# Enhanced AMC (EAMC) to Integrate Heterogeneous Wireless Systems


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*Abstract:* **Next generation wireless networks will offer more choice of access technologies to the end-user. Since there are multiple wireless technologies such as IEEE 802.11, UMTS, Bluetooth and Satellite Networks. These systems are designed for specific purposes and each network system has its own specification and characteristics, however such networks are required to coordinate with one another. This paper introduces an enhancement in the architecture of AMC (*Architecture for ubiquitous Mobile Communications*) for integrating such wireless systems. The basic need for enhancement is to eradicate the bottleneck condition. The AMC has two main components, NIA (*Network Inter-operating Agent*) and IG (*Inter-working Gateway*). The Enhanced AMC architecture proposes multiple NIA, which will diminish the bottleneck situation as well as load on NIA will be distributed. For the proposed solution, the Inter-NIA communication is considered and analyzed. Also the inter-NIA handoff scheme is introduced, that will work on the basis of load on NIA. If the load on NIA increases more then the defined threshold, the hand-off will take place between NIAs. Thus, the process of handing-off between the NIAs will reduce the load on NIA and load will be balanced among multiple NIAs. Therefore, the components of NIA also involve an additional component name "*NIA database*". This component will have the information about all the existing NIAs and the status of each NIA. All of the NIAs will be communicating with each other, asking their individual load, thus the NIA database will be updated automatically after responses have been received. Two algorithms are also proposed, one for inter-NIA handoff and the other is for NIA load-update process. Ultimately with the help of mathematical analysis it has been proved that there is additional load on single NIA, therefore if we have multiple NIA it will have very rare chances of bottleneck, because it is using multiple NIAs instead of single agent. Also the proposed system will use the best features of selected network as well as eliminate the weaknesses of other networks.**



**Keywords:**

Heterogeneous Networks, Quality of Service, Networks Integration, load balancing, hand-off management


## I. INTRODUCTION:

Future wireless networks are expected to use features of each other. Therefore, it is the need of today's wireless environment to introduce some architecture for integration of such ubiquitous technologies. There are multiple wireless technologies such as IEEE 802.11, UMTS (Universal Mobile Telecommunication System), Bluetooth and Satellite Networks and all such systems use different radio technologies. Each network system has its own specification and characteristics and these systems are designed for specific purposes. Such networks are required to coordinate with each other. Thus new architecture is required to integrate such wireless systems.

Since each system has its specification and characteristics, therefore each system is designed for providing specific Quality of Service (QoS) parameters. Each of the network system has its own QoS parameters. For example, WLAN may have better signal quality within its domain due to short coverage area, as well as Satellite Network system have larger coverage area. Thus each network system has its own specific Quality of Service parameters.

Each of the network operators are required to have Service Level Agreement (SLA) with one another. In the previous systems, each network had one-to-one SLA with each network, but the architecture proposed by [1] had reduced significant amount of SLAs. In this architecture each network operator is required to have one SLA with AMC.

Thus, if it is desired to utilize the best features of such network systems, they must be integrated. When all such networks are connected then the problems of best network selection and mobility management arise.

Rest of the paper is organized according to the following scheme. Section-II is about related work, Section–III includes the proposed architecture, section–IV describes the proposed solution showing the flow diagram and proposed algorithm and Section–V presents mathematical performance analysis to prove the motivation of this research.

## II. RELATED WORK:

Some work related to integration of different networks has already been done. But still this area requires more advancement. As identified by [1], most of the researchers have tried to integrate pair of wireless systems. Such as [2], the SMART project uses two different network systems to integrate.

### A. *Previous AMC Architecture:*

In the previous AMC architecture proposed by [1, 3] there is only one NIA (Network Inter-operating Agent), which communicates with each of the IG (Inter-working Gateway). Thus the NIA is the single point of communication with all IGs. When the hand-off will take place between two network systems, the IGs of those network systems will communicate with the NIA. Thus NIA is the single point of communication and thus making bottleneck situation.

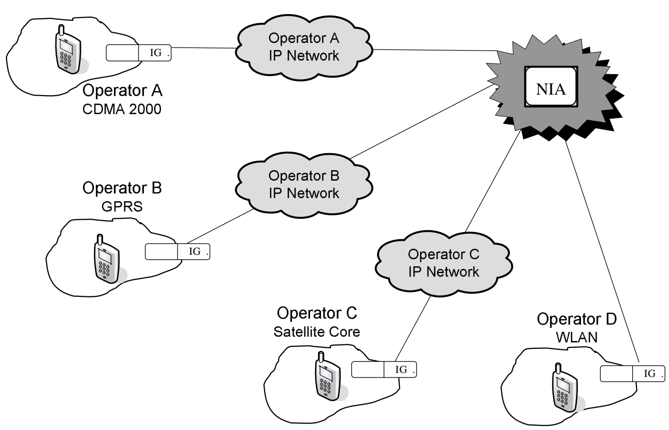


Fig.1 NIA-based integrated architecture for heterogeneous wireless systems [1]

### B. *Components of NIA & IG:*

The components of previous AMC are NIA & IG. NIA and IG further have components which are shown in Fig. 2(a) and (b) respectively. [1]

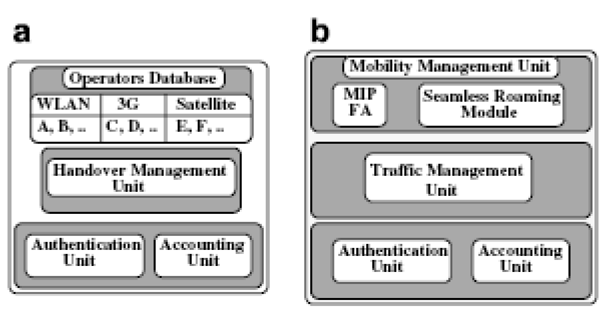


Fig. 2. Logical diagram showing the subsystems of the NIA and IG.

The components of NIA are shown in Fig. 2 (a)

<u>Operator Database:</u>

It includes information about all the network operators which have Service Level Agreement (SLA) with NIA. Therefore, those network operators are part of this architecture.

<u>Handover Management Unit:</u>

This component involves the decision making process about the inter-system handoff (ISHO) should be allowed or not. The ISHO algorithm was proposed by [3], which is responsible for decision making.

<u>Authentication & Accounting Unit:</u>

As its name suggest, this component is used to authenticate the users, who are moving between different networks. The Accounting unit is used for billing purposes.

The components of IG are shown in Fig. 2 (b):

<u>Mobility Management Unit:</u>

This component of IG is responsible for implementing Mobile IP (MIP) [4]. To implement the MIP functionalities, it uses Foreign Agent (FA).

In [1], to illustrate the authentication process they have used EAP-SIM [5], but there are other techniques like EAP-AKA [6], EAP-SKE [7], EAP-TLS [8], these techniques can be used rather then EAP-SIM

This component also has Seamless Roaming Module, which is basically responsible for seamless inter-system (between different network systems) roaming.

<u>Traffic Management:</u>

This is another component of IG, which is basically responsible for discarding the upcoming packets from the unauthenticated users

<u>Authentication & Accounting Unit:</u>

This is responsible for authenticating the user and for billing purposes respectively.

If there is only one NIA, it arise bottleneck situation, for this reason the architecture needs more then one NIA, which is our proposed solution.

If there are more than one NIA, then there must be some technique or strategy to handle the inter-NIA communication. For this purpose, all of the NIAs must be aware of each other, thus it includes additional component in NIA, which will have the information about all the existing NIAs.

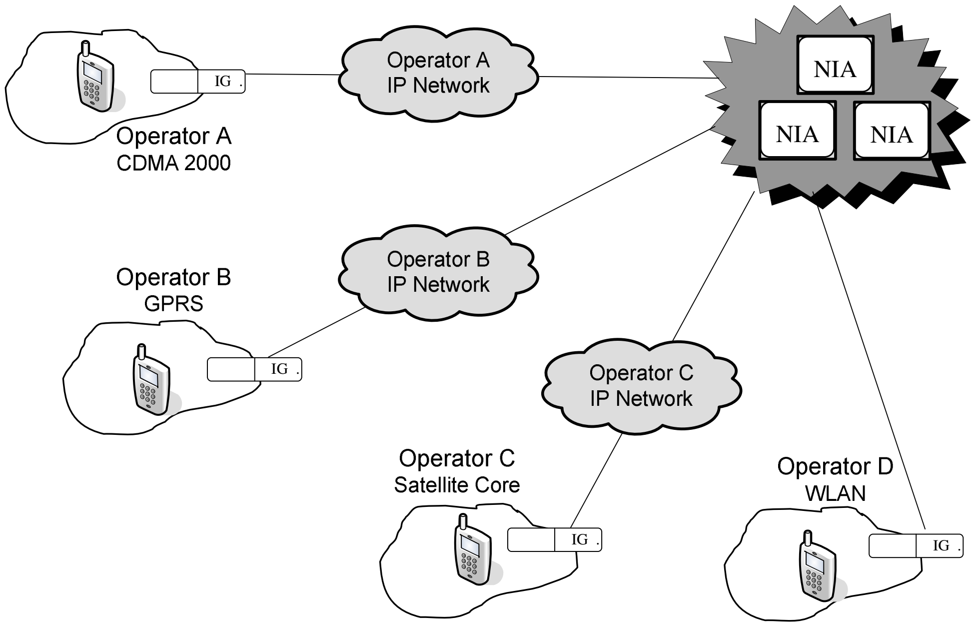


Fig.3. Proposed architecture, Enhanced AMC (EAMC)

## III. PROPOSED ENHANCED AMC (EAMC):

### A. *EAMC Architecture:*

Proposed architecture is the enhancement in the already defined AMC architecture. In proposed architecture, there are more than one NIA (that is multiple NIAs), reducing the bottleneck situation. The proposed architecture is shown in Fig. 3.

If we compare the proposed Enhanced AMC architecture to previous one (AMC architecture), we can see that new proposed architecture involves more than one NIA, therefore it is diminishing the bottleneck situation.

Thus now when we have more than one NIA, it requires Inter-NIA communication about hand-off. Thus all of NIAs have information about each other. Each NIA has information related to status of each NIA and the load on NIA. These NIAs communicate with other.

The status of NIA is stored in database (described in the next section). The information related to NIA is updated after fixed specified period of time. NIAs also communicate with each other on the basis of load on NIAs.

The load on NIA is monitored, if it increases more than the defined threshold value, then it checks the status of other NIAs. Then it compares the loads of each NIA, and the NIA with minimum load in selected for handing-off.

### B. *Components of EAMC:*

There are two components of previous AMC architecture, which are NIA (Network Inter-operating Agent) and the (Inter-working Gateway) IG (See previous section or [1, 3]). The NIA of AMC is the central coordinator, where as IG component reside at each network operator.

Similarly the components of EAMC (proposed solution) also include NIA & IG, but the difference is, there is an additional component of NIA, named as '*NIA Database*'.

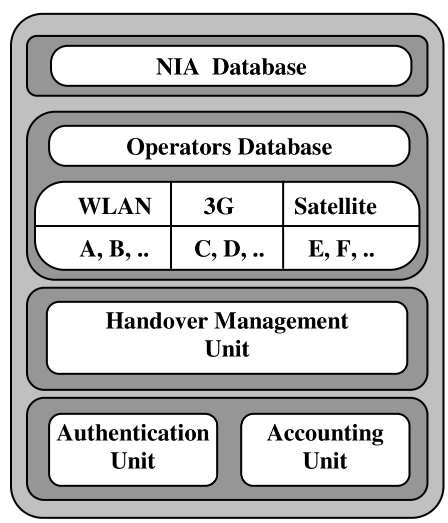


Fig. 4 Components of EAMC-NIA

This component is basically the database / repository, in which all the information related to existing NIAs is stored. Also the status of NIA is stored as well as the information related to load on NIA is also present here. The components of EAMC-NIA (Proposed Solution) are depicted in Fig.4.

## IV. Proposed Solution For EAMC:

The flow diagram of 'inter_NIA handoff' is illustrated in Fig. 5.

It basically continuously monitors the load on NIA. If the load on NIA (denoted by *Load*) exceeds then the threshold value (denoted by $L_{th}$), then, it will check / get the status (load values) of all existed NIAs from the '*NIA database*' component.

Then it will compare all the load values, and the NIA having minimum load (denoted by $L_{min}$) will be selected, and the inter-handoff initiation will take place.

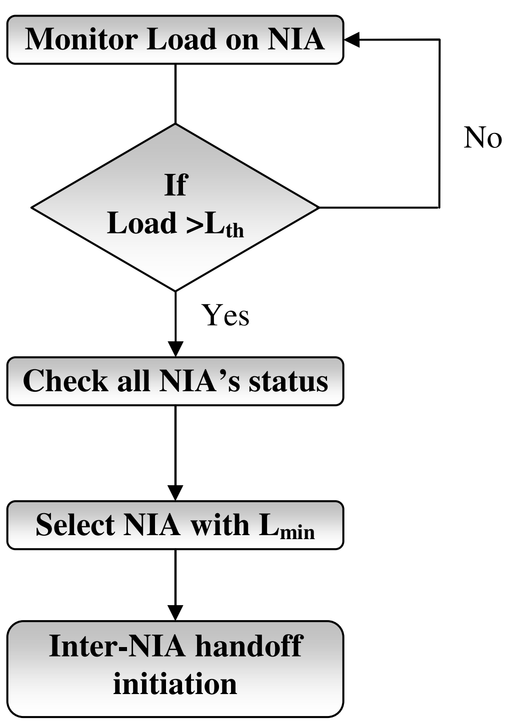


Fig.5 Flow Diagram of Load Management & inter-NIA handoff

When the process of decision making is considered to select NIA that have the minimum load. There are different ways to calculate the load and make decision on selecting NIA with minimum load.

The process of checking load on each NIA can be done in two ways. One way is to calculate load on the basis of number of operators under each NIA or based upon the bandwidth usage (based on actual load).

When we consider this scenario (number of connected operators) for finding the minimum load, it entails a problem, if one NIA is transmitting traffic which is mostly consisted of real time data and the other NIA is just transmitting very little amount of real time data and more data is non-real time.

It does not matter, that how much number of operators is connected with each NIA, rather we can calculate the load based upon the type of traffic it is transmitting and bandwidth usage.

This scenario can be better understood with the help of example. If NIA-1 has 5 number of operators connected to it, and NIA-2 has 8 number connected operators. But suppose NIA-1 is using 30 time slots (TS) and the NIA-2 is utilizing 26 time slots (TS).

Thus on the basis of above mentioned scenario, the NIA-1 will be selected as minimum, because it has less number of operators attached to it. If we actually look upon the load on NIAs, then NIA-1 is heavier than NIA-2, because it is occupying most of the bandwidth by utilizing more time slots.

This problem can probably be solved by calculating the time slots used by each NIA. The NIA which is using more time slot is the busiest NIA, where as the NIA with minimum time slots usage has the minimum load, because it is occupying less bandwidth. Thus the NIA selection is based upon the number of time slots it is using.

This process can be better understood by the algorithm, which is presented in proceeding section (in Fig. 6):

### A. *Inter-NIA Handoff Algorithm*:

The proposed algorithm is based upon the load on NIA. It constantly monitors the load on NIA. Here L denotes the load of the NIA on which algorithm is running at that time and the $L_{th}$ is the fixed threshold load value, that is already predefine.

Thus if the load on NIA (L) increases than $L_{th,}$ then it initiates the process of getting the loads of other NIAs. It gets the values of load on each NIA from the database, which is denoted by n_TS (number of time slots). It compares all the values of n_TS and then selects the minimum n_TS, because the NIA which has minimum load will have the minimum value of n_TS.

Here we are considering the loads based upon the time slot each NIA is using. The NIA acquiring minimum time slots has the minimum load. Therefore, the NIA which has minimum Time Slots is selected.

Then after selecting the $NIA_{min}$ that is NIA with minimum load, inter-NIA handoff initiation takes place. When the inter-NIA handoff is initiated, then the load on $NIA_{min}$ is incremented, because the node which was requesting for hand-off is acquiring some of the bandwidth. Thus the time slots used by that node will be added to the load of selected NIA.

```
Monitor_NIA ( )
    If (L > L_th)
       for i=1 to N
            get n_TS [i] from Database
       for i=1 to N
            NIA_min = Find MINIMUM (n_TS)

    else
         monitor_NIA ( )

  Select NIA_min
  Inter_NIA_handoff_initiation ( )
  Increment load on NIA_min
```

Fig. 6. Inter-NIA handoff

```
update_load ( )
       for i=1 to N
                 n_TS[i] = count TS
       for i=1 to N
                 INSERT n_TS[i] in Database
```

Fig. 7. DB_Update Algorithm

### *B. Database Load Update Algorithm:*

Since there is a need to maintain the database and updating the status of each NIA in database. Therefore another algorithm (See Fig. 7) for broadcasting the load request and updating the loads values is proposed. This is described in the proceeding section

When this algorithm will run, it will get value of time slots (denoted by TS) used by each NIA. These values are stored in the array named n_TS (Number of time slots).

Then each value in an array will be stored / inserted in the database. Now when the load on NIA will increase than the defined threshold value, then it will get values of NIA's load from the database, in which values of loads are stored by this algorithm. The proposed algorithm will run on each NIA after some fixed specified value of time. This algorithm is necessary for updating the values of load on each NIA.

## V PERFORMANCE ANALYSIS

To measure the load on NIA in AMC, [1] only considers on the ratio for Horizontal and vertical handoffs from 3G to WLAN network. But, we must consider handoffs from other networks, like from Satellite to WLAN etc.

If we consider one subnet of 3G network, and we denote the number of cells by R, then the crossing rate in 3G networks as described by [1] is:

$$R_{sg} = \frac{\rho_g \, v \, \boldsymbol{L_b}}{\pi} \quad (1)$$

Here $\boldsymbol{L_b}$ is the perimeter of one subnet of 3G network, $v$ is the average user velocity and the $\rho_g$ is the user density of 3G network. Similarly, if we consider the crossing rate between different networks, like from WLAN to 3G or Satellite to 3G:

$$R_{dwg} = N_w \frac{\rho_w \, v \, \boldsymbol{L_w}}{\pi} \quad (2)$$

$$R_{dgs} = N_g \frac{\frac{\rho_g}{N_g} \, v \, \boldsymbol{L_g}}{\pi} \quad (3)$$

$$R_{dsg} = N_s \frac{\rho_s \, v \, \boldsymbol{L_s}}{\pi} \quad (4)$$

Here $N_{w}$, $N_g$ and $N_s$ are the number of networks for WLAN, 3G and Satellite Network Systems respectively. $\rho_{w}$, $\rho_g$ and $\rho_s$ are the user densities for WLAN, 3G and Satellite Network Systems respectively.

Therefore, we have vertical handoffs as follows from equation (2), (3) & (4):

$$H_v = \left( N_g \frac{\frac{\rho_g}{N_g} v L_g}{\pi} \right) + \left( N_w \frac{\rho_w v L_w}{\pi} \right) + \left( N_s \frac{\rho_s v L_s}{\pi} \right)$$

$$H_v = \frac{N_W \rho_w v \boldsymbol{L_w} + \rho_g v \boldsymbol{L_g} + N_s \rho_s v \boldsymbol{L_s}}{\pi}$$

The ratio between the total numbers of vertical handoffs to that of horizontal handoffs is illustrated as under:

$$\frac{H_v}{H_h} = \frac{(N_W \rho_w v \boldsymbol{L_w} + \rho_g v \boldsymbol{L_g} + N_s \rho_s v \boldsymbol{L_s}) / \pi}{(G_s \rho_g v \boldsymbol{L_b}) / \pi}$$

$$= \frac{N_W \rho_w v \boldsymbol{L_w} + \rho_g v \boldsymbol{L_g} + N_s \rho_s v \boldsymbol{L_s}}{G_s \rho_g v \boldsymbol{L_b}}$$

The ratio for vertical handoffs would be much lager than the horizontal handoffs; therefore the load on NIA will be increased. Thus it requires more than one NIA, so that the load can be distributed among all NIAs.

## CONCLUSION

The proposed system is the enhancement in the AMC architecture, named EAMC (Enhanced AMC). The proposed architecture diminishes the bottleneck situation as found in the previous AMC architecture. EAMC also have two components NIA & IG. The NIA of the EAMC has an additional component named “NIA-Database”. It stores the status of each NIA and the value of load on each NIA.

Two algorithms are proposed, one for inter-NIA handoff. This algorithm will constantly monitor the load on each NIA, when the load on NIA increases, the threshold value, will be checked for the NIA with minimum load, and the handoff will be initiated. Second algorithm is basically introduced to update the load values of each NIA, in the EAMC-NIA component “NIA-Database”.

In the performance analysis section it is proved that there is increased load on single NIA, if we compare the ratio of handoffs, therefore, it requires multiple NIAs to diminish the bottleneck situation as well as to make efficient use of resources with the help of load balancing between NIAs.

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