Routing Protocols for (Dynamic) Wireless Sensor Networks

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Scientific Context. Recently, there was a growing interest in wireless sensor technologies. Such technologies have large-scale applications such as earthquake monitoring or military applications and small-scale services such as home automation.

Sensors are small devices that can generate data about the environment (for example, measure of temperature) and can used them for specific services (for example, emit an alarm when surrounding temperature is too high). They embed wireless communication capabilities for exchanging data between them, shaping thus an implicit network called a *Wireless Sensor Network (WSN)*.

A crucial problem for WSN is the one to transmit data from a given source sensor to a given destination. This is called *routing*. A routing protocol encapsulates the data into messages and then computes a path in the WSN to move them from sensor to sensor until reaching the target.

Routing protocols for WSN have two specifities. First, communications within a WSN are subject to faults such as link failures due to interferences and crash failures due to the low-power batteries of sensors. The structure of a WSN is thus *highly dynamic* and routing paths cannot be computed statically and once for all. Second, sensors can only communicate with other nearby sensors: routing paths can only be computed locally, piece by piece thanks to *distributed algorithms*.

Problem. We consider a network made of many sensors plus a server (so-called *sink node*). The sensors have to regularly route information to the server. Many solutions have been proposed so far to solve this problem in WSNs [AkK04, Gar03]. *Flooding* is a classical mechanism to route messages over the network: any message is repeatedly broadcasted from nodes to all their neighbors until reaching the sink. *Overlay-based* protocols compute a distributed underlying infrastructure (so-called *overlay*) in the network, such as a *spanning tree* or a *cluster* and use this infrastructure to efficiently route messages. *Geographic routing* protocols use node position information to find and forward messages towards the sink.

For those protocols, the hitting time (number of hops for a message to reach the sink) is linear in the number of nodes (even linear in the diameter of the network for some overlay-based protocols). However, this good result comes at the price of communication, memory, and/or computation overheads, and/or extra assumptions, *e.g.*, use of GPS. Those points are real drawbacks when considering WSNs, where sensors are really low resources devices.

Random walks can also be used for the routing. For each datum to send, a message is built and sent over the network until reaching the sink. The next destination for a message is selected at random among the neighbors of the current node. This class of protocols require very low resources (memory and computation time) but suffer from high hitting time — $O(n^2)$ where n is the number of nodes, for some biaised random walks [SIY09].

In a previous work [ADLP11], we proposed to enhance random walks by augmenting them with tabu lists which are used to prevent messages from following cycles. Simulations show that those solutions significantly reduce the hitting time of the random walks while keeping their advantages; and the simulation results have been confirmed by analytical studies in some cases. Nevertheless, this performance analysis is a first step, since it has been conducted assuming a static network. Of course, the performances in terms of hops and delivery rate will be degraded in presence of topological changes. But, it is not clear if their relative performances remain identical.

Subject. We propose to study the impact of network dynamicity on the performance of routing protocols; especially, those proposed in [ADLP11]. A first step will be to compare the behavior of routing protocols in a dynamic environment, and then establish rankings on them according to some relevant criteria. A second step will be to exhibit the weaknesses of these protocols and to find some patches to correct these weaknesses.

Precisely, the subject involves:

- A bibliographical study (routing protocols in WSNs),
- Implementing and simulating routing protocols (in a given simulation framework for testing and validating network algorithms),
- Analysing the performances of the protocols (benchmarks from simulations and complexity analysis).
- Design of improved versions of existing protocols.

Working context The students will be integrated in the lab Verimag[1] in the "synchronous" team. The subject is part of two projects Terra and ARESA 2. Terra[2] (Theoretical Evaluation of Randomized Routing Algorithms) is an academic project which involves teams from Verimag and the Mescal team from LIG/INRIA. ARESA 2 (Embedded Systems and Wireless Sensor Networks) is a national project which involves academic and industrial cooperations.

Possible extensions into a PhD thesis.

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References

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[1] http://www-verimag.imag.fr/
[2] http://www-verimag.imag.fr/Terra.html