Using DSR for Routing Multimedia Traffic in MANETs

Ronald Beaubrun and Badji Molo

Department of Computer sciences and software engineering

Laval University

Québec (Québec), G1K 7P4

CANADA

Abstract – In mobile ad hoc networks (MANETs), links are created and destroyed in an unpredictable way, which makes quite challenging the determination of routes between each pair of nodes. In this paper, we propose a formulation of the routing problem in multi-services MANETs, as well as the implementation of an adaptation of the dynamic source routing (DSR) protocol. Simulation results reveal that DSR enables to provide end-to-end delay less than 0.11 s, as well as packet delivery ratio higher than 99% and normalized routing load less than 13%, for low mobility level and low traffic intensity.

Keywords- DSR, MANET, Multimedia traffic, routing.

1. Introduction

A mobile ad hoc network (MANET) is a decentralised, self-organizing and self-configuring wireless network, without any fixed infrastructure [7]. In this network, each mobile node behaves not only as a host, but also as a router which is capable of communicating with other nodes, using either direct wireless links, or multi-hop wireless links. Examples of ad hoc network applications include business associates sharing information during meetings or conferences, soldiers relaying information on a battlefield, and disaster relief personnel coordinating efforts after fires or earthquakes [8]. With such applications, MANETs are envisioned to become key components in the 4G architecture, as they will offer multimedia services to mobile users in areas with no pre-existing communications infrastructure exists.

As nodes are mobile in a MANET, links are created and destroyed in an unpredictable way, which makes quite challenging the determination of routes between a pair of nodes that want to communicate with each other. In this context, a great number of routing protocols have been proposed [2], [8], [9]**.** Such routing protocols can be classified into two major classes: proactive protocols and reactive protocols. Proactive protocols disseminate routing information from each node to each other periodically, and find routes continuously, whereas reactive protocols find routes on demand, *i.e.* only when a source sends information for forwarding to a destination. Performance analysis shows that, in general, reactive protocols outperform proactive protocols [2]. Dynamic source routing (DSR) is one of the most representative reactive routing protocol [4]. In this paper, we propose a formulation of the routing problem in MANETs in the context of multimedia services. In order to solve such a problem, an adaptation of DSR is implemented, and its performance evaluation is presented, while taking into account the constraints related to each service.

The rest of this paper is organized as follows. Section 2 presents the state of the art on routing in MANETs. Section 3 presents a formulation of the routing problem. Section 4 outlines the most important parameters for the network implementation. Section 5 presents simulation results and analysis, whereas Section 6 gives some concluding remarks.

2. Related work and background

DSR is based on source routing concept, where each sender constructs a source route in the packet's header [1], [8], [12]. More specifically, when a source wants to communicate with a destination, it checks its route cache to see if there is any routing information related to that destination. If such information is not found, the sender initiates a route discovery process by broadcasting a Route Request packet (RREQ) in order to dynamically find a new route. If the route discovery is successful, the sender receives a route reply packet (RREP) listing the sequence of nodes through which it may reach the target. The route carried back by the RREP is cached at the source node and all nodes that have forwarded the RREP for future use.

When a route between a source and a destination is broken, a route maintenance process is invoked by the source in order to detect the broken link. In this context, a route error control packet (RERR) is sent to the source node. Each node that receives the RERR packet removes all routes that contain the broken link from its cache. If the route to the destination is still needed and no alternate route is available in the cache, a new route discovery process must be initiated by the source node. In DSR, route discovery and route maintenance operate on-demand, which is different from other routing protocols that use periodic routing packets that cause overhead in the network.

There have been a lot of research activities on evaluating the performance of DSR [1], [4], [5], [6], [10], [12], [13]. Some of them propose extensions of DSR, and compare performance results with the original protocol [12], [13]. In particular, [12] proposes a routing scheme called Modified Dynamic Source Routing (MDSR) protocol, whereas Wong and Wong [13] evaluated the performance of two extended versions of DSR: the Fuzzy-based DSR (FDSR) and the Enhanced Fuzzy-DSR (EFDSR). In their experiments, all the traffic classes have been considered, but no allusion is made to the throughput required by each class.

Other approaches evaluate the traffic impact on the network performance while using DSR. More specifically, Dyer and Boppana [6] evaluate the impact of multiple HTTP and multimedia flows with and without background traffic on each other. More specifically, they evaluate the capabilities of MANETs in supporting multiple, simultaneous HTTP and multimedia streaming flows. However, no information is provided on the mobility model.

Other schemes compare the performance of DSR with other routing protocols [1], [4], [5], [10]. In particular, DSR is compared with:

- AODV [1], [4], [5], [6], [10];
- ADV [6];
- DSDV [1], [4], [5];

- OLSR [1], [10].

The metrics for comparison performance are: packet delivery ratio [1], [4], [10], end-to-end delay [1], energy consumption [10], mean service time [6], throughput [1], [6], normalized protocol overhead [1], [4]. However, most of those schemes have only considered one class of traffic which can be:

- Constant bit rate (CBR) class [10];
- FTP or HTTP applications [4];
- MPEG-4 traffic [5];
- Exponential or Pareto [1].

Considering only one class of traffic does not make it possible to have a realistic idea of the protocol performance. In principle, services provided by MANETs generate several classes of traffic which combine voice, data and video. In order to provide good quality of services (QoS), each class has its own requirements in terms of throughput, end-to-end delay and packet delivery ratio. Table 1 specifies the minimum required throughput, the maximum end-to-end delay and the maximum percentage of packet loss, as defined by the International Telecommunication Union (ITU) [3]. Such metrics are commonly used by applications to specify QoS requirements to the routing protocols, as they may be used as constraints on route discovery and selection. In addition to QoS requirements, one must consider the normalized routing load (NRL) to evaluate the operating cost and efficiency of a routing protocol. The NRL represents the ratio of routing packets transmitted to packets received at the destination.

In this paper, we evaluate the impact of mobility, traffic type and traffic intensity on the performance of a multiservice MANET while using DSR. The performance parameters are: the end-to-end delay, the packet delivery ratio and the normalized routing load. This will enable to evaluate the efficiency of DSR in several scenarios.

Table 1 : QoS requirements for each class of traffic

METRICS	VOICE	VIDEO	DATA
End-to-end delay (s)	0.150	0.150	0.150
Percentage of packet loss (%)	0.5 %	0.5 %	0 %
Throughput (kbps)	64	384	28.8

3. Formulation of the routing problem

In this section, we formulate the routing problem in the context of a MANET. For such formulation, the following notations will be used:

- A : the service area;
- N : the set of n nodes,
- L = (i, j)\node i is in the range of node j, the set of m links;
- D = $D_\ell \backslash \ell \in L$, the set of link capacities;
- F : the available bandwidth;

- M : the mobility model controlling the node movements;
- S : the set of *s* services;
- Q : the set of *q* service types;
- X : the set of *x* traffic patterns used accordingly to the types of services;
- ${D^{Min}}_k$: the minimum throughput required by service *k*;
- ${T^{Max}}_k$: the maximum delay that can be supported by service *k* from a source to a destination;
- ${P^{Max}}_k$: the maximum packet loss rate that can be supported by service *k*;
- T : the average packet delay from a source to a destination;
- *r*: the ratio of packets transmitted to packets received at the destination.

The routing problem can be formulated as follows:

Given:

$$A, N, L, D, F, M, S, Q, X, D_k^{Min}, T_k^{Max}, P_k^{Max}$$

According to:

- Node mobility
- Quantity of traffic generated

Objective:

Evaluating the impact of multimedia traffic on the performance of the MANET

Subject to:

$$D_t \geq D_k^{Min} \qquad \forall \ell \in L, \forall k \in Q$$
$$T \leq T_k^{Max} \qquad \forall k \in Q$$
$$1 - r \leq P_k^{Max} \qquad \forall k \in Q$$

4. Parameters for the network implementation

First, the network model must define the parameters related to the network environment. Such parameters include the network size, as well as the channel characteristics. In the context of this research, the network consists of 50 nodes that move over an area of 500 x 500 m^2. The channel characteristics mostly depend on the node transmission power. Some nodes may have the ability to vary their transmission power. In this case, the MAC layer protocol considered is 802.11b with a nominal transmission range of 250 meters. It operates in the 2.4-GHz band at 11 Mbps. The propagation model two-ray ground is used at the physical layer.

Moreover, two important variable parameters must be considered in the network model: the node mobility, as well as the traffic type and intensity. The node mobility generally includes the nodes' maximum and minimum speeds, the speed pattern and the pause time. The speed pattern determines whether the node moves at uniform speed, or whether the speed is constantly varying. The pause time determines the length of time each node remains stationary between each period of movement. Combined with the maximum and the minimum speed, this parameter determines how often the network topology changes and how often the network state information must be updated.

In this research, the nodes move according to the random Waypoint model at a speed that is uniformly distributed. Many levels of mobility are considered by varying both speeds and pause times. In particular, speeds are varying from 0 to 20 m/s, whereas pause times take the following values: 0, 100, 200, 300, 400, 500 and 600 seconds.

To complete the model, the number, type and data rate of traffic sources must be specified. Intuitively, the traffic intensity in the network load depends on the number of traffic sources. In fact, all the nodes do not generate traffic at the same time. In order to change the traffic load in the network, we consider the following number of traffic sources respectively: 10, 20, 30 and 40 traffic sources.

Moreover, traffic sources may generate packets at constant bit rate (CBR), or at variable bit rate (VBR). The CBR class is commonly used for voice and data services. In this context, the data rate and the delay remain constant during the packet transmission. More particularly, CBR traffic sources provide a constant flow of data packets of 512 bytes with a transmission rate of 4 packets per second. All CBR traffic scenarios are generated using *cbrgen.tcl* in NS-2. However, the CBR traffic class is not adapted to real-time multimedia traffic generated by on-demand and videoconferencing services [5].

The VBR traffic closely matches the statistical characteristics of a real trace of video frames generated by an MPEG-4 encoder [[5]. Two parameters were used to control the traffic stream. The first parameter, the initial seed, results in the variants of traffic trace. This parameter was kept constant at 0.4, as the same traffic trace needed to be used in all the experiments. The second parameter, the rate factor, determined the level of scaling up (or down) of the video input while preserving the same sample path and autocorrelation function for the frame size distribution. Its value is 0.33 for 40 sources, and 0.25 for 10, 20, 30 sources.

5. Simulation results and analysis

To evaluate the impact of mobility on the performance of each component of the multimedia traffic in a MANET, simulations with NS-2.29 are carried out using three sets of experiments. The first set only considers CBR traffic sources, whereas in the others, a mix of CBR and VBR traffic sources are used. More specifically, the second set has a percentage of 25% of VBR traffic sources and 75% of CBR traffic sources, whereas the third set of experiments has 50% of CBR traffic sources and 50 % of VBR traffic sources. The simulation time is 600 s for each experiment. The performance is expressed in terms of the *average end-to-end delay*, the *packet delivery ratio* and the *normalized routing load*.

Due to space limits, we only present the results related to 20 and 40 traffic sources, which characterizes low and high traffic intensity levels respectively. Such results are illustrated in Figures 1 to 6 which summarize the performance of DSR as a function of mobility and traffic intensity. More specifically, the results show the impact of the pause time and traffic intensity on the average end-to-end delay, the packet delivery ratio and the normalized routing load respectively, for each type of traffic. In this context, R1 represents the results obtained when only considering CBR sources, whereas R2 represents the results obtained when considering 75% of CBR sources and 25% of

VBR sources, and R3 represents the results obtained when considering 50% of CBR and 50% of VBR sources.

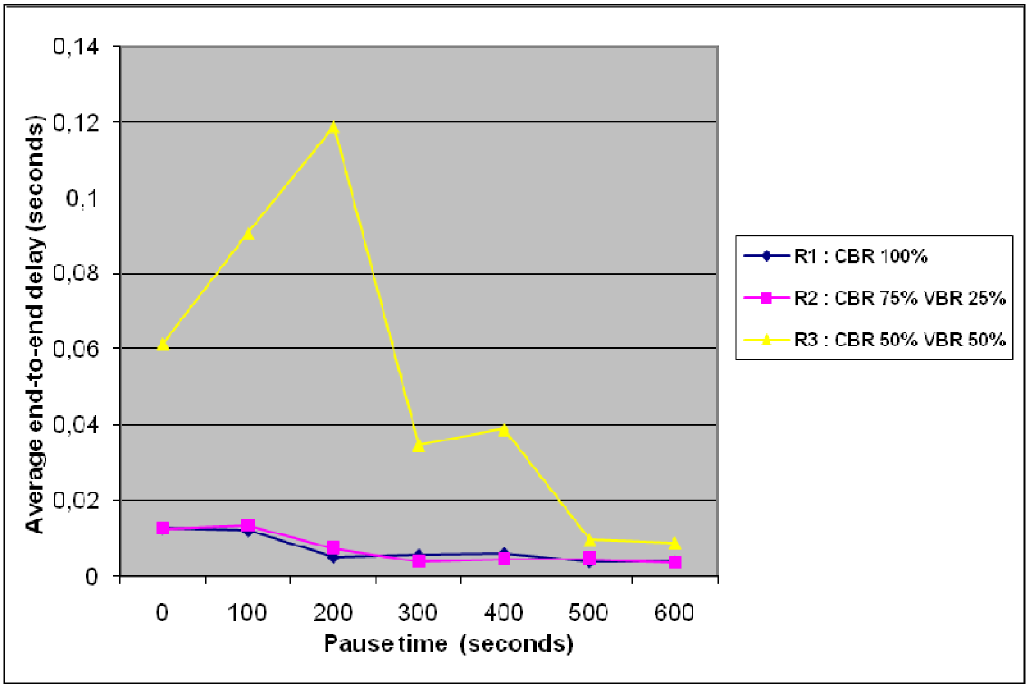

Figure 1. Average end-to-end delay for 20 sources of traffic

We realize that, in general, the average end-to-end delay and the normalized routing load decrease as the node mobility decreases, *i.e.* the pause time increases, which is illustrated in Figures 1, 3, 4, 6. However, the packet delivery ratio increases as the mobility level decreases, which is illustrated in Figures 2 and 5. In particular, low node mobility leads to more stable routes, which generates less overhead packets. As a result, the average end-to-end delay and the normalized routing load are relatively low, whereas the packet delivery ratio is relatively high. On the other hand, high mobility level leads to increase the number of RREQ, RREP and RERR packets. As a result, the end-to-end packet delay and the normalized routing load become relatively high, whereas the packet delivery ratio becomes relatively low.

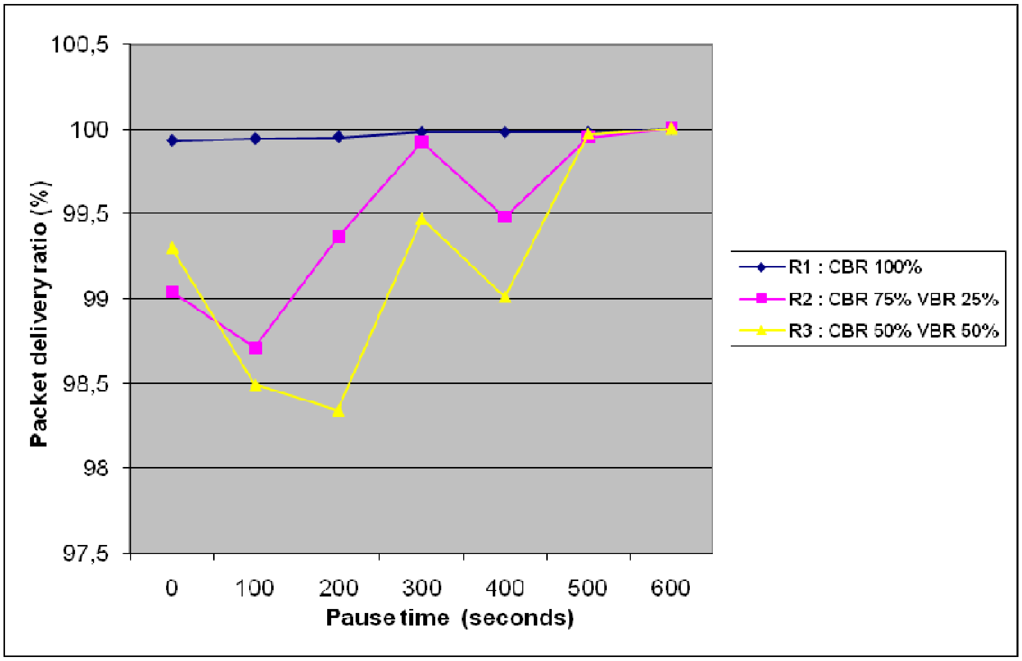

Figure 2. Packet delivery ratio for 20 sources of traffic

Moreover, the performance of DSR depends on the traffic intensity level. More specifically, for the same type of traffic, the end-to-end delay is higher with 40 sources of traffic than that with 20 sources of traffic, which can be illustrated in Figure 1 (max. 0.11 s) and Figure 4 (max. 2.17 s). In the same vein, for the same type of traffic, the normalized routing load is higher with 40 sources of traffic than that with 20 sources of traffic, which can be illustrated in Figure 3 (13.13%) and Figure 6 (max. 22.02%). On the other hand, for the same type of traffic, the packet delivered ratio is lower with 40 sources of traffic than that with 20 sources of traffic, which can be illustrated in Figure 5 (min. 50.13%) and Figure 2 (min. 99.01%). In fact, high traffic intensity tends to create more congestion in the network. In this case, the packets have more chance to be discarded due to the delay associated to such congestion. As a result, more header packets are generated, which leads to high normalized routing load, high end-to-end delay and low packet delivery ratio.

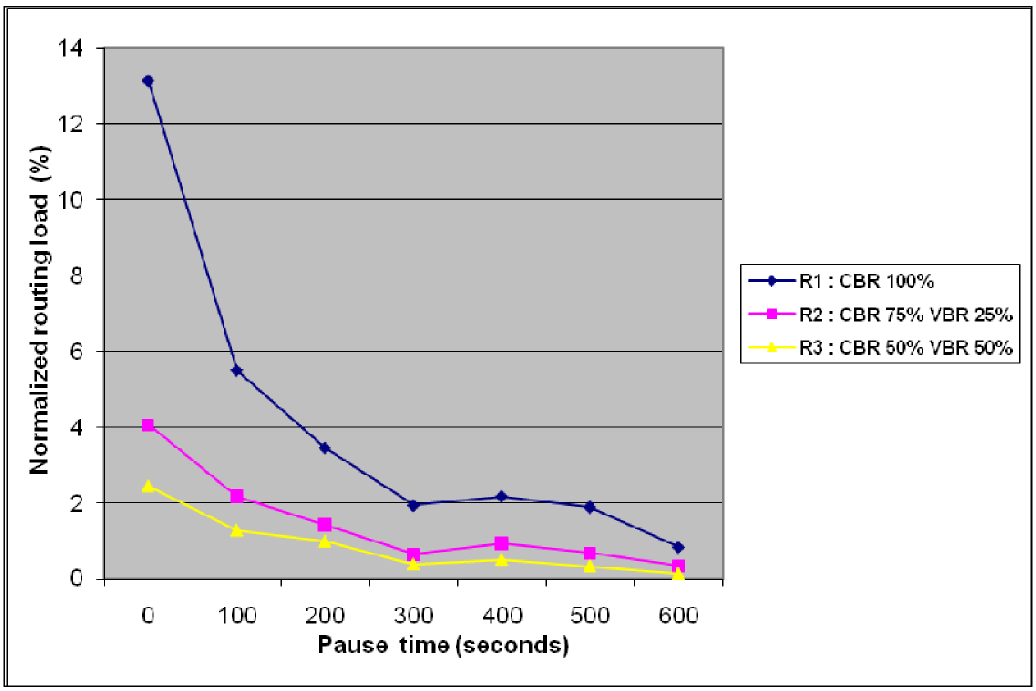

Figure 3. Normalized routing load for 20 sources of traffic

Also, the type of traffic has an impact on the performance of DSR. In general, traffic consisted of only CBR class (scenario R1) offers better delay than a mix of CBR and VBR classes (scenarios R2 and R3). With 20 sources of traffic, the delay reaches 12 ms for scenario R1 while reaching 120 ms for scenario R3, which is illustrated in Figure 1. With 40 sources of traffic, the delay reaches 9 ms for scenario R1 while reaching 776 ms for scenario R2 and 2 179 ms for scenario R3, which is illustrated in Figure 4.

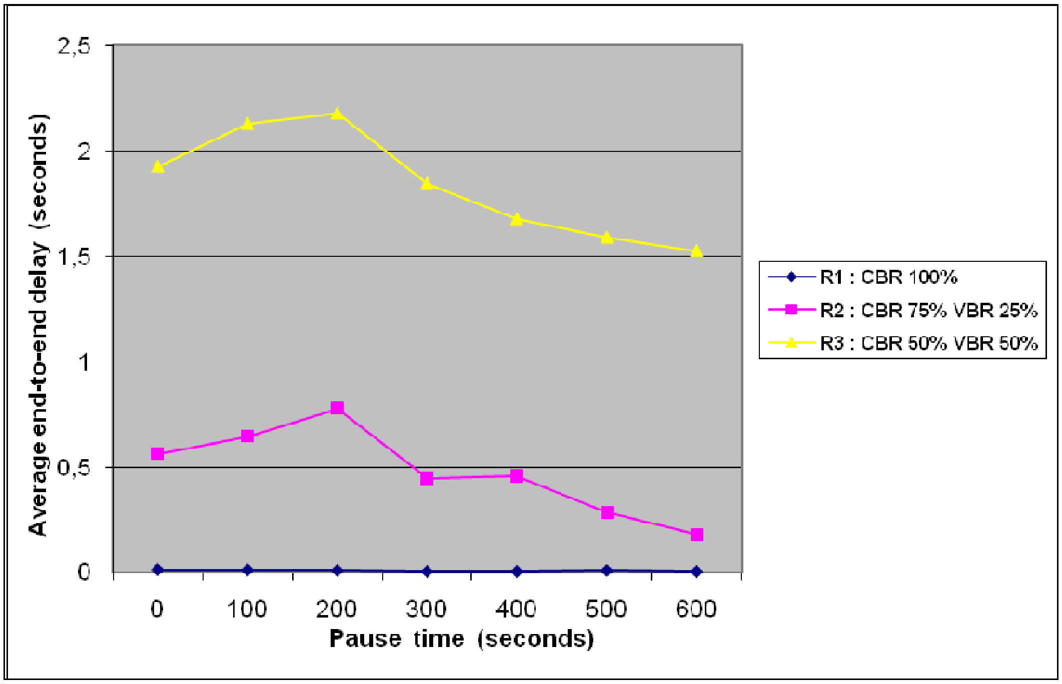

Figure 4. Average end-to-end delay for 40 sources of traffic

The packet delivery ratio, in case of scenario R1, is in general higher than in R2, whereas R2 leads to higher packet delivery ratio than R3 for any pause time and any number of traffic sources, which is illustrated in Figures 2 and 5. In the presence of video traffic, a great number of packets are generated by the sources, which increases the congestion level and increases the packet loss rate. Note that the packet loss rate is identical for CBR and VBR packets in all scenarios except for R3 where, for 40 traffic sources, the packet delivery ratio for CBR traffic is higher than that of VBR traffic.

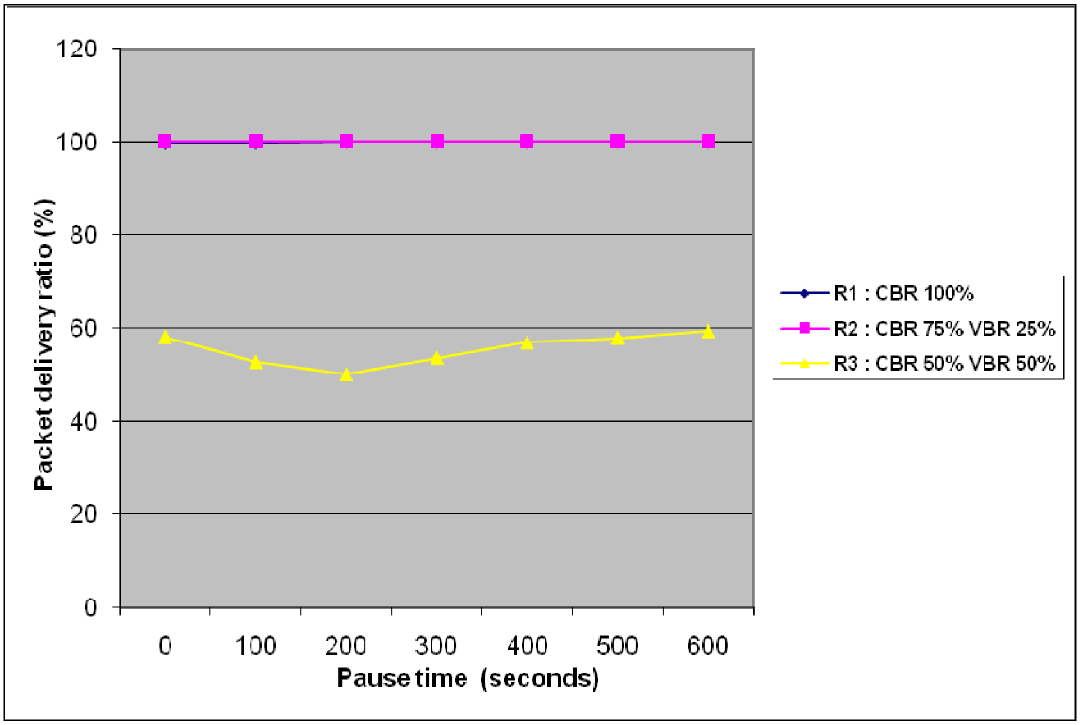

Figure 5. Packet delivery ratio for 40 sources of traffic

The normalized routing load, in case of scenario R1, is in general higher than in R2, whereas R2 leads to higher normalized routing load than R3 for 20 sources of traffic. This is illustrated in Figure 2. However, for 40 sources of traffic, the normalized routing load is in general higher in case of R3 than in R1, whereas R1 leads to higher normalized routing load than R2. This is illustrated in Figure 5. We realize that the presence of VBR traffic strongly deteriorates the performance of DSR.

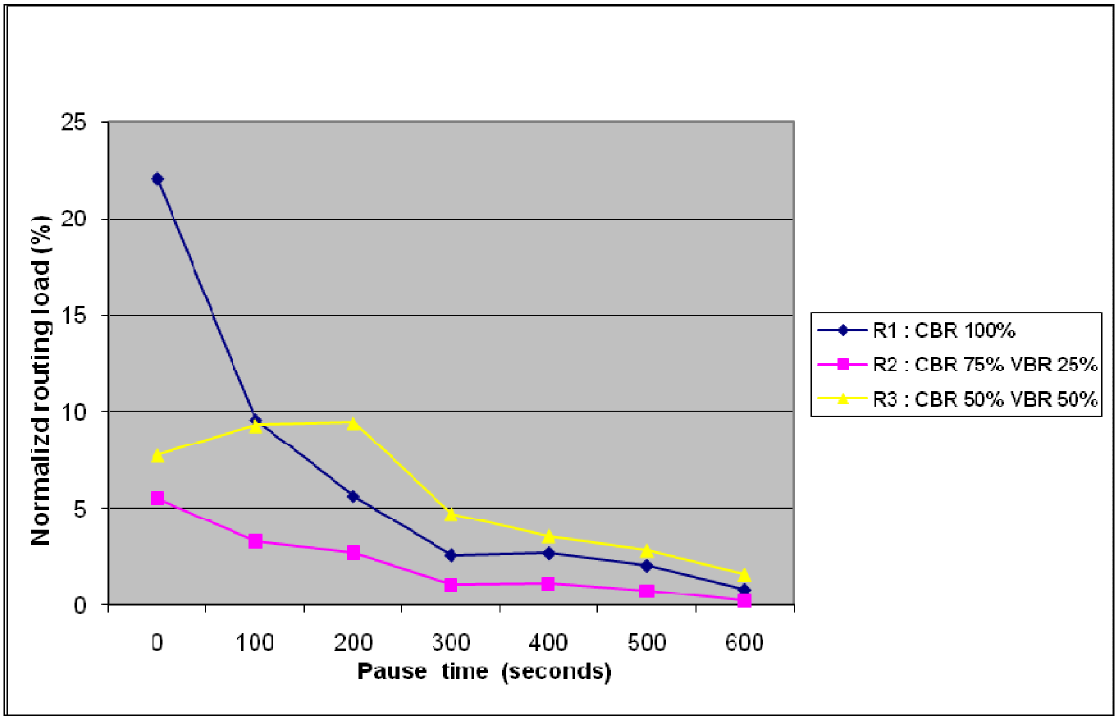

Figure 6. Normalized routing load for 40 sources de traffic

6. Conclusion

In this paper, we proposed a formulation of the routing problem in multi-services MANETs, as well as the implementation of an adaptation of DSR. Services constraints, such as end-to-end delay, packet delivery ratio and normalized routing load, were considered. Simulation results show that DSR performs well with low mobility and low traffic intensity. In particular, DSR enables to provide end-to-end delay less than 0.11 s, packet delivery ratio higher than 99% and normalized routing load less than 13%, for low mobility level and low traffic intensity (*i.e.* 20 traffic sources). However, when considering high traffic intensity (*i.e.* 40 traffic sources), its performance strongly decreases, especially in presence of multimedia traffic. As a result, the delay reaches 2.2 s, whereas the packet delivery ratio reaches 50.13% and the normalized routing load reaches 22%, especially in the presence of multimedia traffic. Future work should be oriented towards the evaluation of DSR in terms of other parameters, such as the jitter.

REFERENCES

[1] A. Al-Maashri, M. Ould-Khaoua, Performance Analysis of MANET Routing Protocols in the Presence of Self-Similar Traffic, Proceedings of 31st IEEE Conference on Local Computer Networks, 14-16 Nov. 2006, pp. 801–807.

[2] R. Bai, M. Singhal, DOA: DSR over AODV Routing for Mobile Ad Hoc Networks, IEEE Transactions on Mobile Computing, Vol. 5, No. 10, pp. 1403–1416, 2006.

[3] P. Calyam, M. Sridharan, W. Mandrawa, P. Schopis, Performance Measurement and Analysis of H.323 Traffic, In Proceedings of 5th International Workshop on Passive and Active Network Measurement (PAM 2004), France, Vol. 3 of Lecture Notes in Computer Science, Springer, pp. 137-146, April 19-20, 2004.

[4] A. Chaplot, A Simulation Study of Multi-Hop Wireless Network, IEEE International Conference on Personal Wireless Communications, pp. 86–89, December 15-17, 2002.

[5] M. U. Chowdhury, D. Perera, T. Pham, A Performance Comparison of three Wireless Multi-hop Ad-hoc Network Routing Protocols when Streaming MPEG-4

Traffic, In Proceedings of the 8th International Multitopic Conference, pp. 516-521, December 24-26, 2004.

[6] T. D. Dyer, R. V. Boppana, On Routing Web and Multimedia Traffic in Mobile Ad hoc Networks, In Proceedings of the 36th Annual Hawaii International Conference on System Sciences (HICSS'03) -, Island of Hawaii, pages 10, January 6-8, 2003.

[7] X. Hong, K. Xu, M. Gerla, Scalable Routing Protocols for Mobile Ad Hoc Networks, IEEE Networks, Vol. 16, No. 4, pp. 11 – 21, 2002.

[8] T.-C. Huang, C.-C. Chan, Caching Strategies for Dynamic Source Routing in Mobile Ad Hoc Networks, IEEE Wireless Communications and Networking Conference (WCNC) 2007, 11-15 March 2007, pp. 4239 – 4243.

[9] C.-C. Ooi, N. Fisal, Implementation of Geocast-enhanced AODV-bis Routing Protocol in MANET, IEEE Region 10 Conference TENCON, Vol. B, pp. 660-663, Chiang Mai, Thailand, November 21-24, 2004.

[10] C. Taddia, A. Giovanardi, G. Mazzini, Energy Efficiency in OLSR Protocol, 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, pp. 792–796, Vol. 3, September 28-28, 2006.

[11] H. Tafazolli, A Survey of QoS Routing Solutions for Mobile Ad Hoc Networks, IEEE Communications Surveys & Tutorials, Vol. 9, No. 2, pp. 50–70, 2007.

[12] N. Taing, S. Thipchaksurat, R. Varakulsiripunth, H. Ishii, Performance Improvement of Dynamic Source Routing Protocol for Multimedia Services in

Mobile Ad Hoc Network, 1st International Symposium on Wireless Pervasive Computing, 2006, 16-18 Jan. 2006, 5 pp.

[13] Y. F. Wong and W. C. Wong, A Fuzzy-Decision-Based Routing Protocol for Mobile Ad Hoc Networks, In Proceedings of the 10th IEEE International Conference on Networks, 2002, ICON 2002, Singapore, pp. 317-322, IEEE Computer Society, August 27-30, 2002.