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Localization Based Routing in WSN for Smart City Applications

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Abstract- In the context of Smart City environments, wireless sensor networking is playing a major role when enabling the utilization of networked infrastructures to introduce or improve a wide variety of services to be available to the citizens. How nodes communicate with each other is a key issue in these types of networks. This work presents a simple but yet efficient network discovery as well as an intelligent metric for route selection in smart environments that combines several parameters through the use of fuzzy logic. SmartSantander is a large-scale experimental framework primarily focused on enabling experimentation in the context of smart cities and Internet of Things.

Keywords- **Virtual back bone scheduling, fuzzy logis, shortest path, resuidal signal strength indicator, localization based routing.**

1. Introduction

Cities have quite an impact in the economic development of a country, being the “platform” where Many people live and work, where services are provided to citizens in a wide range of ways, and where local government officials have a close contact with citizens. It is only natural then that ICT (Information and Communication Technologies) plays an increasing role in the life of both people and private and public entities that are part of a city.

In Fig1. The concept of Smart Cities is gaining increasingly high importance as a means of making available all the services and applications enabled by ICT to citizens, companies and authorities that are part of a city’s system. It aims to increase citizens’ quality of life and improve the efficiency and quality of the services provided by governing entities and businesses. This perspective requires an integrated vision of a city and of its infrastructures, in all its components, and extends beyond the mere “digitalisation” of information and communicatio it has to incorporate a number of dimensions that are not related to technology, e.g., the social and political ones.

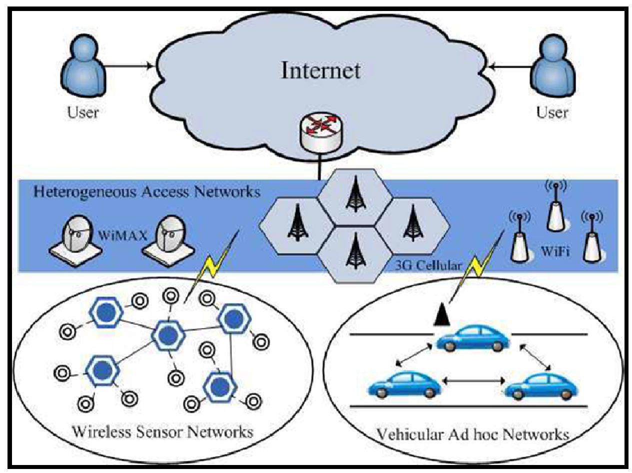

Fig. 1. Internet of Things

When looking at the potential impact that telecommunications, and the services made available by them, may have in cities, a number of opportunities, challenges and barriers can be identified. The deployment of these services implies that other sectors need to be brought to work together with the telecommunications one, hence, requiring that the latter is aware of a number of requirements and constraints, coming from the many applications made possible in a Smart City environment

In this area, we propose to conduct an experimental evaluation of a novel intelligent metric for routing protocols. The work consists of the experimentation of this new metric is Evaluation through simulation.

In this paper for evaluation, a simulator is composed of 47 nodes deployed int as a platform for emulating the future

Smart City deployment. Over this test bed we have performed the experiments described in the following sections.

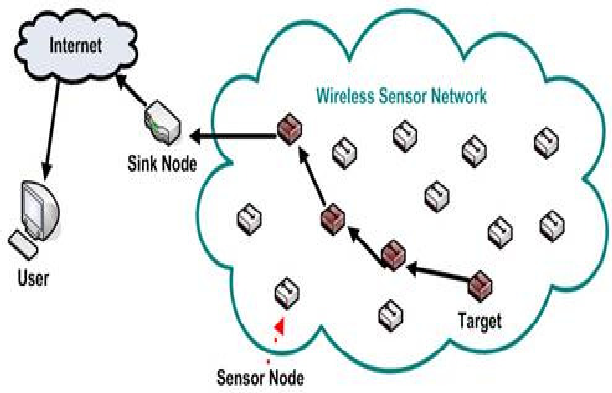

Fig 2: Application Scenario

The aim of the experiments is the creation of an efficient framework that allows data generation nodes (i.e., end devices as start points of Fig. 2) to communicate with a sink (i.e., end point in Fig. 2) through an already deployed sensor network. In order to perform efficient communications among users and the sink node, this work proposes a simple but efficient network discovery and tree-construction protocol that enables the creation of data paths for infrastructure nodes from any node in the network to the end point. Every node in the infrastructure network can be selected as parent by end devices in order to rely data to the end point.

We evaluate the proposed protocol with three different approaches: Shortest Path Tree (SPT) (i.e., lowest number of hops to the end point), Best Received Signal Strength Indicator (RSSI) Spanning Tree,Virtual Backbone Scheduling (VBS) where it increases network lifetime and Fuzzy Logic based metric (FL), that combines residual energy, number of hops and RSSI.

Experiments show relevant performance results such as network generation time, path length, number of children, packet delivery ratio and number of transmissions.

2. Related Work

Managing the growth of our cities is one of the major challenges of this century [4]. IoT-based platforms will support it, with the promise of better environmental monitoring, energy saving, smart grids, more efficient factories, better logistics, better healthcare and smart homes [5]. IoT driven primarily by wireless sensor networks, will require people with new skills, since the focus will be much more on software than hardware. Different companies around the world such as [6] are completing interesting platforms for smart cities control. Several projects have been developed in Europe addressing Smart Cities in their various dimensions, which describe the global perspective that is required in this area: economy (competitiveness), people (social and human capital), governance (participation), mobility (transport and ICT), environment (natural resources), and living (quality of life). opportunity to reduce costs, to improve services to communities, and to make cities smarter. SmartSantander project aims at the creation of an experimental test facility for the research and experimentation of architectures enabling key technologies, services and applications for the IoT in the context of a city. It provides a twofold exploitation opportunity. First, the research community gets benefit from deploying such a unique infrastructure which allows true field experiments, while on the other hand, different applications serving citizen needs will be deployed. The project envisions the deployment of 20,000 sensors in Belgrade, Guildford, Lbeck and Santander.

SmartSantander has conceived a 3-tiered architecture: 1) IoT nodes, responsible for sensing the corresponding parameters (temperature, CO, noise, light, car presence, etc.) The majority of them are integrated in the repeaters, while others stand alone wirelessly communicating with the corresponding repeaters. This stand alone devices must be powered by batteries. 2) Repeaters, that are placed high above ground in street lights, semaphores, information panels, etc., and behave as relaying Considering experimentation and service provision it is necessary to define an infrastructure that allows the execution of both experiments and user-addressed services concurrently, thus providing flexibility for researchers to test their applications while end user services are running.

Smart City researchers will use this scientific ghost town to look at everything, from intelligent traffic systems and next generation wireless networks to automated washing machines and self-flushing toilets. The objective is to enable researchers to test new technologies on existing infrastructure without interfering in everyday life. Before deploying a definitive Smart City environment, it is important to test protocols and applications in a controlled environment. For this, testbeds are platforms that provide support to measure a number of physical parameters in a controlled and reliable platform. These platforms contain the hardware, instrumentations, simulators, various software and other support elements needed to conduct a test [9].

3. Architecture

System architecture is the conceptual design that defines the structure and behavior of a system. An architecture description is a formal description of a system, organized in a way that supports reasoning about the structural properties of the system.

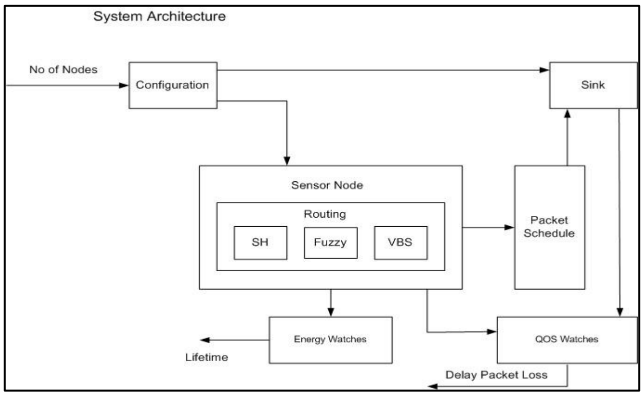

Fig 3: System Architecture

It defines the system components or building blocks and provides a plan from which products can be procured, and systems developed, that will work together to implement the overall system.

1) Configuration: Configuration module will get user input about the number of sensors & create the sensor network. Sensor nodes are placed random in the network.
2) Virtual Backbone Scheduling: This module will organize the network in a tree shape for faster
3) Fuzzy Routing Engine: This module will construct intelligent route from any sensor node to the collection center using fuzzy logic algorithm
4) Sensor Nodes: This module will detect events in their neighbourhood area & send the event messages to the collection center using the routing path got from the Fuzzy routing

The aim of the experiments is the creation of an efficient framework that allows data generation nodes to communicate with a sink through an already deployed sensor network. In order to perform efficient communications among users and the sink node, this work proposes a simple but efficient network discovery and tree-construction protocol that enables the creation of data paths for infrastructure nodes from any node in the network to the end point. Every node in the infrastructure network can be selected as parent by end devices in order to rely data to the end point.

We evaluate the proposed protocol with three different approaches: Shortest Path Tree (SPT) (i.e., lowest number of hops to the end point), Best Received Signal Strength Indicator (RSSI) , and our proposal of Fuzzy Logic based metric (FL), that combines residual energy, number of hops and RSSI. Experiments show relevant performance results such as network generation time, path length, number of hops, packet delivery ratio and number of transmissions. This project consists of user interface for network creation and routing of packets based upon the routing methods. we aim for routing of data that is collected from the wsn are transmitted to the sink via VBS there are several parameter used for routing. Two key features such as Qos and energy levels are monitored.

In this paper, we focus on Backbone Scheduling (BS), which dynamically turns off the radio of the sensor nodes to save energy. BS lets a fraction of some of the sensor nodes in the network in a WSN turn on their radio to forward messages, which forms a backbone; the rest of the sensor nodes turn off their radio to save energy. This technique does not affect communication quality because WSNs have redundancy. By redundancy, we mean that turning off the radio of some sensor nodes in a WSN does not affect the connectivity of the network. This redundancy results in more than necessary wireless links.

Thus, it is possible to construct communication backbones to save energy. Specifically, we use Connected Dominating Set (CDS) algorithms to construct such backbones. A preliminary on CDS algorithms is given in Section 3 of the supplementary file, which can be found on the Computer SocietyDigitalLibraryhttp://doi.ieeecomputersociety.org/10.1109/ TPDS.2011.305.

3.1 Metrics

The protocol proposed above can deal with several metrics, allowing the selection of the most convenient depending on the particular application and current network requirements. In this work, we compare the network performance when using various well-known metrics such as number of hops (SPT), signal strength (RSSI), and fuzzy logic (FL), a promising technique that is able to combine different metrics, and that has already obtained good results in simulated experiments [19].

1) Shortest Path Tree: in a tree-based WSN, the Shortest Path Tree represents a tree in which all nodes have the lowest number of hops to the sink node. This metric is directly related to end to end delay, but node overloading caused by relaying nodes supporting a high number of child nodes may cause data loss and network connectivity failures.

2) Received Signal Strength Indicator: for this metric, the power of the received signal is considered. Nodes will select as parent that node having the highest RSSI value. The use of high RSSI links ensures the correct communication between nodes in the network, since it ensures data delivery in one-hop communication. Selecting the best RSSI link at each hop, the network ensures that data coming from all nodes is correctly delivered to the sink node.

3) Fuzzy Logic based Metric: fuzzy logic is a decision approach that enables the efficient combination of different parameters that can be used as a single metric [20]. It uses human language to define parameter values and their relationships

.

A Fuzzy Logic System (FLS) is a nonlinear mapping of an input data vector into a scalar output. A typical FLS, widely used in fuzzy logic controllers is composed of fuzzifier, fuzzy rules, inference engine and defuzzifier. The operation of a FLS can be summarized as follows: crisp data are fuzzified and converted into fuzzy values. These fuzzy values are evaluated by the inference engine by considering a set of rules that relates input and output variables. The output value obtained in the previous step is then defuzzified, providing a numerical value that can be used as a metric by the external system. The variables considered in this work are as follows:

1) Number of hops: represents the number of necessary message forwardings for a packet to reach the sink node.
2) Residual energy: this parameter must be considered in order to preserve available energy and extend as much as possible node lifetime.
3) RSSI: the quality of the received signal is crucial to ensure correct data reception, so nodes with higher RSSI will be preferred.

4. Experimental Evaluation

In order to analyse the performance of the proposed metric and the network discovery and tree construction protocol, we have conducted an extensive set of experiments, executing the proposed protocol for each one of the aforementioned metrics: SPT, RSSI and FL. These nodes are the same for all the experiments with the aim of testing the different approaches in the same scenario having the same conditions.

4.1 Results

Figure 4 shows the total energy consumption of the network and the number of transmissions per delivered data packet obtained during the experiments for each one of the metrics. The highest energy consumption has been obtained by the RSSI metric, as it considers the quality of the received signal and, as will be shown below, the path length for RSSI is longer so more retransmissions are necessary with the consequent increase of energy consumption. The lowest energy consumption is achieved by the fuzzy logic approach since more parameters are considered and more energy efficient paths have been created. The number of transmissions per delivered packet is directly related to the network overhead.

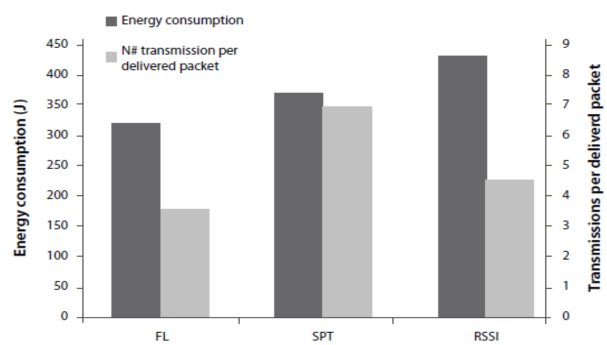

Fig 4: Total Energy Consumed and Number of Transmissions per Delivered Data Packet

Figure 5 shows the number of nodes that are at a determined number of hops (i.e., node frequency) for each considered metric. Note that SPT presents the shortest paths among the other metrics thanks to it merely considers the number of hops to create the data paths.

In turn, RSSI presents more nodes with higher number of hops to the sink due to when using RSSI metric, longer data paths are created to the detriment of other parameters such as the number of hops. The percentage of delivered data packets to the sink with respect to all the data packets sent by data generator nodes is presented.

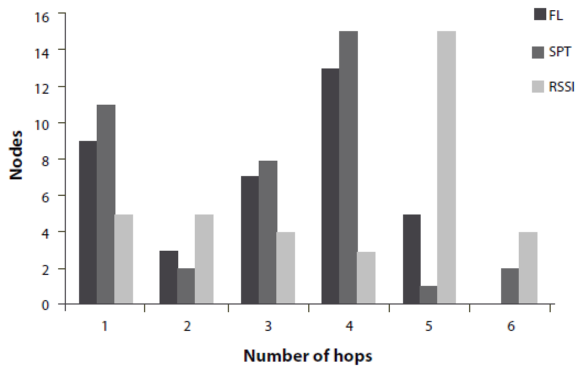

Fig 5: Frequency of number of hops (i.e., number of nodes with determined number of hops).

Figure 6, where it can be seen that the SPT metric obtains the lowest packet delivery ratio since it uses short paths (i.e., lowest number of hops), that may use nodes with low quality reception power that obtains the highest packet delivery ratio thanks to the combination of several metrics with the aim of obtaining high quality communication paths. also shows the average end-to-end delay for data packets in the network for each metric. Similar to the results obtained for the number of transmissions per delivered packet, for end to end delay, FL and RSSI obtain better results than SPT due to the necessary retransmissions performed when using SPT to efficiently deliver data packets to the sink.

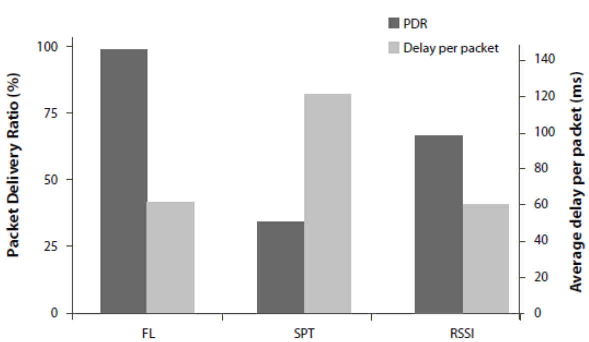

Fig 6 : Packet delivery ratio and average end to end delay

5. Conclusions

As the cities are becoming home for more and more people around the globe, efficient methods for the management of the cities that will ensure sustainable development while providing high quality of living are becoming one of the core challenges in front of us. The SmartSantander framework represents a significant enabler facilitating better understanding of the issues involved, technical, societal and economic, in creating smart and sustainable cities. In the last year of the project, development of the framework will be continued with deployment of more IoT devices and new services. The main focus of experimentation is expected to be on the service, application and user level, although research on the lower layers will be supported as well. The goal of the project's last year will also be to increase the number of users as well as to create mechanisms for keeping the platform running after the project ends.

The applications in this context require the optimization of communication tasks. The work presented herein details a simple but yet efficient network discovery and tree construction protocol that can be executed using different metrics depending on the application and network requirements. A metric based on fuzzy logic has been also proposed. This metric combines several node and network parameters with the aim of constructing an efficient communication tree.

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