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Seamless handoff in Next Generation Wireless System

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Abstract---

Next Generation Wireless system (NGWS) consists of heterogeneous wireless networks. The heterogeneous wireless network should be always best connected in order to satisfy the seamless characteristics in mobile communication. NGWS call for the integration and interoperation of mobility management techniques in heterogeneous networks. One of the research challenges for NGWS is the design of intelligent mobility management techniques to achieve global roaming among various access technologies. This paper presents the survey of various existing system and the need to provide best service in the (NGWS). Also the current state of mobility management in NGWS is presented and NGWS architecture for mobility management is introduced, and related open research issues are discussed in detail.

Keywords—

NGWS, cellular system, handoff management, Seamless handoff, cross layer optimization.

I. INTRODUCTION

Currently, various wireless technologies and networks exists that capture different needs and requirements of mobile users. For high-data-rate local-area access, wireless LANs (WLANs) is satisfactory solutions. For wide-area communications, traditional and next-generation (NG) cellular networks will provide voice and data services. For worldwide coverage, satellite networks have been used extensively in military and commercial applications. As discussed in [2] since different wireless networks are complementary to each other, their integration will empower mobile users to be connected to the system using the best available access network that suits their needs. The integration of different networks generates several research challenges because of the following heterogeneities:

A. Network Architechture and protocols

NG wireless systems will have different network architectures and protocols for transport, routing, mobility management, and so on.

B. Access technologies

NG wireless systems will include many heterogeneous networks using different radio technologies as described in [1]. These networks may have overlapping coverage areas and different cell sizes, ranging from a few square meters to few square kilometres.

C. User Demands for different services

Mobile users demand different services ranging from low-data-rate non real time applications to high-speed real-time multimedia applications offered by various access networks.

The design of intelligent mobility management techniques is to achieve global roaming among heterogeneous networks taking into consideration all above future heterogeneities to make this roaming seamless, the integration and interoperation of heterogeneous mobility management techniques with efficient support for both intra and inter domain roaming are required. Some proposed mobility management techniques try to support mobility associated with intra domain roaming. However, these solutions have high signalling load and long handoff delay for inter domain roaming. Therefore, we advocate new mobility management architectures for a heterogeneous environment that reduce both intra and interdomain signalling load and handoff delay.

II. NEXT GENERATION WIRELESS SYSTEM (NGWS)

NGWS is the system formed by integration of various heterogeneous networks from micro cell to macro cell i.e. from Bluetooth to Global satellite network. Before enhancing ahead we will first understand the cellular system concept.

Normally a practical cell is considered to be a circle but to think on it ideally the boundary portions of any radial cell cannot be captured easily due to the gap after integration of various cell. So on part of this a hexagon is assumed to be the largest area covering the practical cell and capturing the gaps after integration of cells too.

Figure 1 shows single cell with hexagonal as the estimated area and circle as practical cell area and Figure 2 depicts the estimated and practical cell after locating them beside each other.

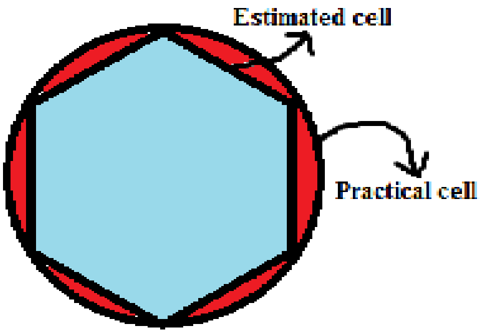

Figure 1. Single cell

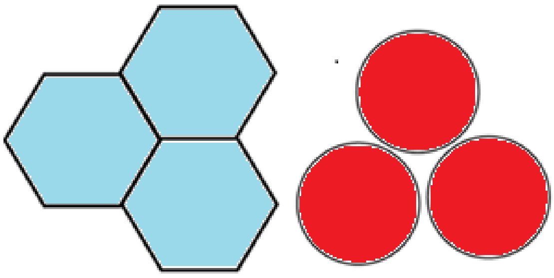

Figure 2. Radial and Hexagonal cell concept.

Cells can be integrated in various forms either partially or totally. Such overlapping has generated the cellular system with three concepts:

A. Un overlapped and equal size cell
B. Partially overlapped and equal size cell
C. Fully overlapped with unequal size cell

For Above two systems there are various existing solutions developed in order to provide seamless characteristics. But when it comes to the third system concept i.e. actual NGWS , various issues like handoff failure and call blocking probability, Quality of service, location and handoff management arise that need to be overcome by enhancing the existing proposed system.

Now we will overview the above concepts, compare them and add on some criteria's so as to

Provide seamless characteristic like minimum handoff latency, low packet loss, minimum handoff failure in NGWS.

A. Unoverlapped and equal size cell

Such cellular system is also known as homogeneous network. Figure 3. Depicts the scenario of homogeneous network where all the cell size is equal and cells are not overlapped. In such case intra system handoff can be easily achieved as complexity of the network is less. Also inter system handoff can be accomplished with seamless characteristic.

One of the existing proposed solutions for seamless handoff in such system is discussed in [5] where it is considered that if the Mobile Station (MS) moves with constant radial speed, the handoff failure probability will be zero for the time taken to travel from its position to boundary. Each cell is served by the Base Station (BS) and when the MS moves out of the coverage of BS handoff takes place. In homogeneous network of hexagonal honeycomb we can estimate from the position the new BS to which MS has the highest probability of moving to. For each 60° section there is a 1:1 correspondence of new base stations.

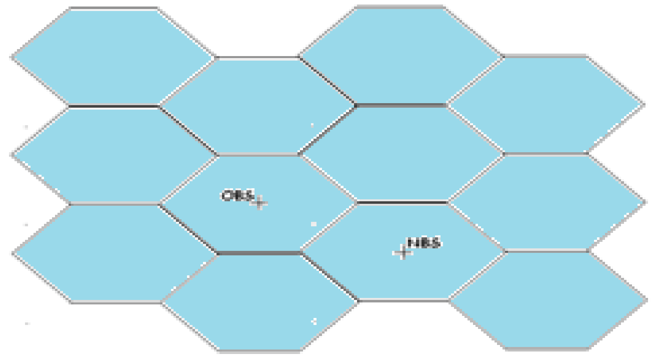

Figure 3. Homogeneous network

Thus minimizing the probability of handoff failure and there with packet loss in unnecessary discovery with new BS as shown in Figure 4.

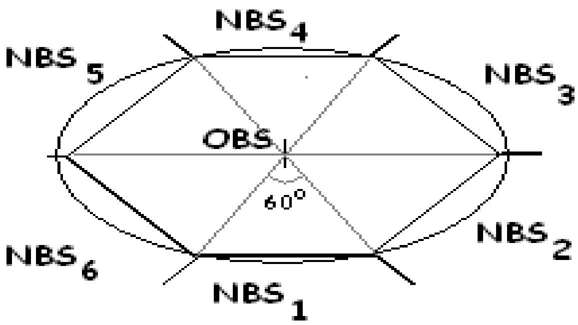

Figure 4. Movement of MS prediction from OBS to NBS

B. Partially overlapped and equal size cell

Previously, we have discussed why the shape of the cell is considered to be a regular hexagon. We have seen two cells overlapping as described in [5] in such a manner that the common cord between two adjacent circular cells also becomes the common side of the regular hexagons, when the cells are considered to be hexagons. However, two cells may overlap in such a way that there is some overlapping hexagonal portion between them. Such type of structure is given below in Figure 5.

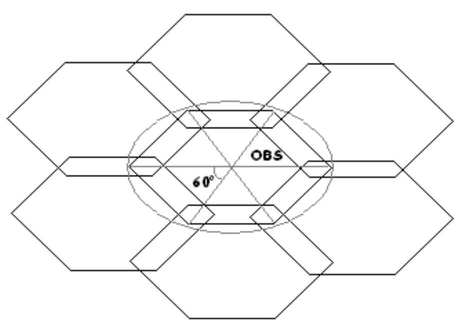

Figure 5. Partially overlapped cells with equal cell size

To minimize false handoff probability as described in [7] we have here in Figure 6. AB is the side of regular hexagonal cell served by the Old BS (OBS). But *A*'*B*' is the common cord of the two adjoining cells, one served by the OBS and the other by the NBS. When a MS crosses *A*'*B*', then it will be under the New BS (NBS). This is because RSS of NBS is greater than RSS of OBS to the right side of *A*'*B*'. Once the MT reaches the boundary of the circular cell (real) then the MT discovers that it may enter into the coverage area. Here, we have considered some hexagonal portion to be overlapping. MT is moving from its current serving BS (old BS), to the future serving BS (new BS).

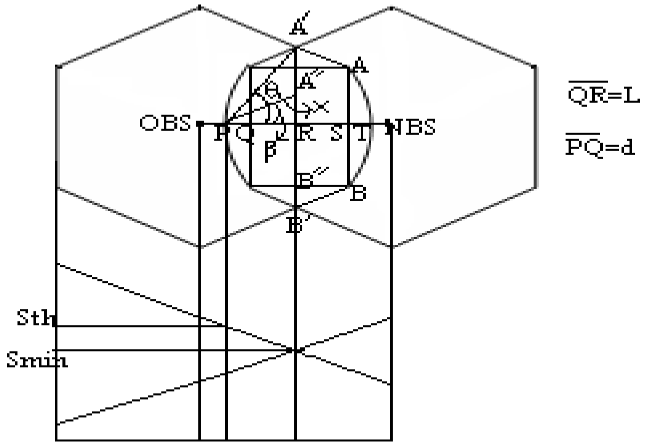

Figure 6. Two hexagonal cells overlapped partially.

The performance analysis shown in [7] specifies that as the value of L increases probability of false handoff increases. Hence it is clear from above that probability of false handoff depends mainly on L i.e. the distance between one hexagon side and common cord of two hexagons rather than the value of d i.e. the distance between the real cell and hexagonal side. Thus with this even if the cell's are equal, the cell size also matter as it becomes complex to analyze false handoff if the cell size is small. So this leaves again a future issue to reduce the complexity of handoff procedure with respect to the cell size.

Above two concepts (handoff in un overlapped and partially overlapped cells) can be easily analyzed for handoff process but still there exists handoff delay and call blocking probability which can be reduced by the proposed system shown in [3] and [4].

Handoff procedure consists of three processes:

1) Discovery or Scanning:

When a mobile station is moving away from its current BS, it initiates the handoff process when the received signal strength and the signal-to-noise-ratio have decreased significantly. The mobile station (MS) scans the channels which the new base station (BS) uses. The MS now begins MAC (Medium access control) layer scanning to find new BS's. It can either opt for a passive scan (where it listens for beacon frames periodically sent out by BS's) or choose a faster active scanning mechanism wherein it regularly sends out probe request frames and waits for responses.

2) Authentication:

Authentication is necessary to associate the link with the new BS. Authentication must either immediately proceed to association or must immediately follow a channel scan cycle. In pre-authentication schemes, the MS authenticates with the new BS immediately after the scan cycle finishes.

3) Registration or Re-association:

Re-association is a process for transferring associations from old AP to new one. Once the MS has been authenticated with the new BS, re-association can be started.

Handoff delay occurs because of the delay in discovery and authentication process in the crucial handoff region. According to [9], 90% of the handoff delay comes from channel scanning. One of the most important reasons of handoff failure is the handoff latency caused by channel scanning and excess wireless traffic. Many methods have been proposed in order to minimize handoff failure, but handoff failure is still an issue unsolved in the cellular world Proposed system in [3] to minimize the handoff failure probability by effectively placing a WLAN AP in the handoff region between two neighbouring cells as shown in Figure 7. We also perform the channel scanning (required for horizontal handover between the two base stations) within the WLAN coverage area, thus minimizing the handoff failure due to scanning delay.

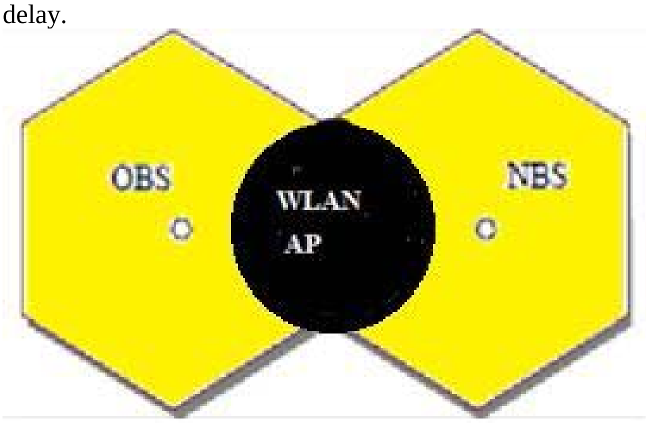

Figure 7. WLAN placed between critical handoff regions

In normal handoff, if the scanning process is time consuming due to high traffic density, the mobile station leaves the handoff region before establishing connection with new BS, resulting in handoff failure. Here, the scanning process is conducted inside the WLAN coverage area such that the scanning delay is completely eliminated from the handoff scheme as it no longer affects the handoff failure probability. However, future works can be done on improving the traffic distribution between the BS and WLAN, so that handoff failure can be eliminated completely.

Similarly call blocking probability can be reduced by adding auxiliary stations as described in [4], Here, a method is proposed which attempts to reduce handoff failures in mobile networks without significant increase in blocking probability of originating calls within a cell. A Mobile Station (MS) on entering a new cell requests a channel from the Base Station (BS) for continuing the existing call. However, if no such free channels are available, then a handoff failure is said to occur, i.e. an existing call is dropped. This failure probability may be reduced if the handoff request is served by an Auxiliary Station (AS) as shown in Figure 8. closest to the MS when no free channel from BS is available. However, the main purpose of the auxiliary station is to provide channels for the originating calls in its area. Thus assigning channels of these AS for handoff would lead to increase in blocking probability of originating calls. So, to prevent this unwanted increase in Blocking Probability, the MS which is occupying a channel of the AS will try to changeover to a channel under the BS at the earliest possible opportunity. This method also ensures that there is no need for repeated handoffs as the MS moves inside the cell from one AS to another. Thus the probability of failure in handoff is reduced.

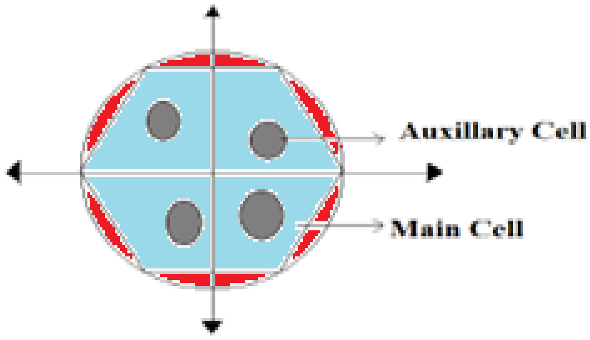

Figure 8. Auxiliary Cell and Main cell

We know, Blocking probability of new calls
= number of originating call rejected / number of originating call
Also, the handoff failure probability
= number of existing call dropped / number of MSs coming into the cell
Now, by applying the AS we can effectively reduce the number of rejected originating calls as well as the number of dropped existing calls. So the Blocking probability of new calls and the handoff failure probability both are reduced simultaneously approach may result in handoff failure when all the channels of the nearest AS will be busy. To find the nearest AS one can follow pre-scanning method but that may increase the expenditure. Such limitations can be effectively eliminated using mobility measurements of the MS involved in handoff as future research.

C. Fully overlapped and unequal size cell:

We have reviewed various proposed system for partially overlapped cellular network. Those proposed system reduce handoff failure probability and call blocking probability as discussed above but complete elimination of handoff failure and call blocking is still a research issue. Fully overlapped cellular network is the integration of all heterogeneous network as where in equal or unequal size of cells are totally overlapped by unequal size of cells as shown in Figure 9. Figure 9 depicts that NGWS which has to full fill the requirement of both unoverlapped and partially overlapped cellular network with elimination of the issues faced with them. As discussed in un-overlapped cellular network the NBS was predicted depending on the mobile movement in the direction of 60^o .For fully overlapped the scenario can be kept same but only the angular value will be changed as per the cells overlapping from current BS to various NBS.

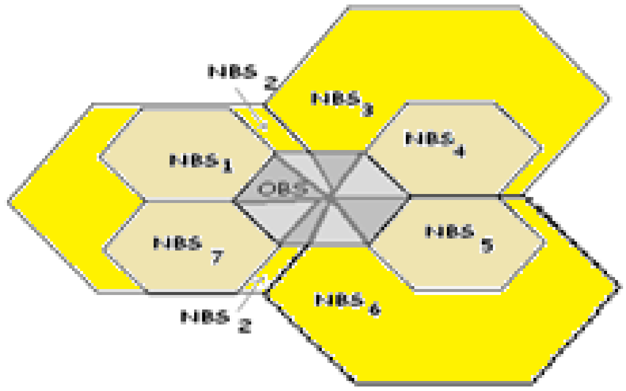

Figure 9. Fully overlapped heterogeneous network

All the proposed system discussed above can be used with this NGWS and some enhancement to the system can be done in order to provide seamless handoff in such heterogeneous system taking into consideration following cases:

1) Distance between the MS and BS:

When the MS travels away from one BS to another in such heterogeneous fully overlapped system, probability of false handoff can increase with the rise of call blocking probability and handoff failure. This situation can be overcome by taking into consideration the distance of MS from the BS beside it in the direction it is travelling and predicting the handoff to the BS it is closer to.
But this case alone won't satisfy the situation of handoff failure, so it needs to be assisted with other case parameters too.

2) Velocity of MS and Signal Strength:

The handoff management is performed at Network layer with the help of information provided through the Data Link layer. Such phenomenon is known as cross layer concept. Cross layer design in [6] makes the system available with the velocity and MS's position with signal strength from link layer to network layer and reduce the handoff delay and signalling load with advantage of pre known MS moving pattern. Velocity of MS can help make decision in predicting the NBS it will move to. If the velocity is more and distance from the BS station to which the MS is travelling is less than it can be predicted that NBS will be the same BS. But again issue of cross layer optimization needs to be resolved of how much coordination and co-operation resides between the layers.

For solving this issues all other cases also needs to be considered.

3) Size of cell:

To make predictions of the NBS from the mobile position remains fine with larger cell size and partially overlapped but complexity of prediction increases as the cell size reduces. As the cell size reduces, the failure probability and network complexity with traffic density increases. For Wireless overlay network where small cells are totally overlapped by large cell it is necessary to know the cell size and predict the NBS at the earliest in order reduce handoff failure.

4) *Traffic handled by the BS:*

With the knowledge of cell size, necessity to have pre-information about the traffic density is also important. If velocity of MS is high and cell size is less, in such case MS's handoff can be predicted to the nearest BS from its position. Now there appears the case of traffic that suppose if the MS travels to the nearest BS but the traffic handled by the BS is more and it is busy to handle other MS then there can be handoff failure. To avoid such situation traffic in the NBS and BS capacity should be considered beforehand which a future issue is again.

5) Service Time of Auxiliary Station (AS):

As we have discussed above if MS travels from current BS to NBS and if NBS is busy handling other traffic, in such case Auxiliary station can provide service to the MS for specified amount of time. As and when the main BS becomes free the service is avail from main BS. Here handoff failure is reduced but not eliminated as AS can avail service for specified amount of time only. After the time expires and still if the main BS is not free then the call is dropped resulting in handoff failure. To avoid this AS must be providing service till BS is busy.

6) Information on Base Station Antenna:

Antennas play a very important part in a communications system, coupling energy between a transmitter or receiver and the propagation medium. While an antenna can be as simple as a piece of wire, more suitable antenna designs are available. Matching the correct antenna to the set ensures maximum radiated power. In practice, different designs suit different applications, which have led to the design and development of a great many different types of antenna.

An antenna ideally has the following characteristics (particularly when deployed as part of a mobile communications system):

6.1 Directionality and gain:

A compromise must be made between saving transmitter power (having high gain) and requiring high alignment accuracy or directionality (difficult to achieve in the field).

6.2 Bandwidth:

The antenna should preferably not require readjustment when the frequency is changed (within limits of course).

6.3 Low side lobes:

The radiation pattern should have limited power in other than the desired direction to limit eavesdropping, direction finding, jamming and mutual interference.

6.4 Size:

Antennas should be small and robust for ease of handling. A base station antenna can be either: Omni antenna and Sectoring antenna where a GSM Omni antenna is a directional base station antenna and a Sectoring antenna is used in GSM cells that cover only part of the area around a base station. A Sectoring antenna often has a beam width of approximately 120 degrees.

NGWS can provide seamless handoff taking into consideration all parameters mentioned in the above cases. Along with this there can be some challenging issues which can be resolved by proposing system undertaking all cases discussed above and in [8] for optimization of decision algorithm for heterogeneous wireless system.

III. RESEARCH ISSUES

There are many challenging research issues related to mobility management for next generation wireless systems. These issues can be solved by improvement in cross layer optimizations. The issues are described as:

-Both the inter domain and intra domain mobility management solutions must work for partially overlapped as well as fully overlapped wireless systems.

-Next generation wireless systems will carry multimedia applications, including best effort real time traffic which have varying requirements which challenge the best effort service model with bandwidth, throughput, timeliness, reliability, perceived quality and costs which are foundations of Quality of service.

-Cross Layer Optimization for partially as well as fully overlapped heterogeneous system. Since global roaming in heterogeneous wireless environments will become an essential trend in near future, further investigation on cross layer optimization for mobility management is necessary.

IV. CONCLUSION

In this paper we have surveyed the cellular system along with the proposed systems for partially and unoverlapped cellular network in order to provide seamless characteristics such as reduce handoff failure, packet loss, handoff and signalling delay with Quality of service. All proposed system had reduced the drawbacks of existing system but not eliminated completely. So as to propose a system for NGWS i.e. Fully overlapped with unequal cell size, few parameters mentioned above in the paper are necessary to consider, where in each parameter needs to be co-ordinated with other in order to provide seamless handoff.

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