# ARCS: A SIMULATOR FOR DISTRIBUTED SENSOR NETWORKS

**Zdravko Georgiev Karakehayov**

University of Southern Denmark, Mads Clausen Institute, Grundtvigs Alle 150, DK-6400, Sønderborg, Denmark, phone: +45 6550 1696, e-mail: zdravko@mci.sdu.dk

**Zdravko Todorov Monov**

Faculty of German Engineering Education and Industrial Management, Technical university of Sofia, 8 Kliment Ohridski bul., 1000 Sofia, Bulgaria, phone: +3592 965 3213, e-mail: zdravko@programmer.net

**Ludmila Verter Karakehayova**

Technical University of Sofia, 1750 Sofia, Bulgaria, "Mladost" 1 residential area, room 34, phone: +3592 875 1094, e-mail: lvk@tu-sofia.bg

*This paper describes ARCS – ad-hoc routing and connectivity simulator, a tool that is able to simulate the routing process in distributed sensor networks. The simulator allows a random deployment over a two-dimensional area. Each node is aware of its own position and the position of its neighbours. After a configuration phase the nodes are ready to route different types of messages. Two versions of the routing algorithm are currently supported. In order to determine the more effective protocol ARCS produces a rich set of simulation results in its environment. Using the simulator and its graphical module we can assess the capability of the network to route traffic.*

**Keywords:** distributed sensor networks, ad-hoc networks, geographic routing.

## 1. INTRODUCTION

Distributed sensor networks (DSN) can be scalable to thousands of nodes that cooperatively perform complex tasks. Different protocols have been developed for routing in wireless ad-hoc networks [1]. Dynamic topologies, environmental radio propagation conditions, depletion of batteries and congestion make the experiments difficult and expensive in real-world systems [2]. To better understand the functionality of distributed sensor networks simulations are performed. Simulators such ns-2, Glomosim, Tossim are examples of this approach. They allow complex and precise simulations, while keeping the results reliable for any real world system. Designing a new simulator for a general DSN is a complex task that requires the consideration of many parameters.

## 2. ARCS OVERVIEW

Our simulator, ARCS (ad-hoc routing and connectivity simulator), has five major components:

- DSN generator,
- network organization unit,
- route generator,
- routing protocol, and
- computation module.

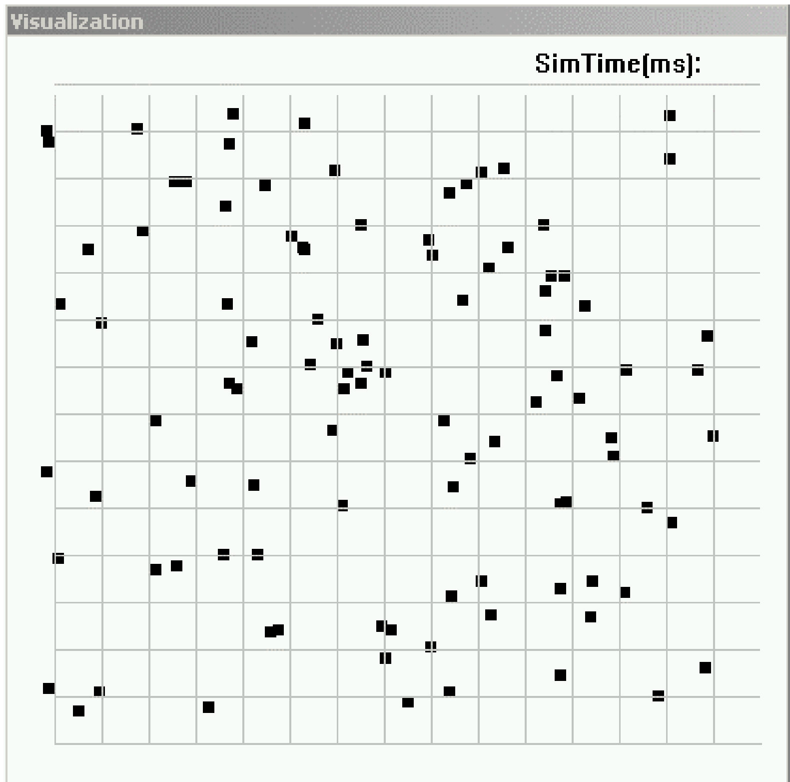


Figure 1. Locations after an example deployment

The network nodes are randomly distributed in a sensor field. Nodes have a specified wireless cell size. Also, the design entry includes the communication rate, packet data structure, timing and energy parameters. The computation module software is written in the C++ programming language.

### 3. NETWORK ORGANIZATION AND STRUCTURE

Each node is characterized by its ID and location. The current version of ARCS assumes a static topology. Once the parameters are input, the nodes are positioned using random coordinates. Figure 1 shows an example deployment.

The network organization begins with broadcast messages which the nodes transmit after random delays. The messages include the node own ID and location. In addition, each node copies to the message its own database. Figure 2 shows the network connectivity after a configuration phase. ARCS is able to keep track on the simulation time. By defining the input timing parameters a specific mathematical algorithm is inovked in order to determine the correct behavior of each node.

## 4. ARCS ROUTING

The route generator randomly selects two nodes as source and destination. The procedure is repeated until the specified number of messages is met. Reaching a dead-end (or void) interrupts the current routing as Figure 3 presents.

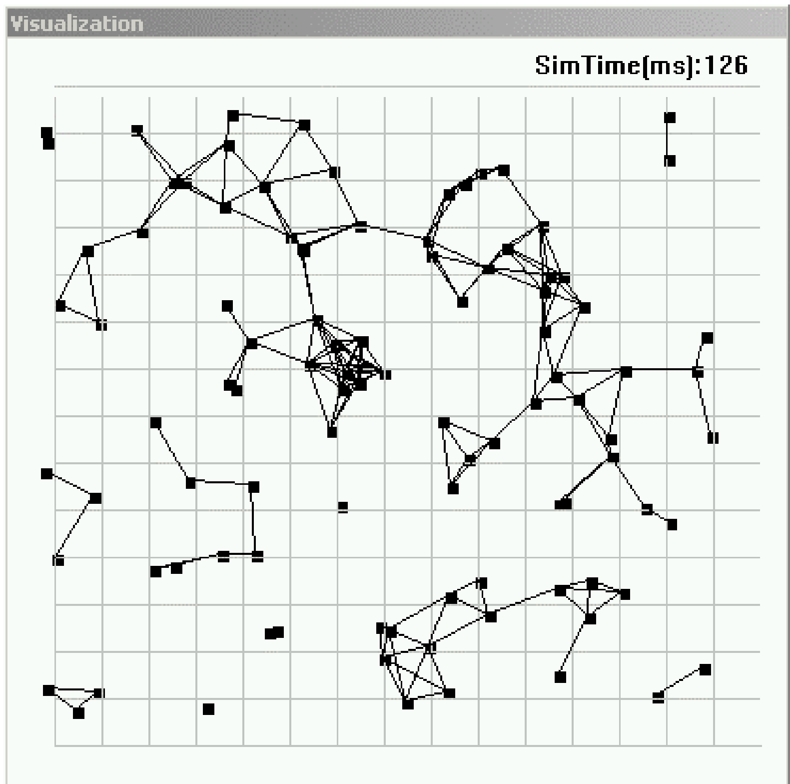


Figure 2. Network connectivity after a configuration phase

The simulator is based on two versions of Most Forward within the transmission Range (MFR) routing protocol. MFR assumes that it will be most beneficial to transmit the packet to the closest to the destination node [3]. Figure 4 shows a complete route under the MFR. Figure 5 indicates the routes when a modification of the MFR protocol is applied. While in the case of geographic routing we may need additional information, the physical position of the participating nodes, on the positive side is the opportunity to forward packets without pre-established routes [4, 5].

The simulation requires only the destination to send an acknowledgement back. Usually, the acknowledgement travels over the same intermediate nodes. ARCS introduces another option – the reverse route is generated by applying MFR again. The difference in routes could be quite significant if the network deployment is reasonably dense. Also the simulation results state a negligible drop in the successful routings, while preserving the nodes from multiple transmissions. Using different routes may be benefical for both power efficiency and security.

The modification of the MFR protocol consists in the different distances that are compared. The next node will be that one, that is farther away from the sender and its position is on the way to the destination.

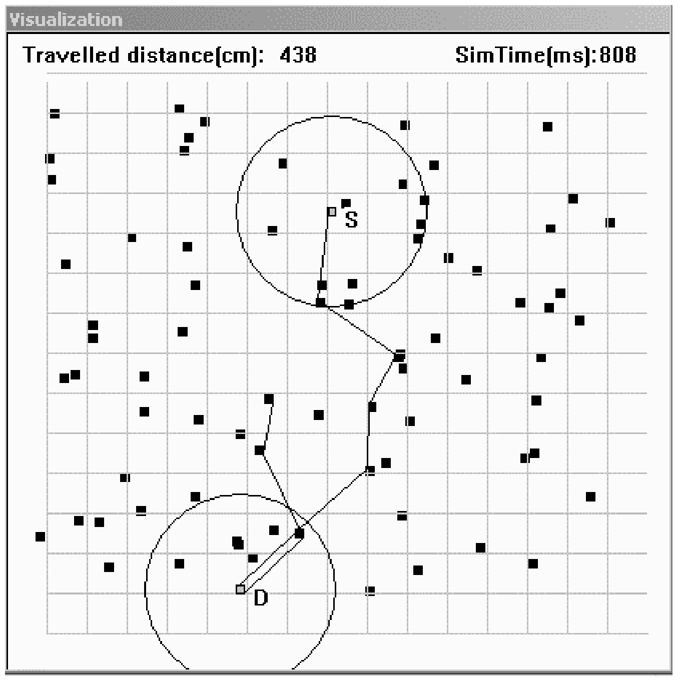


Figure 3. Unsuccessful routing for the acknowledgement

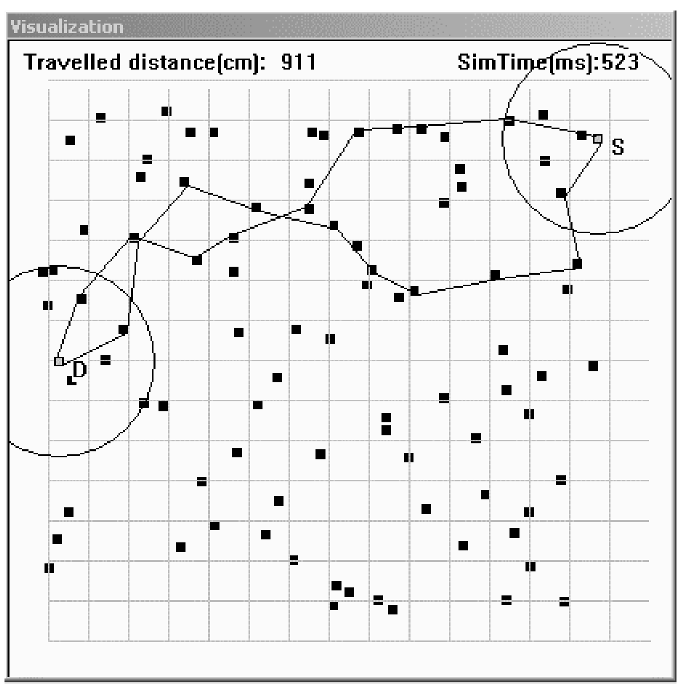


Figure 4. Successful routing using MFR protocol

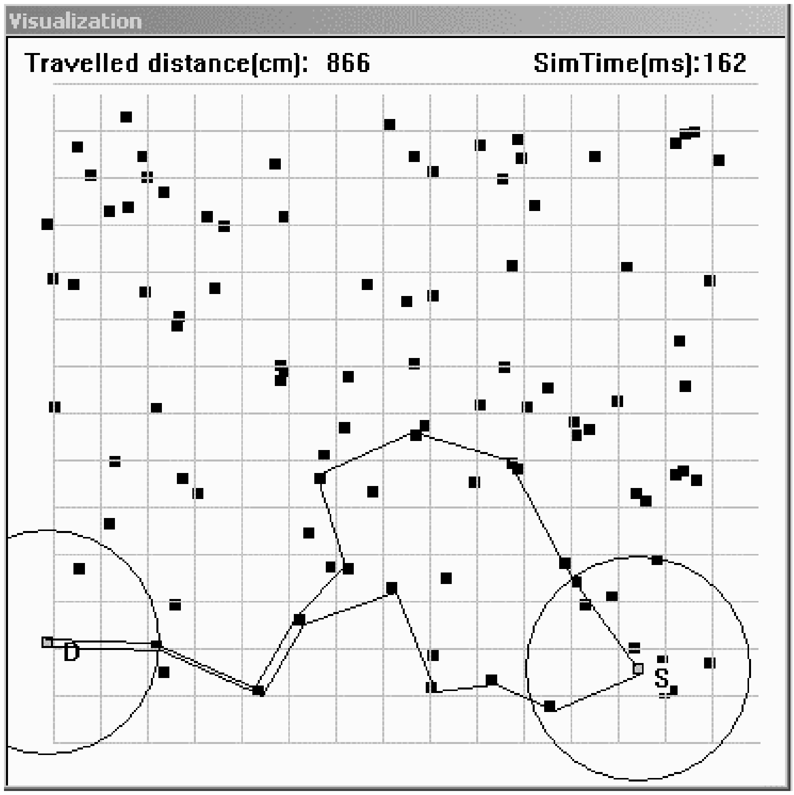


Figure 5. MFR modification algorithm

The records in the address table are usually sorted using a specific criterion – for example, by the distance from the node. The node states which is the farthest node. Then a direction check must be done. If the selected hop doesn't match the corresponding direction, the next node is chosen, and so on. Once a suitable hop is found, the sender transmits the packet.

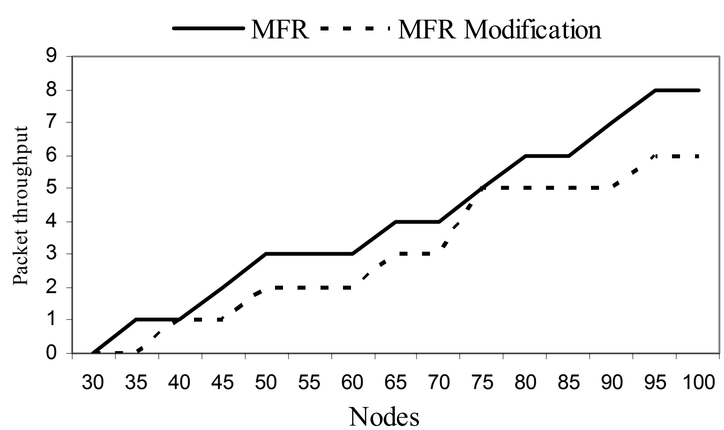


Figure 6. The fraction of packets delivered for
different density of the network

Using ARCS and its graphical presentation of the network connections, we realized that the modification of MFR protocol does not provide the needed efficiency, as Figure 6 shows. The routes are significantly longer. A longer route means that a larger number of nodes is involved in the routing process. Further more, this leads to increases in the timing parameters – respectively, the packet may not reach the destination in a specific period of time. The general form of the routes generated by the modificated MFR is usually too far from the straight line that connects the initial sender and the final destination.

## 5. CONCLUSION

Simulation results indicate that the original MFR protocol provides better connectivity for both sparse and dense networks. Simulations helped to identify cases such as unsuccessful routing for the acknowlegement.

## 6. REFERENCES

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