising of QoS parameters like jitter, delay, packet loss, network resource availability, mobility and service fare parameter. Agents in the DMAS interact with each other and work cooperatively to provide both QoS and mobility information. Based on the type of information provided, two types of handoff came in to existence. A detailed explanation of these handoffs with phases is discussed in this paper. Finally, a comparison is made between general IMS handoff procedure and DMAS-IMS handoff procedure with the help of signal flow diagram.

Keywords: 4G; IMS; CLOUD; Q-learning algorithm.

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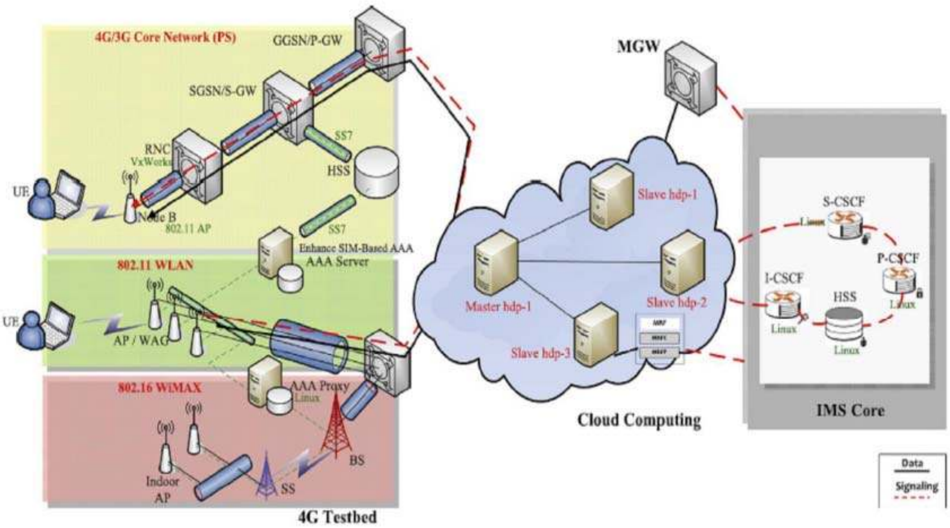
1 Introduction

The tremendous developments in the field of internet have led to many innovations in mobile computing and wireless communication technologies. Wireless communication has improved from providing only voice services to offering high speed data rates. Cloud computing system in the service domain, make the service application to disperse from single to several domains and with the help of distributed computing technology, it provides many new services (Glitho, 2014). Besides these, a newly emerged technology IP multimedia subsystems provides several services like voicemail, voice over IP, etc. It also increases the experience of the end user in receiving application services. IMS provides policies regarding QoS and supports heterogeneous networks (Alamri and Adra, 2012; Camarillo and Garcia-Martin, 2007). IMS provides three important functionalities for a packet switching-based core network. They are maintaining QoS for service applications, providing charging mechanisms for using multimedia services and integration of all IP services. With the aim of providing high quality services, an IMS-4G-Cloud heterogeneous architecture is developed. Respective block diagram is shown as Figure 1. It combines 4G/3G, WLAN, and Wimax. 4G core network comprises of serving gate way (S-GW), packet data gate way (P-GW). IMS core comprises of S-CSCF, P-CSCF, I-CSCF, HSS.

Recently, cloud computing developed as a client server technology infrastructure and act as a platform for distributed service applications. Cloud computing has three different categories with in. They are software as a service (SaaS), platform as a service (PaaS), infrastructure as a service (IaaS) (Glitho, 2014; Nadjaran et al., 2014). Applications are accessed by user from the network with the help of SaaS. Resources needed by the user to enable the service application are provided by PaaS. IaaS is used for processing, storage, networking and other fundamental computing resources. In the integrated architecture in order to support QoS mechanism mobility management is very essential. General mobility management method only reduces the paging cost. Developments have been started to design new method for mobility management in the integrated architecture. Long handoff delay diminishes QoS performance. For IMS complaint management application server were used to enable service continuity and vertical layer handoff (Corradi et al., 2010; Lu et al., 2015; Chen et al., 2011; Suthar and Stolic, 2015; Buyya et al., 2013). A distributes multi agent scheme (DMAS) is proposed which act as a new artificial intelligence mechanism for IMS-based mobility management. DMAS comprises of several problem solving agents which are autonomous and solve typical problems (Larosa and Chen, 2011). All the available problem solving agents communicate and cooperate with each other. Several knowledge modules are also present. These modules are collaborated with a cloud database and used while performing problem solving tasks.

In Section 2, a discussion is made on QoS mechanism-based DMAS and then implementation of agents in proposed DMAS architecture is discussed in Section 3.

Figure 1 IMS-4G-cloud network architecture (see online version for colours)



2 DMAS scheme

2.1 *Quality of service mechanism*

By measuring and monitoring quality of service (QoS) parameters like network availability, bandwidth, delay, jitter, packet loss we can check whether an offered service level is achieved or not. Performance of the application is affected by each of these QoS parameters. A differentiated service mechanism guarantees QoS for internet users. Unlike perflow guarantees by the intServ mechanism (integrated service mechanism), multiple flows are mapped in to appropriate service class and it is denoted by a 6-bit differentiated services code point (DSCP) in the IP packet header. When a marked DSCP is recognised, specific treatment is given or per hop behaviour is performed according to the class priority of each network node along the path. By using delay, jitter, free resource delay, service fare and mobility, two functions named cost function and QoS function are defined. Packet loss, jitter, delay are expressed as the ratio of the value of specific parameter of the particular network to sum of the parametric value of all the networks. Mathematical formulas used for the calculation are

$$\begin{aligned} D^{\wedge} &= 1-\left[\text{delay}_j \Big/ \left(\sum\nolimits_{j=1\text{ton}} \text{delay}_n\right)\right] \\ L^{\wedge}1 &= -\left[\text{loss}_j \Big/ \left(\sum\nolimits_{j=1\text{ton}} \text{loss}_n\right)\right] \\ J^{\wedge} &= 1-\left[\text{jitter}_j \Big/ \left(\sum\nolimits_{j=1\text{ton}} \text{jitter}_n\right)\right] \end{aligned} \tag{1}$$

where D is the delay, L is the packet loss and J is the jitter. Further parameter like mobility cost is calculated by variable m which is the ratio of duration of user movement T to the user's life time connection (t). mb = (T / t). Based on the coverage area of UMTS, WLAN, WiMax and depending upon the values of T, M values varies between 0 and 1.

$$\begin{aligned} MB_{UMTS} &= \{1, \text{ for } T = 0; \\ &\quad\ 0, \text{ for } T = t; \\ MB_{WLAN} &= \{0, \text{ for } T = 0; \\ &\quad\ 1, \text{ for } T = t; \\ MB_{wi\max} &= mb \end{aligned} \tag{2}$$

When network resources are available network resource availability N equals to 1. Service fare parameter S is made constant such that it is 0 in case of WLAN and 1 in case of UMTS and WIMAX networks. Now, QOS cost function is defined by using all these parameters.

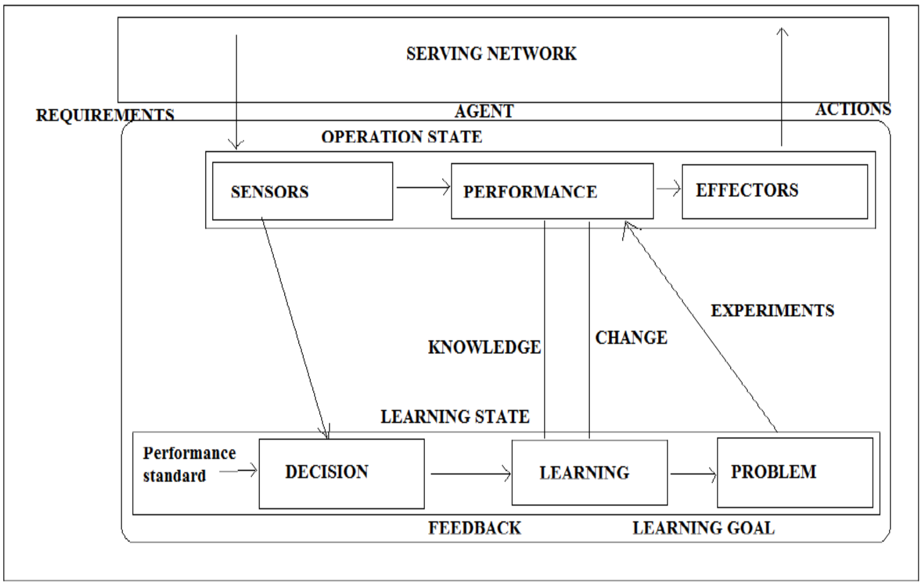
$$\text{Cost}_{QoS} = \left[(E * MB_n) + (B * + D^{\wedge}) + (H * J^{\wedge}) + (O * L^{\wedge}) + (k * S)\right] \big/ (N). \tag{3}$$

The weighing values E + B + H + O + K = 1.maximum QoS cost is 1. Accessing of a high quality network is denoted by a low value. From the cost function, we can get the operating value. With this value we can estimate Q-value by Q-learning algorithm and this Q value is further stored by DMAS knowledge source so that it can be helpful in finding the adaptive networks when QoS is not guaranteed by the original access network.

2.2 Intelligent agent

Intelligent improves the efficiency in problem solving by getting information about network behaviour and its patterns. Simply, agents are like software modules which have cooperative capabilities. Figure 2 explains the intelligent agent operation. When a learning agent executes an action during a certain status, a reinforcement value is rewarded to learning agent by the environment or it is punished.

Figure 2 Intelligent agent operation



2.3 Q-learning algorithm

Learning in this algorithm is enabled by reinforcement. At first the algorithm makes the system to monitor and record the rewards and then perform all possible actions in each state. The highest exceptive reward for an action in each state is R and it is given by Chopra (2010), Chang and Chen (2009) and Nadjaran et al. (2014).

$$R = Q(s_i, d_i) + \left[\beta\left\{e_{i+1} + \mu * \max Q(s_{i+1}, d) - Q(s_i, d_i)\right\}\right] \quad (4)$$

where exceptive reward given for the action d_i in the state s_i is given by $Q(s_i, d_i)$.e_{i+1} is the reward. μ is the discount rate. β value indicates weight of the reward just received and also learning rate of control convergence speed. β value is set to 1 usually by the system, which indicates the maximum weight for learning experience. When the state is stabilised learning experience parameter is set to zero. All the steps involved in Q-learning algorithm are shown as Figure 3.

The basic DMAS architecture for heterogeneous networking is shown in Figure 4. It consists of several network elements and agents which are the problem solvers and these are connected with one another and form a communication network. Agent also solves QoS policy related issues in heterogeneous networks. Agents must cooperate themselves to share database and solve the complex problems. In this architecture, QoS information's collected from each access network are sent to all other agents for learning and operations. QoS-pAgent sends QoS information to each agent in heterogeneous network (Hamdaoui and Venkataraman, 2011; Yanf and Larosa, 2011). QoS-dbAgent located in

IMS stores QoS parameters in HSS of IMS and in cloud database. It also displays all the QoS parameters through web interface. From the Q-learning reward set QoS learning agent selects one of the adaptive network (Glitho, 2014).

Figure 3 Q-learning steps

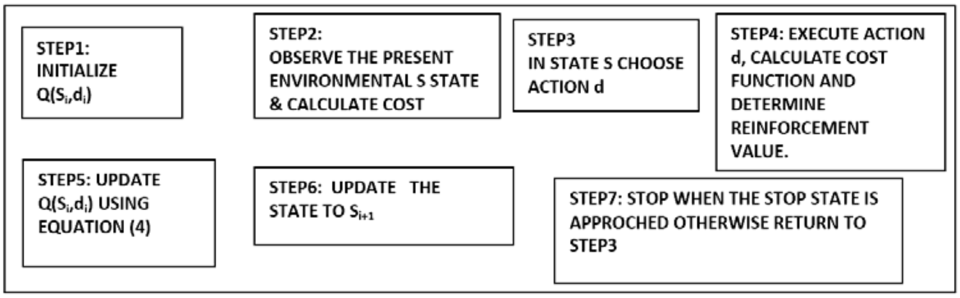
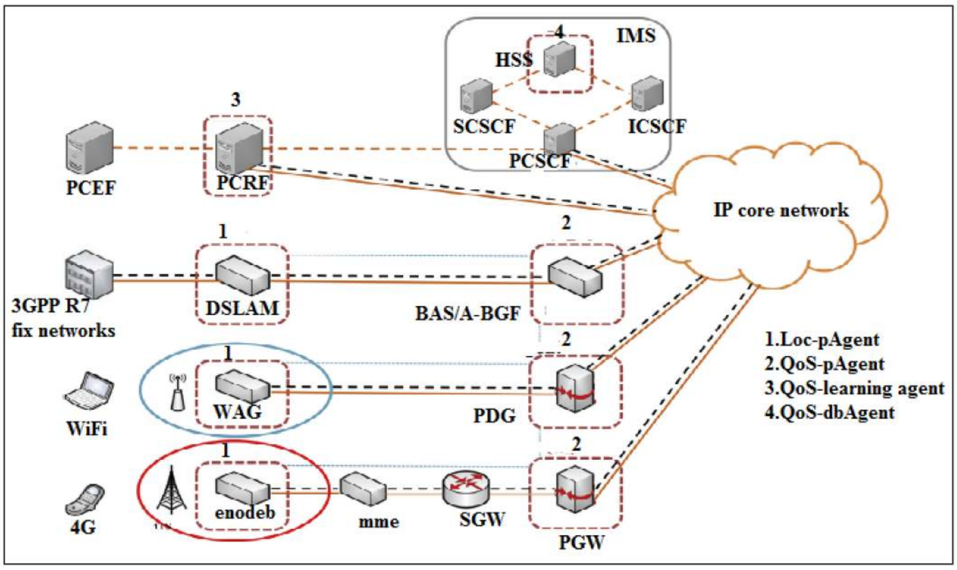
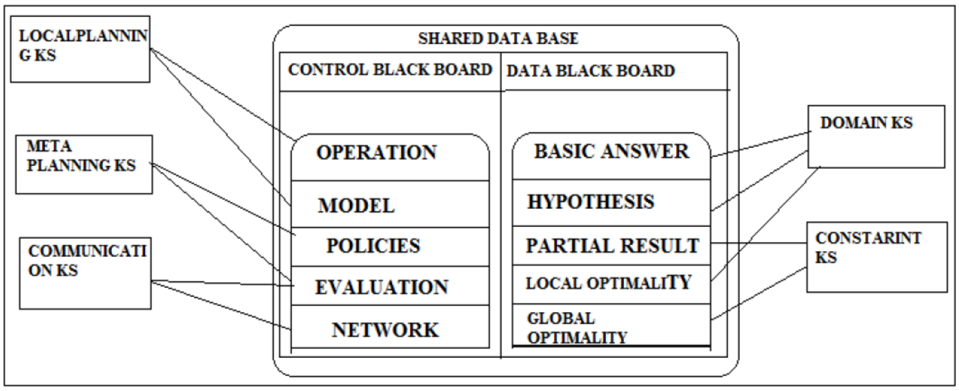


Figure 4 DMAS architecture for session continuity (see online version for colours)



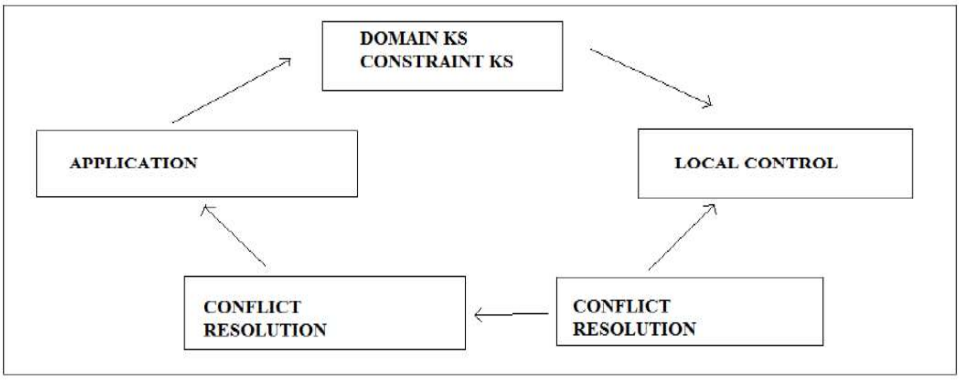
To solve the QoS policy issue each agent must cooperate with each other and compute autonomously. This idea can be realised by using modules. Respective block diagram and connections between the modules are shown in Figure 5. These are the modules having different knowledge and different in their way of approaching a problem and solving. There are five categories of knowledge source. Local planning KS obtain Information from QoS-pAgent. The information includes the partial results obtained during the problem solving by the agent. Meta planning QoS monitors maintain the global status and take decisions (Glitho, 2014). Communication KS receives results and then broadcast it in the network. Required criteria regarding bandwidth, i.e., allocated bandwidth is less than total bandwidth is defined in the application domain by constraint KS. The domain KS in a skilful way controls some rules like service priority, minimum bandwidth required for different type of traffic. Initially, after enabling DMAS scheme current is given to the test environment and then domain KS is given in to scheme from which suitable schedules which satisfy basic rule is found. In order to optimise the result some criteria has to define in the architecture.

Figure 5 Proposed DMAS paradigm



Some times in cloud black board system shares the KS when they work cooperatively to solve the problems. As a shared database it consists of data black board and control blackboard. The data black board which gives the results is classified in to five layers. They are basic answer, hypothesis, partial result, local optimality, global optimality. In order to increase the efficiency of inference process, the control board consists of operation, model, policies, evaluation and network layers (Glitho, 2014). Respective block diagram is shown as Figure 5.

Figure 6 Proposed control engine

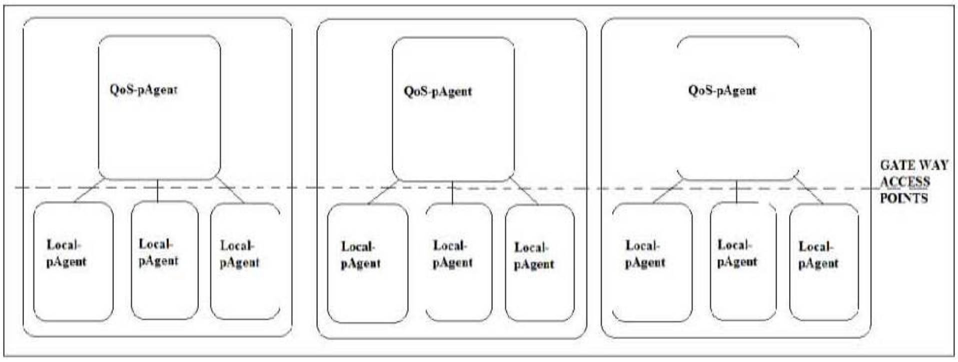


2.4 Control engine

When designing the multi agent cooperative system two issues were considered. The first one is optimal controlling problem solving agent and the second one is to transfer the partial results in to global optimal. The following were the steps followed by the control engine and respective block diagram is shown in Figure 6.

- domain and constraint knowledge are broadcasted to each QoS_pAgent which participates in the problem solving tasks
- based on the black board system each agent undergoes local control
- conflicts in the Q-learning algorithm are resolved by broadcasting partial or local optimal to the QoS_learning agent.

Figure 7 Proposed control engine



3 Service continuity with DMAS support

DMAS makes their agents to support session service continuity. Agent implementation in the proposed architecture is shown in Figure 4. QoS-pAgents are located at the boundary of IP core network and the gateway of each access network. In the each access network a local-pAgent is present at the other end and connected to QoS-pAgent hierarchically. This agent helps in finding the location of the user. QoS-pAgent control several Loc-pAgents and gets information needed for the continuity of service. Besides these, it also exchanges the location information of mobile node. The universal resource identifier gives information about their inter operation and its format follows as Local-pAgent@Qos-pAgent.General procedure for IMS handoff is shown in Figure 8. When there is an interruption in the data flow, mobile network triggers the IMS to start a new session. Now, dynamic host configuration protocol (DHCP) server allots the new IP address and a data link handover is happened (Glitho, 2014). Now, MN sends a register message to its corresponding S-CSCF which in turn forwards the request to the S-CSCF of the core network if and only if the user is authorised.

In the proposed session setup by the DMAS system three phases were identified. They are predictive, pre-registration and pre negotiation phase (Glitho, 2014). These can be further defined as two handoffs. The first one is change in the attachment points whenever there is reduction in the value of service quality and the second one is whenever user moves from the coverage area (as RSSI value decreases).

Figure 8 Conventional IMS-based handoff

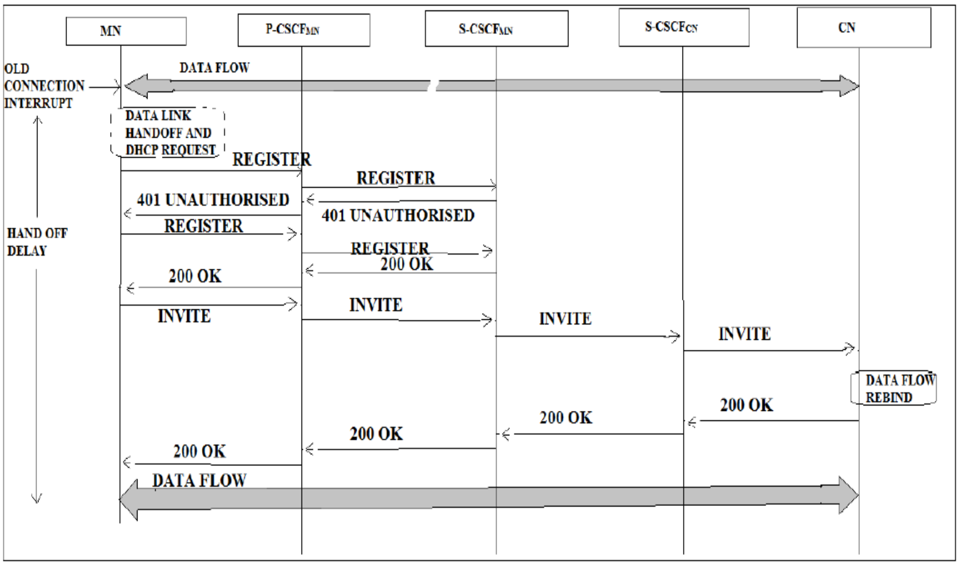
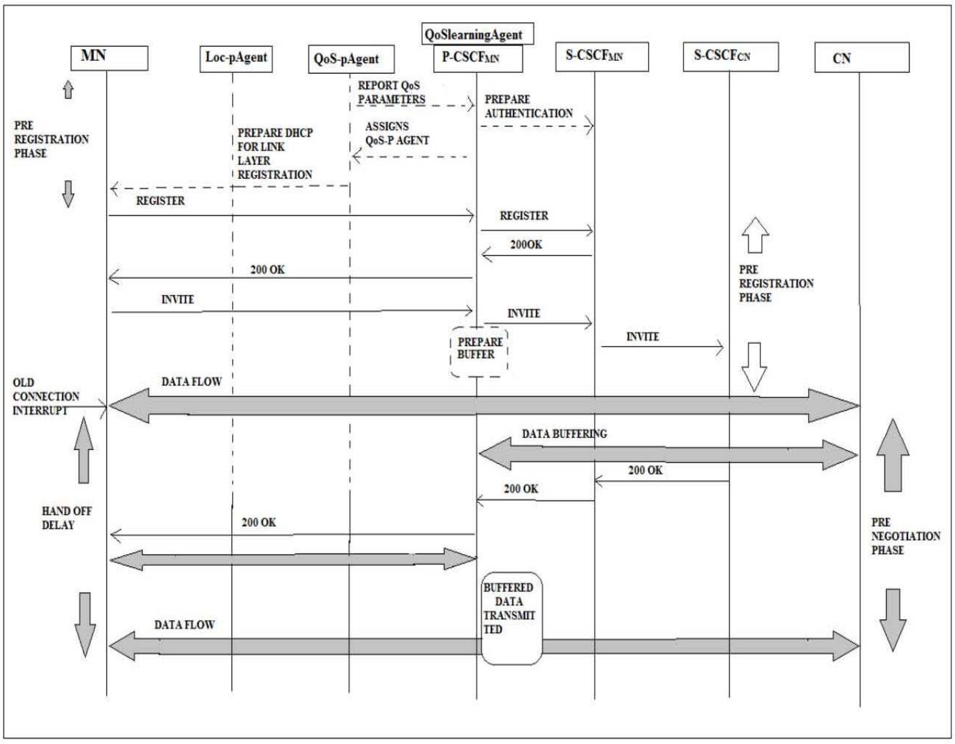


Figure 9 Proposed DMAS-IMS handoff



In first approach, QoS parameter of the current using network is analysed by all other QoS-pAgent. This is the predictive phase. QoS-pAgent checks the degradation in the QoS by interfacing with local-pAgent. All the updated parameters at the local-pAgent or QoS-pAgent are passed by the MN to the QoS learning agent. Updated cost is compared to the original (stored) QoS cost parameter in the QoS-dbAgent. The QoS learning agent replies to QoS-pAgent about the desired QoS cost for mobile network. This information is broadcasted to the neighbouring QoS-pAgent. The QoS-pAgent which satisfies the QoS cost request is considered as a new attachment point. During the pre-registration phase local-pAgent which is nearer to the original point of attachment of MN makes registration with the DHCP server to obtain new IP address. P-CSCF act as a data buffer whenever there is an interruption in data reception. QoS-pAgent itself prepares the registration with the S-CSCF.

In the second approach, during the prediction phase change in the mobility parameter in the cost function is monitored and then takes decision. In the pre-registration phase QoS learning agent find the network with large coverage area by querying the QoS-pAgent and further two phases follows the same mechanism as in the first approach (Glitho, 2014). A DMAS-IMS handoff is shown in Figure 9, which shows the reduction in the handoff delay when compared to general handoff procedure shown in Figure 8.

4 Conclusions

Distributed multi agent scheme (DMAS) helps in maintaining service continuity in heterogeneous networks like IMS-4G-cloud networks, etc., by using artificial intelligence, Q learning algorithm and the values obtained from cost function calculated with various QoS parameters like delay, packet loss, jitter, etc. Implementation of this DMAS scheme results in the less handoff delay when compared to general procedure followed in IMS handoff. Hence, this DMAS scheme can be implemented in any heterogeneous networks for service continuity with the desired QoS of the user.

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