PROBABILITY BASED HANDOVER VS MOBILE – IP FOR A MULTI-HOMED HETEROGENEOUS NETWORK ENVIRONMENT

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ABSTRACT

Traditional handover mechanisms trigger network selection based on dynamic performance metrics such as Received Signal Strength (RSS), Delay, and Loss etc. These dynamic approaches do not take into account how the predictability of end user movement can be used to influence and optimize handover selection. For systems with repeated movement such approaches are limited as they do not consider how the predictable nature of mobility can be used to influence network selection. Some places where we can see predictable movement would be motorway roads or public service vehicles and educational institution. Traditional network selection mechanisms do not exploit this predictability. This performance work proposes PHANS – A Probability Based Handover Algorithm for Network Selection Using End User Predicted Movement in order to weigh the relative importance of both dynamic performance metrics together with predictable movement patterns in order to optimise network selection. Results presented illustrate that significant performance improvements are achievable when the predictability of end user movement is considered as part of a network selection decision.

KEYWORDS

Network handover, Mobility, Probability, Mobile-IP

1. INTRODUCTION

In principle, each mobile terminal (node) is, at all times connected to a network and within range of at least one network access point on that network (Nasser, 2006). The area serviced by a Base Station (BS) is identified as its cell. As a mobile device moves in and out of coverage it hands over its connection from one cell on a network to another cell. Most network selection approaches use an evaluation of network performance to determine when handover should take place (Stewart, Sep.2007) (Kassar, 2008) (NIST, January 2007). Traditional handover initiations are based on RSS, Delay and Loss (L.-H. Chen, 2010) (B.-J. Chang, 2008). Such approaches have evolved by proactively predicting RSS values, though still making use of static handover triggering thresholds (M. Li, 2007) (N. Capela, June 2011). Other criteria that are now taken into account in handover initiations include; bandwidth, latency, link quality and Quality of Service (QoS) (Kassar, 2008). Such network selection approaches are limited as they do not consider how the predictable nature of mobility can be used to influence network selection. It has been proven by researchers in Northeastern University (Nyul, 2010) that 93% of human movement is predictable regardless of the different distances people travel. The 93% predictability remains true both for those who travel far distances on a regular basis and for those who typically stay close to home. Some situations/instances where predictable movement can be seen would be on motorway roads or Public service vehicles such as buses and trains typically operate in preconfigured routes which are repeated at routine intervals. In an educational institution students mainly follow predictable routes between classes. This paper shows that taking predictable movement as an input metric in the decision making process can change the decision of network handover and optimise the network using SCTP and its features of multi-homing and multi-streaming which are inherited from TCP because these are ideal to compare mobility of end to end users and there network handover (Armagan, 2010).

2. RELATED WORK

Traditionally most network handover was done by using a static rules based system which would utilize static thresholds that were applied to different metrics such as Delay, Loss and RSS to determine network handover. These approaches are still being used with greater accuracy by proactively predicting the RSS values, though it still makes use of the static thresholds. While RSS is an important performance parameter, used alone it does not provide an accurate view of the dynamic status of a link. That is why handover approaches have considered multiple performance parameters which include RSS, delay and loss rate. Some solutions also consider metrics related to the content delivery quality as experienced by end users (Atiquzzaman, 2006). Such approaches however are performance limited as they apply static performance thresholds, which when exceeded, trigger handover. Applying a static performance threshold makes assumptions regarding the status of a network. Previous work undertaken (E. Fallon, 2011) illustrates that it is beneficial for the handover management algorithm to probe network performance and dynamically alter thresholds through synaptic weights. Related work in this area suggest using non rules based approaches and multi-homing to achieve continuous network access across mobile nodes and provide support for several heterogeneous network interfaces (Siddiqui, CNSR 2006).

3. TECHNOLOGY OVERVIEW

3.1 Application Layer - SIP

Session Initiation Protocol (SIP) (Rosenberg, 2002) is one of the IP phone signalling protocols. SIP is an application-layer VoIP protocol which is based on Hyper Text Transfer Protocol (HTTP) standard. It runs on top of transport layer protocols like TCP, UDP or SCTP. SIP is used for handling multimedia sessions over the Internet, allowing the user to initiate, modify and terminate a session on an IP network. SIP may be an attractive candidate as an application layer mobility management protocol for vertical handoff over IP.

3.2 Network Layer Mobility- Mobile IP

Mobile IP was proposed by (Perkins, 2002) to solve the problem of mobility over IP. The main components of mobile IP are the following:

- **Mobile node**: Mobile node (MN) is a device such as a cell phone, smartphone, tablet or laptop whose software enables network roaming capabilities.
- **Home Agent:** Home Agent (HA) is a router on the home network serving as the anchor point for communication with the Mobile Node; it tunnels packets from a device on the Internet, called a Correspondent Node, to the roaming Mobile Node.
- **Foreign Agent**: Foreign Agent (FA) is a router that may function as the point of attachment for the Mobile Node when it roams to a foreign network, delivering packets from the Home Agent to the Mobile Node.
- **Care of Address**: Care of address (CoA) is the termination point of the tunnel toward the Mobile Node when it is on a foreign network. The Home Agent maintains an association between the home IP address of the Mobile Node and it’s care of address, which is the current location of the Mobile Node on the foreign or visited network (Cisco, 2006).

3.3 Other Solutions for IP Mobility

Other solutions for IP mobility include Migrate, Host Identity Payload (HIP), Client Mobile IP (CMIP), and Proxy Mobile IP (PMIP).

Migrate involves shifting an existing TCP connection from one IP address to another by using a modified TCP SYN message and subsequent TCP ACK message.

HIP proposes a globally unique identifier for any host with an IP stack. This name is cryptographic by design and can be used to authenticate transactions. Furthermore HIP proposes to interpose a protocol layer between the network (IP) layer and the transport layer.

CMIP is the most popular solution for mobility but there are limitations such as long handover latency and it cannot provide the total mobility solution.

PMIP is a mobility mechanism to ensure mobility management of the user terminal in different access networks (Armagan, 2010).

3.4 Transport Layer Mobility- SCTP

SCTP (Stewart, 2007) is a transport layer protocol that extends the functionality of the celebrated TCP standard. SCTP provides a hybrid service called partial reliable SCTP (PRSCTP). PR-SCTP is used to support real-time applications by relaxing retransmission guarantees (M. Fiore, 2007). SCTP provides support for multi-homed end-points, i.e., devices with more than one network interface (Wallace & Shami, Second Quarter 2012).

3.5 Artificial Neural Networks

An Artificial Neural Network (ANN) is a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs (Caudill, Dec. 1987). ANN can be compared to the biological systems that make up a human brain in terms of how one learns to achieve a goal or solve a problem. An ANN is made up of three layers the input, output and hidden. ANN approaches belong generally to two classes: supervised and unsupervised. Unsupervised approaches are motivated by the requirement to be autonomous self-organizing structures. The most popular unsupervised learning approaches are Adaptive Resonance Theory (ART) (Kohonen, 2010) and Kohonen networks (S.Grossberg, 1976). Supervised learning is the machine learning task of inferring a function from labelled training data. The training data consist of a set of training examples. In supervised learning, each example is a pair consisting of an input object (typically a vector) and a desired output value (Fallon, et al., 2013).

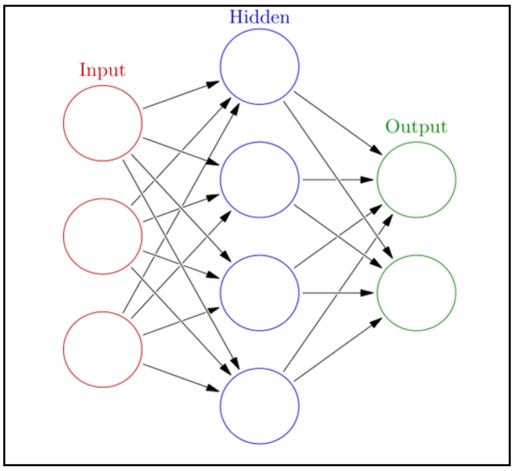

Figure 1. An Artificial Neural Network structure

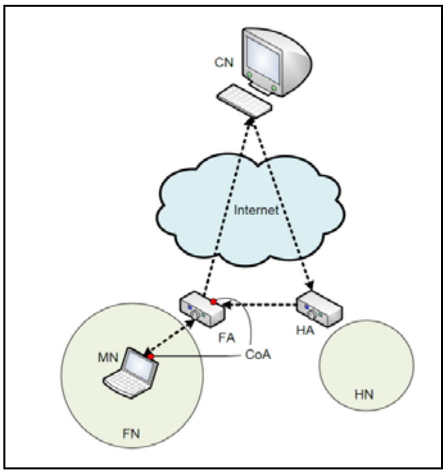

Figure 2. Mobile – IP structure and component

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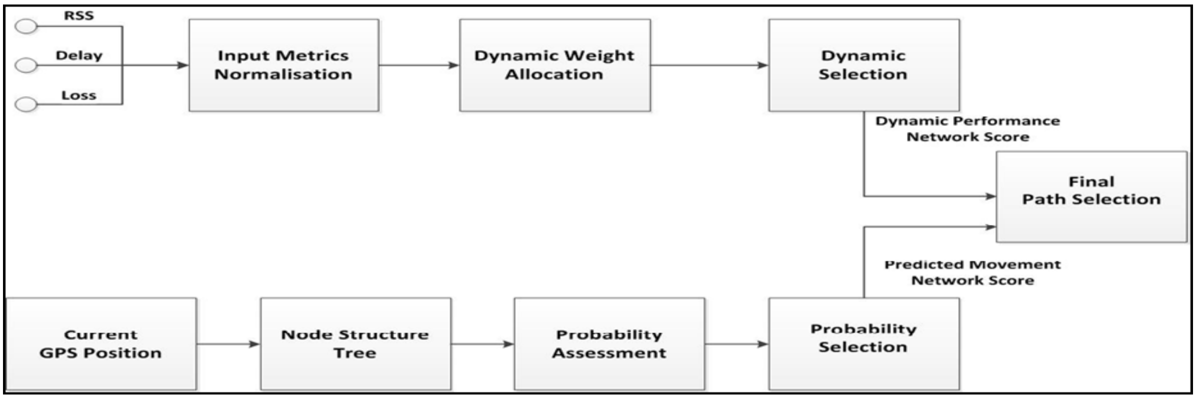

Figure 3. Illustrates the major components of the PHANS algorithm.

4. PROPOSED APPROACH

Dynamic Network Performance Evaluation: PHANS takes an input of dynamic network performance metrics; RSS, Delay, and Loss. These metrics are parsed and normalised on a scale of 1 (poor performance) to 100 (excellent performance). Following performance normalisation, dynamic weight allocation provides a weight reflecting the relative importance of each metric. The dynamic weight is then multiplied by the normalised inputs and summed to indicate dynamic network performance.

Probability of Movement Evaluation: In the PHANS approach a nodal structure is dynamically created representing the Access Points (AP) topology in a given area. The topology is constructed based on previous mobility recorded by the GPS module on the device. Using historical data, PHANS overlays the probability of inter AP movement to the topology. The node with the highest score is suggested by the probability assessment module as the candidate AP.

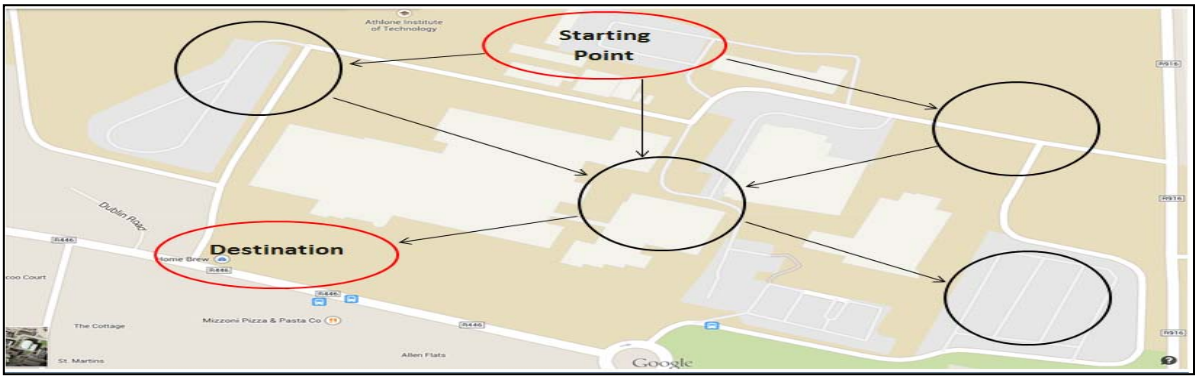

Figure 4. Proximity Nodes Structured Tree

Figure 4 is an image of Athlone Institute of Technology taking from Google maps which was overlaid on an example of a nodal structure that would be created by PHANS to represent the APs in the area that were used to run the simulations. It also shows the starting point and destination of the student group

Candidate Path Selection: Within the PHANS algorithm, the path selection subcomponent takes two inputs (a) a candidate AP selection based on dynamic performance (b) a candidate AP selection based on predicted movement. If these selections conflict the PHANS algorithm will weigh the previous performance of each selection when determining the current optimal path selection.

5. RESULTS

5.1 Experimental Evaluation of Characteristics

In order to determine network performance using the PHANS algorithm, a series of experiments tests were undertaken at the Engineering building at Athlone Institute of Technology. To create the experiments the movement was examined of a group of students from one class room to another. A Linksys wireless broadband router was placed at specific locations associated with the movement of students on their route from one class to another. The route the students took was then physically walked, passing into and out of the access point coverage areas recording delay, loss and RSS. This data was collected using network tools and the metrics extracted were then input into the NS2 simulation model and the throughput of the simulations were collected and compared.

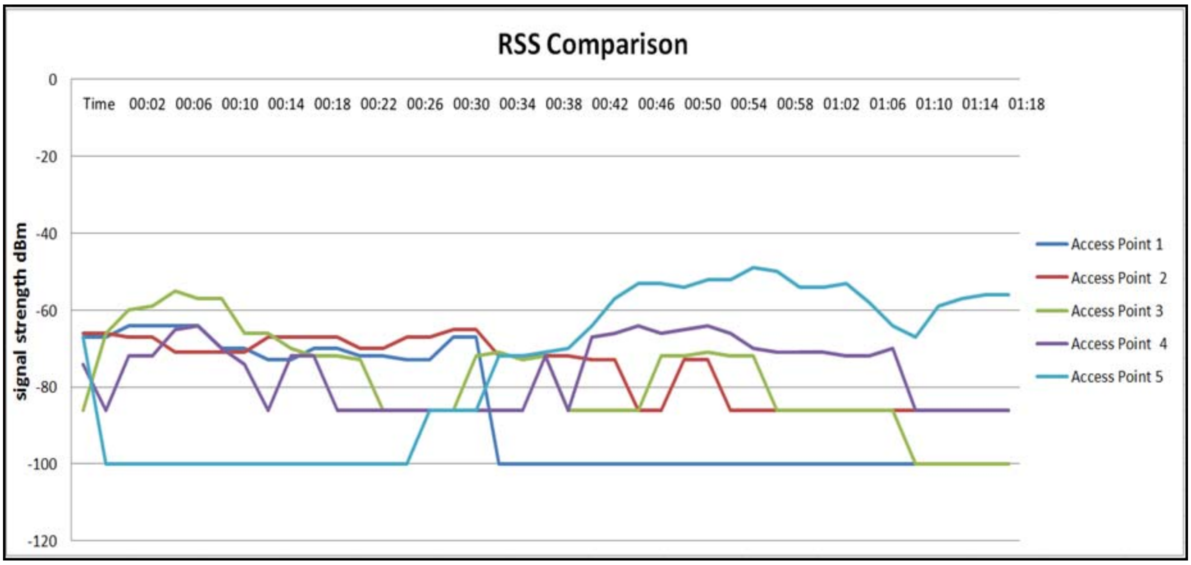

Figure 5. Illustrates the recorded RSS for the 5 aps in the configuration.

If the RSS in Figure 5 is examined at the 2 second mark it indicates that AP3 was the best available AP. Using traditional handover decision making the decision would be made to connect to AP3, but in contrast the PHANS algorithm would connect to AP2 because at that time on AP2 there was a 25% loss rate and as you can see from the graph the access point begins to degrade a short time after. Such an approach would avoid a potentially spurious handover to AP3. The RSS signature from Figure 5 indicates the end used is walking in the direction of access point 2 and away from AP1 and AP3. Therefore using predicted movement to influence the decision of the handover and optimise the possible throughput as seen in Table 1.

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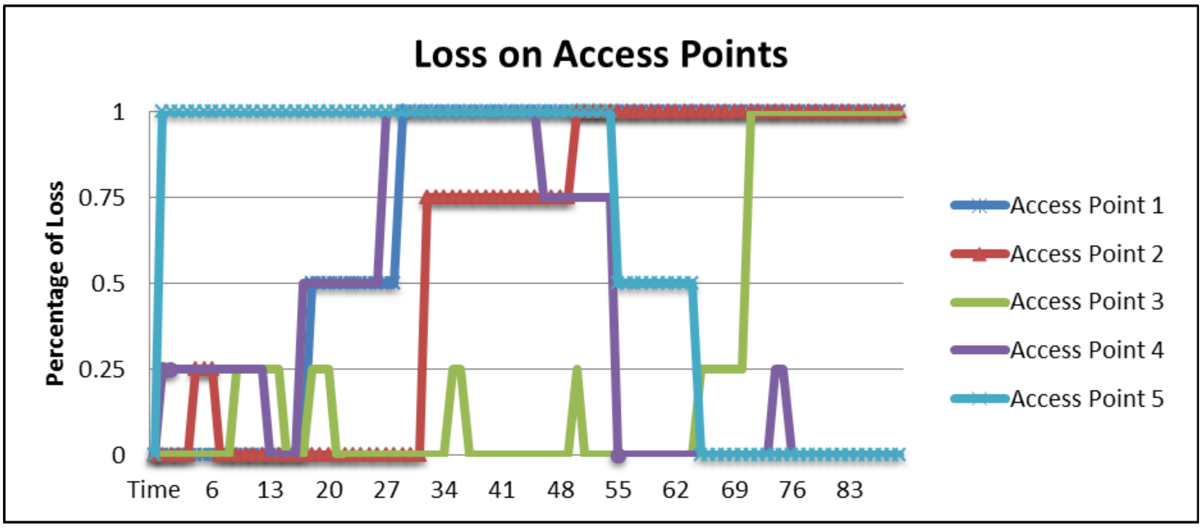

Figure 6. Illustrates the recorded Loss for the 5 APs in the configuration

In figure 6 the loss of the five access points on the network at the time of the experiment were recorded and the information was used in the creation of the simulation.

5.2 Simulated Evaluation of the PHANS Algorithm:

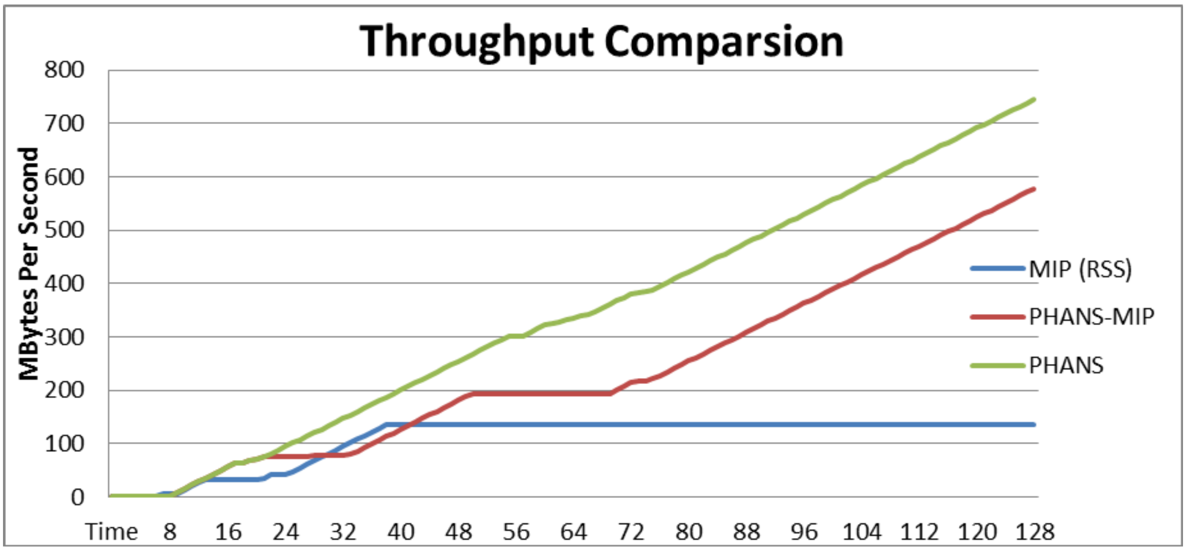

Figure 7. illustrates the throughput performance of the PHANS algorithm against the Mobile-IP (MIP) mobility protocol.

5.2.1 MIP

The NS2 simulation model was run using MIP, as can be seen from the graph MIP makes a handover at different times to the PHANS algorithm because it is based on RSS. From Figure 7 it can be seen that MIP hands over at the following times 4, 19, 36, 38 and 60 seconds. Each one of these handovers are hard handover meaning that it drops connection with the current AP and establishes a new connection with the new AP and can take up to 2 seconds. MIP makes a handover decision to connect to AP3 at 36 seconds, while trying to re-establish connection to AP3 it begins to fail and starts receiving an access error from AP3 and after a 25 seconds of retrying to establish connection the timeout counter has increased and the receiver buffer block becomes full causing the simulation to stop sending packets and finally crashing.

5.2.2 MIP & PHANS

Using MIP with the PHANS algorithm to help network selection it chooses to handover to different APs from standard MIP and at different times. It can be seen from Figure 7 that MIP & PHANS hand over 3 times in the simulation. What is clear from the graph is that MIP has a better throughput than MIP & PHANS between 28 and 36 seconds because of the different handover decision. But using PHANS and MIP prevents the simulation from handing over to AP3 at 36 seconds and instead hands over to AP4 which prevents the simulation from crashing. This allows the simulations to run and output a realistic throughput for the route using MIP & PHANS.

5.2.3 PHANS

Finally a comparison of both MIP against MIP & PHANS was made against PHANS. As can be seen from Table 1, PHANS has the best throughput through the simulation. The reason for this is that PHANS is a soft handover strategy whereas MIP is a hard handover strategy. This means that PHANS can establish a connection to the chosen AP before handing over, where MIP has to drop connection with its current AP to allow it to target a new AP for connection. This proves that the PHANS algorithm is a better mobile handover strategy than standalone MIP. PHANS improved the throughput of the simulation by 420% compared to MIP over this simulation and a further 31% improvement compared to MIP & PHANS as is displayed in Figure 7 above.

Table 1. Handover decisions for MIP and PHANS

Time(Seconds)	MIP(Access points)	PHANS(Access points)
0	**1**	**1**
4	2	
19	1	
22		2
36	2	
38	3	
56		3
60	4	
67		4

6. CONCLUSION AND FUTURE WORK

In this work a probability based handover management function was proposed for SCTP which exploits historic end user movement patterns while also considering dynamic network conditions. In order to populate the algorithm with historic usage patterns this data had to be entered manually that was gathered from the experiments. Results illustrate that our probability based handover algorithm generally has significant performance improvement over standard MIP handover mechanisms.

In future work much more significant amounts of data will be collected and analysed. Network data and the end user geographical positions will be recorded using a mobile App. An appropriate method of storing this historical data will be investigated. The geographical positions, together with the duration of time spent at certain locations and the direction travelled will be used to generate a rooted tree representing end user movement. During execution this tree will be used to weigh the relative importance of candidate wireless access points. This will also allow for the comparison of the Dynamic Performance Network Score and the Predicted Movement Network Score. This will then inform the final decision on handover. SIP will be investigated as an application layer mobility management protocol.

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