Minimisation of Hand-off Failure Probablity and False Hand-off Initiation in Low Latency Next Generation Wireless Networks

Koushik Kumar Nundy[1], Himanish Mukherjee[2], Debabrata Sarddar[3], U. Biswas[4], M.K.Naskar[5].

***Abstract*—This paper presents a method of reducing hand off delay and minimising handoff failure probability using available technology, without compromising bandwidth efficiency considerably, by altering and streamlining the functionality and task division of the contemporary handoff technique. This would result in fewer call failures and in congestion-free networks.**

***Index Terms*—NGWS, 4G Networks, handoff, intrasystem,**

I. Introduction

THERE is a need for reduced handoff time in Next Generation Wireless Systems (NGWS), since lower handoff periods would result in higher data efficiency and fewer handoff failures. This would cause fewer data packet losses resulting in higher QoS, which is a primary facet of NGWS networks. Moreover, 4G networks integrate certain microcellular networks, like IEEE 802.11, which requires quicker handoff because number of handoffs become exponentially higher and cell size dramatically drops with respect to macrocellular networks. Also effectively, the time spent in handoff cannot be used for useful data transfer. In this paper, we propose a mechanism to reduce handoff latency time and produce a handoff mechanism with failure probability tending to zero.

II. Method

Proposed methods in the literature have used velocity and position information using layer (2+3) of the mobile station ([1] and [3]), for both contemporary and NGWS networks. Here we use a simple approach based on the above mentioned technologies to reduce handoff failure rate by dividing the handoff procedure into two major subparts:

1) A General Part, which is same for all mobile stations, and
2) A Specific part, which is for each individual mobile station.

The general part includes sections like probability of movement to a certain New Base Station (NBS), based on location region. This can be saved in a tabular form as it is constant for all mobile stations. The specific part contains International Mobile Subscriber Identity (IMSI), authentication, etc. This part is considered the effective handoff delay in the scenario in discussion.

A. Basic cell patterns

Here for simplicity, we consider an intrasystem handoff in a homogenous honeycomb network.

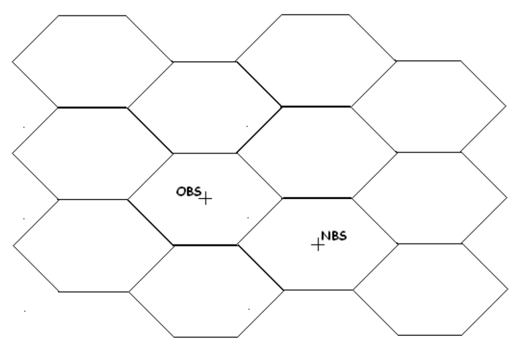

Figure 1. Honeycomb Homogenous network.

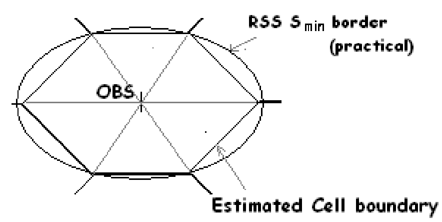

Figure 2. One Cell

For an intrasystem handoff we know the time required to perform the handoff. Let us consider it as τ_1. We may get the velocity and position of the mobile station using Doppler effect and received signal strength (RSS), from [2] and [3]. If we know the velocity, the total time delay for handoff and the cell size for RSS $\geq$ Threshold value, we can calculate the position from which we can optimally begin handoff.

If radial velocity of Mobile Station (MS) = v and effective radius of cell = r, then let us assume we need to begin the handoff at distance r_1 from OBS using circular cell. Therefore, $\frac{r-r_1}{v}$ = t_d is the time taken to traverse from given position to boundary.

The authors [1] & [2] are associated with NIT Durgapur, [3] & [5] with Jadavpur University and [4] with Kalyani University.
[1] kknundy@gmail.com
[2] himanish@sify.com
[3] dsarddar@rediffmail.com
[4] utpal01in@yahoo.com
[5] mrinalnaskar@yahoo.co.in.

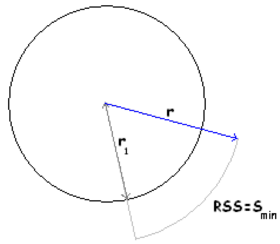

Figure 3. Radial distances from OBS for circular cell

For maximum efficiency, t_d -> τ_1.

For zero failure probability, t_d >> τ_1.

However, considering that MS is moving at constant radial speed,we can say that handoff failure probability is zero for t_d = τ_1 + Δt, where Δt is a tiny amount of time. With higher data efficiency (low latency) or low velocity, r_1 approaches higher value, with limiting case (ideal) being r_1= r, when latency time is reduced to zero. In a hexagonal honeycomb we can estimate from the position the new base station to which MS has the highest probability of moving to. For each 60° section there is a 1:1 correspondence of new base stations.

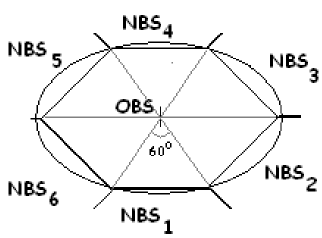

Figure 4. 1:1 NBS correspondence per 60° division

So we can proceed with parts of handoff like checking for channel availability without actually waiting for the detection of NBS from MS. Although this results in higher bandwidth cost, it causes moving of major handoff data to preregistration period,causing fewer data packet losses during actual handoff, resulting in reduced failure probability.

B. Bandwidth Offset

This approach however has a shortcoming. Due to considering only position and not direction of travel, false handoff probability is higher than usual. However there is a provision for low latency. This results in increase in r_1. This in turn reduces area of concern. This negates the previous effect to a certain degree as from lower area of concern, probability of moving to other new base stations is low thus reducing false handoff.

C. Overlapping factor

We see from the following figure that the 60° divisions remains same for similar honeycomb patterns, even if the cells overlap partially, as long as there is some semblance of

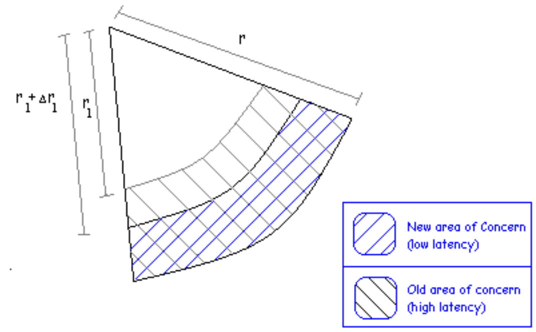

Figure 5. Old and new latency regions

uniformity *(Figure 6)*. Consequently, the 1:1 correspondence is still maintained in this case, between each 60°sector and the neighbouring NBSs.

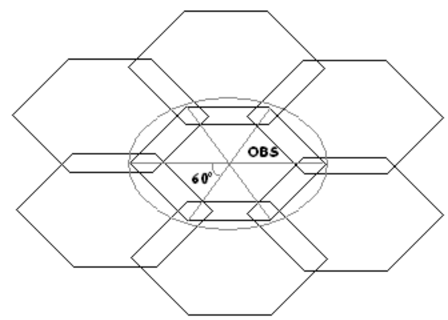

Figure 6. Overlapping cells

D. Unequal Cells

For cells of unequal size, the logic remains unchanged *(Figure 7)*. Only the aforementioned value of 60° changes according to the cell topography.

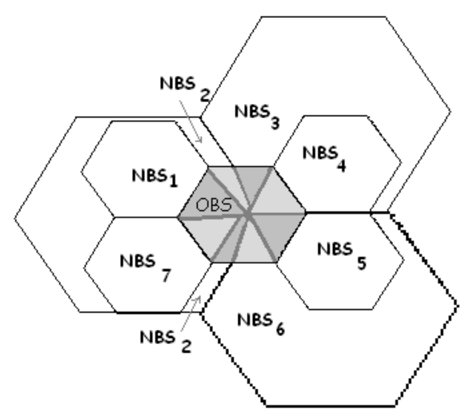

Figure 7. Unequal cells

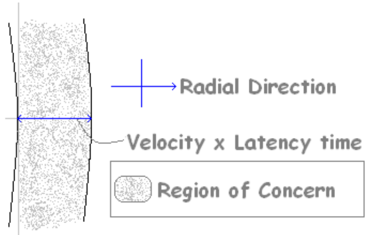

Figure 8. Region of Concern

III. Mathematical analysis

Considering radial velocity is outward, which is obvious (because, there is no requirement of handoff otherwise), we get a 180° band which is our region of concern for calculation of false handoff initiation linear invariant velocity estimation.

A. Low latency microcellular

1) Radius of circular cell = 20 m
2) Latency time = 100 ms
3) Speed (Outward radial) = 18 km/h
4) Starting point of handoff (distance from OBS) = 19.5 m
5) Point beyond which false handoff cannot occur (for 60° region explained in section II (A)) = 17.32 m

Thus, Probability of false handoff (for 60° region explained in section II (A)) = 0%

B. Low latency macrocellular

1) Radius of circular cell = 1000 m
2) Latency time = 100 ms
3) Speed (Outward radial) = 36 km/h
4) Starting point of handoff (distance from OBS) = 999 m
5) Point beyond which false handoff cannot occur (for 60° region) = 867 m

Thus, Probability of false handoff (for 60° region) = 0%

C. High latency microcellular

1) Radius of circular cell = 20 m
2) Latency time = 1 s
3) Speed (Outward radial) = 18 km/h
4) Starting point of handoff (distance from OBS) = 15 m
5) Point beyond which false handoff cannot occur (for 60° region) = 17.32 m

Thus, Probability of false handoff (for 60° region) = $\frac{180^o - 153.9^o}{180^o} \times 100\%$ = 14.5%

D. High latency macrocellular

1) Radius of circular cell = 1000 m
2) Latency time = 1 s
3) Speed (Outward radial) = 36 km/h
4) Starting point of handoff (distance from OBS) = 990 m
5) Point beyond which false handoff cannot occur (for 60° region) = 867 m

Thus, Probability of false handoff (for 60° region) = 0%.

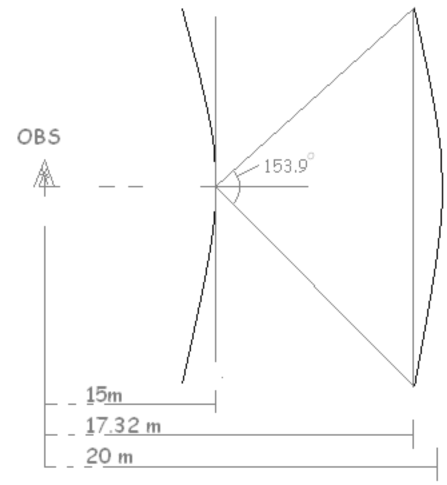

Figure 9. Geometric Representation of high latency microcellular

Hence, we can see that the problem of false handoff initiation discussed in II (B) is faced minimally (mostly in high latency microcellular networks). This, too, is not a major issue of concern, as we are considering low latency networks here. Moreover, in microcellular networks, we generally do not see mobile stations moving at velocities as high as 18 km/h. At a velocity of 9.65 km/h or below, the probability would be reduced to zero. So, the problem of II (B) is taken care of.

IV. Simulation

For varied values of velocity and cell size, in both high and low latency networks, we see how the false handoff initiation probability varies in figures 10 to 13.

As we can see above, the question of false hand off initiation arises only at very high velocities, more so for low latency networks. This is due to the reasons explained earlier in Section III. These speeds are rarely if ever reached and thus need not bother us.

Moreover, the minor shortcomings of this near perfect behaviour, is offset by the fact that our procedure accounts for zero handoff failure probability in practically all scenarios.

V. Conclusions

Thus we can see that by suitably restructuring the functional divisions as explained above, we can reduce the latency period, albeit at a minimally higher bandwidth cost, for a short period, which would be offset by the lower network congestion due to lower latency. This would then result in speedier handoffs, lower handoff failure rates and higher network efficiency. This behaviour would be present irrespective of the presence of overlap and heterogenous networks as explained above.

References

1) Shantidev Mohanty, "Architecture and Cross-Layer Mobility Management Protocols for Next-Generation Wireless Systems", PhD Thesis, Georgia Institute of Technology, December 2005.

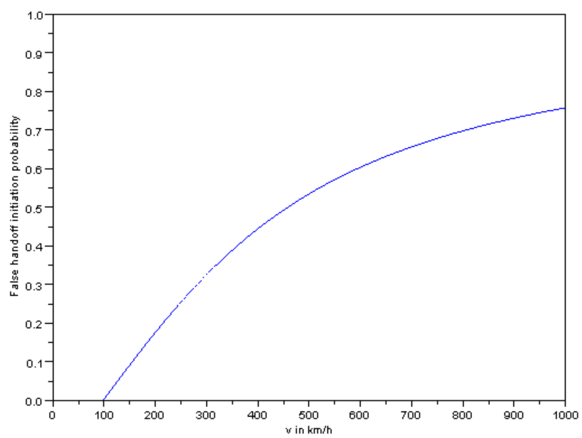

Figure 10. Low latency microcellular
t_d= 100ms, r = 20m.

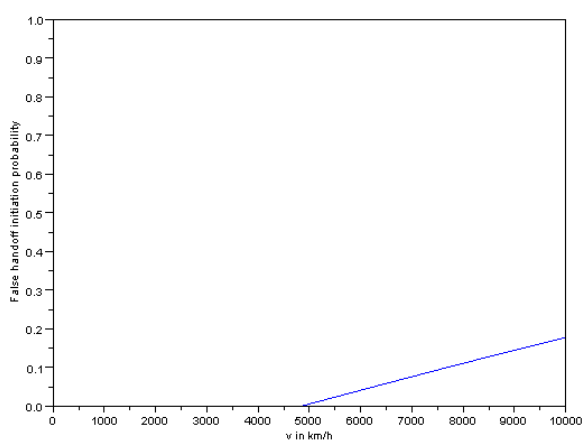

Figure 11. Low latency macrocellular
t_d= 100ms, r = 1000m.

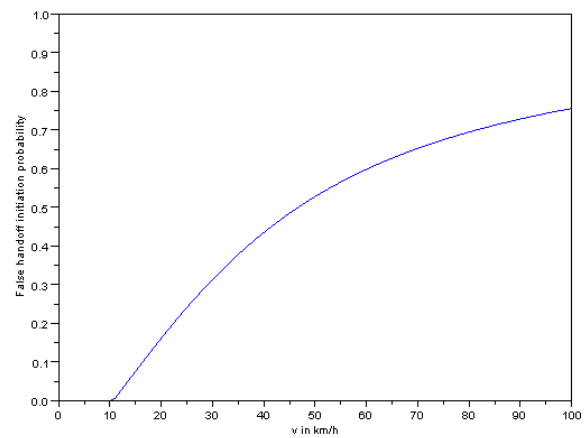

Figure 12. High latency microcellular
t_d= 1s, r = 20m.

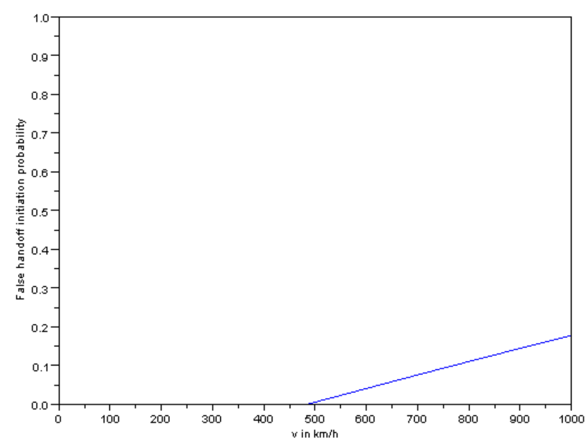

Figure 13. High latency macrocellular
t_d= 1s, r = 1000m.

2) Ravi Narasimhan and Donald C. Cox, “Speed Estimation in Wireless Systems Using Wavelets”, IEEE Transactions on Communications, Vol. 47, No. 9, pp.1357-1364 September 1999.
3) Ravi Narasimhan and Donald C. Cox, “Estimation of Mobile Speed and Average Received Power in Wireless Systems Using Best Basis Methods”, IEEE Transactions on Communications, Vol. 49, pp.2172-2183, No. 12, December 2001.
4) Janise McNair, Tuna Tugcu, Wenye Wang, Jiang Xie, “A survey of cross-layer performance enhancements for mobile IP networks”
5) Ian F. Akyildiz, Shantidev Mohanty and Jiang Xie, “A Ubiquitous Mobile Communication Architecture for Next-Generation Heterogeneous Wireless Systems”, IEEE Radio Communications,Vol. 43, No. 6, pp.529-536, June 2005.
6) I. Smaoui, F. Zarai, L. Kamoun, “An anticipated handoff management mechanism for next generation wireless networks”, Communications, Propagation and Electronics, 2008.
7) E. Stevens-Navarro, V.W.S. Wong, “Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks”, Vehicular Technology Conference, 2006.