http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 7 (5): 820-824, 2008
ISSN 1812-5638

Cross-Layer Handoff Management Algorithm on Heterogeneous Wireless Networks

Thazin Ei and Wang Furong
Friendship Apartment, Huazhong University of Science and Technology,
Hubei, 430074, Wuhan, People's Republic of China

Abstract: Among heterogeneous wireless networks for achieving seamless vertical handoff with required QoS we propose cross layer handoff management algorithm that performs the better handoff in network layer (layer 3) with the aid of link layer (layer 2) information. Since some networks are overlapped each other on heterogeneous wireless networks, Mobile Terminal (MT) may be possible to move to many networks. Among these overlapped networks, our algorithm is developed with the aid of Global Positioning System (GPS) that can trace the position and direction of the Mobile Terminal (MT). Using GPS and layer 2 information we decrease the probability of false handoff initiation that results wastage resources and also increases the load on network.

Key words: Handoff management algorithms in wireless networks, network layer handoff, link layer handoff and cross-layer handoff management algorithm

INTRODUCTION

Next-Generation Wireless Systems (NGWS) integrate different wireless networks such as Bluetooth, IEEE 802.11, Universal Mobile Telecommunication System (UMTS) and satellite networks, etc. These networks are designed for specific service needs. They can vary widely in terms of bandwidth, latency, area of coverage, cost and Quality of Service (QoS) provisioning, etc. There are no existing wireless systems that can satisfy all needs at the same time. Therefore, we advocate the use of integration of the existing wireless systems. Following this approach, heterogeneous wireless systems will cooperate with each other to provide anytime, anywhere and anyway to a mobile user which is called ABC (always best connected). Handoff management is the process by which an MT keeps its connection active when it moves from one access point to another. The handoff process can be intra (horizontal handoff) or intersystem (vertical handoff). Horizontal handoff occurs when the user moves among the same service area, technology or access point where as vertical handoff occurs when the user moves among different service areas, technologies or access points. While handoff is performing, to minimize the interruption of cell transport, an efficient switching of the active (virtual circuits) VCs from the old data path to the new data path is needed. Also, the switching should be fast enough to make the new VCs available to the mobile users (Hac, 2002). There are three handoff stage processes such as (1) initiation (2) new connection generation (3) data-flow control. Initiation is the process that the user, a network agent, or changing network conditions recognize the need for handoff. New connection generation is the process that the network must find new resources for the handoff connection and perform any additional routing operations. Data-flow control is the process that the delivery of the data from the old connection path to the new connection path is maintained according to agreed-upon service guarantees. In supporting acceptable levels of QoS for vertical handoff we will decrease the probability of false handoff initiation.

HANDOFF MANAGEMENT ALGORITHMS IN WIRELESS NETWORKS

During handoff for required QoS, we need to consider many parameters in real life. Alkyildiz and Wang (2004), described about user mobility profile frame work for multimedia networks predicting the future positions of mobile terminals. They predicted future positions of MTs depending on many factors like historical records, direction and velocity of mobile objects, stochastic behaviors considering about the residence time and part information and then zone partition is also introduced. Depending on these many factors authors have predicted future probable cells. While handoff is performing for resource reservation, choosing the minimal number of neighboring cells is important. Meaning QoS during handoff, many algorithms are proposed like direction-based motion prediction scheme and Global Positioning System (GPS), etc. Back Propagation Neural Network (BPN) considered MT's current location, velocity,

Corresponding Authors: Thazin Ei and Wang Furong, Friendship Apartment, Huazhong University of Science and Technology, Hubei, 430074, Wuhan, People's Republic of China

direction, etc., as input parameters and generative handoff possibilities to all target cells as output values, is proposed (Yu *et al*., 2001). Many proposals are for achieving seamless vertical handoff with required QoS. Chang *et al.* (2006) presented Area-based vertical motion estimation (AVME) scheme for prediction target wireless networks for next handoff on heterogeneous wireless networks. This scheme discoveries neighboring cells for each cell in different wireless networks and generates the corresponding external and internal resource maps. And it uses historical handoff data of each area by these maps to train the BPN network. And then it predicts next possible areas which consist of target networks and corresponding target cells for resource reservation of next handoff. McNair *et al.* (2000) proposed the concept of intersystem boundary cells to prepare the users for a possible intersystem handoff in advance. This reduces the intersystem handoff failure probability significantly. Many proposals have been shown that location services (information below network layer) can be used to aid handoff management decisions in addition to mobile navigation services. Cross-layer handoff algorithm employed in the physical layer solutions and also employed in the network layer or above is proposed in (Jie *et al*., 2006). In this handoff management platform, Handoff Managers (HM) stored network resource information such as address, routing and subnet resource utilization is introduced. Handoff between same networks is controlled by local HM (LHM) and handoff among different wireless networks is controlled by global HM (GHM). Handoff Manager (HM) decides that MN needs to handoff using layer 2 information for reducing communication interruption time and the number of lost packets due to handoff and handoff latency. This scheme improves the performance of handoff management in all IP-based heterogeneous communication environments. The goal of cross layer mobility algorithm is the better handoff in layer 3 (network layer) with the aid of layer 2 (link layer) information (Akyildiz *et al.*, 2004). Network layer solutions provide mobility issues that concern with IP layer and link layer solutions provide mobility issues that concern with underlying radio systems. Network layer mobility management solutions are divided into (1) macro-mobility that mobile users move between two network domains and (2) micro-mobility that mobile users move between two subnets within one domain. In network layer solutions, mobile IP that can support mobility across both homogeneous and heterogeneous systems is proposed. Many micro-mobility solutions that based on (1) tunnel and (2) routing micro mobility schemes have been studied. Tunnel-based micro-mobility protocols consist of mobile IP regional registration (MIP-RR), hierarchical mobile IP (HMIP) and intradomain mobility management protocol (IDMP) (Misra *et al*., 2002). Routing-based micro-mobility protocols consist of cellular IP (CIP) (Campbell *et al*., 2000) and handoff aware wireless access Internet infrastructure (HAWAII) (Ramjee *et al*., 2002). Link layer solutions provide two issues for intersystem roaming. These are air interface protocol and the Mobile Application Part (MAP). Layer 2 mobility requires additional entities and signaling traffic for interworking and interoperation between different systems. By obtaining signal strength reports and velocity information from the link layer, the system can make better preparation for the network layer handoff. Under thinking of these algorithms, we propose about cross-layer handoff management algorithm that decreases the probability of false handoff initiation process till zero.

CROSS-LAYER HANDOFF MANAGEMENT ALGORITHM

Mohanty and Akyildiz (2006) proposed a cross-layer handoff management protocol (CHMP) that uses mobile's speed and handoff signaling delay information to enhance the handoff performance in intra and intersystem handoff management in next generation wireless systems (NGWs). In that research, at first, the handoff performance of mobile IP is analyzed with link layer and network layer parameters and then CHMP architecture is developed. According to mobile's speed and signaling delay information the probability of handoff failure is calculated. By this calculation, CHMP is developed with zero handoff failure probability. Although this protocol is very efficient with zero handoff failure probability, authors didn't consider about precise position and direction of MT for calculating probability of false handoff initiation.

Based on the assumption that the handoff latency of the intra and intersystem handoffs is constant in link-layer-assisted handoff protocols, these protocols initiate handoff when the (received signal strength) RSS of the current serving (base station) BS drops below a predefined fixed threshold value. While MT is moving, RSS of the base station A is starting to drop below the threshold value S_{th} at point P. Therefore, MT will be handoff process very soon. If the RSS of base station B is larger and more optimized than the RSS of base station A, MT will send handoff registration messages to base station B. We assume that MT can move in any direction with equal probability, therefore, the pdf (power density function) of MT's direction of motion ϕ is:

$$f_\phi(\phi) = \frac{1}{2\pi} \qquad -\pi < \phi < \pi \tag{1}$$

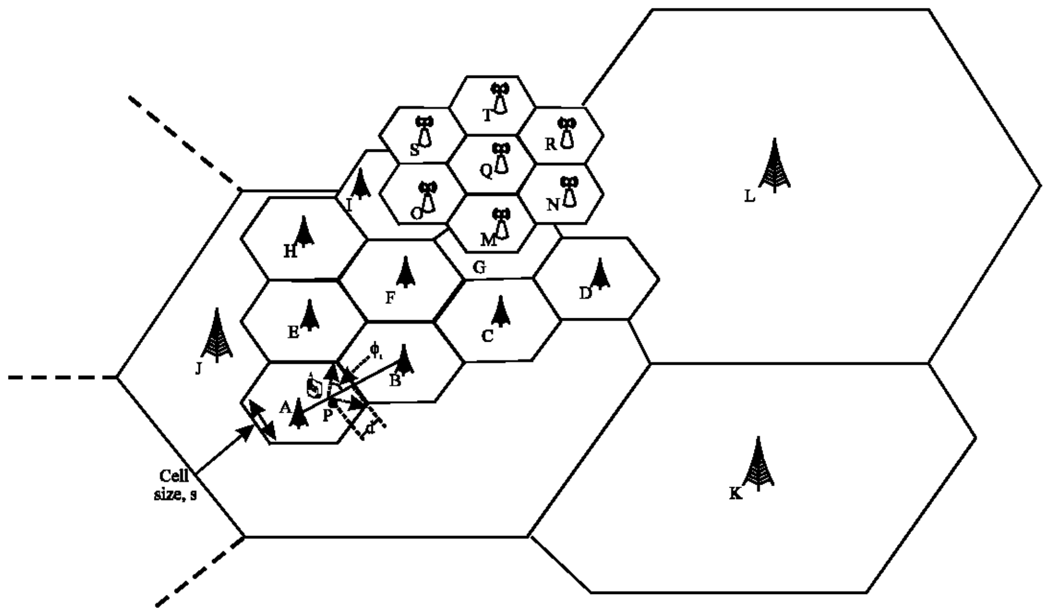

Fig. 1: Architecture of heterogeneous wireless networks

As shown in Fig. 1, the handoff will happen to base station B in the range [$\phi\in(-\phi_1, \phi_1)$], where, ϕ_1 = arctan (s/2d). By Eq. 1, we can calculate the probability of false handoff initiation as follow:

$$P_a = 1 - \int_{-\phi_1}^{\phi_1} f_\phi(\phi)d\phi \tag{2}$$

In current condition, base station A's RSS is decreasing and MT is meaning to handoff to base station B at this point (P). By Eq. 2 we can calculate false handoff initiation probability. If we don't trace about the direction and precise position of MT, due to larger RSS of base station E, when mobile's direction suddenly changes to base station E from going to base station B, the calculation value of the probability of false handoff initiation will be as follow:

$$P_a = 1 - 0 = 1 \tag{3}$$

It is clear that since MT's direction will not be between $-\phi_1$ and ϕ_1, the part

$$\int_{-\phi_1}^{\phi_1} f_\phi(\phi)d\phi$$

equals to zero and the probability of false handoff initiation will be hundred percent.

As shown in Fig. 1, heterogeneous wireless networks configure with different network architectures such as pico-cell, micro-cell, macro-cell and satellite systems, etc. MT is currently located in the coverage area of cell A and it may possibly move into the area of cell B or cell E or cell J, respectively. The future location of an MT depends on its moving direction. MT's current position is closely related to its next position due to the continuity of movement. If MT is moving to east, it is likely that it is going to move into cell B. Currently MT's direction changes from east to north it is most likely that it is going to move into cell E. Therefore incorporation of an MT's movement direction and position is very important to provide an accurate mobility pattern for handoff.

In current, though MT's coming direction had already changed to cell E, its direction can change to cell J also. Future communication environment has been composed of different types of heterogeneous wireless networks, which are overlapped with each other. Therefore, MT currently in base station A can be possible handoff process to most networks. In wireless networks, the movement patterns of mobile objects are very important because mobility and resource management play in a vital role for supporting mobility and providing QoS. Let assume the shape of each cell is hexagons and it has six neighbors. In that case, although we can assume the probability of an MT leaving along one side is 1/6, it is false for the MTs with an active connection and a specific destination. If we can know MT's current precise position and direction, we can decrease the false handoff initiation probability to nearly zero. The more we can predict MT's current position and direction exactly, the more accurate the probability of handoff initiation we get.

For the purpose of estimation the precise position and direction of MT, Soh and Kim (1999) propose the use

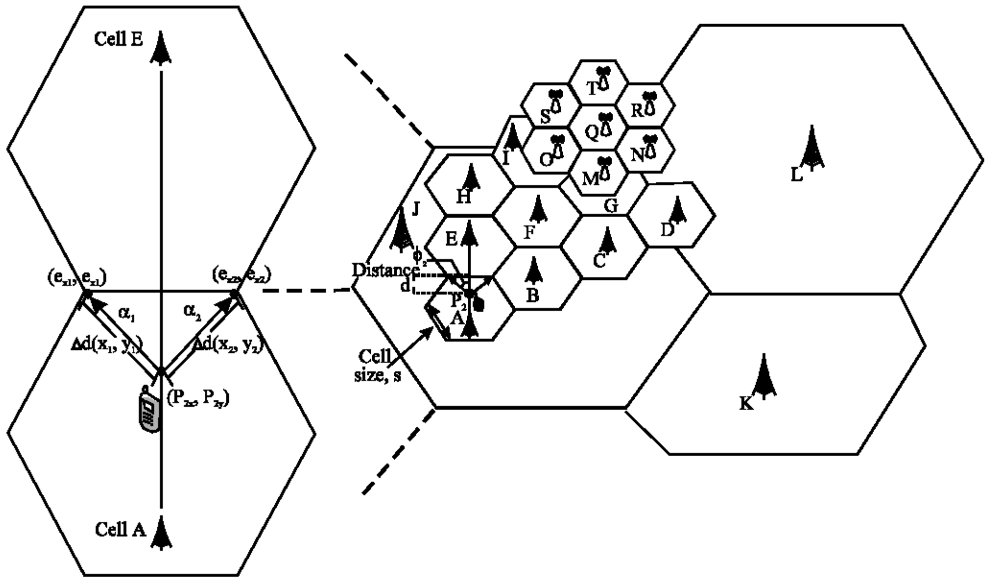

Fig. 2: Analysis of handoff process using precise position and direction of MT

of Global Positioning System (GPS) in each MT. By using GPS, a MT obtains its own position and direction information at regular time intervals ΔT and keeps track of its previous positions and direction over the last N intervals. Predictions are performed by individual MT to avoid overloading the network.

In this algorithm, by using GPS, we can know that MT's direction already changed to base station E. We are tracing MT by GPS at the whole time before handoff. MT is nearer and nearer the boundary of cell E and it's RSS is also decreasing and decreasing. As shown in Fig. 2, let assume when MT reaches point P_2, MT will start handoff process to cell E. By GPS, we know MT's exact coordinate at point (P_2) and vector velocity directly leading to cell E at this point. Using GPS we can choose probable value of distance (d) from this cell boundary for corresponding value of S_{th} with the meaning of decreasing probability of false handoff initiation. The possible moving directions (let assume that α_1 and α_2) to cell E for handoff initiation process can be calculated as follow:

We assume that the coordinates in boundary are $(e1_{x1}, e1_{y1}) = (50, 10)$; $(e2_{x2}, e2_{y2}) = (50, 50)$ and $(P_{2x}, P_{2y}) = (10, 25)$ using GPS.

By substituting these values, we can calculate the distance between one cell boundary edge and MT's current position:

$$\Delta d_{y1} = e1_{y1} - P_{2y} \qquad (4)$$
$$\Delta d_{y1} = (10- 25) = -15$$

$$\Delta d_{x1} = e1_{x1} - P_{2x} \qquad (5)$$
$$= (50-10) = 40$$

From Eq. 4 and 5, we can calculate the direction:

$$\alpha_1 = \arctan\frac{\Delta d_{y1}}{\Delta d_{x1}} = \arctan\frac{-15}{40} = -20.25°$$

The distance between next cell boundary edge and MT's current position is calculated:

$$\Delta d_{y2} = e2_{y2} - P_{2y} \qquad (6)$$
$$= (50-25) = 25$$

$$\Delta d_{x2} = e2_{x2} - P_{2x} \qquad (7)$$
$$= (50-10) = 40$$

From Eq. 6 and 7, we can calculate the direction:

$$\alpha_2 = \arctan\frac{\Delta d_{y2}}{\Delta d_{x2}} = \arctan\frac{25}{40} = 32°$$

It is clear that MT's direction to cell E (α), must be between α_1 = -20.55° and α_2 = 32°. Otherwise, the handoff will start to another one. Therefore, the probability of false handoff initiation will be as follow:

$$P_a = 0 \quad \text{if} \quad \alpha_1 \le \alpha \le \alpha_2.$$

By using velocity information, $[\bar{v} = (v_x, v_y)]$ from link layer, we can calculate MT's moving direction to cell E (α) as follow:

Let assume MT is moving with $\bar{v} = (v_x, v_y) = (100,50)$.

Therefore, MT' moving direction to cell E (α) as follow:

$$\alpha = \arctan\frac{50}{100} = 26.56^{\circ}$$

Since MT's moving direction (α) is between α_1 and α_2, MT is sure to handoff from this cell boundary to cell E and hence we can decrease the false handoff initiation probability until zero with the aid of GPS data. Unless (α) is between α_1 and α_2, MT will handoff to another cell, but, false handoff initiation probability will always be zero with the aid of GPS.

If we do not consider about precise position and direction of MT, the probability of false handoff initiation is

$$P_a = 1 - \int_{-\phi_1}^{\phi_1} f_{\phi}(\phi)d\phi \text{ by Eq. 2, where } \phi_1 = \arctan(\frac{s}{2d}).$$

It can be seen clearly that the probability of false handoff initiation will vary as cell size (s) and distance (d) vary.

The possible directions to considerable cell boundary (Cell E's boundary) can be known by using GPS. And we know the precise position (P_{2x}, P_{2y}) and direction (α) of MT by link layer information and using GPS. If MT's direction (α) is between these possible directions (α_1 and α_2), MT is sure to handoff from this considerable cell boundary and hence the probability of false handoff initiation (Pa) will always be zero in our algorithm.

CONCLUSION

In this research, we studied handoff management in wireless networks and then cross-layer handoff management algorithm is proposed for the better handoff in layer 3 with the aid of layer 2 information. We carried out the detailed analysis of cross-layer handoff management algorithm and we calculated to show that our algorithm significantly accurate the handoff initiation process and hence it decreases false handoff initiation probability. On the other hand, it has efficient use of network resources with exact handoff initiation and it improves reliability. Therefore this algorithm shows that cooperation between the network and link layer is able to improve the performance of both intra and intersystem handoffs.

ACKNOWLEDGMENTS

This research was supported by the National Sciences foundation of China under grant No. 60572047 and by the program for New Century Excellent Talents in University, NCET-06-0642.

REFERENCES

Akyildiz, I.F., J. Xie and S. Mohanty, 2004. A survey of mobility management in next-generation All-IP-based wireless systems. IEEE Wireless Commun., 11: 16-28.

Anna Hac, 2002. Mobile Telecommunications Protocols for Data Networks. University of Hawaii at Manoa, Honolulu. 1st Edn., British Library Cataloguing in Publication Data, ISBN: 0-470-85056-6 .

Campbell, A.T., J. Gomez, S. Kim and A.G. Valko, 2000. Design, implementation and evaluation of cellular IP. IEEE Pers. Commun., 7: 42-49.

Chang, I.C., C.H. Wang and L.H. Chang, 2006. An area-based vertical motion estimation on heterogeneous wireless networks. Lecture Notes Comput. Sci., 4138: 187-198.

Ian, F.A. and W. Wang, 2004. The predictive user mobility profile framework for wireless multimedia networks. IEEE/ACM Trans. Networking, 12: 1021-1035.

Jie, C., L. Chulin and L. Shaoqian, 2006. Cross-layer handoff management scheme in heterogeneous networks. 6th International Conference on ITS Telecommunications Proceedings. June 21-23, IEEE, pp: 1041-1044.

McNair, J., I.F. Akyildiz and M. Bender, 2000. An inter-system handoff technique for the IMT-2000 system. Proc. IEEE INFOCOM, 1: 208-216.

Misra, A., S. Das, A. Dutta, A. McAuley and S.K. Das, 2002. IDMP-based fast handoffs and paging in IP-Based 4G mobile networks. IEEE Commun. Manage, 40: 138-145.

Mohanty, S. and I.F. Akyildiz, 2006. A cross-layer (Layer 2 + 3) handoff management protocol for next-generation wireless systems. IEEE Trans. Mobile Comput., 5: 1347-1360.

Ramjee, R., K. Varadhan, L. Salgarelli and S.R. Thuel, 2002. HAWAII: A domain-based approach for supporting mobility in wide-area wireless networks. IEEE/ACM Trans. Net., 10: 396-410.

Scott, C., M. Cooper, D. Podlich and G. Hammer, 2003. Evaluating plant breeding strategies by simulating gene action and dryland environment effects. Agron. J., 95: 99-113.

Wee-Seng, S. and H.S. Kim, 1999. Dynamic bandwidth reservation in hierarchical wireless ATM networks using GPS-based prediction. IEEE, 1: 528-532.

Yu, W.W.H. and C.H. He, 2001. Resource reservation in wireless networks based on pattern recognition. IEEE Int. Joint Conf. Neural Network (IJCNN'01), 3: 2264-2269.