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# PERFORMANCE ANALYSIS OF AUTONOMOUS LOCATION BASED ENERGY EFFICIENT ACO ROUTING PROTOCOLWITH DISSIMILAR MANET MOBILITY MODELS

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## ABSTRACT

Performance evaluations of routing protocols for wireless adhoc networks were largely done using simulation tools. Few factors need to be controlled to have useful simulation results are transmission power, power consumption, mobility model, traffic etc. since performance of an ad hoc network protocol can vary significantly with different mobility models and also under same mobility models with different parameters, we consider the mobility model of nodes, which determines the frequent link changes as one of the factor for evaluating our routing protocol for Mobile Adhoc Networks(MANETS).Therefore, the goal of this paper is to evaluate an Autonomous Location based Energy Efficient routing Protocol with ACO (ALEEP-with-ACO) for MANETS under two specific mobility models i.e Disaster area and random street model and compare the same with the benchmark Random Way Point mobility model. We use Bonn Motion Mobility scenario generation and analysis tool in ns-2.34. Simulation results showed that ALEEP-with ACO performs well in Disaster area and Random Way Point model and setback with Random street model in most of the metrics.

**Keywords:** Location based routing, mobility model, Energy Efficient, ACO.

## 1. INTRODUCTION

A mobile Ad Hoc Network (MANET) is a network independent of pre-installed infrastructure. It is autonomous as the network is required to perform self configuration by means of the cooperation of mobile devices: all nodes operate as routers and need to be capable of discovering and maintaining routes, and to exchange information by multi hop routing. Since the nodes are mobile, the network topology changes dynamically and is unstructured i.e nodes may enter or leave at their will. A node can communicate to other nodes which are within its transmission range. All nodes are supposed to be equal in processing power. The movement of mobile nodes requires the employment of quite complex routing algorithms, as routes are not stable and need to be updated continuously.

The biggest challenge in this kind of networks is to find most efficient routing due to the changing topology and to reduce the energy consumption of the nodes as they are battery operated. Ant Colony Optimization (ACO) is special kind of optimization technique which is highly suitable for finding the adaptive routing for volatile network. They use reinforcement learning problems with hidden state [1].ACO based routing protocols are more suitable for MANET environment because they are more robust, reliable, and scalable than other conventional routing algorithms[2].The major disadvantage of ACO based routing algorithm is long convergence time [3]. Regarding the dynamic nature of mobile ad-hoc networks, a long convergence time is a significant drawback. This drawback was overcome by considering location information as a routing metric, which can reduce the searching region into a limited region, and can achieve lower convergence rate.

Existing location based routing algorithms may fail to find energy efficient route in some of the indoor Mobile ad-hoc networks and if they find a route, it may be much longer than the shortest path which increases the computation energy. Most of the location based algorithm with benchmark mobility model uses GPS for location determination, which increases node complexity and mostly it fails in indoor and disaster area environments. Location based routing for MANETs was addressed in [4, 5]. Instead of using GPS for finding out the position, RSSI value on the transceiver is used to determine the location of nodes.

Several comparative studies in MANETS have shown that there is no single protocol which works well in a wide variety of network conditions. ACO based energy efficient routing algorithms with Adaptive Transmission Power Control (ATPC) and autonomous localization methods were used to improve network lifetime [5]. Residual Energy based algorithm plays an important trolein maintaining network connectivity and efficiently operates the energy of the node for long ernet work life time. An autonomous localization based energy efficient routing protocol (ALEEP_with_ACO) was developed by combining the strengths of best existing protocols of MANETs and carried out its performance evaluation with standard mobility model.

Results in [6-8] show that the mobility model has a significant influence on the performance of the wireless network. This is true for ad-hoc networks that rely on multi hop routing. Previous work [7] demonstrated that the absolute value of a performance measure of a routing protocol vary with different mobility models. Scenario-dependent mobility modeling [8] is required for the reliable performance evaluation of MANETs. Most of the synthetic mobility models [9] proposed lack realism as they miss geographic restrictions need to be considered in disaster areas.

Our work is an extension of [5] which compares the performance of ALEEP_with_ACO under two different mobility models; Disaster Area and Random Street mobility model. Since our routing algorithm is location based, geographic restrictions and temporal and spatial velocity mobility characteristics can be very well analyzed using these two specified mobility models.

The rest of this paper is organized as follows. Section II explains major sources of energy consumption; location based routing algorithms, ACO algorithms for MANETS and different mobility models. In Section III the performance evaluation of the ALEEP_with_ACO using Bonn Motion Mobility Model in NS 2.34 is described by simulations. Finally Section IV concludes the paper.

## 2. RELATED WORKS

### A. Sources of Energy Consumption

With respect to the network operations the major sources of energy consumption in MANETs are of two types: communication-related and computation-related. Communication involves usage of the transceiver at the source, intermediate and destination nodes. They perform forward and storage operation. Understanding energy characteristics of the mobile radio used in MANETs is important for efficient design of routing protocols. Maximum energy consumed in the transmit mode and least in standby mode. Thus the objective of designing energy efficient routing protocol is to optimize the transceiver usage. Most of the proposed algorithms used adaptive Transmission Power Control mechanism to optimize the transmission cost [10, 11].

### B. Location Based Routing Algorithms

GPSR [12] and Compass routing [13] are examples of location based routing algorithms in which a routing decision is made locally in each node that is reached in the routing process. The drawback of these algorithms is that they may fail in indoor ad hoc networks to find a route or they may find a non-optimum route in some situations. Moreover failures occur rarely when the network graph is dense [13].

Several other location based routing algorithms have been proposed, but they have similar shortcomings of either not guaranteeing to find a path to the destination or finding a path which is much longer than the shortest path [14].

### C. Ant Colony Algorithms

Ant colony optimization (ACO) is a stochastic approach for solving combinatorial optimization problems, which is highly suitable for finding the adaptive routing for highly volatile network [15].ANTNET and ANTHOCNET are two well known ant colony based routing algorithms. ANTNET is adaptive, distributed and mobile agent based routing algorithm. ANTHOCNET is a reactive routing algorithm. They have a very high delivery rate and find routes whose lengths are very close to the length of the shortest path [16]. The drawback of ANTHOCNET is higher overhead that needs to be sent in the network for establishing routes to the destination.

### D. Posant

Position based ANT (POSANT), is a combination of ant colony based routing algorithm that uses the information about the position of nodes to increase the efficiency of ant routing. In contrast to other position based routing algorithms, POSANT does not fail when the network contains nodes with different transmission ranges. Unlike the previously defined location based routing algorithms which are single path, POSANT is a multipath routing algorithm. The use of location information as a heuristic parameter resulted in a significant reduction of the time needed to establish routes from a source to a destination which is important for a reactive routing algorithm. POSANT uses GPS to find position information [17, 18].

### E. Lobant

Most of the position based algorithms which uses GPS failed in indoor and disaster area MANET applications. Work in [4] proposes a Location based ANT Algorithm (LOBANT), which uses Received Signal Strength Indicator (RSSI) to calculate the distance to consider as a routing metric. In addition to having a short route establishment time, LOBANT reduces greatly the number of generated overheads, unlike some ACO routing algorithms, e.g. ANTHOCNET, which use flooding to reduce the route establishment time, making them un scalable. Simulation results showed that LOBANT has a higher delivery rate with a shorter average packet delay than GPSR and POSANT. LOBANT also reaches a stable behavior faster than ANTNET. It is more suitable for MANETs with irregular transmission ranges. Energy aware metrics were not taken into consideration in this work.

### F. ALEEP_with_ACO

ALEEP_with_ACO, a new ant colony based algorithm that uses the location of the nodes, ATP and energy aware metrics to increase the efficiency of routing. This algorithm uses a joint evaluation function where it reduces greatly power wasted by transmission by applying ATP and uses FANTs to determine eligible energetic possible paths. Most of the position based algorithms which use GPS failed in indoor mobile ad hoc network applications. The simulation showed that ALEEP_with_ACO is a scalable and energy efficient reactive routing algorithm which attempts to greatly improve MANETs lifetime. Autonomous localization based on RSSI is simpler and more suitable for MANETs established in disaster area where GPS based localization fails.

VOL. 10, NO. 4, MARCH 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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## 3. PERFORMANCE EVALUATION

We use Bonn Motion mobility model with NS-2.34 to evaluate the performance of ALEEP_with_ACO with two selected mobility models. Bonn Motion [19] is a mobility scenario generation and analysis tool that is most commonly used as a tool for the investigation of mobile ad hoc network characteristics.BonnMotion defines the size of the scenario, the number of nodes, their speed, the duration of the simulation.

### A. Disaster Area Mobility Model

Nils Aschenbruck et.al [20] provides disaster area mobility model that realistically represents the movements in a disaster area scenario. This analysis provides characteristics influencing network performance like heterogeneous area-based movement, obstacles and joining/leaving of nodes. Disaster Area gives us lots of flexibility and a really accurate model to use when modeling rescue operations. It provides options to define the shape, no. of different zones, obstacles as required, variable node velocity (heterogeneous nodes) and also on the time. The movement of node is not random as it is lead by a leader in particular zone. It chooses optimal (shortest) paths and avoids obstacles. It support to group movement is optional. It supports important mobility characteristics such as temporal and spatial dependency of velocity and geographic restrictions where other models such as Manhattan grid and Gauss-Markov cannot support.

### B. Random Street Model

An Opportunistic network is scenario dependent and requires synthetic mobility models with geographic restrictions. Location based Routing algorithm can help integrating geographic restrictions into mobility models. Our paper constructs the random street mobility model with BonnMotion Software which integrates location based services into a scenario modeling tool.

### C. Simulation Settings And Evaluation Metrics

Table-1 Specifies the simulation settings used in NS2.34.

**Table-1.** Simulation parameters.

| | |
|---|---|
| Routing Protocol | LOBANT |
| No of Nodes | 100 |
| Area size | 1000 m * 1000m |
| MAC | 802 .11 b |
| Radio Range | 250m |
| Simulation Time | 6 sec |
| Traffic Source | CBR |
| Packet Size | 512 KB |
| Patch File | BonnMotion |
| Mobility model | Disaster area Mobility Model and Random Street Model |
| Speed | 5 m/s |
| Initial Energy | 0.5 Joules |

### D. Evaluation Metrics

Mobility model performance metrics are classified as protocol independent metrics and protocol dependant metrics, respectively. We focus on the following protocol dependent and independent metrics.

1. Protocol independent metrics:
These metrics can be extracted directly from the traces resulting from the mobility model. Link based metrics and range based metrics are used with more realistic propagation models.

- Average node degree: It represents the no. of nodes connected to a particular node under consideration on the average. It is a measure for the node density.

- Average time to link break: How often links and based on links route fails obtained by varying transmission range.

2. Protocol dependent metrics:
- Packet delivery fraction%: Ratio of data packets delivered to the destinations to those generated by the source. It Figure-1 out the link failures due to energy constraints
- End to end delay: the time a packet takes from its sending till it arrives at the destination.
- Average Throughput: Average no. of packets arrived/sec at each destination.

### E. Simulation Results

Performance comparison of ALEEP_with_ACO in two different mobility models is discussed in this section.

**Average node degree**

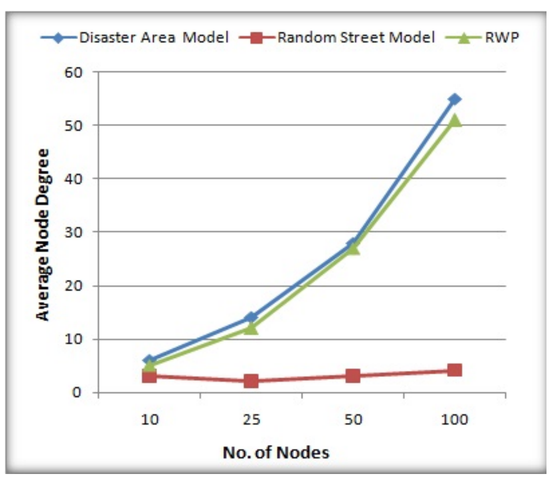


**Figure-1.** Average Node Degree.

VOL. 10, NO. 4, MARCH 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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The average node degree increases in a linear way as the routing protocol ALEEP_with_ACO is highly scalable in Disaster area mobility model and there are slight variations in linearity for Random street model and RWP. This is because disaster model captures the interdependent movement of nodes. RWP provides decaying mobility speed and unfair node distribution in a given scenario. Random street model movements of nodes follows random street pattern and hence node degree is very less. Figure 1 shows the average node degree that figures out dense MANET environment.

**Average time to link failure**

Average time to link failure is large as ALEEP_with_ACO is robust against link breaks. In disaster area model as the region is small in comparison with the number of nodes and transmission range, more than half of the nodes can be reached by other nodes. There is a higher relative mobility as DA model correlates velocities of different nodes with a specific transmission range. Hence a lower average time to link break same as for RWP. Random Street model provides link failure in lower transmission range. Figure-2 demonstrates the evaluation of average time to link break metric.

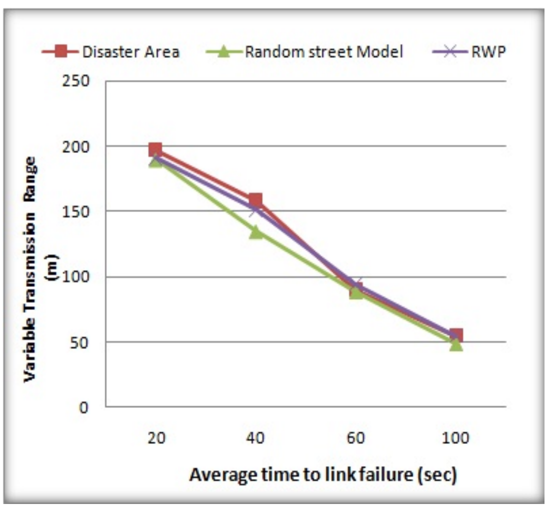


**Figure-2.** Average time to link failure.

**Packet delivery fraction**

Figure-3 show the Success rate (PDF) measured for ALEEP_with_ACO on the two mobility models including RWP. Due to the characteristics of random street model, mobile nodes are restricted to a portion of the simulation area. In RWP, the mobile node will explore a larger part of the simulation area compared to the area explored with Disaster model.

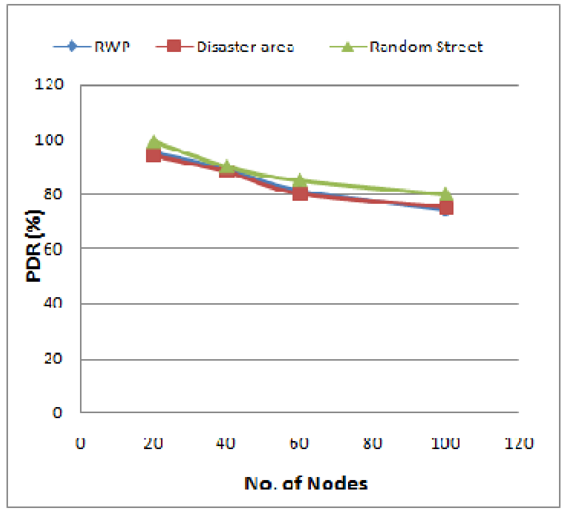


**Figure-3.** PDR% of ALEEP_with_ACO for different Mobility models.

Moreover, ALEEP_with_ACO adapts various mechanisms for proactive route maintenance and reactive route repair allow dealing better with the longer paths in large networks, and helping it avoid the need for new route setups. ALEEP_with_ACO has the highest delivery rate in Random street model among others. RWP mobility model describe random-based movement and distribute the nodes over the complete simulation area. Disaster area model defines node mobility based on the area and class of the node which allows different speed intervals..It considers stationary nodes movement according to the random waypoint model. With increased node density, disaster and RWP mobility model performs similar as they provide 85% PDR as shown inFigure 3. Hence with the simulation results it's clear that ALEEP_with_ACO performs well par to RWP in disaster model. Random street model is more suitable for analyzing scenario based networks; its PDR with respect to ALEEP_with_ACO is higher than RWP and disaster area model.

**End-to-end Delay**

This metric represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. In ALEEP_with_ACOlocation determination before route discovery reduces convergence time, and also reduces overall end to end delay [4]. We compare the end-to-end delay of the ALEEP_with_ACO routing protocol with the two mobility models (Disaster area and random street) and RWP. Figure-4 shows end - to -end delay of ALEEP_with_ACO with different mobility models.

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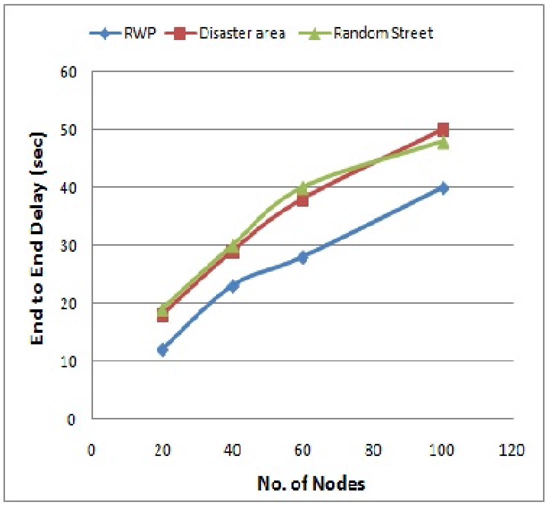


**Figure-4.** End -to-end delay of ALEEP_with_ACO for different mobility models.

Since ALEEP_with_ACO uses contact information of mobile nodes in disaster model, the nodes will make smart routing decisions.End-to-end delay is considerably low in RWP than compared with DA model as it specifies next node in forwarding data with structured movement traces. Hence, delay is less in RWP than in disaster model.

**Average Throughput**

ALEEP_with_ACO is highly reliable and hence provides better throughput in RWP model scenario and goodput in disaster area model. Throuhput in Random street model is less as its hihly vulnerable to link breaks. Figure-5 explains the throughput of ALEEP_with_ACO in different mobility models.

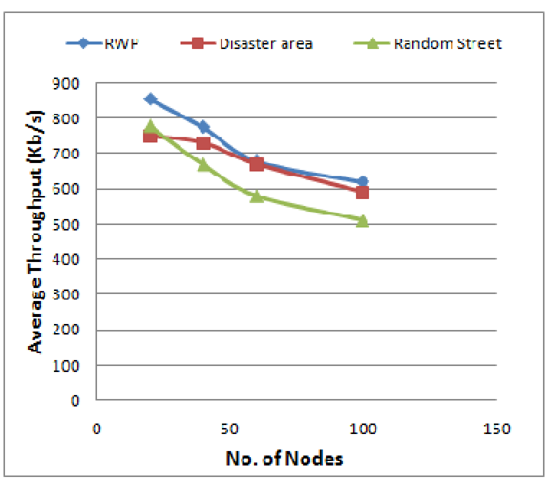


**Figure-5.** No. of nodes Vs average throughput.

## 4. CONCLUSIONS

In this paper, we carry out the performance analysis of energy efficient routing protocol with different mobility models. One more relevant to MANET real world application i.e disaster area mobility model and other not much suitable for MANETs i.e Random street model and compared them with standard RWP model. Protocol independent and protocol dependent performance metrics were evaluated. It's a great challenge for a protocol to handle new connections than to maintain existing ones. Performance evaluation of ALEEP_with_ACO shows significant differences under different mobility models. However ALEEP_with_ACO faces high density of nodes, stable scenario due to slow speed in a small area under disaster area model, results shows that it outperforms well due to its scalable and reliable properties in both RWP and Disaster area model with variable node density. Its performance under random street mobility model is fair with other models. In future a case study can be carried out using ALEEP_with_ACO as routing protocol for different mobility models.

## REFERENCES


[1] Gurpreet Singh., Neeraj Kumar., Anil Kumar Verma. Ant Colony Algorithms in MANETs: A Review. Journal of Network and Computer Applications. 2012.

[2] Marco Dorigo. Optimization, Learning and Natural Algorithms. PhD thesis, Dipartimento die Elettronica, Politecnico di Milano. Milan, 1992.

[3] WANG Jia-jia., SONG Mei., ZHANG Yong., WANG Jing-yao., MAN Yi. An ACO and position information based intelligent QoS routing mechanism in MANET. The Journal of China Universities of Posts and Telecommunications. 2010.

[4] Vallikannu R., Jubin Sebastian E. A Location based ACO Routing for mobile ad hoc Networks using RSSI. 2nd IEEE International Conference on Communication and Signal Processing. April 2013.

[5] R.Vallikannu., A. George. and S. K. Srivatsa. Autonomous Localization based Energy Saving Mechanism in Indoor MANETs using ACO Journal of Discrete Algorithms, DOI: 10.1016/j.jda.2014.11.001,2014.

[6] T. Camp., J. Boleng. and V. Davies. A survey of mobility models for ad hoc network research. Wireless Communications & Mobile Computing (WCMC) Special issue on Mobile Ad Hoc Networking: Research,Trends and Applications. Vol. 2, no. 5, pp. 483–502, 2002.

[7] F. Bai., N. Sadagopan. and A. Helmy. Important: A framework to systematically analyze the impact of mobility on performance of routing protocols for adhoc networks. in Proc. of IEEEINFOCOM 2003, (San Francisco, CA), March/April 2003.

[8] P. Johansson., T. Larsson., N. Hedman., B. Mielczarek. and M. Degermark. Scenario-based performance analysis of routing protocols for ad hoc networks. in Proc. of the 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'99), (Seattle, Washington), 1999.

[9] Aschenbruck. and M. Schwamborn. Synthetic map-based mobility traces for the performance evaluation in opportunistic networks. In Proceedings of the 2nd International Workshop on Mobile Opportunistic Networking, MobiOpp 2010, Pisa, Italy, February, 2010. ACM, 2010, pp. 143- 146.

[10] Ghufran Ahmed., Noor M Khan., Mirza M. Yasir Masood. A Dynamic Transmission Power Control Routing Protocol to Avoid Network Partitioning in Wireless Sensor Networks, IEEE 4th International Conference on Information and Communication Technologies, pp. 1-4, 2011.

[11] Martin Kubisch., Holger Karl., Adam Wolisz., Lizhi Charlie Zhong. and Jan Rabaey. Distributed Algorithms for Transmission Power Control in Wireless Sensor Networks. IEEE International conference on WirelessCommunications and Networking Conference (WCNC). PP. 558 -563,2003.

[12] B. Karp. and H. T. Kung. GPSR: Greedy perimeter stateless routing for wireless networks. In Proc. ACM/IEEE MobiCom conference,pages 243–254, 2000.

[13] E. Kranakis., H. Singh. and J. Urrutia. Compass routing on geometric networks. In Proc. of 11th Canadian Conference on Computational Geometry, pages 51–54, August 1999.

[14] L. Barri`ere., P. Fraigniaud., L. Narayanan. and J. Opatrny. Robust position-based routing in wireless ad-hoc networks with irregular transmission ranges. Wireless Communications and Mobile Computing Journal, pages 141–153, 2003.

[15] G. Di Caro. and M. Dorigo. AntNet: A mobile agents approach to adaptive routing. Technical report TR-97-12. Université Libre de Bruxelles. IRIDIA, 1997.

[16] G. D. Caro., F. Ducatelle. and L. M. Gambardella. Anthocnet: An adaptive nature-inspired algorithm for routing in mobile ad hoc networks. Special Issue on Self-Organisation in Mobile Networking, 16:443–455, 2005.

[17] Shahab Kamali., Jaroslav Opatrny. A Position Based Ant Colony Routing Algorithm for Mobile Ad-hoc Networks. JOURNAL OF NETWORKS. VOL. 3, NO. 4, APRIL 2008.

[18] S. Giordano., I. Stojmenovic. and I. Blazevic. Position based routing algorithms for ad hoc networks: taxonomy. Ad Hoc Wireless Networking, 2003.

[19] BonnMotion: A Mobility Scenario Generation and Analysis Tool Documentation Version: July 8, 2013.

[20] Nils Aschenbruck., Elmar Gerhards-Padilla. and Peter Martini. Modeling mobility in disaster area scenarios. Performance Evaluation Journal. Volume 66, Issue 12, December 2009, Pages 773–790.

[21] N. Aschenbruck., E. Gerhards-Padilla., M. Gerharz., M. Frank. and P. Martini, Modelling Mobility in Disaster Area Scenarios. Proc. 10th ACM-IEEE Int. Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM), pp. 4-12, 2007.