Dynamic route detection using advanced routing algorithm in wireless sensor networks

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Abstract: Dynamic routing in wireless sensor networks (WSNs) is an essential mechanism for efficiently transmitting data from source nodes to destination nodes. WSNs consist of a large number of tiny sensor nodes that are deployed in a geographical area to monitor physical phenomena such as temperature, humidity, and pressure. These nodes have limited battery power, processing capability, and communication range, which makes routing a challenging task in WSNs. Dynamic routing is a technique that allows the network to adapt to changes in the environment, such as node failures, traffic congestion, and changes in network topology. In dynamic routing, the routing paths are not predetermined, but they are discovered and updated dynamically based on the network conditions. This helps to improve the network performance, increase the network lifetime, and reduce the energy consumption of sensor nodes. There are various dynamic routing protocols proposed for WSNs, including geographic routing, multipath routing, and cluster-based routing. Geographic routing uses location information to forward packets to the destination node. Multipath routing uses multiple paths to transmit data to the destination node, which improves the reliability and fault tolerance of the network. Cluster-based routing divides the network into clusters, and each cluster has a cluster head that acts as a gateway to transmit data between clusters.

Keywords: wireless sensor networks (WSNs), dynamic routing, temperature, humidity, and pressure.

INTRODUCTION

Smart City is a concept that is rising in the last years. It is not only an academic topic, but also a trending topic for political and public organizations. Its relevance is pushing research groups around the world to analyse and study how to develop and to connect it with citizenship. Recent projects and studies show the relevance of this topic [1,2,3], dealing with how to instantiate it.

Technology is moving forward very quickly and what some years ago was expensive and unsustainable is feasible today. Thus, embedded electronics are a very interesting option today for the development of a Smart City infrastructure. It presents different possibilities like 8-, 16-, 32- or 64-bit architectures, low-power systems, cable- or wireless-communications, etc. It is possible to build up a specific system with relative ease and a contained cost. Some examples are systems like Raspberry Pi Zero [4] or Arduino [5]. With the expansion of affordable embedded systems such as the cited ones, another necessity as to the communication appears. As long as the systems are small in size, these communications need to be wireless, also allowing the ability to reach places difficult to access and expand the available applications.

Technology is already capable of supporting projects like Smart City, but there are still other issues to be solved such as the number of nodes a Smart City needs. Well, that is an uncertain question; it depends on the service offer and the government. However, considering large-size scenarios such as Smart Cities or Internet of Things, there is always a common actor, the infrastructure, which is usually based on a combination of fixed and mobile devices. The infrastructure must provide the support for many other services, spreading out the devices as much as possible in order to completely cover a certain scenario. A good approach to answer the question previously formulated, is the work of Calderoni et al. [1] or even the work of Sánchez et al. [6], where they presented precise data about the ideal Smart City node distribution. Using the data published in these works as reference, the conclusion is that the total number of nodes of each particular scenario depends on its size, and thus the node density appears as a fundamental parameter in Smart City deployments. The node density of a large infrastructure like a Smart City can be defined as medium or low, depending on the available services in the scenario. The definition of *node density* can be found in the work of Kermajani et al. [7], which defines the high, medium and low density as 15, 10 and 5, respectively.

The wireless communication field is wide but there are some well-known standards that regulate it and mark the development. Some of these standards are the ones from the Institute of Electrical and Electronics Engineers (IEEE) *IEEE 802.11*[8], *IEEE 802.15.1* [9], *IEEE 802.15.3* [10] and *IEEE 802.15.4* [11]. These technologies are a major area of research, mainly *IEEE 802.11* and *IEEE 802.15.1*, but considering the scenario and topic of this work, *IEEE 802.15.4* is the most suitable standard because it is oriented towards wireless sensor networks (WSN) and low-rate communications. This standard is well-known in industrial sectors or areas like home automation, so it is also logical to extend its application to the Smart City. As *IEEE 802.15.4* regulates only the access to the medium by definition of the physical (PHY) and medium access (MAC) layers, there exist different routing algorithms, due to the lack of an advanced routing method in the standard. Star and peer-to-peer topologies are standard-defined but cluster-tree and mesh (also defined by *IEEE 802.15.5* [12]) are extended by algorithms in upper layers. These routing algorithms are needed for complex scenarios, and indeed the Smart Cities are one of the most complex possible scenarios. Moreover, other features more than topology are required, and routing algorithms are fully qualified to provide them. Reliability, granted Quality of Service (QoS), energy efficiency, duty cycle control, synchronization, etc., are some necessities for modern wireless communications that can only be covered by advanced routing algorithms.

LITERATURE SURVEY

Routing algorithms are an important part in Smart City and Internet of Things (IoT) projects, due to the critical function they play. Although there are different routing methodologies like multicast [15], mesh [16] or graph-based [17], routing algorithms based on clustering [18,19,20] are designed to improve different parameters such as QoS [21], network lifetime [22], energy consumption [23], traffic reduction or range maximization [24]. Thus, our proposal, DARAL, is based on clustering techniques. Within clustering-based routing algorithms, there are mainly hierarchical cluster tree algorithms, but other alternatives exist like the clustering mesh-like alternative proposed by Wang in [18] or the spanning tree proposed by Saravanan et al. in [25].

Usually, the implementation of a hierarchical clustering scheme is based on the definition of two different roles or functionalities for the nodes of the network, the cluster-heads and non-heads nodes. A cluster is formed by a cluster-head and a set of non-head nodes, where the nodes of the cluster communicate between them (sensor-to-sensor) and mainly with their cluster-head, which also leads the inter-cluster communications.

As the role selection mechanism is a fundamental aspect in hierarchical cluster-based routing algorithms, there exist different cluster-head election schemes that consider a wide range of parameters such as location, residual energy or Link Quality Indicator (LQI). For example, Jiasong et al. [26] described an adaptive routing optimization based on the energy balancing algorithm for hierarchical networks in ZigBee, where they limited the number of hops depending on the battery available, limiting the range of a certain node as well. Another possibility for the cluster-head election is the one proposed by the MultihopLQI routing algorithm [27], where a tree of multiple hops is dynamically built for routing tasks by the analysis of the impact of an LQI threshold in the routing formation, considering MinLQI and MaxLQI values. However, this cluster-head election scheme does not take into account some important parameters such as QoS, convergence time or control overhead, focusing instead on the analysis of path length and network lifetime. This is a common pitfall in most of the common cluster-head election schemes. As long as they need to analyse different parameters to produce a measurable result, they suffer from two major drawbacks: an increment of the convergence time and also a message overhead, making them unsuitable for Smart City or IoT projects.

DYNAMIC ROUTING IN WSN

Routing is a procedure of making decisions in which the router (which is a hardware device used in

networking to receive and send data in the form of packets on a network) selects the best path to make data transfer from source to destination. A router exists in the network layer in the OSI as well as TCP/IP model. Some functions of a router are:
Building an optimal path on a network to reach its destination (in which static and dynamic routing take place).

- Taking routing decisions.
- Balancing load.

Types of Routing:

- Static routing
- Default routing
- Dynamic routing
- Static and Default routing has some drawbacks, due to which Dynamic Routing was introduced.

Drawbacks of Static Routing:
It is a burdensome task to sum up or add-on each route manually to the routing map in a large network.

- Managing its ordering is time-consuming.
- It cannot reroute traffic in case some link fails.

Drawbacks of Default routing was:
If the network is complex then it is more difficult to set up.
To overcome the shortcomings of static and default routing, Back in the 1980s, the first-ever Dynamic routing was used in a computer and the protocol which was used in it was the RIP(routing information protocol).

Dynamic Routing
Dynamic routing is known as a technique of finding the best path for the data to travel over a network in this process a router can transmit data through various different routes and reach its destination on the basis of conditions at that time of communication circuits.

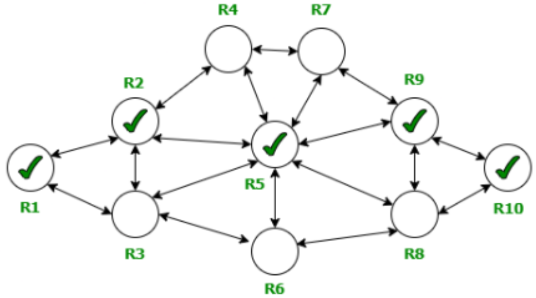

Figure 1: Network Architecture

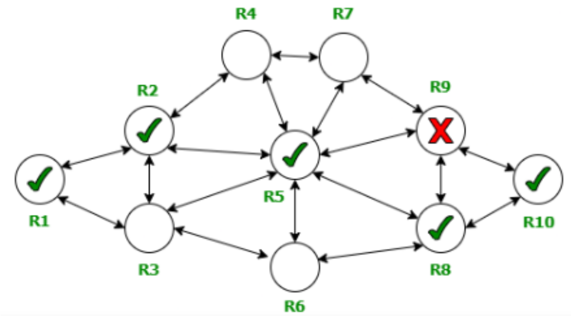

Figure 2: Dynamic Routing

Dynamic routers are smart enough to take the best path for data based on the condition of the present scenario at that time of the network. In case one section fails in the network to transfer data forward dynamic router will use its algorithm (in which they use routing protocols to gather and share information of the current path among them) and it will re-route the previous network over another network in real-time. And this amazing capability and functionality to change paths in real-time over the network by sharing status among them is the key functionality of Dynamic Routing. OSPF (open shortest path first) and RIP are some protocols used for dynamic routing. In the image above the upper image depicts the path R1->R2->R5->R9->R10 to take data from R1 (source) to R10 (destination) but, then due to some reason R9 fails to process its work then it dynamically builds a new path which is R1->R2->R5->R8->R10. Unlike the static routers in which the admin was there to reconfigure the change in the router, here it itself changes the route and finds the best network/path.

CONCLUSION

The wireless sensor network deployed in the field or on each floor of a large building works in a passive environment for a long time, so the time that the wireless sensor network can work, that is, the life span of the wireless sensor network is limited. ,therefore, how to use the existing science and technology to extend the life of the wireless sensor network as much as possible, and even make the wireless sensor network work continuously without dying due to energy problems is very necessary. Routing in traditional networks hardly needs to consider the energy sharing of nodes, but the energy efficiency of routing algorithms in wireless sensor networks is often more important than finding the shortest path.

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