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Evaluation of Dual Soft Handoff in a Seamless Roaming Environment

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Abstract - In this paper we try to see how dual soft handoff is effective in achieving higher efficiency in terms of dropping probabilities in relation to various distances and speeds along with consideration for different types of roads while selecting a combination of three emerging algorithms for Dual Soft Handoff. Moreover we go deeper into the actual workings of DSH with some results based on these parameters.

Keywords - *Mobile Communication, Wireless Communication, High Speed Wireless Transfer, Dual Soft Handoff, Moments of Handoff, Handoff Algorithms, Handoff Types*

1. Introduction

With the development of wireless technology, wireless local area network (WLAN) and mobile communication have been penetrated into all aspects of our life. Roaming is the general topic for mobile nodes (MN).Because of the limitation of sending power and coverage, handoff is necessary and frequent when a MN roaming in WLAN. IEEE 802.11 deploys hard handoff. It disconnects with the current access point (AP) at first, and then connects to new AP. There is a handoff interval during which MN can't send or receive any data. There are many studies on how to diminish this interval or how to buffer data and resend them after reconnecting. But the existing interval may be intolerable for real-time applications such as video monitor system, voice over IP (VoIP) and kinds of alarm systems. With this we are trying to introduce a solution for eliminating the interval without data link and providing seamless data transmission during roaming with high speed.

2. Handoff Algorithms

2.1 Conventional Handoff Algorithms

Handoff algorithms are distinguished from one another in two ways, handoff criteria and processing of handoff criteria. Figure 1 shows Handoff Algorithms at Glance.

2.2 Signal Strength Based Algorithms

There are several variations of signal strength based algorithms, including relative signal strength algorithms, absolute signal strength algorithms, and combined absolute and relative signal strength algorithms.

2.3 Relative Signal Strength Algorithms

According to the relative signal strength criterion, the BS that receives the strongest signal from the MS is connected to the MS. The advantage of this algorithm is its ability to connect the MS with the strongest BS. However, the disadvantage is the excessive handoffs due to shadow fading variations associated with the signal strength. In many of the existing systems, measurements for candidate BSs are not performed if field strength for the existing BS exceeds a prescribed threshold.

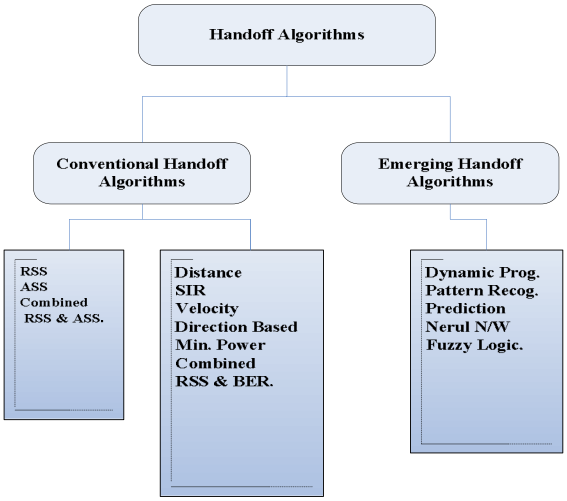


Fig 1: Handoff algorithm criteria

The disadvantage is the MS's retained connection to the current BS even if it passes the planned cell boundary as long as the signal strength is above the threshold. A variation of this basic relative signal strength algorithm incorporates hysteresis. For such an algorithm, a handoff is made if the RSS from another BS exceeds the RSS from the current BS by an amount of hysteresis.

2.4 Emerging Handoff Algorithms

2.4.1 Dynamic Programming Based Handoff Algorithms

Dynamic programming allows a systematic approach to optimization. However, it is usually model dependent (particularly the propagation model) and requires the estimation of some parameters and handoff criteria, such as signal strengths. So far, dynamic programming has been applied to very simplified handoff scenarios only. Handoff is viewed as a reward/cost optimization problem. RSS samples at the MS are modeled as stochastic processes. The reward is a function of several characteristics (e.g., signal strength, CIR, channel fading, shadowing, propagation loss, power control strategies, traffic distribution, cell loading profiles, and channel assignment). Handoffs are modeled as switching penalties that are based on resources needed for a successful handoff. A signal strength based handoff as an optimization problem to obtain a tradeoff between the expected number of handoffs and number of service failures, events that occur when the signal strength drops below a level required for an acceptable service to the user.

2.4.2 Pattern Recognition Based Handoff Algorithms

Pattern recognition (PR) identifies meaningful regularities in noisy or complex environments. These techniques are based on the idea that the points that are close to each other in a mathematically defined feature space represent the same class of objects or variables. Explicit PR techniques use discriminate functions that define (n-1) hyper surfaces in an n-dimensional feature space. The input pattern is classified according to their location on the hyper surfaces. Implicit PR techniques measure the distance of the input pattern to the predefined representative patterns in each class. The sensitivity of the distance measurement to different representative patterns can be adjusted using weights. The clustering algorithms and fuzzy classifiers are examples of implicit methods. The environment in the region near cell boundaries is unstable, and many unnecessary handoffs are likely to occur. The PR techniques can help reduce this uncertainty by efficiently processing the RSS measurements.

2.4.3 Prediction-based Handoff Algorithms

Prediction-based handoff algorithms use the estimates of future values of handoff criteria, such as RSS. Signal strength based handoff algorithms can use path loss and shadow fading to make a handoff decision. The path loss depends on distance and is determinate. The shadow fading variations are correlated and hence can be predicted. The correlation factor is a function of the distance between the two locations and the nature of the surrounding environment. The prediction based algorithm exploits the correlation property to avoid unnecessary handoffs. The future RSS is estimated based on previously measured RSSs using an adaptive FIR filter. The FIR filter coefficients are continuously updated by minimizing the prediction error. Depending upon the current value of the RSS (RSSc) and the predicted future value of the RSS (RSSp), handoff decision is given a certain priority. Based on the combination of RSSc and RSSp, hysteresis may be added if it will not affect the handoff performance adversely. The final handoff decision is made based on the calculated handoff priority.

2.4.4 Neural Handoff Algorithms

Most of the proposed neural techniques have shown only preliminary simulations or have proposed methodologies without the simulation results. These techniques have used simplified simulation models. Learning capabilities of several paradigms of neural networks have not been utilized effectively in conjunction with handoff algorithms to date. A signal strength based handoff initiation algorithm using a binary hypothesis test implemented as a neural network.

2.4.5 Fuzzy Handoff Algorithms

The fuzzy handoff algorithm has shown to possess enhanced stability (i.e., less frequent handoffs). A hysteresis value used in a conventional handoff algorithm may not be enough for heavy fadings, while fuzzy logic has inherent fuzziness that can model the overlap region between the adjacent cells, which is the motivation behind this fuzzy logic algorithm. It incorporates signal strength, distance, and traffic. The methodology proposed in this paper allows systematic inclusion of different weight criteria and reduces the number of handoffs without excessive cell coverage overlapping. A change of RSS threshold as a means of introducing a bias is an effective way to balance traffic while allowing few or no additional handoffs. A combination of range and RSS modified by traffic weighting might give good performance. Different fuzzy composition methods to combine the cell membership degrees of different criteria methods can be adopted.

3. Dual Soft Handoff

The Dual-Soft-Handoff scheme discussed in this topic is shown in Fig. 2.

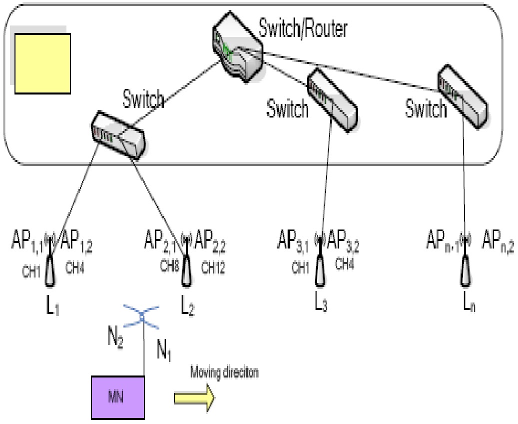


Fig 2: Soft-Dual-Handoff architecture

Network B is a large network connected by switches and routers. MN is the mobile node which can transfer data with nodes in Network B through APs along the line. Each access point has two APs with directional antennas mounted back-to-back. $AP_{i,j}$ is the AP at point L_i, and j shows its antennas direction:

j=1: It's opposite with MN's moving direction;
j=2: It's the same with MN's moving direction.
MN has two network cards (N_1, N_2) with directional antennas mounted back-to-back.

In topic, we put forward the Dual-Soft-Handoff scheme to support fast seamless roaming in WLAN.

When the MN moves from L_1 to L_2, it can receive signal from $AP_{0,2}$, $AP_{1,2}$, $AP_{2,1}$, and $AP_{3,1}$. The $RSS_{2,1}$ strengthens while $RSS_{1,2}$ lessens continuously. However, after the MN passes L_2, the $RSS_{2,1}$ falls to zero very quickly, and the $RSS_{1,2}$ keeps the link in a period of time. Therefore, N_1's handoff from $AP_{2,1}$ to $AP_{3,1}$ should be completed before arriving L_2. Data transfer is taken on by N_2 through $AP_{1,2}$ at this time. When the MN arrives L_2, $RSS_{2,2}$ is at its maximum and N_2 can find $AP_{2,2}$. N_2 needs to switch to $AP_{2,2}$ before $RSS_{1,2}$ is under the threshold. The MN has connected with $AP_{3,1}$ by N_1, so data communication is held by N_1 and $AP_{3,1}$. Fig. 2 describes the general process of DSH during the MN roaming from L_i to L_{i+1}. It includes two phases.

Phase 1 is the forward handoff, and the new AP (NAP) is in front of the MN. It includes:
1) Data transfer between N_2 and $AP_{i,2}$;
2) N_1 switches from $AP_{i+1,1}$ to $AP_{i+2,1}$.

Phase 2 is the backward handoff, and the NAP is in back of the moving MN. It includes:
1) Data transfer between N_1 and $AP_{i+2,1}$;
2) N_2 switches from $AP_{i,2}$ to $AP_{i+1,2}$.

Here one network card's handoff occurs while the other works normally, so the data link can't be interrupted.

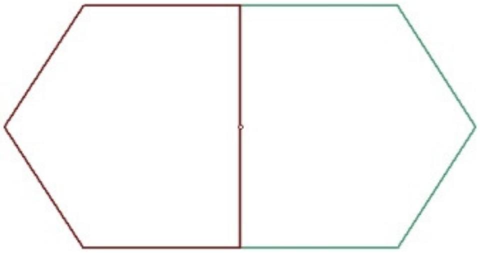


Figure 3 Directional attenuation's coverage

It includes two back-to-back APs. With directional antennas, AP's coverage is similar to a polygon, which is different from the omni-directional antenna.

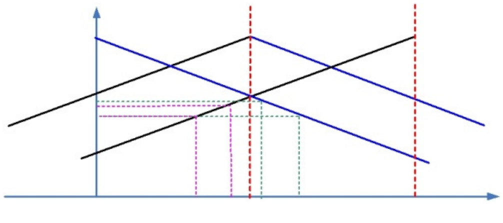


Figure 4 Receiving sig attenuation model of the MN

It describes the change of the signal strength of APs during the MN's moving. In Fig. 4, L_i is the location of AP; $RSS_{i,j}$ is the N_j Received Signal Strength of $AP_{i,j}$; T_i is the time MN passing L_i; t_1 is the time N_1 can switch; t_2 is the earliest time N_1 finishing switch; t_3 is the time N_2 beginning to switch; t_4 is the time N_2 must finish the switch; S_{min} is the threshold of N_1 to be able to probe a AP.There are different policies to handle the handoff while passing L_2 from L_1:

1) MN finishes the handoff only before the original AP (OAP)'s signal reaches the connection threshold.

2)MN switches immediately when new AP (NAP)'s signal reaches the connection threshold.

If we adopt the former, it has some risk of N_1's handoff not fulfilling accidently. So we choose the latter: N_1 starts its handoff at t_1, just since probing $AP_{3,1}$'s signal; and N_2 also starts handoff at t_3($t_3 = T_2$) when receiving signal from $AP_{2,2}$. This policy can ensure both the handoff and the data communication.

4. Dual Soft Handoff Specifics

4.1 Handoff triggering time

Using the immediate handoff policy, it's clear that the backward handoff to be triggered when passing the access point. But the triggering time of forward handoff is worthy researching. Fig.5 illustrates N1 and N2's handoff model.

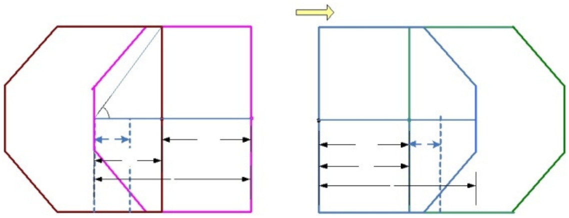


Figure 5. N_1's forward handoff and N_2's backward handoff

In Fig. 5, N_1/N_2 begin to switch at P_1/P_3, and finish switching at P_2/P_4; the distance needed for handoff is d; the distance from the switching point to the OAP is d_{th}; the distance between L_i and L_j is $D_{i,j}$; l is the AP's effective coverage; is the maximum deviation angle of MN's track.

4.2 Model for DSH

The program describes the major work of Soft-Dual-Handoff. It records moments and positions of handoffs, which are used to make later handoff trigger more accurately.

```
Dual_Handoff (int D_AB )
{ // $N_2$ takes charge of data transfer with $AP_{1,2}$
i = 1;
while ( dis_current() < D_AB ) { // D_AB=|AB|
if ( distance_fw () >= L_cov - distance_ap( i, i+1) )
  if ( probe(i, FW)==true) //find $AP_{i,1}$'s signal
  if ( trigger_handoff(N1, i, FW) == true) {
  Handoff(N1, i, FW ); // $N_1$'s forward handoff
  data_handover( N1 ); //$N_1$ takes over data transfer
  }
  if ( distance_bk () >= distance_ap( i, i+1) )
if ( probe( i, BK) == true) // find $AP_{i,2}$'s signal
  if ( trigger_handoff(N2, i, BK) == true) {
  Handoff(N2, i, BK ); // $N_2$'s backward handoff
  data_handover( N2 ); //$N_2$ takes over data transfer
  }i++;}}
```

4.3 Message flow in Dual Soft Handoff

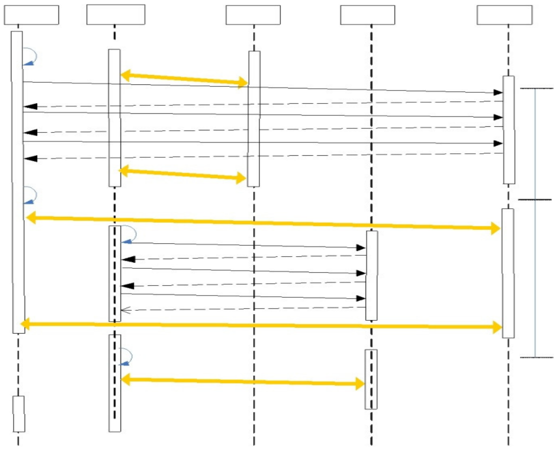


Figure 6 Message Flow in Dual Soft Handoff

4.4 Equations pertaining to DSH

If MN's velocity is *(t)* and passes the distance *d(t)* in a period of t ($\tau_1 \le t \le \tau_2$). The distance *d(t)* can be denoted as:

$$d(t) = \int_{\tau_1}^{\tau_2} v(t)dt \qquad (1)$$

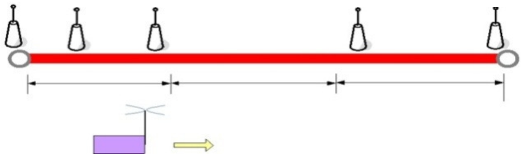


Figure 7 MN running at different speed in three stages

Fig. 5.4 is supposing that MN moves from station A to B, it goes through three stages: accelerating with the acceleration a_1; moving with even speed; decelerating with the acceleration $-a_2$. So we can get $v(t)$ and $d(t)$:

$$v(t) = \begin{cases} v_0 + a_1 t = a_1 t & (v_0 = 0, t \in [\tau_0, \tau_1], a_1 > 0) \\ v_{\max} & (\tau_2 \in (\tau_1, \tau_2)) \\ v_{\max} - a_2 t & (t \in [\tau_2, \tau_3], a_2 > 0) \end{cases} \qquad (2)$$

$$d(t) = \begin{cases} \frac{1}{2} a_1 t^2 & (t \in [\tau_0, \tau_1], a_1 > 0) \\ v_{\max}(\tau_j - \tau_i) & (\tau_2 \in (\tau_1, \tau_2)) \\ v_{\max}(\tau_j - \tau_i) - \frac{1}{2} a_2 t^2 & (t \in [\tau_2, \tau_3], a_2 > 0) \end{cases} \qquad (3)$$

If MN moves with the deviation direction , the distance is *d*.

$$d \le d(t) \sec \beta, \beta \in [-\theta, \theta] \qquad (4)$$

$$d \ge d(t) \cos \beta \qquad (5)$$

When $d = d(t) \cos \beta \ge d(t)$, d is the minimum distance for successful handoff in the direction of APs and $d_{max} = d(t)$.We can get d_{th-N_1} and d_{th-N_2} from figure which can be amended by history data.

$$d_{th-N_1} = l - D_{i,j}, \quad d_{th-N_2} = D_{i,j} \qquad (6)$$

5. Results and Performance Analysis

According to the above analysis, we need to verify whether the Dual-Handoff model runs correctly. We designed a program to simulate the moving mode of MN. The simulation refers to some settings of subway data communication environment. It is supposed that the MN moves on the constant acceleration with the maximum velocity vmax. Thj,i is the time Nj begins to handoff from APi,j to APi+1,j; Tcj,i is the time Nj connects to APi+1,j; Data transfer between Nj and APi+1,j until Tdj,i. To reduce the interference, channel 1, 8 assign to AP0,2 and AP1,2; channel 4, 11 assign to AP1,1 and AP2,1, and so on.

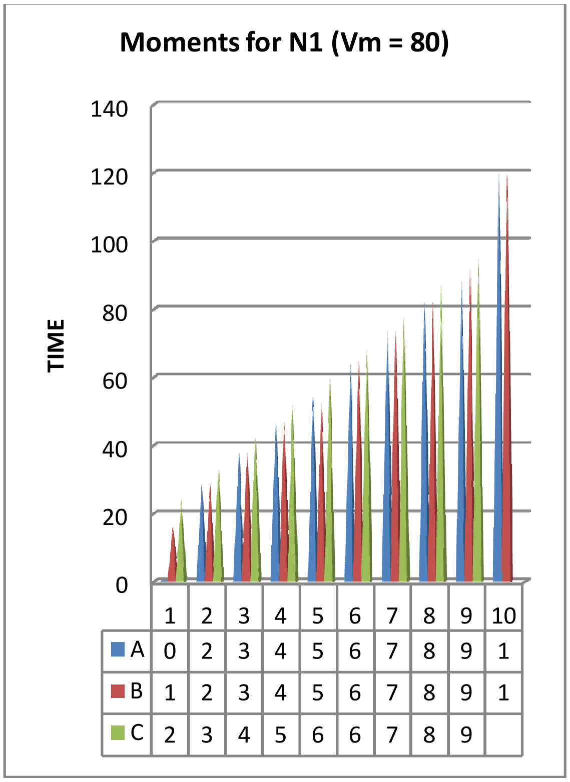
5.1 Moments

Table 5.1: Different Parameters involved with meanings, values and units

Parameter	Meanings	Value	Unit
D_{AB}	Distance between A and B	2000	m
$D_{i,j}$	Distance between adjacent APs	170 - 230	m
L	Coverage of each AP	300	m
v_{max}	MN's maximum velocity	60/80/120	Km/h
T_a	Accelerating/Decelerating Time	30/40	s
T_{max}	Handoff Time	300	ms

Table 5.2: The Moments of Dual Soft Handoff (for 80km/h)
V_{MAX}=80KM/H, T_A=30S, 170M< $D_{I,J}$ = D_{TH_N2}< 230M, 70M<D_{TH_N1}<130M

I	N1(s)			N2(s)		
	$T_{h1,i}$	$T_{c1,i}$	$T_{d1,i}$	$T_{h2,i}$	$T_{c2,i}$	$T_{d2,i}$
1	15.76	16.06	24.22	23.92	24.22	28.86
2	28.56	28.86	32.94	32.64	32.94	38.16
3	37.86	38.16	42.39	42.09	42.39	46.71
4	46.41	46.71	51.66	51.36	51.66	54.59
5	54.29	54.59	60.21	59.91	60.21	64.71
6	64.41	64.71	68.09	67.79	68.09	73.85
7	73.55	73.85	78.21	77.91	78.21	82.80
8	82.50	82.80	87.35	87.05	87.35	91.45
9	91.15	91.45	95.12	94.82	95.12	120.00
10	120.00	120.30				



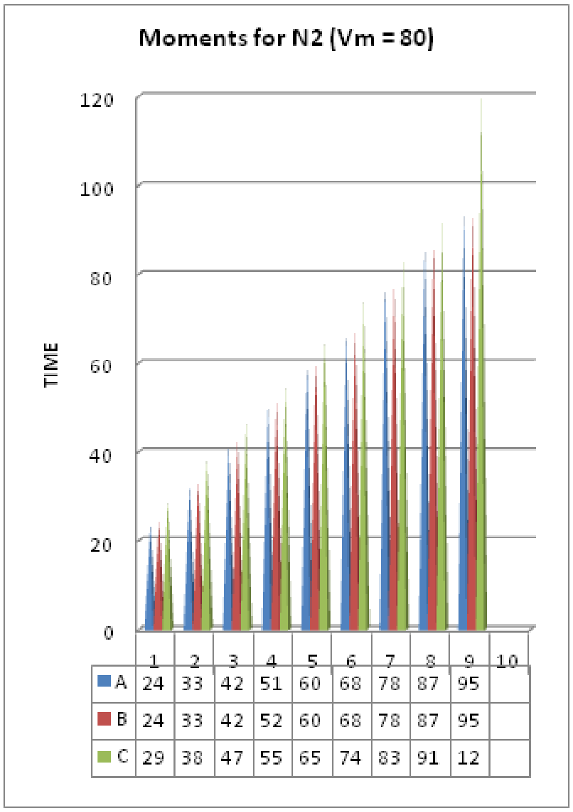
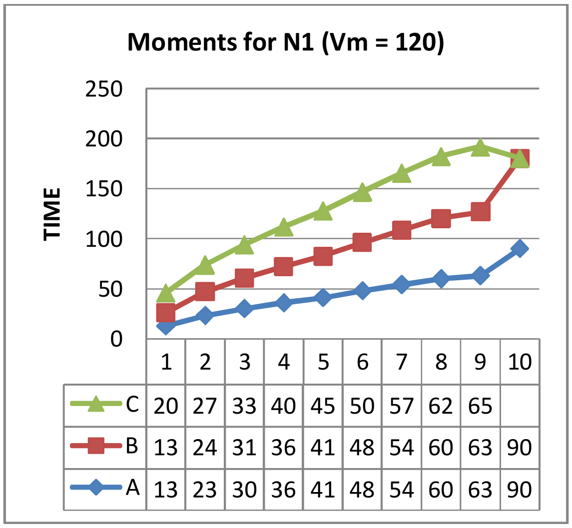
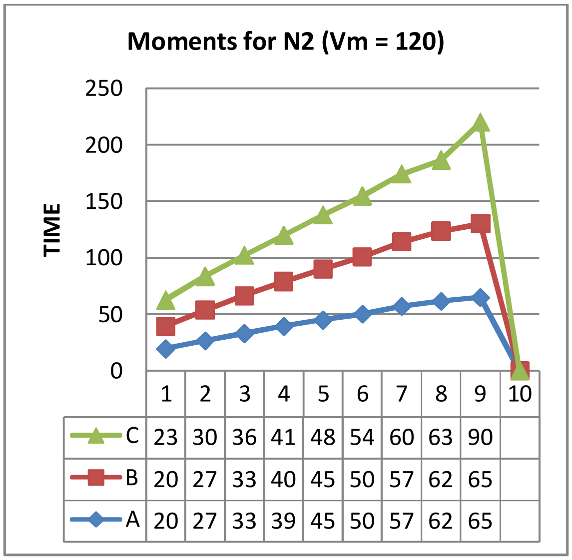


Table 5.3: The Moments of Dual Soft Handoff (for 120km/h)
V_{MAX}=120KM/H, T_A=30S, 170M< $D_{I,J}$ =D_{TH_N2}< 230M, 70M<D_{TH_N1}<130M

i	N1(s)			N2(s)		
	$T_{h1,i}$	$T_{c1,i}$	$T_{d1,i}$	$T_{h2,i}$	$T_{c2,i}$	$T_{d2,i}$
1	12.87	13.17	19.83	19.53	19.83	23.32
2	23.32	23.62	26.86	26.56	26.86	30.24
3	30.24	30.54	33.36	33.06	33.36	35.94
4	35.94	36.24	39.54	39.24	39.54	41.19
5	41.19	41.49	45.24	44.94	45.24	47.94
6	47.94	48.24	50.49	50.19	50.49	54.03
7	54.03	54.33	57.24	56.94	57.24	60.00
8	60.00	60.30	61.86	61.56	61.86	63.17
9	63.17	63.47	65.16	64.86	65.16	90.00
10	90.00	90.30				





From Tab. 5.2 to Tab. 5.3, we can find that:

$$T_{c1,i+1}\,, T_{c2,i} = T_{d2,i}\,, T_{d1,i} \; \dots (7)$$
$$T_{h1,i+1}\,, T_{h2,i} > T_{c2,i}\,, T_{c1,i} \; \dots (8)$$

These mean that one network card's data link maintains until another ready to built new data link; and the handoffs won't happen simultaneously. Therefore, the SDH can provide seamless connection during MN's fast roaming.

5.2 Speed

Table 5.4 Dropping Probability in relation to Speed (80)

For Vmax = 80km/h			
Time in Min. (10)	Speed	Normal D. P.	Dual Soft D.P.
0	0	8	2
1	5	17.32	15
2	20	32.16	23
3	45	47.85	34
4	60	58.02	48
5	75	71.01	54
6	80	85.21	60
7	75	70.65	53
8	60	60.19	46
9	45	49.61	33
10	20	33.82	21
11	5	16.55	12
12	0	9.1	3

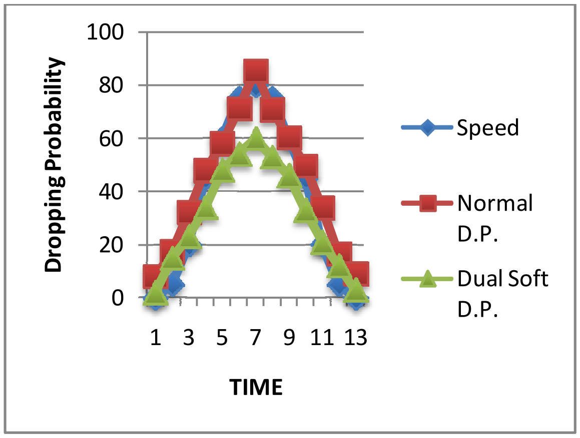
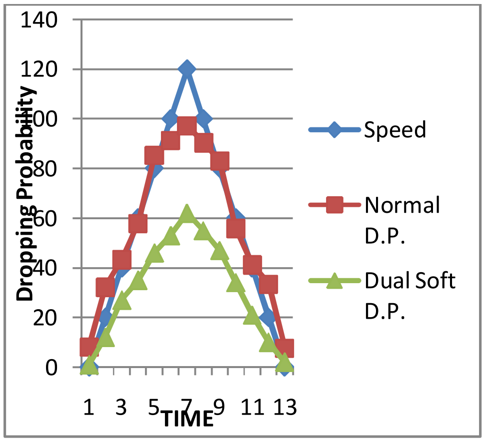


Table 5.5 Dropping Probability in relation to Speed (120)

For Vmax = 120km/h			
Time in Min. (10)	Speed	Normal D. P.	Dual Soft D.P.
0	0	8	1
1	20	32.16	12
2	40	43.27	27
3	60	58.02	35
4	80	85.21	46
5	100	91.23	53
6	120	97.11	62
7	100	90.46	55
8	80	83.02	47
9	60	55.86	34
10	40	41.25	21
11	20	33.47	10
12	0	7.6	2



5.4 Inference for Speed

Under Speed conditions if we look at the table and chart for 80km/h, we can see that it increases to a peak value of 80km/h and then decreases again. During the increase section we can observe that there is a similar increase in dropping probability for a normal handoff method. This increase tends to go to a level of around 85%. The same norm is followed during the decrease portion. The same holds true for the table in reference to 120km/h. The only difference that can be seen is the uniformity in the interval between each of the stages. This uniformity could not be achieved in the case of the latter because we had taken a total sample count of 0 to 12 which worked in favor of the higher speed.

If we scrutinize the initial value changes for both dropping probabilities, we can very well mention that there is a large gap between the first and the second values. This phenomenon is due to the fact that the overall acceleration averages out but always has a very high value at its initial stage, thus, leading to the anomaly that is seen by us. It can also be brought to our notice that in both cases there is a lower value assumed by the Dual Soft Dropping Probability (DSDP) for the peak value of speed taken. This tells us that the values of 60% and 62% of DSDP as opposed to 85% and 97% of Normal Dropping Probability (NDP) for 80km/h and 120km/h speeds just goes to show how efficient Dual Soft Handoff. If we try to look deeper in the values that have been provided we see that for NDP conditions there is a very steep rise of 12% in the peak DP variables whereas for the same case under DSDP conditions there is only a minimal rise of 2%. This gives us a result that is very much in accordance with what we require. Basically, it says that however much the speed is increased its effect on the DSDP at its peak value is minimal or almost tending to zero. Thus we can conclude that the Dropping Probability is much lower in cases of Dual Soft Handoff and remains so even for higher speeds.

5.5 Distance

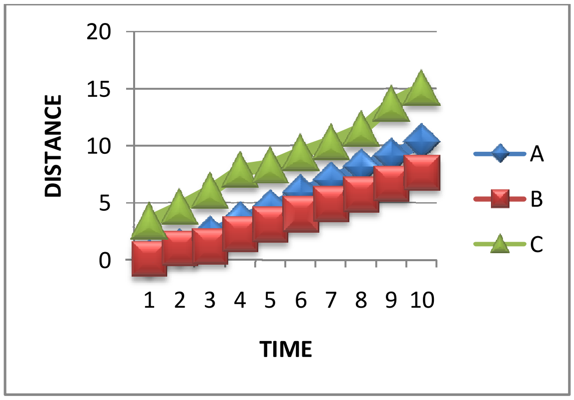
Comparison of Different Roads

A is Normal, B is Bumpy, C is Combination of Smooth and Rough

The Table 5.6 denote the graph of distance versus time in correlation to a speed of 80 km/h being travelled by the mobile node.

Table 5.6 Distance versus Time (80)

For Vmax =80km/h			
Time in Min.	A (km)	B (km)	C (km)
1	0.16	0.05	3.36
2	1.12	0.96	4.58
3	2.23	1.15	6.01
4	3.46	2.24	7.85
5	4.52	3.05	8.25
6	5.86	3.99	9.36
7	6.94	4.86	10.27
8	8.11	5.72	11.42
9	9.06	6.66	13.65
10	10.32	7.61	15.02

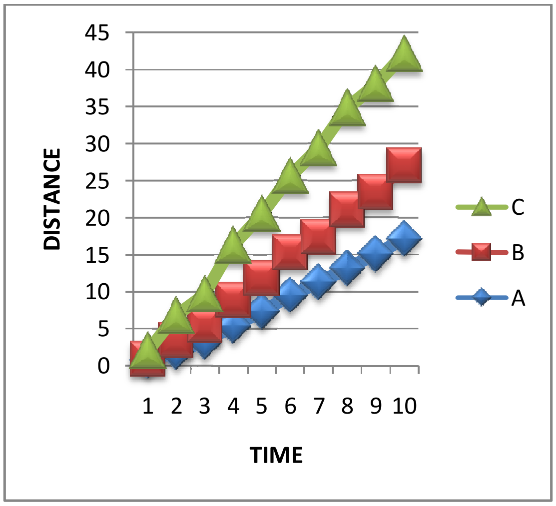


This elaborates the different amount of distances covered at different intervals of time taken along different types of roads, namely A, B and C types of road. Furthermore, the distance achieved is given in kilometres whereas time is in minutes.

Table 5.7 Distance versus Time (120)

For Vmax =120km/h			
Time in Min.	A (km)	B (km)	C (km)
1	0.75	0.18	1.01
2	1.86	1.59	3.26
3	3.24	2.23	4.15
4	5.41	3.48	7.31
5	7.32	4.46	8.66
6	9.52	5.75	10.27
7	11.28	6.12	11.89
8	13.18	7.86	13.72
9	15.07	8.35	14.53
10	17.11	9.92	15.02

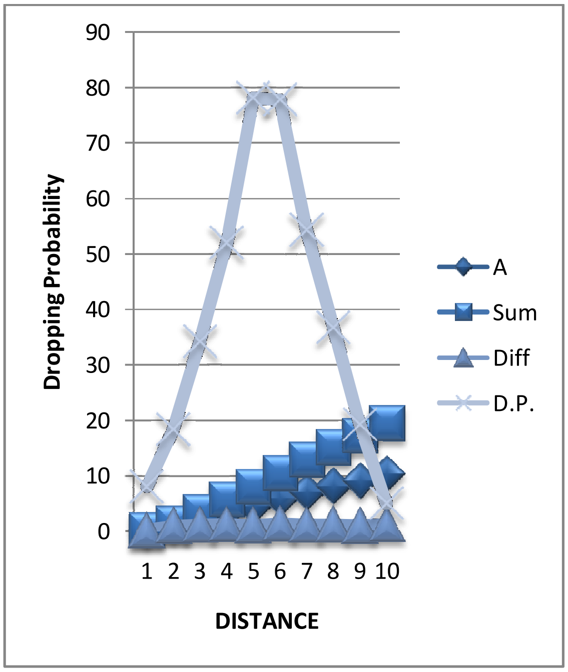
The Table 5.7 denote the graph of distance versus time in correlation to a speed of 120 km/h being travelled by the mobile node. This elaborates the different amount of distances covered at different intervals of time taken along different types of roads, namely A, B and C types of road. Furthermore, the distance achieved is given in kilometres whereas time is in minutes.



Dropping Probability for different roads at Vmax = 80km/h

Table 6.8 Distance (A) versus Dropping Probability (80)

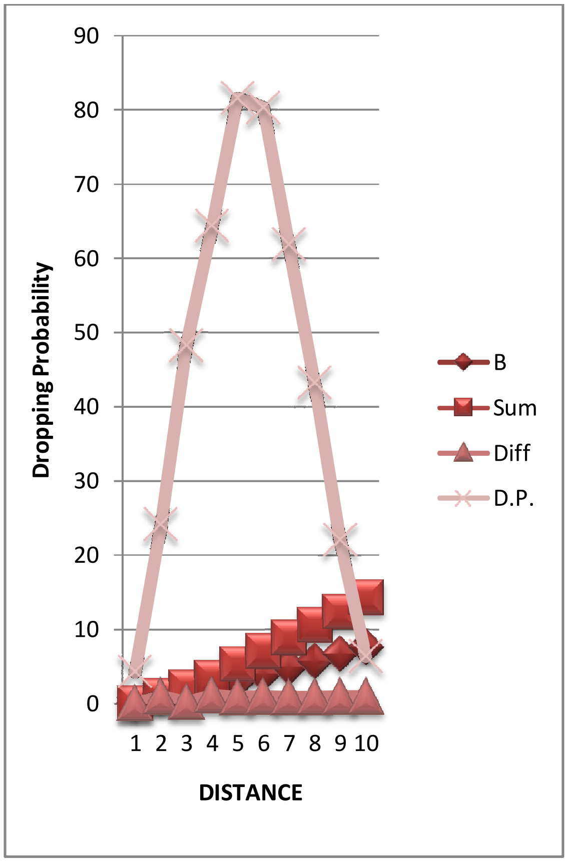
A (km)	Sum	Difference	Dropping Probability
0.16	0.16	0.16	8
1.12	1.28	0.96	18.32
2.23	3.35	1.11	34.21
3.46	5.69	1.23	52
4.52	7.98	1.06	78.1
5.86	10.38	1.34	77.8
6.94	12.8	1.08	54.3
8.11	15.05	1.17	36.71
9.06	17.17	0.95	19.22
10.32	19.38	1.26	5



The Table 5.8 denotes the graph of distance versus dropping probability in correlation to a speed of 80 km/h being travelled by the mobile node specifically for Roadway A. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.6. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

Table 5.9 Distance (B) versus Dropping Probability (80)

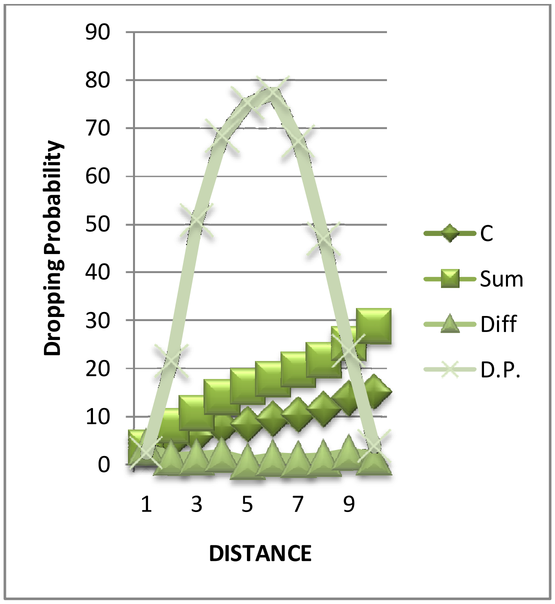
B (km)	Sum	Difference	Dropping Probability
0.05	0.05	0.05	4.23
0.96	1.01	0.91	24.07
1.15	2.11	0.19	48.2
2.24	3.39	1.09	64.32
3.05	5.29	0.81	81.54
3.99	7.04	0.94	80.25
4.86	8.85	0.87	61.79
5.72	10.58	0.86	43.15
6.66	12.38	0.94	22.03
7.61	14.27	0.95	6.32



The Table 5.9 denote the graph of distance versus dropping probability in correlation to a speed of 80 km/h being travelled by the mobile node specifically for Roadway B. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.6. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

Table 5.10 Distance (C) versus Dropping Probability (80)

C (km)	Sum	Difference	Dropping Probability
3.36	3.36	3.36	2.21
4.58	7.94	1.22	21.46
6.01	10.59	1.43	50.69
7.85	13.86	1.84	68.23
8.25	16.1	0.4	75.11
9.36	17.61	1.11	77.26
10.27	19.63	0.91	67.14
11.42	21.69	1.15	46.8
13.65	25.07	2.23	23.47
15.02	28.67	1.37	3.65

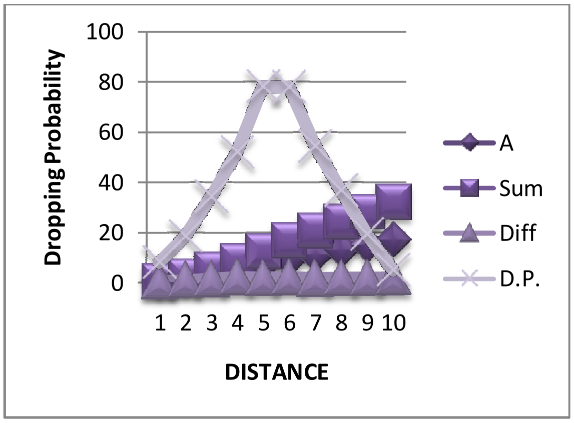


The Table 5.10 denote the graph of distance versus dropping probability in correlation to a speed of 80 km/h being travelled by the mobile node specifically for Roadway C. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.6. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

Dropping Probability for different roads at Vmax = 120km/h

Table 5.11 Distance (A) versus Dropping Probability (120)

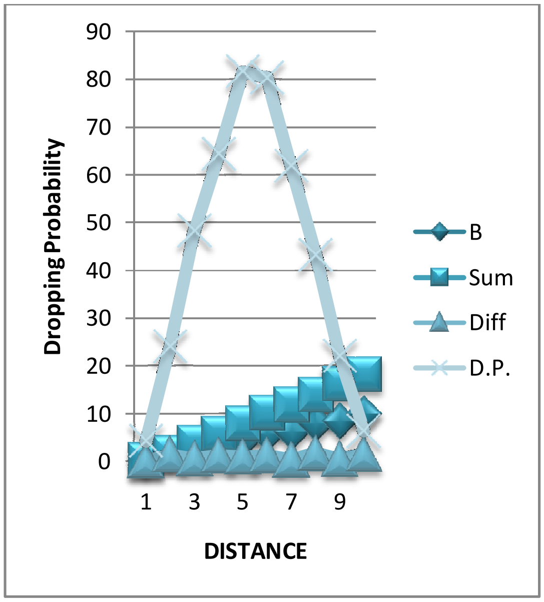
A (km)	Sum	Difference	Dropping Probability
0.75	0.75	0.75	8
1.86	2.61	1.11	18.32
3.24	5.1	1.38	34.21
5.41	8.65	2.17	52
7.32	12.73	1.91	78.1
9.52	16.84	2.2	77.8
11.28	20.8	1.76	54.3
13.18	24.46	1.9	36.71
15.07	28.25	1.89	19.22
17.11	32.18	2.04	5



The Table 5.11 denote the graph of distance versus dropping probability in correlation to a speed of 120 km/h being travelled by the mobile node specifically for Roadway A. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.7. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

Table 5.12 Distance (B) versus Dropping Probability (120)

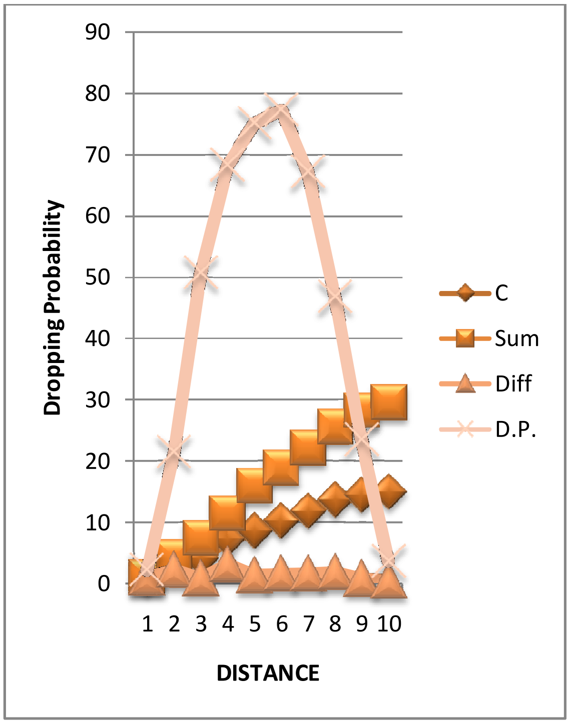
B (km)	Sum	Difference	Dropping Probability
0.18	0.18	0.18	4.23
1.59	1.77	1.41	24.07
2.23	3.82	0.64	48.2
3.48	5.71	1.25	64.32
4.46	7.94	0.98	81.54
5.75	10.21	1.29	80.25
6.12	11.87	0.37	61.79
7.86	13.98	1.74	43.15
8.35	16.21	0.49	22.03
9.92	18.27	1.57	6.32



The Table 5.12 denotes the graph of distance versus dropping probability in correlation to a speed of 120 km/h being travelled by the mobile node specifically for Roadway B. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.7. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

Table 5.13 Distance (C) versus Dropping Probability (120)

C (km)	Sum	Difference	Dropping Probability
1.01	1.01	1.01	2.21
3.26	4.27	2.25	21.46
4.15	7.41	0.89	50.69
7.31	11.46	3.16	68.23
8.66	15.97	1.35	75.11
10.27	18.93	1.61	77.26
11.89	22.16	1.62	67.14
13.72	25.61	1.83	46.8
14.53	28.25	0.81	23.47
15.02	29.55	0.49	3.65



The Table 5.13 denotes the graph of distance versus dropping probability in correlation to a speed of 120 km/h being travelled by the mobile node specifically for Roadway C. This elaborates the different dropping probabilities occurring at different distances for intervals of time taken in Table 5.7. Furthermore, the cumulative distance achieved is given in the form of a sum and a difference column.

5.6 Inference for Distance

In this paper I have taken into account three types of roads to give us a brief look at how certain roads affect the speeds at which a node travels which in turn gives rise to a difference in the times taken by them to reach their destinations on their respective paths.

A is the first kind of road. I have taken it to be a normal road meaning it has a little edge here or a little puddle there but overall it averages out to a flat surface. Thus the distances travelled in each interval tend to remain constant or at least have a high degree of similarity. A perfect example of such a road would be a normal everyday road being travelled upon by cars, bikes and other vehicles. This road tends to give out a good estimate of the Dropping Probability for both 80km/h and 120km/h speeds.

B is the second kind of road. It is mentioned to be a bumpy one for lack of a better terminology that would clearly define this road’s aspects. It would rather resemble a dirt road that has been seldom travelled thus making a journey through it arduous and painfully slow as compared to its high paced counterparts. The constant jolts that are felt will definitely cause a change for the reception of the signal at a micro level which in turn gives rise to a slightly higher Dropping Probability value. Examples of roads like this would be the untrodden ghat roads. Furthermore for roads such as these there is always a danger of there being a landslide causing a huge amount of disruption and interference leading to the signal or call being eventually dropped due to the fact of the obstacle providing poor reception. Even if one does manage to reach high speeds, which actually seems impossible, one may have to give up on the prospect of maintaining a call unless a very strong base station is available. Overall the Dropping Probability increases in a steady manner for both cases.
C is the third and last kind of road being a mixture of a very smooth and a very rough surface. The former would be similar to a race track and the latter to a village road in a marsh or swamp conditions. Thus the smooth surface would offer a higher acceleration growth leading to a lower Dropping Probability whereas for the rough wetland surface there would be a lower acceleration growth causing the Dropping Probability to increase due to jolts and random movements of the node. Hence in some places the DP would increase sharply where in others it would do so at a slower rate.

If we look at all the tables and charts except for the first two we would notice that there is a sum and a difference column. These values have either been summed or accumulated into the upper previous values or they have been subtracted or differenced from them. This has been done to properly analyze the distances being covered and give proper inferences for the Dropping Probabilities.

6. Conclusion

The proposed Soft-Dual-Handoff scheme aims at providing high quality data link for the rapid motion nodes. It has high reliability, which is important for applications such as subway control, video or audio transmission. If one link is broken- down, the SDH switch automatically to single network card mode, which can earn time for resuming from failure. The SDH requires only the cooperation of mobile nodes, and AP needn't any modification. Therefore, AP can adopt standard IEEE 802.11 serial products to save investment.

In fast MSs, a handoff occurs frequently in WLANs due to their small coverage area. It implies that the frequency of handoff s will increase especially in WLANs, so a large number of handoff requests must be handled. Therefore, the handoff dropping probability is increasing, and the service quality (e.g., GoS) becomes worse. On the other hand, the CDMA system is large enough to accommodate fast MSs, and lower handoff request rates, thus resulting in lower burden and good service quality. It is safe to assume that either slow or stationary MSs transmit more data and that fast moving stations communicate at lower data rates. Therefore, according to the MS speed, the load balancing handoff between WLAN and CDMA results in good service quality and the avoidance of unnecessary handoff s. Our proposed methods adopt the mobility management concept through the MS speed cost function to minimize the GoS.

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