SRA: A Salmon-Like Approach to MANET Routing

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Abstract. Wireless mobile ad-hoc networks are characterized by the lack of physical connections. Due to the mobility of nodes, interferences, multipath propagations and path losses, they do not exhibit a fixed topology; hence, dynamic routing protocols are required. In recent years, new approaches inspired by nature have been tried: among them, particular interest has been raised by ants and bees colonies. The characteristics inherited by the collective behaviors of social insects empower algorithms with features such autonomy, self-organization, adaptivity, robustness, and scalability. Here, we propose a salmon-based approach, that, although different since salmons do not show evidence of social behaviors, suggests interesting cues to solve the routing problem when observing salmons in their way from the birth river to the sea, and back at the spawning time.

Keywords: Wireless communications, mobile ad-hoc networks, routing algorithms, bio-inspired paradigms of computation.

1 Introduction

Advances in wireless communication technology have strongly encouraged the use of low-cost and powerful wireless transceivers in mobile applications. As compared with wired networks, mobile networks exhibit unique features: recurrent network topology changes, link capacity fluctuations, critical bounds to their performances.

Mobile networks can be classified into infrastructure networks and mobile ad hoc networks [1]. In an infrastructure mobile network, mobile nodes communicate through wired access points that work in the node transmission range and create the backbone of the network. In a mobile ad hoc network (MANET) nodes are self-organized without any infrastructure support: they move arbitrarily causing the network to experience quick and random topology changes, some of them do not communicate directly with each other, every node has to act as a router, too.

The design of MANET routing protocols is a challenging task. *Proactive* routing, *reactive* routing and *hybrid* routing, [2] are the most popular classes of MANET routing protocols. In a *proactive* routing protocol nodes continuously evaluate routes towards all reachable nodes and maintain consistent, up-to-date routing information even though network topology changes occur. In a *reactive* routing protocol, routing paths are searched only when needed by means of a route discovery operation established between the source and destination node. *Hybrid* routing protocols

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combine the merits of both proactive and reactive protocols and overcome their shortcomings.

Many routing protocols for MANETs, have been considered in the literature for a number of different network scenarios. Among them, algorithms inspired by the behavior of some classes of insects have shown interesting performances. More specifically, the ability of ant colonies to discover shortest paths between their nest and sources of food has been put to work in the general optimization framework of the Ant Colony Optimization (ACO), and the communication and recruitment strategies adopted for effective foraging within a beehive have inspired the development of some novel algorithms for routing problems, [3].

In the remainder of this report, Sections 2 and 3, respectively, introduce the basic salmon behaviors and a new routing algorithm for MANET inspired by it. Even though different from the underlying philosophy of self organized systems intrinsic with social insects, this new approach suggests interesting cues to solve MANET routing.

2 Homing Mechanisms in Salmons

In the framework of nature inspired algorithms, we have examined the salmon behavior. Their life history is dominated by their strong tendency to home to their natal site for reproduction. Typically, salmons spawn in streams or lakes and, after a variable period of freshwater residence (0–3 years), the offspring migrate to the ocean. Salmons remain in the ocean until they mature and then return to their natal site to spawn. Homing migrations are often thousands of kilometers from home river, and in-river migrations back to their natal site may be as long as the ocean migration. These diverse marine and freshwater habitats provide distinct sets of orientation clues and pose distinct challenges for orientation. Despite these challenges, homing is generally precise. Although little experimental evidence exists regarding orientation mechanisms in the ocean, the final freshwater phase of the homing migration is governed primarily by olfactory discrimination of the homestream water. The olfactory imprinting hypothesis for salmon homing was first proposed by Hasler and Wisby (1951) based on behavioral experiments demonstrating that fish can discriminate between the waters of different streams on the basis of odors. This hypothesis has several components: (1) streams differ in chemical characteristics that are stable over time; (2) salmon can distinguish these differences; and (3) salmon learn the chemical characteristics of their natal stream prior to or during their seaward migration, remember (even after 4 years) them without reinforcement during ocean residence, and respond to them as adults,[4].

Foraging ants in a colony converge on the shortest paths connecting their nest to a food source by means of a catalyst, the pheromone. While moving, ants lay pheromone on the ground attracting, in this way, other ants on the same path, that is to say they use a form of learning and control based on indirect communication which locally modify the environment and react to these modifications leading to a phase of global coordination (stigmergy).

Thus, the common point between the ant and salmon behaviors is the recognition of a trail on the route they passed through some time before. The main differences rely on two aspects: first, the salmon learning is individual, second the learning object is used quite immediately by ants and after a long time by salmons.

3 Salmon Routing Algorithm

In this section we propose the Salmon Routing Algorithm (SRA), based on the behavior of salmons. The network topology is determined by the stream morphology of the areas interested by the salmon migration; thus, we consider a star topology where all nodes connect to a unique destination (the sea). Such an hypothesis of unique destination exactly reflects the migration conditions. SRA is constituted by two phases: *Descent*, associated to the salmon path from its birth river to the sea, and *Ascent*: associated to the salmon path from the sea to its birth river. *Descent* and *Ascent* are similar to *forward* and *backward* phases of ACO with the substantial difference that *forward* and *backward* are consecutively executed, whereas a *Ascent* is executed a long time after a *Descent* according to the real behaviour of a salmon. In the network context, this implies that the routing information stored in *Descent* will not be any more consistent for *Ascent* because the high node mobility will have completely modified the network topology. To overcome this mess, SRA uses different data in the two phases: routing information in *Descent*, and *pheromone tables* in *Ascent*. Network topology changes and nodes mobility are accounted by river modifications due to landslides, floods, earthquakes, etc. Such cases, where in nature salmons cannot return to their birth rivers, are associated in the network framework to a link failure state, where the *salmon packet* cannot reach the source node.

In the next subsection we analyze two variants of the SRA algorithm: P-SRA (ProactiveSRA), and R-SRA(Reactive SRA), which, respectively, in *Descent* use AODV and DSR paradigms. The *Ascent* is the same for both proactive and reactive versions.

3.1 P-SRA

A proactive algorithm maintains routing information for each node of the network through the periodic update of *routing tables* ensuring stable and reliable routing information. In the P-SRA, as well as in ACO, we use two tables:

Routing table: destination, next hop, distance of the destination, sequence number
Pheromone table: pheromone values, that is to say the identification items*, id*, of the salmon packets traversing a node in the descent phase.
P-SRA executes the *Descent* and *Ascen*t as follows:

- *Descent*: the *salmon packet* leaves from the source node *s* and arrives at the destination node *sea* by using the information in the *routing tables* of each node it passes through. Along the path, for each node P-SRA builds/updates the *pheromone table* by means of the *id* of the *salmon packet*.

- <u>*Ascent*</u>: the *salmon packet* ascends from the destination node *sea* to the source node *s* by using the information stored in the *pheromone tables*. More specifically, P-SRA looks for an entry correspondent with the *id* of its *salmon packet* in order to choose the correct sub-network containing its birth river. If there is a link failure in the path, the salmon packet will be eliminated after a fixed TTL.

3.2 R-SRA

A reactive algorithm does not maintain routing information for each node of the network, but looks for and obtains a path only on demand ensuring a scarce overhead for routing information.
R-SRA executes the *Descent* and *Ascen*t as follows:

- <u>*Descent*</u>: two types of packets, *SalmonRouteRequest* and *SalmonRouteReply*, are flooded through the network. The first is used when a path for a determinate destination is required; the second is a reply and contains a possible path known by the destination node itself or another node of the network. Every *SalmonRouteRequest* contains a *sequence number* of updating useful to prevent cycles and multiple transmissions of the same messge.
- <u>*Ascent*</u>: it is the same as P-RSA.

3.3 Performance Evaluation

We are actually testing SRA on a real MANET constituted by 12 node positioned along the perimeter of our campus. The mobility is simulated by means of random changes in the topology of network, and the SRA performances are compared to AODV, DSR, DSDV, ACO algorithms and BeeAdHoc [5]. Although in an early stage, experimental results seem to be encouraging because of the following considerations.

SRA drastically decreases the overhead for storing the routing information. More precisely, major advantages are achieved by P-SRA *Ascent* since the routing of packets is exclusively based on the *pheromone table*s stored in *Descent*: there is no need of *routing tables*. A same result holds for R-SRA *Ascent* where the use of pheromone tables allows to avoid the flooding of *SalmonRouteRequest* and *SalmonRouteReply* packets. *Descent* shows similar performances to AODV for P-SRA and to DSR for R-SRA, respectively.

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