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A Handoff Technique to Improve TCP Performance in Next Generation Wireless Networks

[1]A. Ezil Sam Leni and [2]S.K. Srivatsa
[1]Department of Computer Science and Engineering, Sathyabama University, Chennai 119, Tamil Nadu, India
[2]St. Joseph's College of Engineering, Chennai 119, Tamil Nadu, India

Abstract: In this study, we propose a new technique based on the information from the Data Link Layer and Network Layer, which reduces the handoff delay and improves the TCP Performance in integrated wireless networks. The Candidate Access Route Discovery (CARD) Protocol is used to identify the Neighbor Routers during handover. The proposed technique is developed to support seamless Intra and Inter System Handoff in next generation wireless networks. The performance of the proposed technique is simulated and the results are also shown in this study.

Key words: Handoff, next generation wireless systems, TCP/IP, ubiquitous communications, candidate access route discovery

INTRODUCTION

High capacity wireless access for mobile users is increasing rapidly. Rapid progress in the research and development of wireless networking and communication technologies has created several wireless communication systems such as GSM (Global System for Communication), GPRS (General Packet Radio Services), UMTS (Universal Mobile Telecommunication Services) and Wireless LAN (WLAN), Bluetooth for personal area and Satellite networks for Global networking. These networks complementary to each other and hence their integration can realize unified Next-Generation Wireless Systems (NGWS). In the integrated NGWS, users are always connected to the best available networks and switch between different networks based on their service needs (Akyyildiz *et al*., 2005). A challenging issue in NGWS is to support seamless mobility management. Mobility Management consists of two components as shown in Fig. 1. Location Management enables the system to keep track of the location of mobile users between consecutive communications. Handoff management is to keep the user connection active when they move from one Base Station to other. There are several solutions for Location Management, but the solution for handoff management suffers from handoff delay. The Handoff types in NGWS are shown in Fig. 2.

Horizontal handoff: Handoff between two Base Station of the same system. It is further classified into

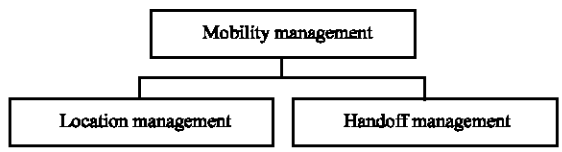

Fig. 1: Mobility management

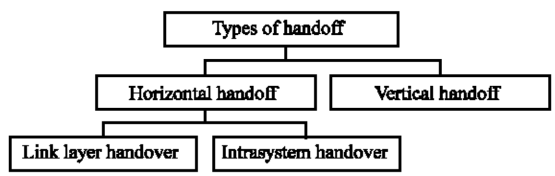

Fig. 2: Type of handoff

- **Link layer handoff:** Handoff between two BSs that are under the same foreign agent (FA)
- **Intrasystem handoff:** Handoff between two BSs that belong to two different FAs and both the FAs belong to the same system.

Vertical handoff: Handoff between two Base Station that belong to two different systems.

In the literature there are several algorithms to support seamless link-layer handoff (Perkins *et al*., 2002). The solution for Intra system and intersystem handoff is still a research issue. The efficient intra and inter system handoff depends on the following characteristics for seamless handoff and are:

Corresponding Author: A. Ezil Sam Leni, Department of Computer Science and Engineering, Sathyabama University, Chennai 119, Tamil Nadu, India

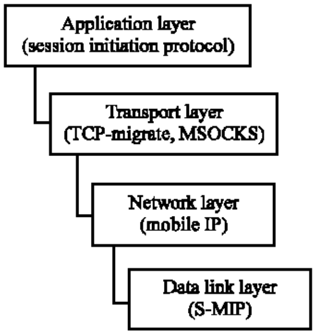

Fig. 3: Handoff management protocols in TCP/IP stack

- Minimum handoff latency
- Low packet loss
- Limited handoff failure

There exist many solutions for Handoff management in different layers of Internet Protocol. The different layers and the techniques used are shown in Fig. 3. The Application Layer handoff is initiated using the Session Initiation Protocol (SIP) and it doesn't require any changes to the TCP/IP Protocol Stack (Wedlund and Schulzrinne, 1999). In the Transport Layer TCP-Migrate is used to support end-to-end Transport Layer Handoff Management (Snoeren and Balakrishnan, 2000). An architecture called MSOCKS is proposed (Matz and Bhagwat, 1998) for handoff using split-connection proxy architecture. In the Network Layer Mobile IP (Perkins *et al*., 2002) is proposed to support mobility management in IP based Networks. It uses Tunneling to forward IP packets when the MS moves away from the Home Network (HN).

Mobile IP is simple to implement but suffers from:

- Triangular routing
- High global signaling load
- High handoff latency

Triangular routing is eliminated by optimized Mobile IP, the handoff latency is not addressed by it. At present the use of link layer information to reduce the handoff requirement detection delay has gained attention in (Akyyildiz *et al*., 2004; Akyyildiz and Wang, 2004). The Link Layer information is used to anticipate the possibility of inter and intra system handoff in advance so that the handoff procedures can be carried successfully before the MT moves out of the coverage area of the serving Base Station (BS). The use of link layer information significantly reduces the handoff latency and handoff failure probability of handoff management protocols (Akyyildiz *et al*., 2004).

PROPOSED SYSTEM

Handoff architecture: In the proposed system we have used architecture as shown in Fig. 4 for Physical and data link layer. In the physical layer it has two units: Speed Estimation unit and RSS measurement unit. In the Data Link Layer it has Neighbor Discovery unit and the Handoff signaling delay estimation unit.

The functions of each unit and the information used by them are as follows. Information is collected from the Physical and Data Link Layer and is used to carry out the handoff procedures, handoff trigger unit and handoff execution unit. The functions of these units are listed below.

- **Neighbor discovery unit:** It assists the Mobile Node to learn about the neighboring nodes. It uses Candidate Access Route Discovery protocol (Liebsch *et al*., 2004) to identify the neighboring routers.
- **Handoff signaling delay estimation unit:** It estimates the delay associated with intra and intersystem handoff.
- **Speed estimation unit:** This unit estimates the mobile's speed using VEPSD (Velocity estimation using the power spectral density of the received signal envelope) as in (Zhang and Holtzman, 1996). Here Doppler frequency f_m is related to speed of a mobile user, speed of light in free space and carrier frequency of the received signal, through

$$v = (c/f_c)\, f_m \qquad (1)$$

where, v is the speed of the mobile device, c is the speed of light in free space, fc is the carrier frequency of the received signal, fm is the Doppler frequency related to the speed of the mobile user.

- **Handoff trigger unit:** It collects information from the handoff signaling delay estimation unit, speed estimation unit, RSS measurement unit and determines the appropriate time to start handoff procedures.
- **Handoff execution unit:** It starts the Handoff registration process at the handoff initiation time calculated by the handoff trigger unit.

Operation: The proposed architecture uses Data Link and Network Layer information to initiate and manage the handoff process. It depends on the mobile's speed and handoff signaling delay as the major information. The operation of the proposed system is subdivided into five

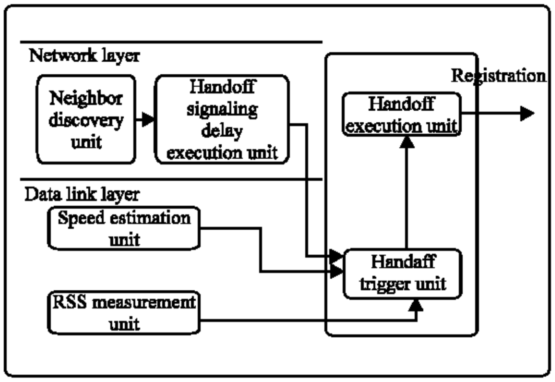

Fig. 4: Modules in handoff management architecture

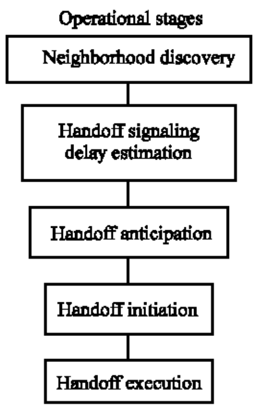

Fig. 5: Stages in handoff operation

stages as shown in Fig. 5. Each stage and the happening are explained below. The flow of the proposed mechanism is shown in Fig. 6.

Neighborhood discovery: In a Wireless system, Mobile Station (MS) is served by a Base Station (BS) and it learns about the neighboring BSs (BSs that are the immediate neighbors of the serving BS) using the Neighbor Discovery unit. Some of the neighboring BSs can present in the serving FA, whereas other may belong to different FA. When the MS moves into the coverage of a neighboring BS that belongs to its serving FA, the resulting handoff is Link Layer Handoff. In this case the existing handoff algorithms (Zhang and Holtzman, 1996) can be used without the proposed algorithm. When the neighboring BS belongs to a different FA under the serving system, it is known as the Intra system handoff. When the neighboring BS belongs to a different system other than the serving BS, the resulting handoff is an Intersystem handoff. The proposed algorithm is used in Inter and Intra system handoff.

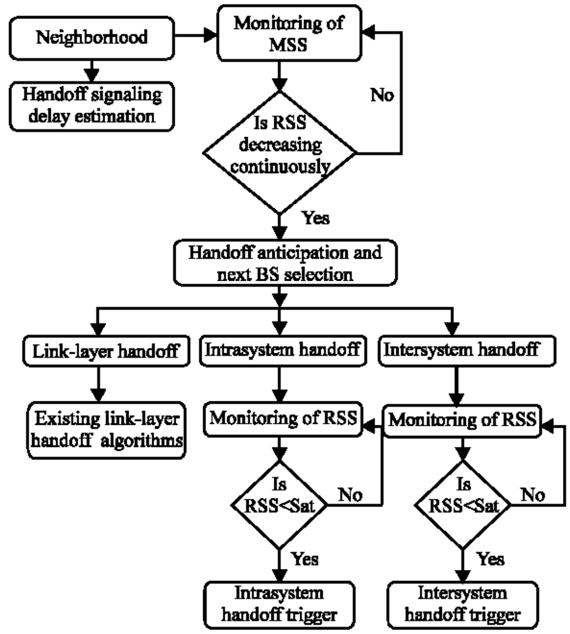

Fig. 6: Flow of handoff operation

Handoff signaling delay estimation: During change in location, it is difficult to predict to which particular BS the MS will move. The main objective of the proposed system is to estimate the handoff signaling delay in advance without knowing to which particular BS the MS will move. In the proposed algorithm, we estimate the handoff signaling delay of a possible handoff to a particular neighboring BS in advance we use the following steps. We have used Invalid authentication extensions to just learn the handoff signaling delay without changing the mobility binding at GFA or HA.

- For Intrasystem Handoff, MS sends HMIP registration message to the GFA with an invalid Mobile-GFA Authentication extension.
- For Intersystem Handoff, MS sends HMIP registration message to the HA with an invalid Mobile-Home Authentication extension.
- When GFA or HA receives the HMIP registration messages and learns the presence of invalid Authentication Extensions, they return the HMIP Registration Reply with the appropriate code that signifies the MS has failed authentication.

The handoff signaling delay is estimated based on the difference between the transmission time of the HMIP registration request message and the reception time of the Handoff registration reply message. Using the above steps the MS learns (i) handoff signaling delay in the event of movement to the BS, (ii) signaling delay of the associated handoffs to other neighboring BSs. From the above study it shows that for intrasystem handoff, as few messages are exchanged the handoff delay is lower compared to intersystem handoff.

Handoff anticipation: This stage requires information from the RSS measurement unit. If the RSS of the serving BS decreases continuously it shows a handoff is anticipated. The Handoff Trigger learns the signaling delay for that particular BS from the handoff signaling delay estimation unit.

Handoff initiation: Once the MS learns the BS that it is going to move, it estimates the right time to start the HMIP registration. The Handoff Trigger unit uses the speed and handoff signaling delay information to estimate the threshold T1. When the RSS of the serving BS drops below T1, the Handoff Trigger Unit sends a trigger to the Handoff execution unit to start the HMIP handoff procedure.

Handoff execution: The Handoff execution unit receives the handoff trigger from the handoff trigger unit it starts the handoff registration. Once the handoff registration is competed, the MT is switched to the new BS. The MS keeps its registration with the old BS for a specified time period to avoid the ping-pong effects during handoff using the binding method. The MS binds the CoA of the old FA and new FA at the GFA in intrasystem handoff and at HA in intersystem handoff. Thus GFA and HA forwards packets destined for the MS to both CoAs during this time interval (Zhang and Holtzman, 1996).

The operation of Handoff management is explained with the diagram shown in Fig. 6. The Mobile Station (MS) learns about the neighbor BSs using the neighbor discovery protocol and determines the type of handover in the movement to the new Base Station (BS). Once the neighboring BS is learnt, the Handoff Signaling Delay Estimation Unit estimates the signaling delay associated with the neighboring BS. The RSS monitoring unit starts to monitor the RSS of the serving BS and anticipates a handoff when the RSS decreases continuously and in the selection of the next BS. The different types of handover are as follows.

- **Link layer handoff:** If the associated handoff to the next BS is link layer handoff, the existing algorithm by Zhang and Holtzman (1996) is used.
- **Intrasystem handoff:** If the associated handoff to the next BS is an intrasystem handoff, the handoff trigger unit estimates the dynamic RSS threshold t_1.When the RSS of the current BS drops below t_1, the MS starts the proposed mechanism with the next BS.
- **Intersystem handoff:** If the associated handoff to the next BS is an intersystem handoff, the handoff trigger unit estimates the dynamic RSS threshold t_2. When the RSS of the current BS drops below t_2, the MS starts with the intersystem handoff procedure that we have proposed.

RESULTS AND DISCUSSION

The typical handoff scenario in the next generation wireless networks is shown in Fig. 7. We have considered an integrated architecture in which two different wireless systems namely System A (Cells shown in straight lines) and System B (Cells shown in dotted lines) are connected to the Internet using Gateway foreign Agents GFA1, GFA2, respectively. The Base Stations BS10 and BS12 of System A are connected to Foreign Agents FA10, Base Station BS11 is connected to Foreign Agent FA11 and then connected to the Internet Backbone using Gateway Foreign Agent GFA1. The Base Stations BS20 and BS21 of System B are connected to Foreign Agent FA20 and then connected to the Internet Backbone using Gateway Foreign Agent GFA2.

To evaluate the performance of TCP during handoff in such integrated next generation wireless system (NGWS), we have used the handoff scenario as shown in Fig. 8. Handoff takes from the current BS referred as old (OBS), to the future BS, referred as (NBS). We have used the following parameters,

- T_{avg} : The threshold value of the RSS(Received Signal Strength) to initiate the proposed handoff process. When the RSS of OBS drops below the proposed registration procedure is initiated for MS's handover to the new BS(NBS).
- t_2 : The minimum value of RSS required for successful communication between an MS and OBS.
- a : Cell size and we have taken hexagonal cell shape.

In the simulation, we have considered that the MS is served by the OBS and is moving with a speed v. The speed v is uniformly distributed in $[v_{min}, v_{max}]$. The probability density function (pdf) of v is given by

$$fv(v) = (1/(v_{max}-v_{min})) \qquad v_{min}<v<v_{max} \qquad (2)$$

During the movement of the mobile station (MS) it is to move into the coverage area of the NBS and the proposed registration procedure is needed to register with the FA of the serving NBS known as (NFA). The MS can learn about the possibility of moving into another cell when the RSS of OBS decreases continuously. Once the MS knows that it can move into the coverage area of the NBS, the next step is to determine the right time to decide

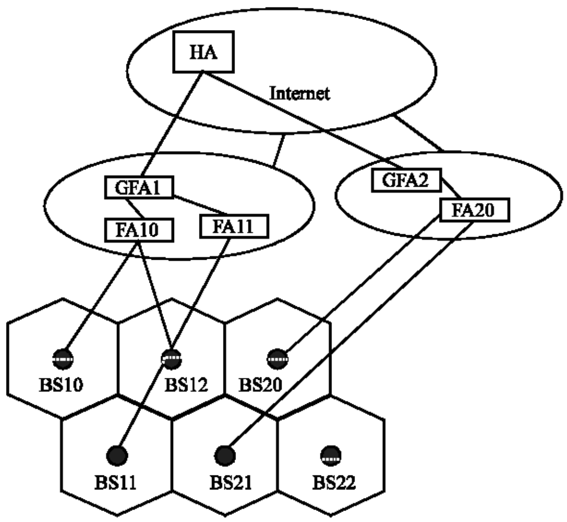

Fig. 7: Architecture of next generation wireless system

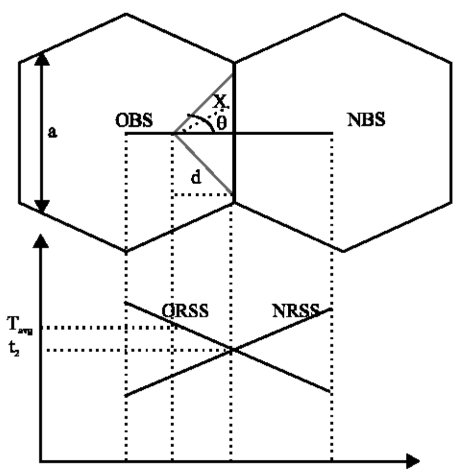

Fig. 8: Handoff scenario

registration to the NFA. For our simulation, we consider a microcellular system with a cell size of a = 1 km, macro cell reference distance d0 = 100 m, a standard deviation of shadow fading parameter e = 8 dB, path-loss co-efficient = 4, handoff failure probability p_f = 0.02 and maximum value of mobile speed as 14 km h^{-1}. The minimum RSS required for successful communication between MS and BS as -64 dBm. In the simulation environment we assumed that the MS moves from the old base station (OBS) to a new base station (NBS). During data transmission between the MS and BS we have used the TCP/IP as the protocol and the behavior of the proposed mechanism is analyzed with the following parameters and are discussed.

Simulation of the proposed handoff Management mechanism is carried out in ns-2 simulator and we obtained the results for various factors and are discussed as follows.

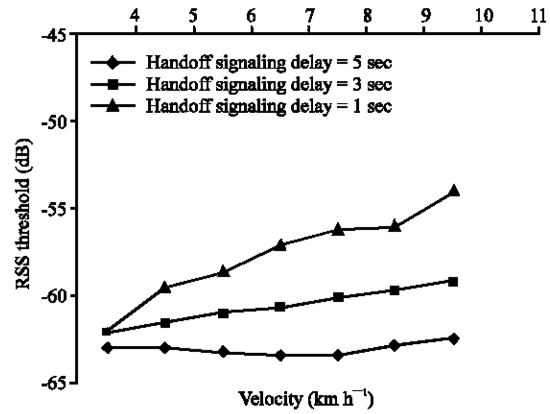

Fig. 9: Relationship between RSS and speed of mobile device

Relationship between RSS Threshold T_{avg} and speed: For different values of handoff signaling delay, we analyzed the relationship between T_{avg} and MS speed (v). Taking different values of speed, we calculated the required value of d and using all we found the required value of T_{avg}. The relationship T_{avg} between and speed in microcellular system is shown in Fig. 9. The graph implies that, for an MT moving at high speed the handoff should be initiated earlier as compared to a slow-moving MT to guarantee the desired handoff failure probability independent of MTs speed. When τ is large, the handoff must start earlier compared to when τ is small. The small and large values of τ correspond to intra and inter handoffs respectively and so calculation of T_{avg} is adaptive v and τ.

Relationship between handoff failure probability and speed: In the simulation environment, we analyzed the handoff failure probability for different types of inter and intrasystem handoffs and compared that with existing fixed RSS-threshold-based handoff protocols. We calculated T_{avg} using speed and handoff signaling delay information and 20% of error is introduced in speed estimation. Then T_{avg} is used to initiate the handoff and determine handoff failure probability. The relationship is shown in Fig. 10. From the graph it shows that with the existing fixed RSS-threshold based algorithms in the proposed mechanism error is reduced 70-80% and shows that handoff mechanisms should be adaptive to the type of handoff.

Relationship between handoff failure probability and handoff signaling delay: We analyzed the handoff failure probability for different values of handoff signaling delay, τ. The analysis showed that unlike the fixed RSS-based handoff protocols, p_f remains independent of τ. The proposed mechanism estimates τ and uses it for

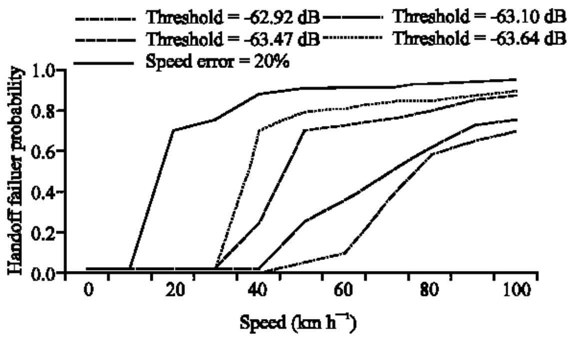

Fig. 10: Relationship between handoff failure probability and speed of the mobile device

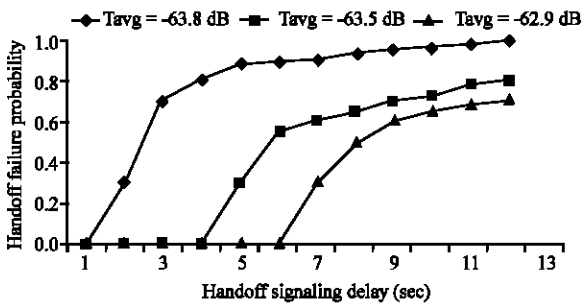

Fig. 11: Relationship between handoff failure probability and handoff signaling delay

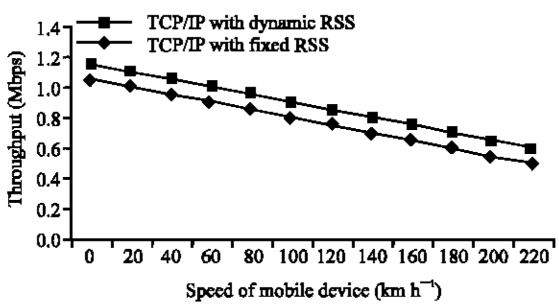

Fig. 12: Performance of TCP/IP with and without the proposed mechanism

the calculation of dynamic RSS threshold and it enables 70-80% reduction in p_f compared to the fixed RSS-based handoff protocols. The lower value corresponds to intersystem handoff and higher value corresponds to intersystem handoff. The Relationship between Handoff Failure Probability and Handoff Signaling Delay is shown in Fig. 11.

Performance of TCP/IP

Performance of TCP/IP protocol in wireless: Environment is studied and the results are shown in Fig. 12. When TCP/IP protocol is used without the proposed mechanism the throughput decreases during the event of handover with the speed of the mobile device. If the proposed mechanism is used the throughput increases compared to the fixed RSS-based handoff. This is because we are following five stages in the operation of the proposed mechanism.

CONCLUSION

In this study, we have studied the different types of handoff mechanism in wireless environment. The different handoff mechanism in the TCP/IP protocol stack is listed. The proposed mechanism with five different stages and the operation of the proposed mechanism is explained as next. In the last section we have shown the performance of the proposed mechanism, with the data link layer and network layer information which gave enhanced performance compared to the fixed RSS based mechanism. At last we studied the performance of TCP/IP protocol if the proposed mechanism is used during handoff. The proposed mechanism gives improvised throughput and goodput in wireless environment.

REFERENCES

Akyyildiz, I.F. and W. Wang, 2004. A predictive user mobility profile for wireless multimedia networks. IEEE/ACM Trans. Networking, 12 (6): 1021-1035.

Akyyildiz, I.F., S. Mohanty and J. Xie, 2004. A survey on mobility management in next generation all-ip based wireless systems. IEEE Wireless Commun., 11 (4): 16-28.

Akyyildiz, I.F., S. Mohanty and J. Xie, 2005. A ubiquitous mobile communication architecture for next generation heterogeneous wireless systems. IEEE Radio Commun. Mage., 43 (6): s29-s36.

Liebsch, M. *et al.*, 2004. Candidate access router discovery. Internet Draft, Internet Engineering Task Force, draft-ietf-seamoby-card-protocol-07.txt.

Matz, D. and P. Bhagwat, 1998. Msocks: An architecture for transport layer mobility. Proceeding IEEE Infocom '98, pp: 1037-1045.

Perkins, C. *et al.*, 2002. IP Mobility support for Ipv4. Internet Engineering Task force RFC 3344.

Snoeren, A.C. and H. Balakrishnan, 2000. An end-to-end approach to host mobility. 6th ACM/IEEE International Conference on Mobil Computing and Networks, Mobicom 2000.

Wedlund, E. and H. Schulzrinne, 1999. Mobility support using sip. Proceeding 2nd ACM/IEEE International Conference on Wireless and Mobile Multimedia. oWMoM'99).

Zhang, N. and J.M. Holtzman, 1996. Analysis of handoff algorithms using both absolute and relative measurements. IEEE Trans. Vehicular Technol., 45 (1): 174-179.