Routing in « Delay Tolerant Networks » (DTN) Improved Routing With Prophet and the Model of "Transfer by Delegation" (Custody Transfer)

El Mastapha Sammou sammouelmastapha@yahoo.fr
Department of Computer Science,
Faculty of Science and Technology,
University Cadi Ayyad,
Marrakech, 40000, Morocco

Abdelmounaim Abdali aabdali5@ gmail.fr
Department of Computer Science,
Faculty of Science and Technology,
University Cadi Ayyad,
Marrakech, 40000, Morocco

Abstract

In this paper, we address the problem of routing in "delay tolerant networks" (DTN). In such networks there is no guarantee of finding a complete communication path connecting the source and the destination at any time, especially when the destination is not in the same region of the source, what makes the traditional routing protocols inefficient in that transmission of the messages between nodes. We propose to combine the routing protocol Prophet and the model of "transfer by delegation" (custody transfer) to improve the routing in DTN network and to exploit the nodes as a common carriers of messages between the network partitioned.
To implement this approach and assess those improvements and changes we developed a DTN simulator.
Simulation examples are illustrated in the article.

Keywords: Routing, Delay Tolerant Networks, DTN, Intermittent network connectivity, Simulator.

1. INTRODUCTION

Delay tolerant networks or networks with intermittent connectivity networks are wireless mobile ad hoc often where a communication path between a source node and destination node does not exist, either directly or through established routes by intermediate nodes. This situation occurs if the network is sparse and partitioned into several areas due to high mobility, low density nodes or when the network extends over long distances; In these cases, the traditional routing protocols have been developed for mobile ad hoc networks proved to be insufficient because they require the existence of a dense and connected in order to route the packets, To resolve this problem of routing in DTN networks, researchers have proposed the use of routing approaches based on the Principe "Store-Carry-and-forward [8], such as:
The epidemic routing protocol [9]: Messages propagate through the network like an outbreak of disease. This approach ensures that the message reaches its destination as much as possible, but it also wastes a lot of resources by unnecessary transfers of messages.

The Prophet routing protocol [1] is one of the routing algorithms that have been proposed to use these resources properly. Prophet introduced a metric called Delivery Predectability , $P(A, B) \in [0, 1]$. This metric is calculated by each node A of the DTN network and for each known destination B and will be used to decide which messages to be exchanged whenever two nodes meet.
The model of "transfer by delegation"(custody transfer) [2] [3] [8]: In this model by assigning responsibility for a message to a single node at any time. This model has the advantage of being economical in terms of resources, since a message is the responsibility of a node at any time during its delivery. However it now risk losing the message if the wearer goes down or destroyed.

Our approach is to combine the two approaches to routing, Prophet [1] and the model of "transfer by delegation" (custody transfer) [2] [3] [8] to overcome the problems of routing in DTN networks.

2. OUR APPROACH TO ROUTING

Normally, one of the most fundamental requirements is to find a communication path between nodes in a sparse network and partitioned into several zones, in this case, communication between areas of the network depends only on the displacement of certain nodes between areas (as shown in Figure 1) As the delivery of messages depends on the mobility of nodes, it is very difficult to obtain global information and routing becomes an important issue.

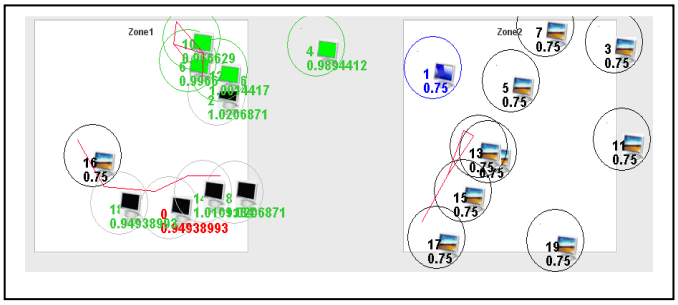


FIGURE 1: Illustrating the transport of messages by a mobile node moving between two areas, each consisting of a few nodes

With the aim to maximize the chances that a message reaches its destination and to minimize the resources consumed in the network such as bandwidth, capacity of storage devices and the energy of the different nodes in an environment characterized by disconnections that often occur because of the low density of nodes, node mobility and energy failure.

Our approach is to combine the routing protocol Prophet [1] and the model of "transfer by delegation"(custody transfer) [2] [3] [8] to exploit the nodes as carriers of messages between the network partitioned . The combination of these two approaches (Prophet and The model of "transfer by delegation") combines two kinds of routing technique based on the degree of the knowledge that the node has about its future contacts with other nodes in the network [4]:

- Technique of controlled routing.
- Technical routing predicted.

The key issues resolved by our approach:

- The choice of nodes that can act as carriers of messages (delegates) between the network partitioned.
- Nodes incorporating elements of knowledge and contextual elements.
- Increases the chances that a message reaches its destination while minimizing the time from End to End.
- Economic from the point of view of the network resources consumed.

In this work we have developed a DTN simulator written in Java which is based on our approach to evaluate the different routing parameters.

3. SCENARIO OF OUR APPROACH

The probability of delivery are calculated locally in each area according to the approach of Prophet [1] and the nodes move according to the two mobility models: Model *Random Waypoint* and model *Restricted Random Waypoint* [10] [11] [12] as shown in Figure 2:

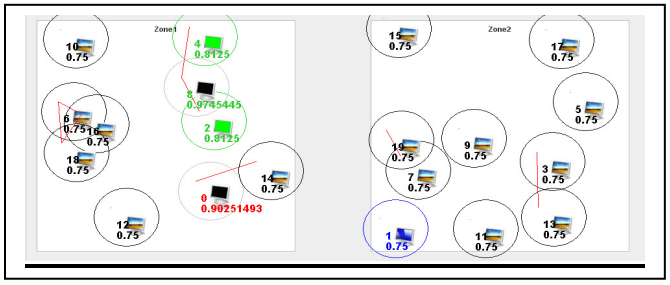


FIGURE 2: Illustrates the calculation of probability according to Prophet in each zone.

N0 node wants to send a message to N1. This can not be done because there is no path between the two areas. The message is sent to N4 that has a better probability of delivery and a planned movement and stores it. As shown in Figure 3:

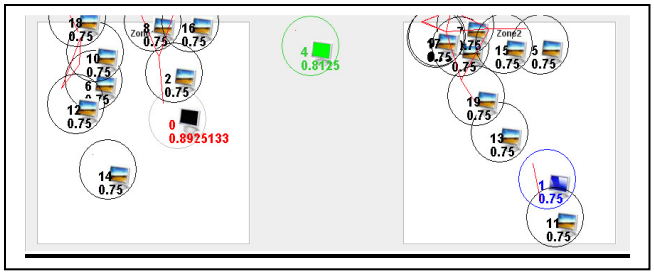


FIGURE 3: Illustrates the transport of messages by a mobile node moving between two areas.

After a certain period of time, N4 moves to another area (as shown in Figure 4). The message reached its intended recipient using the routing protocol Prophet.

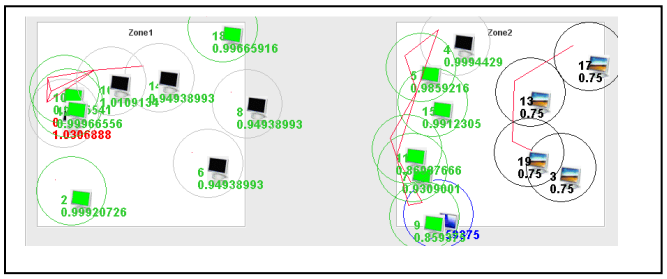


FIGURE 4: Illustrates the node N4 in the second zone so that the message is delivered to its intended recipient

4. STRATEGY FOR TRANSMISSION OF OUR APPROACH

When the source and destination are in two different areas [1] [2] [3] [6] [7] [8]

1. Nodes that can act as carriers are the nodes that have:
   - A high probability of delivery.
   - The planned movements between zones.
   - A sufficient transmission energy.
2. In the case of a network where there are nodes that have random movements, the best carriers are the nodes that have:
   - A high probability of delivery.
   - A sufficient transmission energy.
3. In the case of a network where there are nodes that have random movements and nodes which have planned movements, the best carriers are the nodes that have:
   - A planned and controlled movement between areas.
   - A sufficient transmission energy.
4. When the nodes which have planned and controlled movements between zones are nodes that have better features in terms of energy and storage capacity as the case of buses, planes, trains … We may use them :
   - On the one hand as the best carriers (delegates) of the message.
   - Secondly as fixed relay " mobile "with a periodic occurrence in both areas, these relays can be exploited on the one hand to describe the movements and mobility of nodes [5] in each zone, based on the frequency of visits to these relays [6], secondly to increase the number of contacts between nodes.

The principle of communication in the same area [1] [2] [3] [6] [7] [8]

- When a node encounters another node with the greatest probability of delivery, it sends the message to that node and still keep the message for transmission to other nodes in the future.
- When a node encounters another node that has a planned movement and a low probability of delivery, it sends this message to the node even if the probability of delivery is low, then it deletes the copy of the message, then it frees up the space at its storage unit.
- When a node encounters another node that has a planned movement and a high probability of delivery, it sends the message to this node, then it deletes the copy of the message, then it releases the space at its storage unit.

Mechanisms of acquittals

The acknowledgment mechanism between nodes is done according to the acknowledgment mechanism used by the model of "transfer by delegation"(custody transfer) [2] [3] [8].

Cases where the nodes are not allowed to transmit messages

- When a node encounters another node that has a high probability of delivery and has not enough energy.
- When a node encounters another node that has a planned movement and controlled and not enough energy.
- When a node encounters another node that has a planned and controlled movement and a high probability of delivery and has not enough energy.

5. SIMULATION AND TEST

The simulator is written in Java. JAVA is an object-oriented programming language, allows one hand to develop real applications and the other hand the object-oriented approach considers a program as consisting of a set of objects which adapts our approach. Figure 5 shows the general design of the application and Figure 6 shows the main interface of the application.

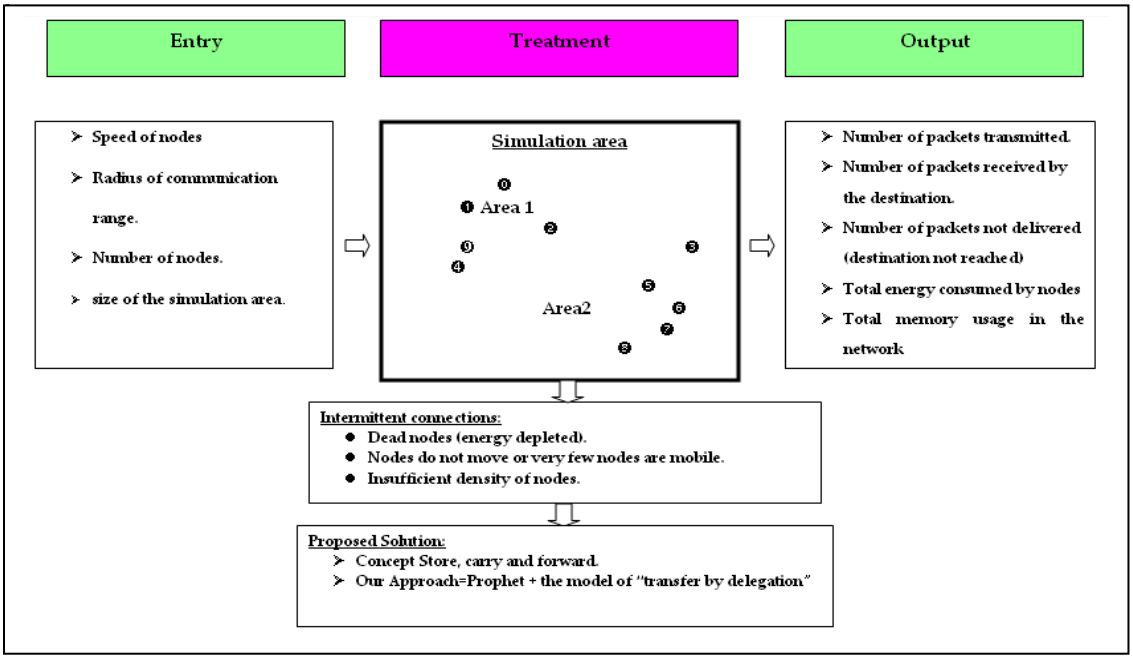


FIGURE 5: Illustrates the general design of the application

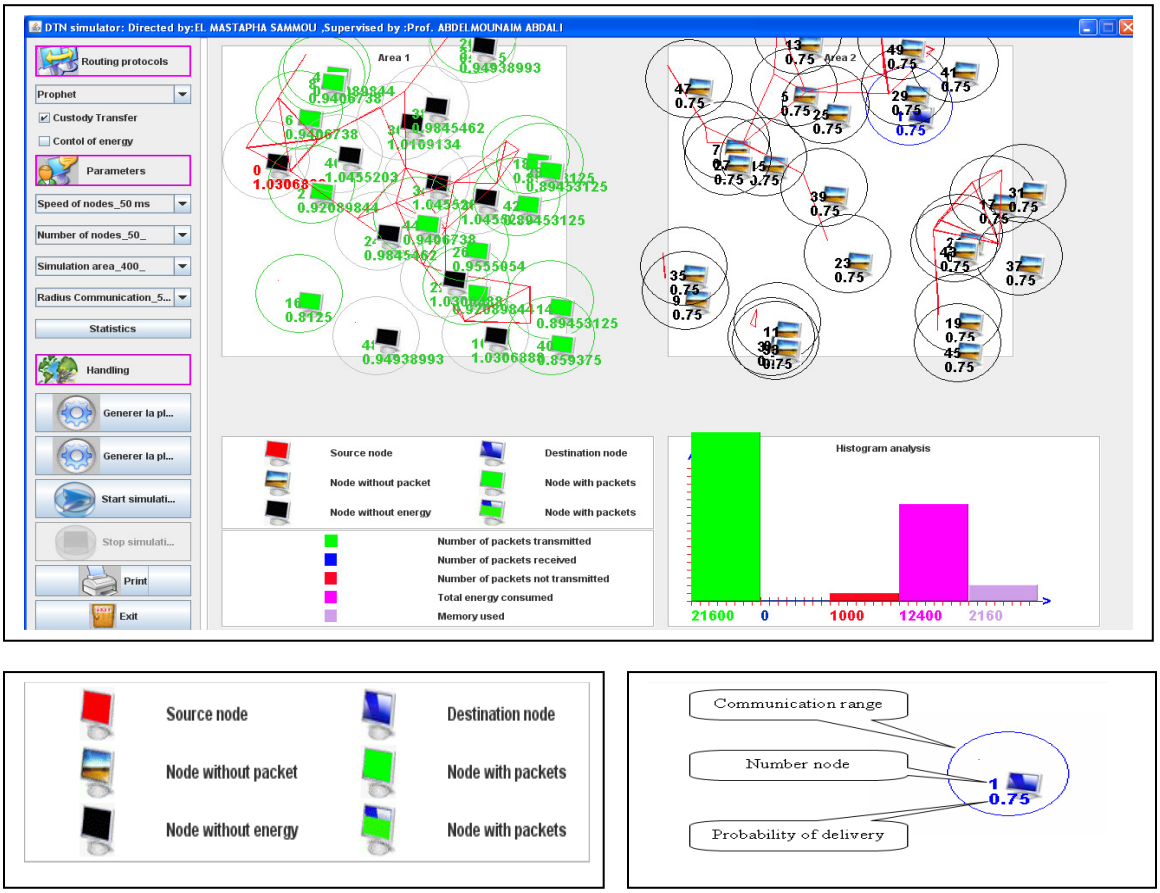


FIGURE 6: Illustrates the main interface of the application

Assumptions and Data Analysis

1. Assumptions: We assume that Packet routing is done from the "store-carry-and-forward" ; The volume of the queue is considered infinite; The nodes move according to the two models of random mobility: Restricted random waypoint and Radom Waypoint [10] [11] [12]; The speed of nodes varies between Vmin= 200 ms and Vmax = 50 ms; The space of traveled nodes varies between 50 and 500 units of surface; The number of nodes varies between 8 and 300 nodes; The number of packets from the source is 1000 packets; The energy level of each node is 1000 units of energy ; The probability of delivery is calculated locally according to formulas presented by the routing protocol prophet [1].

$$P(A,B) = P(A,\mathrm{B})_{\mathrm{old}} + (1 - P(A,B)_{\mathrm{old}}) * P_{init}$$
$$P(A,C) = P(A,C)_{\mathrm{old}} + (1 - P(A,C)_{\mathrm{old}}) * P(A,B) * P(B,C) * \beta$$
$$P(A,B) = P(A,B) * \Upsilon^{k}$$

2. Data analysis: In this simulator we have analyzed the following data: The number of packets transmitted in the network; The number of packets not sent; The number of packets received by the destination; The energy consumed in the network; The amount of memory consumed in the network. This analysis is done according to the approach of the Prophet and in our approach to compare the two approaches.

Tests and results

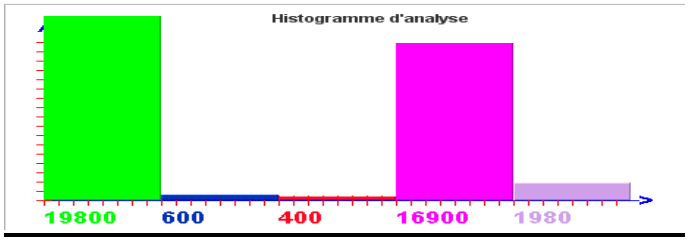
1. **Scénario1**

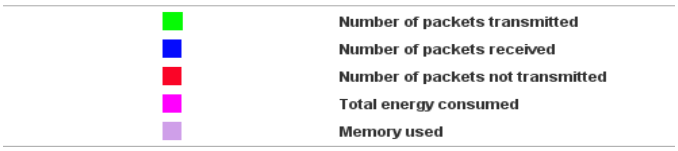
Both areas are dense and connected. The internal connectivity of each zone is guaranteed. However, there is no permanent connection between the two areas.

Simulation parameters 1	Values
Number of nodes	50
Energy level of each node	1000
Radius of the focused communication	50 m
Maximum Speed	50 ms
Size of each area	300*300
Simulation time	1500 ms
Initial probability	0,75
β	0,25
Υ	0,98

TABLE1: Parameters of simulation 1

- Simulation results under the approach of Prophet.





- Simulati

FIGURE 7: Illustrates the result of analysis of the approach of the prophet depending on the parameters of simulation 1

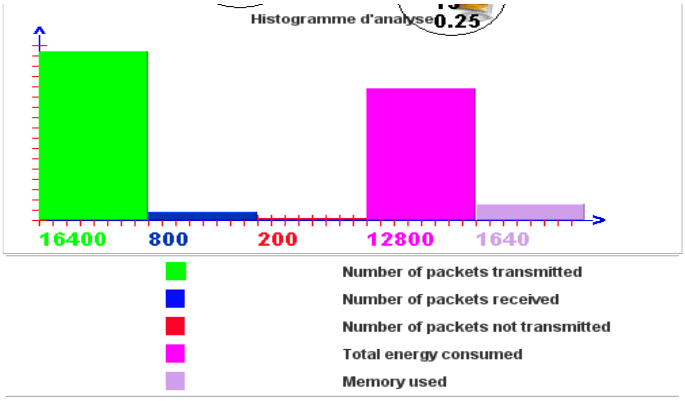


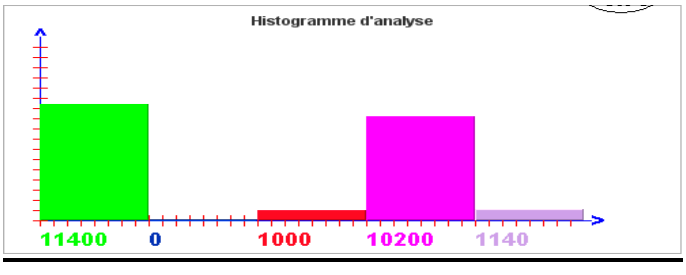
Figure 8: Illustrates the analytical result of our approach Depending on the parameters of simulation 1

2. **Scénario2**: The node density is low in both areas. The internal connectivity of each zone is not guaranteed and there is no permanent connection between the two areas.

Simulation parameters 2	Values
Number of nodes	20
Energy level of each node	1000
Radius of the focused communication	40
Maximum Speed	50 ms
Size of each area	500*500
Simulation time	1500 ms
Initial probability	0,75
β	0,25
ϒ	0,98

TABLE2: Parameters of simulation 2

- Simulation results under the approach of Prophet.



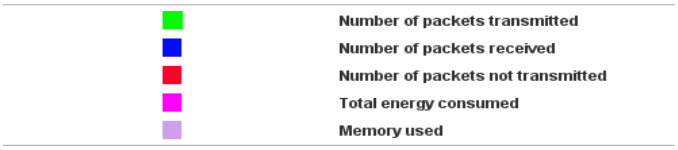


FIGURE 9: Illustrates the result of analysis of the approach of Prophet depending on the parameters simulation 2

- Simulation results based on our approach.

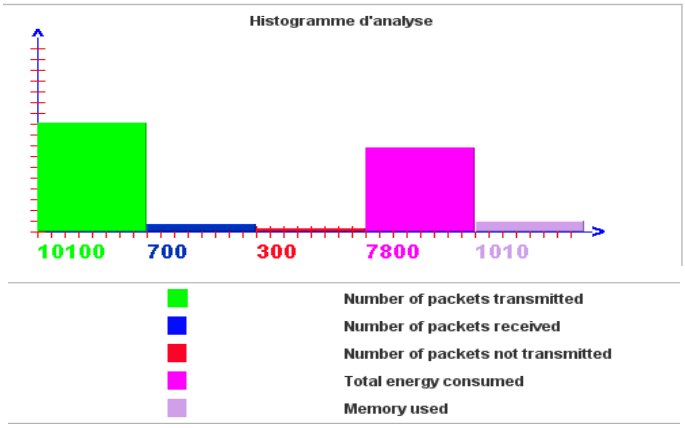


FIGURE 10: Illustrates the result of analysis of our approach Depending on the parameters of simulation 2

6. CONCLUSION

DTN networks suffer from several shortcomings related to routing, especially when the network is partitioned into several zones and where the destination is not in the same region of the source, what makes traditional routing protocols ineffective to the extent of transmit messages between nodes.

We proposed an approach that involves combining the routing protocol Prophet and the model of "transfer by delegation" (custody transfer) to improve routing in DTN networks based on contextual elements and the elements of knowledge a node has about its future contacts with other nodes in the network.

According to the simulations realized, our approach has good performance in comparison to the Prophet algorithm, but its effectiveness can be further improved.

7. REFERENCES

1. A.Lindgren, A. Doria and O. Scheln. *Probabilistic routing in intermittently connected networks. In Proceedings of ACM MobiHoc (poster session), Maryland, USA, June2003.*

2. F. GUIDEC, *"Deployment and implementation support services communicating in pervasive computing environments, ", "Déploiement et support à l'exécution de services communicants dans les environnements d'informatique ambiante,"L'UNIVERSITÉ DE BRETAGNE SUD, June 2008, pp. 35-65*

3. Kevin Fall, Wei Hong, and Samuel Madden. *Custody Transfer for Reliable Delivery in Delay Tolerant Networks. Technical report, Intel Research Berkeley, 2003.*

4. M. IBRAHIM *"Routing and performance evaluation of Disruption tolerant networks," l'Université de Nice - Sophia Antipolis, Novembre 2008.*

5. *J. Leguay, "Heterogeneity and Routing in Delay Tolerant Networks," l'Université Paris VI, juillet 2007.*

6. J. Leguay, T. Friedman and V. Conan*, " Evaluating Mobility Pattern Space Routing for DTNs," Université Pierre et Marie Curie, Laboratoire LiP6–CNRS.*

7. M. Musolesi, S. Hailes and C. Mascolo*, "Context-aware Adaptive Routingfor Delay Tolerant Mobile Networks" in Proc. WOWMOM, 2005.*

8. F. Warthman*, "Delay Tolerant Networks", Delay Tolerant Networking Tutorial,2003, http://www.ipnsig.org/reports/DTN_Tutorial11.pdf*

9. A. Vahdat and D. Becker*, "Epidemic routing for partially connected ad hoc networks," Technical Report CS-200006, Duke University, April 2000".*

10. Christian Bettstetter, Hannes Hartenstein*, and Xavier Pérez-Costa, "Stochastic properties of the random waypoint mobility model," ACM/Kluwer Wireless Networks, Special Issue on Modeling and Analysis of Mobile Networks, 10(5) :555–567, Sept.2004.*

11. Christian Bettstetter, Giovanni Resta, and Paolo Santi*. The node distribution of the random waypoint mobility model for wireless ad hoc networks. IEEE Transactions on Mobile Computing, 2(3) :257–269, July 2003.*

12. Christian Bettstetter and Christian Wagner*, "The spatial node distribution of the random waypoint mobility model,". In Proc. German Workshop on Mobile Ad-Hoc Networks (WMAN), GI Lecture Notes in Informatics, Ulm, Germany, Mar. 2002.*