Serge Fdida
Kazunori Sugiura (Eds.)

LNCS 4866

Sustainable Internet

Third Asian Internet Engineering Conference, AINTEC 2007
Phuket, Thailand, November 2007
Proceedings

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Library of Congress Control Number: 2007939171

CR Subject Classification (1998): C.2, C.3, F.1, F.2.2, K.6

LNCS Sublibrary: SL 5 – Computer Communication Networks
and Telecommunications

ISSN 0302-9743
ISBN-10 3-540-76808-4 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-76808-1 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springer.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 12192373 06/3180 5 4 3 2 1 0

Preface

The 3rd Asian Internet Engineering Conference (AINTEC) followed the first two successful editions held in Bangkok, Thailand, and focused on developing synergies between researchers in Asia and worldwide, but was also a unique chance for young, talented regional scientists to meet and interact. AINTEC 2007 was therefore a major opportunity for presentations and discussions around these objectives. In particular, it aimed at addressing issues pertinent to the Asian region with vast diversities of socio-economic and networking conditions while inviting high-quality and recent research results from the global international research community to be presented. The conference is single-track to favor discussions among a diverse set of participants.

We want to thank the authors of the 66 papers submitted for considering AINTEC as the right target for their paper. The submissions came from 18 countries with, as expected, a majority from Asia. The program was composed of 14 accepted papers organized in 6 technical sessions including 7 invited talks by leading experts on innovative topics, presentations of papers, demos, posters and a pre-conference 18th Asian School on Computer Science (November, 25–26 2007).

You might think that AINTEC is yet another conference but it has different objectives and spirit, it offers a great opportunity to discuss future challenges for a sustainable Internet, and to get to know the local and regional researchers and enjoy the great hospitality of Thailand.

This edition was made possible thanks to many individuals. We want to warmly thank the Program Committee members for accepting to spend time in supporting the conference and carefully reviewing the submissions. We are very pleased with the support from Springer as a publisher for the proceedings and would like to thank them for their trust. Finally, our strong recognition goes to Apinun Tunpan, who took care of all the logistics in managing the review process and Kanchana Kanchanasut for perfectly orchestrating the event. We, personally, enjoyed being involved in this edition of AINTEC.

November 2007

Serge Fdida
Kazunori Sugiura

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Packet Forwarding in Pocket Switched Networks – An Empirical Characterization of Human Mobility

Christophe Diot

Thomson, France

Abstract. Pocket switched networks (PSNs) make use of human mobility and local forwarding in order to distribute data. Information can be stored and passed, taking advantage of the device mobility, or forwarded over a wireless link when an appropriate contact is met. Such networks fall into the fields of mobile ad-hoc networking and delay-tolerant networking. PSN are totally distributed and cannot rely on central services for issues such as naming, authentication, trustatibility. The direct consequence is that forwarding in PSN is non trivial. In order to better understand the challenges associated to PSN design, we have collected human mobility data.

We establish three fundamental properties of PSNs. First, the distribution of inter-contact time follows an approximate power law over a large time range in all data sets. This observation is at odds with the exponential decay expected by many currently used mobility models. Second, we establish that the diameter of PSNs is in the order of 10 hops, confirming the existence of the well know "small world" phenomenon in human mobility. Last, we show that all forwarding algorithms are equivalent from a delay and success rate standpoint due to a "path explosion" phenomenon that generally occurs a coupe of minute after the optimal path. We establish these three properties experimentally and give in each case a simple analytical model that explains our observations. We discuss the implications of these observations on forwarding algorithms in PSN. We conclude the talk by early results on the role of communities and interest in the PSN node population. These communities could be later used to optimize packet forwarding. We describe the on-going implementation of our PSN application.

S. Fdida and K. Sugiura (Eds.): AINTEC 2007, LNCS 4866, p. 1, 2007.

Mobility Versus Density Metric for OLSR Enhancement

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Abstract. In order to improve network performance, adaptive protocol would adapt to different aspects of the network dynamic exhibited by the wireless systems and more particularly by the ad hoc networks. In this paper we consider the adaptation to the ad hoc network dynamic through two parameters: mobility and density. We study the impact part of the density metric and of the mobility metric. Considering the Optimized Link State Routing protocol (OLSR), our work focus on the Multipoint Relays (MPR) selection. A new approach to select a MPR by using a simple modification and no additional packet header is proposed. It introduces the idea of Link Duration criterion as mobility metric for MPR selection. From simulation results it appears that the protocol performance can be enhanced by mobility adaptation after the density one. The proposed scheme outperforms the standard protocol for large number of nodes.

Keywords: OLSR, MPR Selection, Link Duration, Mobility Metric.

1 Introduction

Ad-hoc network are characterized by an absence of pre-existent infrastructure that can induce suddenly and unpredictably change of the network. A route can be broken by the move of an intermediate node or by the bad quality of a wireless link. Mobile nodes can enter or leave the network and thus modify the network density and the connectivity. So, to improve their performance, protocols would adjust their behavior to network conditions. Protocol adaptations would be based on metrics to capture mobility, node density or link quality.

A first question is: how to describe the mobility? It may be defined by different metrics. A metric is a probability, a direct or indirect measurement of mobility. A direct measurement is based on the position or the absolute or relative velocity of the nodes. It is thus necessary to associate this kind of metric to a positioning system. An indirect measurement of mobility is based on the assumption: if an increase in mobility degrades a metric, it is assumed that a degradation of this metric indicates an increase in mobility. The present study on mobility is based on indirect measurement of mobility.

A synthesis of mobility metrics is given in [1]. It indicates a classification based on the means of detection of the indicators and the functions which they influence. Metrics are obtained from different levels (i.e. at physical, logical link and network

S. Fdida and K. Sugiura (Eds.): AINTEC 2007, LNCS 4866, pp. 2–17, 2007.

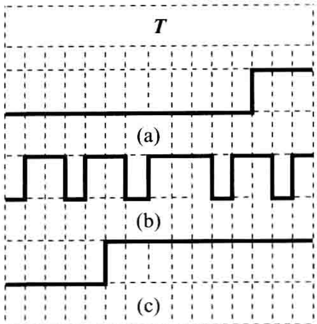
level). In [2] we evaluate three mobility metrics: Frequency of Link State Changes (LC), Link Connectivity Duration (LD) and Link Stability Metric (LS). In [3], a mobile adaptive routing strategy is presented. Mobility metrics are used to select cluster head and to change the routing mode: in case of high network dynamic, the routing mode is flat, while it is hierarchical for low mobile environment. In a similar way, others protocols would be enhanced by knowing the *"less"* mobile element. Optimized Link State Routing (OLSR) protocol [4] is a well-known manet protocol based on specific nodes called *Multipoint Relays (MPRs).* Because only the MPRs are in charge of the control traffic flooding, the control overhead is reduced. Furthermore, only a part of the topology information is exchanged through MPRs. To minimize the MPR set, the MPR Selection heuristic actually focuses on the density. The research of stable MPRs set would yield to better results [5].

We propose to take into account link duration criterion in MPR selection process. As a result, the network has a stable MPR set; it would also provide route stability because OLSR uses only MPRs in route calculation. So, by selecting stable MPR set, which we can observe by the number of MPR changes, we would improve the route stability, decrease the end-to-end delay and decrease the overhead for route maintenance. Meanwhile, because MPR stability is also related to the network density we propose to conserve the density criteria. In this paper we investigate the impact of the mobility compared to the density for the OLSR performance.

Paper organization is as follows: section 2 presents mobility metrics, section 3 depicts OLSR and MPR selection algorithm improvements, section 4 describes the proposed heuristic for MPR selection with mobility metric and section 5 indicates performance metrics and simulation models to evaluate density and mobility impact over OLSR and performance simulation results are discussed in the final of this section.

2 Mobility Metric

In this section, we present the study of mobility metrics. Good mobility metric characteristics [6] should to be: computable in a distributed way without global network knowledge, able to indicate or predict the protocol's performance, feasible to compute (in terms of node resources), independent of any specific protocol and computable in real network. According to these characteristics, Frequency of Link State Changes (LC) and Link Connectivity Duration (LD) metrics are studied in [6]. *LC* is the number of link state changes. When Node comes into the transmission range of another node, the value of this metric is increased by one indicating a link connection. When Node moves out of the transmission range, the value of this metric is increased by one indicating link breakage. The average LC is done over the number of considered nodes. *LD* indicates the period a link is in the transmission range of a determined node. Results show a better performance correlation with LD than with LC. Thus LD is considered to be better than LC. However, the connection period is not shown in LC and the frequency of link changes is not presented in LD. Hence, the authors in [7, 8] present *LS* that combines the information of both LD and LC. LS capture link longevity as well as frequency of link changes. It is defined as: LS = LD/LC. Meanwhile we do not consider LS as a *"good metric"* as explained in figure1.



	a	*b*	*c*
LC	1/T	9/T	1/T
LD	T/5	2T/3	2T/3
LS	$T^2/5$	$2T^2/27$	$2T^2/3$

(d)

Fig. 1. Impact of mobility on three mobility metrics

As shown in figure1-a and 1-c, LC in both cases is equal but the link duration is different. The routing protocol may work better in the case 1-c than in the case 1-a because of the long duration connectivity which means that there is a route to the destination (if there is a route the protocol can find it). Average LC in figure1-b is more frequent than in figure1-a. However, the routing protocol can perform better in figure1-b than in figure1-a because of the long duration connectivity. Hence, the average LC is not the best mobility metric.

LS can indicate LD as well as LC. Nevertheless, LS is not really a good metric because it depends on LC. According to figure1-d, the value of LS, it ordered by $2T^2/3$ (c) > $T^2/5$ (a) > $2T^2/27$ (b). It appears that LS in figure1-a is more stable than in figure1-b. Indeed, the routing protocol can work better with LS in case 1-b than in case 1-a because of the long duration connectivity. Therefore, the average LS does not seem to be the best mobility metric.

As illustrated in figure1-b and figure1-c, LD in both cases is equal but the frequency of link change is different. Network goodput can probably be good in 2 cases because of the long duration connectivity. Although, the overhead is higher in figure1-b case than in figure1-c, because of LC value. The average LD in figure1-b is more stable than in figure1-a but it is more frequent too. However, the routing protocol can be more efficient in figure1-b than in figure1-a. Hence, the average LD would be the best mobility metric among all three mobility metric.

Considering by NS2 simulations the performance correlation with the three metrics, Figure 2 shows the pertinence of the LD metric compare with LC and LS, since the growth of the metric induces an increase of the packet delivery ratio for many routing protocols (AODV, DSR, OLSR) over different mobility models, such as Random Way Point (RWP) and Reference Point Group Mobility model (RPGM). For the results of LC and LS, there are no good relations between the packet delivery ratios with mobility metric.

Meanwhile the computation of LD is closely dependant of the node number. In case of low number of nodes, the number of neighbors for each node is not sufficient to obtain valuable value; the confidence interval is too large. Note that the confidence interval can be reduced by an increase of the observation period, but in this case the adaptation process would be too long to reflect the network dynamic.

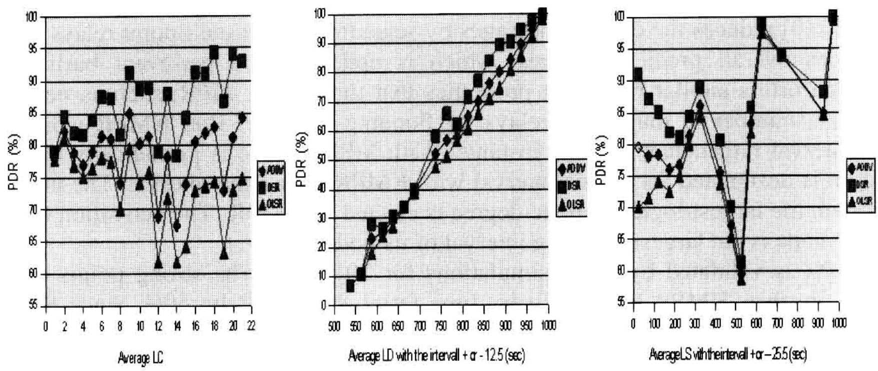


Fig. 2. Performances relative with different mobility metrics

As a conclusion it appears that even if the mobility metric, especially link duration, influences the protocol performance, density has not to be neglected.

3 Optimized Link State Routing Protocol (OLSR) and MPR Selection Algorithm

Many works have been done to improve OLSR such as increasing Hello message interval (Fast-OLSR) [9], increasing topology maintenance interval (OLSR-TM) [10], Multi-channel OLSR [11] and Link Buffering for OLSR [12]. As for us we focus on the MPR selection algorithm.

3.1 MPR Basics

The OLSR [4] main concept is Multipoint Relays (MPR). The idea of MPR is to reduce the information exchange overhead in the same region in the network. Each node periodically broadcasts HELLO messages, containing the information about its neighbors and their link status. From these messages nodes select MPR.

More precisely, the MPR set includes minimum number of one-hop symmetric neighbors from which it is possible to reach all the symmetrical strict two-hops neighbors. The node must have the information about one and two-hop symmetric neighbors to calculate for the MPR set. All the information exchanges are broadcasted using Hello messages. The symmetric neighbors who have indicated their interest in the Hello message can be selected to act as MPR.

The main criteria of Multipoint Relay selection algorithm is the reachability number of two-hop node, we can say that it is based on a *density metric*. The given node chooses the one-hop neighbor nodes that reach the maximum number of two-hops nodes as MPR.

3.2 MPR Modified Selection Algorithm

This sub-section presents works using different metrics to choose MPR set.

3.2.1 Kinetic Multipoint Relays (KMPR)

KMPR [13] reduces the control messages by selecting kinetic multipoint relays based on nodes overall predicted degree, which is updated on a per-event basis. The approach offers similar broadcast properties that the regular MPR, such as network coverage, number of multipoint relays, or flooding capacity. But, KMPR works on time interval rather than on time instants. With MPR a node is periodically chosen, while it is designated for a time interval with KMPR for a time interval. The node in *N(i)* with the largest logical kinetic degree is elected as KMPR. The activation of this KMPR node is the largest covering interval of its nodes in $N^2(i)$.

KMPR is validated by NS-2 simulations for 20 nodes. The strong points of the results are that, KMPR has a delivery time faster than MPR by 50%, since KMPR uses mobility predictions and does not rely on periodic maintenance; the routing overhead may be reduced by 75%.The weak points of the results is to determine the influence of the mobility metrics compare to the density one, as there is a low network density, 20 nodes.

3.2.2 Link Stability Based Enhancements to OLSR (LS-OLSR)

LS-OLSR [5] introduces the statistical based link stability metrics [14] for selecting a MPR. *Link stability* is defined as link's probability to persist for certain span of time. *Residual Link lifetime* is the average amount of lifetime left in terms of probability for a link which has survived age *'a'*. Density (d_a) of residual link lifetimes for links of age *'a'* is derivated from density function, *'d'* and distribution of link lifetime duration function, *'D(a)'*. The average residual link lifetime is calculated from the equation of mean residual link lifetime of a link with age *'a'*.

The objective is to select a neighbor with maximum residual time as MPR until all the 2-hop neighbors are covered, thus ending up with a MPR set having maximum residual lifetime. In order to calculate the residual age or α-quantile, each node maintains a *Link_Life_Array* referred as *'d[t]'*. *Link_Life_Window* is the number of elements stored in array *'d[t]'* for maintaining the link duration distribution. Observation period is defined as a period of time during which node observes the link life duration and populates the array *'d[t]'*. The observation period should be set long enough to capture the data of longest link survived by the node. *Link set* which records the link information should be modified to carry information regarding the age *'a'*.

LS-OLSR is evaluated by NS-2 simulations for 75 nodes. The strong points of results are that, the average percentage increase of path duration and the average throughput are increased; the average of link changes and the packet loss are reduced. The weak points of this approach are that, the MPR set size is increased about 21%. As a result the end-to-end delay as well as the overhead is increased. Furthermore, it is difficult to set the observation period to set long enough to capture the data of longest link survived by the node.

4 OLSR with Link Duration

From works presented in section 2, we choose to introduce the Link Duration metric in the MPR selection algorithm. Our proposition differs from LS_OLSR by the way to compute the Link Duration and by the fact that Link Duration is not the only criterion for MPR selection. We propose to combine it with density criterion. Selection algorithm would be enhanced by, firstly, using the original density metric with the number of the reachability, secondly, by using the LD metric beyond the first consideration.

The simple way for a node to compute LD value is to use HELLO messages. When a node receives a HELLO from a neighbor, it checks to see if the HELLO contains the IP address of the interface on which the message was received. The link set is then updated as follows:

- If no link entry exists for the tuple (*originating IP, IP of received interface*) then such an entry is established. The originating IP is obtained from the IP header of the received packet. Whenever a link entry is established, a corresponding neighbor entry is initiated as well if no such entry exists.
- The validity time received is used to update an asymmetric timer. This timer indicates for how long the link entry is considered as asymmetric if the symmetric timer times out.
- If the address of the receiving interface is included in the received HELLO, the symmetric timer is updated. The status of the link and the status of the neighbor entries according to this link entry are updated if necessary.
- The maximum of the asymmetric timer and the symmetric timer is used to set the actual holding time for this entry.

Examining the Hello processing on an example (figure 3), we state the difficulty to compute directly the Link Duration from the HELLO message. At t = t1, node X first sends an empty HELLO message. Node Y receives this message and records X as an asymmetric neighbor, as it can not find its own address in the HELLO message. An asymmetric timer (*Asym*) and an actual holding time (*Time*) of this entry are set to t1 + V (Validity time). Then, at t = t2, Y sends a HELLO message declaring Y as an asymmetric neighbor. When X obtains this message it finds its own address in it and therefore sets Y as a symmetric neighbor. At t = t3, X includes Y in its HELLO message. Y records X as a symmetric neighbor upon reception of the HELLO message from X. Furthermore, the asymmetric timer, symmetric timer (*Sym*) and actual holding time of this entry are set to t3 + V. At t = t4, Y sends a HELLO message declaring Y as a symmetric neighbor. At t = t5, X transmits a HELLO message declaring Y as a symmetric neighbor. Upon reception of the HELLO message, Y then updates all the timer of this entry = t5 + v.

As shown in the example, when a node updates a link entry, it only records the time during which this link is considered valid. It can not find link duration because it did not record a time starting point. Thus we modify the OLSR procedure in the simplest way without any addition in the OLSR header packet. The element *"Start Connection Time"* (*Start_t*) is just added to the Link Tuple. When a node has to choose a MPR, it calculates LD by the difference between actual time and *Start_t*. It then can get LD of each node. Refer to MPR selection process, the MPR set is selected from one-hop symmetric neighbors from which it is possible to reach all the symmetrical strict two-hops neighbors. In our proposed solution, we think that Link Duration should to start since a node knows its neighbors. Therefore the started time is recorded since the node status is asymmetric. However the node is not selected as