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Coherent Route Cache In Dynamic Source Routing For Ad Hoc Networks

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Abstract

Ad hoc network is a set of nodes that are able to move and can be connected in an arbitrary manner. Each node acts as a router and communicates using a multi-hop wireless links. Nodes within ad hoc networks need efficient dynamic routing protocols to facilitate communication. An Efficient routing protocol can provide significant benefits to mobile ad hoc networks, in terms of both performance and reliability. Several routing protocols exist allowing and facilitating communication between mobile nodes. One of the promising routing protocols is DSR (Dynamic Source Routing). This protocol presents some problems. The major problem in DSR is that the route cache contains some inconsistence routing information; this is due to node mobility. This problem generates longer delays for data packets. In order to reduce the delays we propose a technique based on cleaning route caches for nodes within an active route. Our approach has been implemented and tested in the well known network simulator GLOMOSIM and the simulation results show that protocol performance have been enhanced.

Keywords: Ad Hoc Networks, Mobile Networking, Minimizing Delay, Stale routes problem, DSR.

1 Introduction

Each node in a mobile ad hoc network (MANET) is a router. Communication between nodes requires a multihop wireless path from a source to a destination, so nodes must cooperate in routing operation.

All nodes are mobile and can be connected dynamically in an arbitrary manner to form a network [1]. A challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two nodes. The key task of routing protocols is to deliver packets from the source node to the given destination [2]. The existing routing protocols are, traditionally, divided into two classes, depending on when a node acquires a route to a destination. Reactive protocols invoke a route discovery procedure on demand only. Thus, when a route is needed, some sort of flooding-based global search procedure is employed. One of the promising reactive routing protocols is DSR. In general, routing protocol presents some problems, and one of the major problems in DSR is longer data packets delays caused by the search process in the cache. In this paper, we propose a technique to solve this problem.

The remainder of the paper is organized as follows. First, we give an overview on DSR and its operations. This is followed by focusing on stale routes problem in section 3. In section 4, a presentation of different works that tries to solve this problem is given. Next, we concentrate on the proposed technique to solve the problem of delay caused by stale routes in cache in section 5. In section 6, we present the performance evolution of the proposed approaches, and finally, we conclude in section 7.

2 Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing [3, 4] is based on source routing, where the source node specifies the whole path to destination node in the packet header. When a source node needs to communicate with a destination node, it first searches in its route cache for a route to the destination, if a route is found, the source node uses it, otherwise the source node initiates a route discovery mechanism to discover a route. In a route discovery mechanism, the source node floods a route request message (RREQ) to neighboring nodes. The message contains the source address, the destination address, the request id, and a list containing the complete path to destination. When a node receives this request, it proceeds as following:

- If the node has seen this same request before, it ignored the request.
- If the receiving node is the destination itself or a node having a route to the destination in its cache, it returns a route reply message (RREP), which contains: the source address, the destination address, and the route record in the route request message. The route reply message is sent back to the source node by following the same route record in the route request message in reverse order.
- Otherwise, it appends its own address to the route record, and rebroadcast the route request message to its neighboring nodes.

When the source node receives the route reply message, it starts sending data packets to the destination. When a route failure happens, the node upstream the broken link sends back to the effective source a route error message (RERR). Nodes receiving RERR message remove broken link from its routes cache. The source node initiates a route discovery if it receives RERR message, it still needs a route to the destination and no alternate route in its cache.

3 The Stale Routes Problem in the DSR Protocol

The DSR has the advantage of learning routes by scanning for information in packets that are received. A route from A to C through B means that A learns the route to C, but also that it will learn the route to B. The source route will also mean that B learns the route to A and C and that C learns the route to A and B. This form of active learning is very good and reduces overhead in the network, by this way each node in DSR can find alternative routes when link failure happens. This property will have a bad repercussion on route cache when node mobility is high. The route caches will contain in this case many stale routes to destinations that may be used to reach a destination and this generates longer delay for data packets. Several previous studies deal with stale routes problem [5, 6].

4 Related Work

In this section we will present some ideas to enhance the DSR routing protocol.

Chen and Hou in [5] used a neighbor link-state information exchange mechanism. Once a connection has been established, the neighbor link-state information is exchanged among nodes along the route from the source to the destination. As the information of the neighbor lists is piggybacked in data packets, the nodes on the source route are able to learn the partial topology around the neighborhood of the connection. The simulation results show that with limited overhead incurred in neighbor list dissemination, the proposed protocol outperforms DSR with either path or link caches in terms of packet delivery ratio and route discovery overhead.

In [7], He et al propose an active packet technique to improve DSR. The mean idea is allowing a packet to visit each node twice. This packet is named "Active packet". The objective of the first visit is to obtain topology information of the network; and the objective of the second visit is to update route caches according to the obtained information. In the header active packet header contains a marker field to indicate if the packet is in the first or the second visit. The payload of the active packet is a connection matrix for the network topology. The active packet is generated periodically. Simulation results show that the method reduced the miss rates by up to 60% and routing packet numbers by up to 47%.

An enhancement to DSR by using a link breakage prediction algorithm was proposed in [8]. A mobile node uses signal power strength from the received packets to predict the link breakage time, and sends a warning to the source node only if the link is soon-to-be-broken. The source node can perform a pro-active route rebuild to avoid disconnection. Simulation results show that the method reduced the dropped packets (by at least 20%). The tradeoff is an increase in the number of control messages by at most 33.5%.

5 The Proposed Technique

In order to minimize the delay which is experienced by data packets and reduce stale routes in caches, we add an expiration time for each route inserted in the cache. This idea is inspired from route management in the routing table of AODV [9, 10]. When learning new routes, a node must set an expiration time for each route inserted in the cache, and when this time expires, the route is removed from the route cache of the node. Each time a route is used the expiration time is set. The max value is fixed to 10 Seconds (represent approximately 1% of simulation time) empirically.

6 Performance Evaluation & Simulation Results

In order to evaluate the effectiveness of the proposed technique described above, we add it to the basic version 3 of DSR available in the GLOMOSIM simulator, and we compare it with the original version using performance metrics.

The simulation environment and the performance metrics used will be described in the next paragraph, the simulation results presentation and discussion is done later.

6.1 Simulation Environment

We have used the implementation of DSR version 3 included in the well known GlomoSim simulator. Our results are based on the simulation of 50 wireless nodes forming an ad hoc network moving about in a rectangular area of 1500 meters by 300 meters for 900 seconds of simulated time. The source-destination pairs are spread randomly over the simulation area, sending four data packets per second following a

CBR (constant bit rate) fashion. For our simulation 10-20-30 and 40 source-destination pairs are chosen. Traffic sessions are established randomly and stay active until the simulation ends. A random waypoint mobility model [3] is used. The movement scenario we used for each simulation is characterized by a pause time. Each node begins the simulation by selecting a random destination in the simulation area and moving to that destination at a speed distributed uniformly between 0 and 20 meters per second. It then remains stationary for pause time seconds. This scenario is repeated for the duration of the simulation. We carry out simulations with movement patterns generated for 10 different pause times starting by 0s varying by a step of 100s until 900s (the length of the simulation) is reached, which corresponds to limited motion. The physical radio characteristics of each mobile node's network interface, such as the antenna gain, transmission power, and receiver sensitivity, were chosen to approximate the Lucent WaveLAN direct sequence spread spectrum radio[11]. The performance metrics [12] used to evaluate performance are:

- **Average end-to-end delay of data packets**: This includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays at the MAC layer, and propagation and transfer times.

- **Communication overhead** is the total number of control packets, and including route request, route reply, and route error packets generated for each delivered data packet.

- **Number of broken links** is the number of invalid routes for sending data across it; the proposed technique reduces the use of the broken links.

6.2 Simulation Results and Discussions

We report the results of the simulation experiments for the original DSR protocol and for Optimized DSR (DSR Opt). In all figures below, Pause time varied between 0 seconds and 900 seconds. When pause time is 0 seconds this denotes high mobility, while 900 seconds pause time means no mobility. Each scenario is repeated five times and the average values of the results are chosen.

6.2.1 Broken Links

In high mobility, the number of broken links is high (Figures 1, 2, 3 and 4). This is due to constant changement in the network topology and the incapability to find a valid alternative link. The number of sources also affects the number of broken links. When the number of sources increases, the number of broken links also increases because the need of more routes to destinations and the failure of one link can induce a breach of several communications. It can be noticed from those figures that DSR Opt results in substantially fewer link breaks, especially when pause times are small (high mobility). This is due to the expiration time mechanism added to DSR and consequently, the probability of using a stale route is minimized (The protocol tends to use fresher valid routes).

6.2.2 Average End-To-End Delay

In Figures 5, 6, 7 and 8 the results obtained for the end-to-end delay metric are presented. We observe that the end-to-end delay increases significantly when the number of sources increases, especially in high mobility because queues of nodes are almost full and nodes try to salvage many data packets. Minimizing stale routes contribute directly to minimizing end to end delay for data packets. When a broken link happens in DSR Opt, data packets experience a lower delay than in DSR because of the reduced number of cached route. The results show that DSR Opt outperforms DSR significantly when the number of sources is low and motion of nodes is high. This enhancement of DSR is suitable for Multimedia flows which cannot tolerate higher delays.

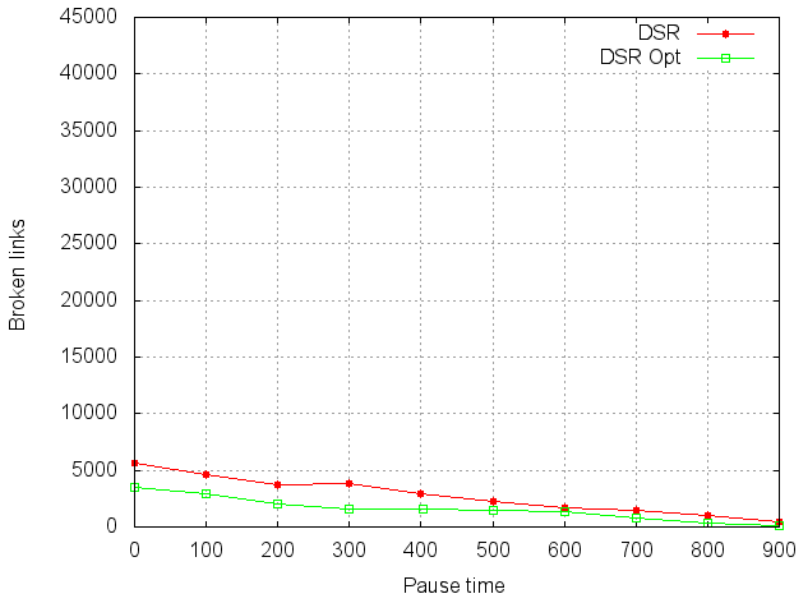

Figure 1. Number of Broken Links for 10 sources

6.2.3 Communication Overhead

Figures 9, 10, 11 and 12 show how mobility and number of sources affect the communication overhead. We notice that communication overhead is high when node mobility is high; this is due to the dynamic and constant change in network topology. It is also observed that the overhead is high when the number of sources is high. This results from the fact that many sources try to discover routes to destinations, which increase the number of control packets and so the communication overhead. The results show that DSR Opt results in substantially less overhead when the mobility is moderate (100s to 400s); this has a good impact on energy consumption because the number of control packets generated is low. Sometimes, DSR Opt generates higher overhead than DSR, this can be explained by the fact that when using the expiration time technique, some valid routes may be removed from the cache, which generates a new route discovery.

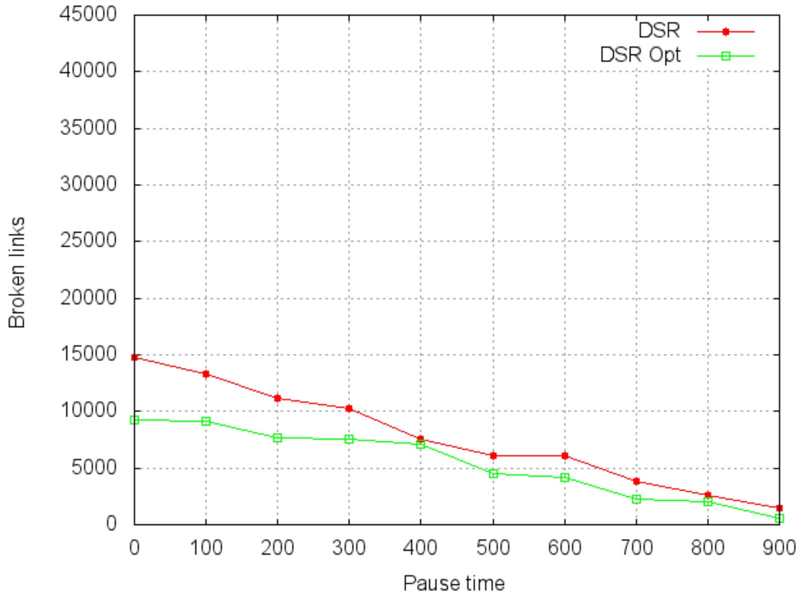

Figure 2. Number of Broken Links for 20 sources

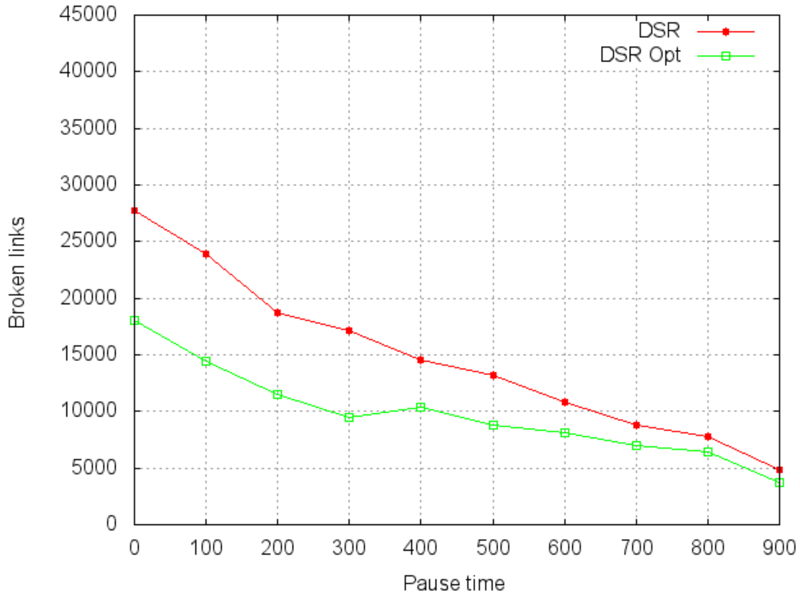

Figure 3. Number of Broken Links for 30 sources

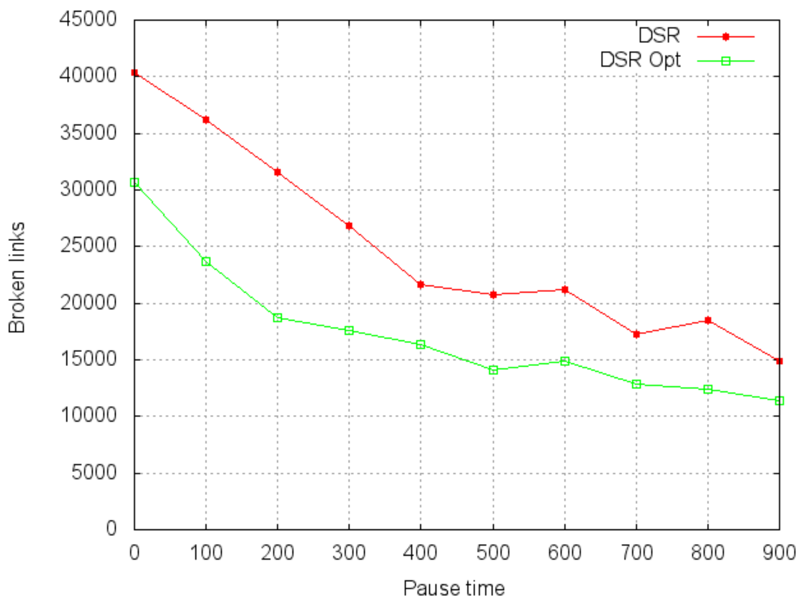

Figure 4. Number of Broken Links for 40 sources

7 Conclusion

In this paper, we have improved the promising DSR routing protocol for ad hoc networks. We have equipped DSR with expiration time technique for routes in route cache. This technique has been inspired from route management in the routing table of AODV routing protocol, in order to avoid the use of stale route in routing. The performance of the proposed technique was evaluated and compared with DSR using detailed simulations. Several common performance metrics were considered. The simulation results show that the proposed algorithm performs well; it can overall generate lower communication overhead, fewer broken links and lower Average end-to-end delay.

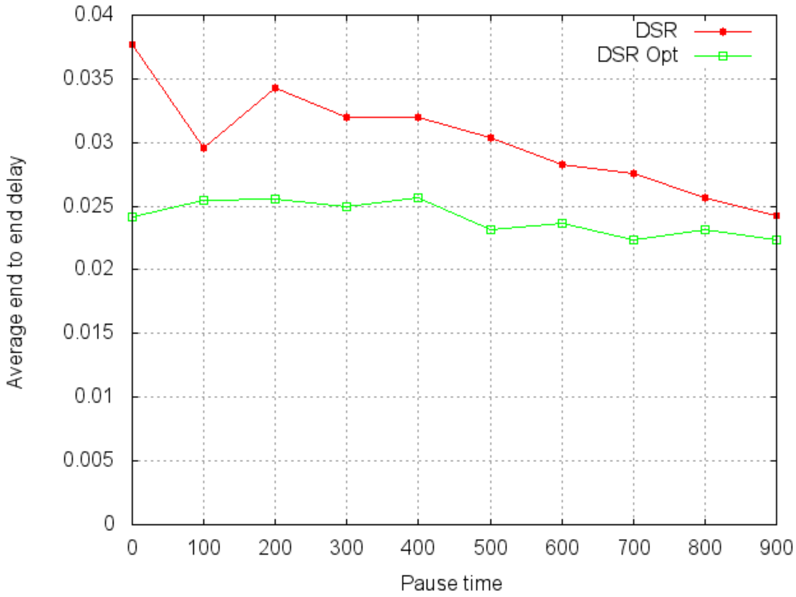

Figure 5. Average end to end delay for 10 sources

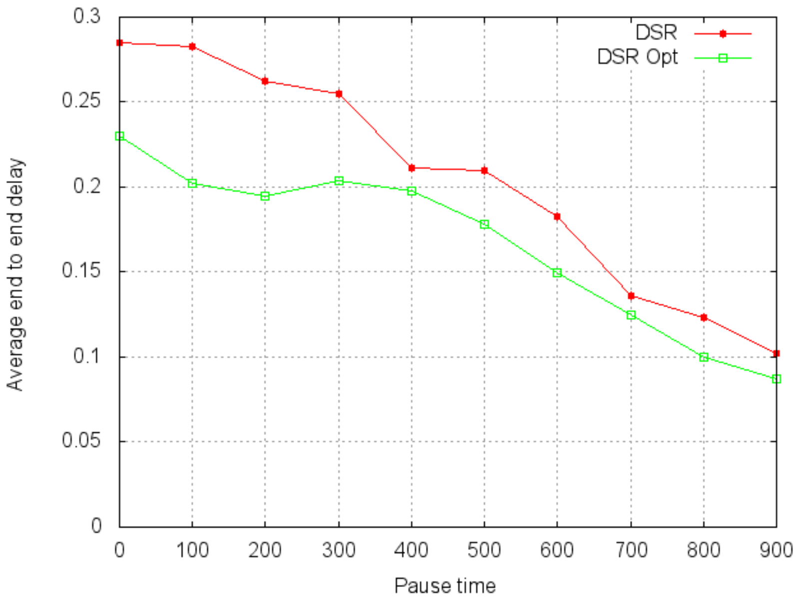

Figure 6. Average end to end delay for 20 sources

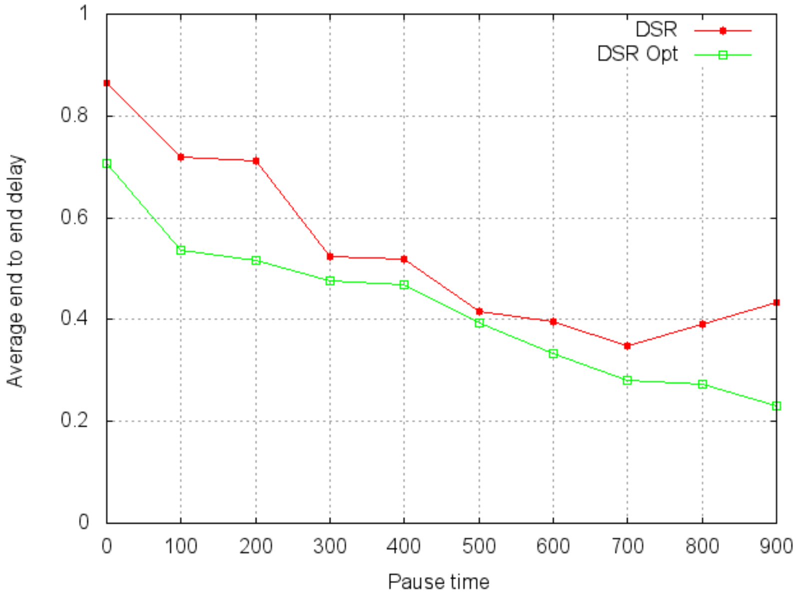

Figure 7. Average end to end delay for 30 sources

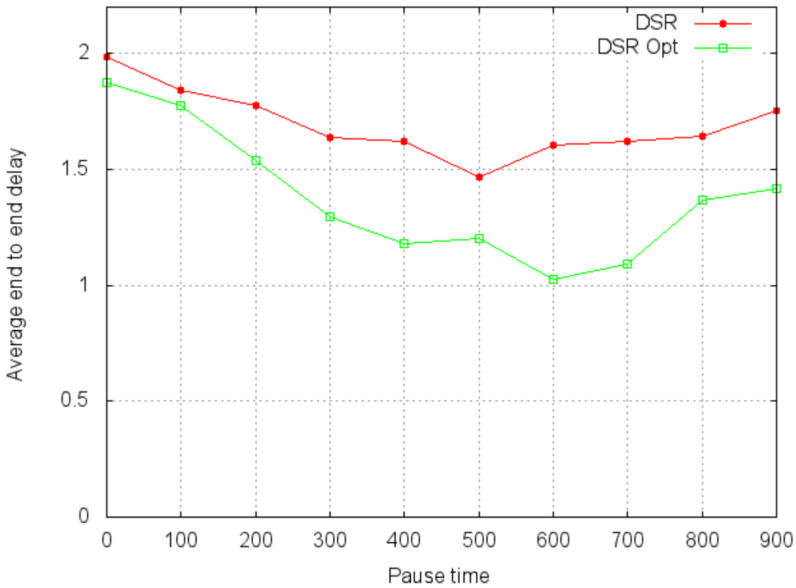

Figure 8. Average end to end delay for 40 sources

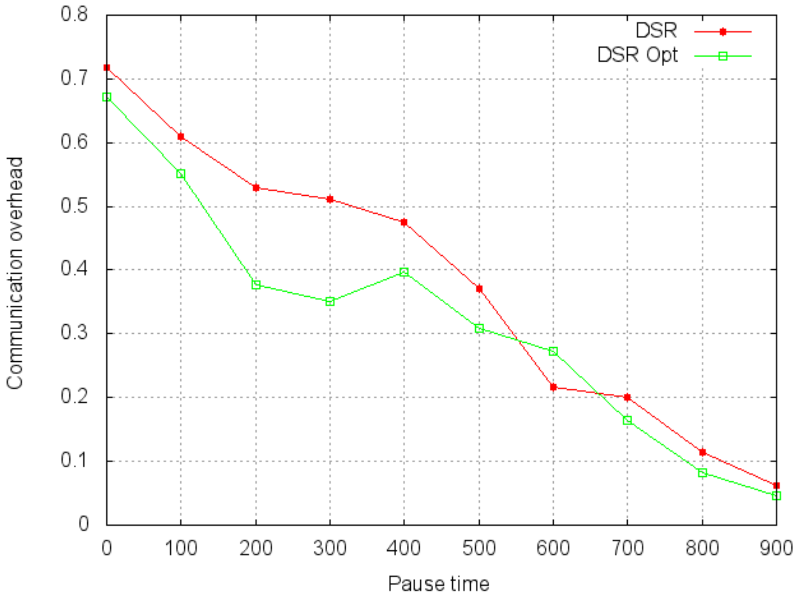

Figure 9. Communication overhead for 10 sources

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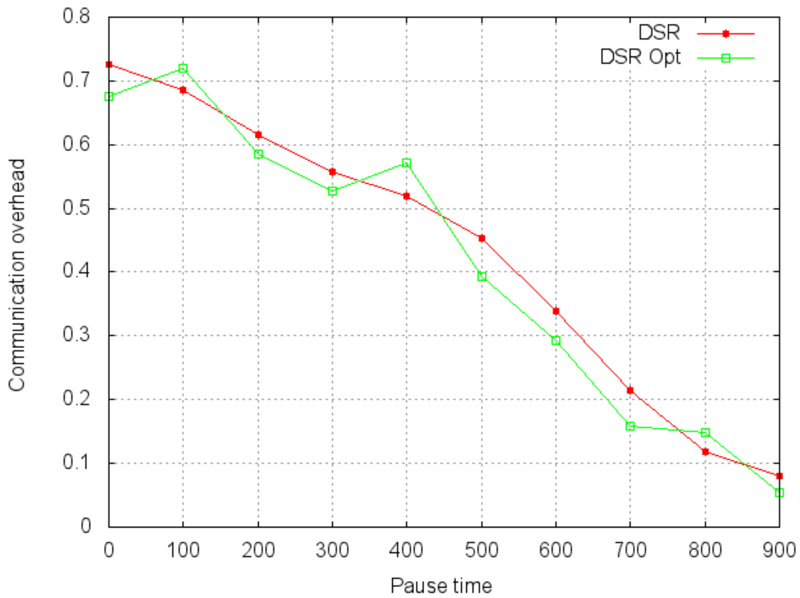

Figure 10. Communication overhead for 20 sources

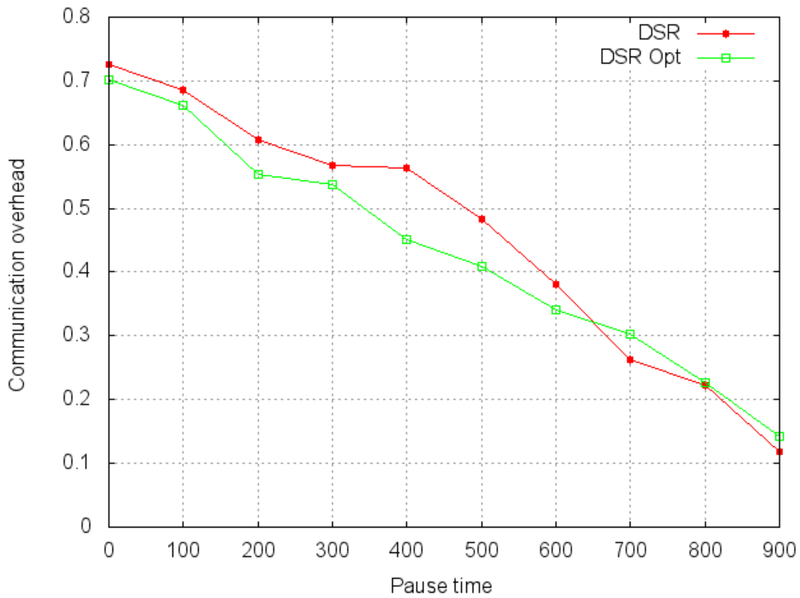

Figure 11. Communication overhead for 30 sources

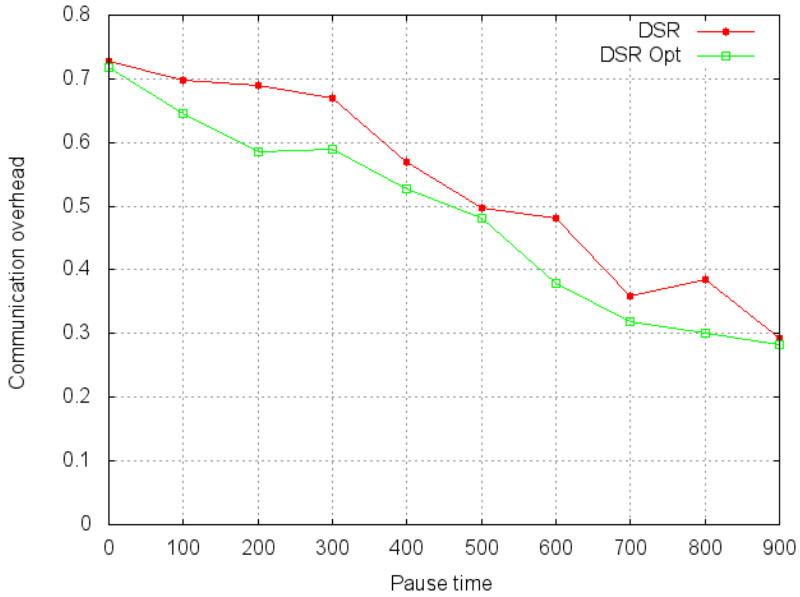

Figure 12. Communication overhead for 40 sources

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