Modified Q-learning Routing Algorithm in Fixed Networks

Mahmoud Alilou, Mohammad Ali Jabraeli Jamali, Behrooz Talebzadeh and Maysam Alilou

1Department of Computer, Salmas Branch, Islamic Azad University, Salmas, Iran.
2Department of Computer, Shabestar Branch, Islamic Azad University, Shabestar, Iran.
3Department of Computer, Sofian Branch, Islamic Azad University, Sofian, Iran.
4Sama Technical and Vocational Training College, Islamic Azad University, Khoy Branch, Khoy, Iran.

Abstract: In this paper we are going to introduce a new routing algorithm, which compared to its similar algorithms, can provide an easier method in order to obtain shorter and optimized routes by a massive reduction in the calculations. Furthermore because of the variety of the path that this algorithm possesses, it is able to manage the load balance effectively. The proposed algorithm which is named as Modified Q-learning Routing Algorithm (MQRA) shows a high fault tolerance and by obtaining all of the possible routes between the source and the destination nodes, in the worst conditions, it can easily make the best choice. MQRA guarantees the delivery of the packets to the destination and by its intrinsic it prevents any live-lock occurrences. The purpose of this paper is to introduce the MQRA algorithm and show its capabilities by comparing it to the Bellman-Ford algorithm.

Key words: Routing Algorithm, Networks, Reinforcement learning.

INTRODUCTION

Fixed networks are networks in which the nodes are fixed and located in specific coordinates. These networks typically have a certain topology, but according to the requirements they may have non-standard or ad hoc structure (Horst F. Wedde, 2006). Fixed networks take advantage of their static nature in two ways. First, they proactively distribute network topology information among the nodes, and each node pre-computes routes through that topology using relatively inexpensive algorithms. Second, fixed networks embed routing hints in node addresses because the complete topology of a large network is too unwieldy to process or distribute globally (T.N. Saadawi, 1994). Neither of these techniques works well for networks with mobile nodes because movement invalidates topology information and permanent node addresses cannot include dynamic location information. However, there is a topological assumption that works well for radio-based ad hoc networks: nodes that are physically close are likely to be close in the network topology; that is, they will be connected by a small number of radio hops (L.M. Feeney, 1999).

MATERIALS AND METHODS

Bellman-Ford Algorithm vs MQRA Algorithm:

In order to assess the performance of the MQRA algorithm in constant networks, we apply the Bellman-Ford algorithm (Thomas H. Cormen, 2001; Richard Bellman, 1958) and the MQRA algorithm in a same network and study each algorithm’s routing method in similar conditions.

Assume a 5*5 mesh network, in which the nodes are placed in a fixed distance from each other steadily. Of course it is not necessary for the network to have a standard topology, and also the connection between the nodes may be wired or even wireless and the mesh network has been chosen in order to easier understanding of the subject.

Fig. 1: 5*5 mesh network.
Our goal is to find the shortest route from every other node to node number 8 with the coordination (1,2), which is shown by a different color in the figure. By executing the Bellman-ford algorithm on this network, all the routes to node 8 will be obtained as it follows.

![Figure 2: The obtained routes by Bellman-ford algorithm.](image)

As it can be seen from the figure 2, there is route from each node to the destination which is considered as the shortest route to the destination. The obtained routes will be saved in a table as it is shown in the following and the mention table is used in cases that we need to perform routing in order to send an information packet.

The table is showed in figure 3 is saved in every node by taking every other node into account and in times of routing, the next step for the mentioned node is derived easily by a simple function from this routing table. For example, to send a packet from node 7 to 0, the next step which is derived from the table would be node number 2. After sending the mentioned packet to node 2, this node has to use a similar routing table which is specified to it to determine the next step which will lead the packet to node 0.

![Figure 3: Bellman-ford routing table.](image)

The MQRA algorithm has the ability of discovering the shortest routes too. The MQRA algorithm work in such way that, in order to find the shortest routes to a node it first gives the value 1.0 to that node and evaluates the other nodes as 0. Then using the Node_value=maximum_adjacent_node_value*(1-Link_Value) formula the value of each node will be calculated. These values can be calculated using the algorithm which was mention earlier in the in-chip networks or they can be sent from the source node to other nodes by the broadcast method. As it can be seen in figure 4, the adjacent nodes to the destination node are evaluated according to their distance from the destination node. The badge on each node shows that each has received its value according to which one of its neighbors. For instance, in the above figure, the badge on node 6 is R which means that the value of this node is calculated from it node 7 which is on its Right.
After finishing the algorithm as it shown in figure 5, evaluating will be executed as following. Usually we can use an identification number of the node or a cursor to the next node, instead of the badges. We can maintain the calculated values in some tables, so that in times of necessity like occurring damage in one of the nodes or one the links in a route, we may use it to find a new route and use it for the purpose of packet sending.

One of the problems which are obvious in Bellman-ford algorithm is that in only obtains the shortest route between the source and the destination, without taking other effective parameters like the number of steps between the source and the destination or the bandwidth of the existing routes, into account. Since each node consumes energy or power in order send or receive a packet and also in order to calculate the next step, a specific amount of time consumed and on the other hand the bandwidth of the connection links between the nodes are different, the shortest route doesn’t necessarily mean the optimized route, so using these route may consume big amount of energy from the network.

The MQRA algorithm has the capability of taking other parameters such as number of steps and the bandwidth of the links into account, by adding some extra coefficient to the above mentioned formula, so by this method it can discover and save the optimized routes instead of the shortest routes between the source and the destination. In order to do so it is enough to modify the formula as the following: Node_value=maximum_adjacent_node_value*(1-Link_Value)*(1/L)*N. In which L is the bandwidth and N is the consumed energy by each node to receive the packet, discover the next step and send it.

One of the other advantages of the MQRA algorithm to the Bellman-ford algorithm is the time of the calculations executed for the routing purpose, which the time complexity of each algorithm has been discussed earlier.

Experiment Results:
In this section the simulation results of the proposed method is compared to bellman-ford algorithm. In order to compare the MQRA and bellman-ford algorithm a wireless ad hoc network with 100 nodes is considered. The radio bandwidth is varied among the nodes and is between 2-10 mbps and the nodes are located in different distances from each other from 1-50 meter in an area of 2000 square meter. In this paper each node's battery energy is considered unlimited since the related subjects are not studied. As it is illustrated in figure 6 the average length of the routes in Bellman-ford and MQRA algorithms is showed. Both of the algorithms are capable of finding the shortest route to the destination.
Figure 6: Average length of the routes in Bellman-ford and MQRA algorithms.

Figure 7 shows the overload originated from sending the packets in the network in such conditions in which we tend to send the packets from short routes in proportion with the distance between the nodes, or the optimized routes which are not necessarily the shortest routes. In times of using the optimized routes plus the distance of the nodes, there are some other factors which need to be considered such as the number of taken steps or the bandwidth of the links. As it was mentioned in the last section, unlike the MQRA, the Bellman-ford algorithm doesn’t have the capability of obtaining the optimized route.

Figure 8 shows the timing table in MQRA and Bellman-ford algorithm. As it is noted before, the time complexity in Bellman-ford algorithm is $O(|V|*|E|)$, and considering that the MQRA algorithm uses a learning method to disperse the routing packets, it has a less time complexity than Bellman-ford algorithm, this fact is obvious in the given chart.

Figure 8: Convergence time of the routing table in Bellman-ford and MQRA algorithms.
Conclusion:

The MQRA algorithm causes a massive reduction in network’s energy by discovering all of the short and optimized routed in the network, and also compared to other algorithms; due to its variety of routes it is able to modify the load balance to be more Monotonous. Another advantage of this algorithm is the simple calculations it performs to discover a route. This characteristic causes the MQRA algorithm to reduce the total delay of the network and to increase the operation power in the network.

REFERENCES