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A Novel approach to Intelligent Nodes Connectivity in IoT Applications using the Proactive Routing Protocol

[1]Mohammed Abdullha Ayshan, [2]Abdullah Saad Alasmari, [3]Dr Prakash Kuppuswamy,

[1,2] Computer Technology Department Tanomah Technical College, Abha, KSA

[3]Department of Computer Engineering & Networks, Jazan University, KSA

m.ayshsn@tvtc.gov.sa, a.alasmari@tvtc.gov.sa, prakashcnet@gmail.com

Abstract : IoT collaborates with digital data in a real-time environment where sensor nodes dynamically join the network. The wireless sensor network can be integrated dynamically with the Internet of Things to provide numerous services, such as setting up smart cities, health care, military organizations, geographic research, and so forth. In a broader sense, the Internet of Things is like a brain. It can both store and monitor real-world information, making interpretations and decisions based on the sensed information. IoT application depends on smart devices and their considerable point of size, energy capacity and computation power, and data transmission ability. Efficient data transmission follows various routing protocols. Router protocols must be able to scale well with increases in network scope and node density. Since wireless sensor nodes are usually limited in energy and cannot be recharged, their energy consumption directly affects the protocol's scalability. Presently, there is no solution to the energy problem posed by large-scale networks using IoT applications in real time. FSR's routing protocol helps IoT nodes connect 360 degrees with the nearest node to ensure uninterrupted communication with IoT devices. Fisheye State Routing establishes routes when no routes exist or when routes are broken. In this research article, we are attempting to control the route request packets in the existing FSR protocol in IoT applications through wireless sensor networks.

***IndexTerms* - IoT, FSR routing protocol, Wireless sensor networks, Smart application, Routing table, GSR.**

INTRODUCTION

The term Internet of Things was first described by Kevin Ashton in 1999 in the context of supply chain management [1]. IoT is a self-configuring wireless network of sensors that creates a world where each of its entities sends information to other objects and to people. This world, in which everything is tagged and communicated, provides information and knowledge that enables ease and convenience in everyday living [2]. The radical evolution of the current Internet into a network of interconnected objects that not only produces information from sensors and communication with real-time usage, in addition to it involves existing standards that provide services for transferring information, analytics, communication and uses. The Internet of Things has stepped out of its infancy and is poised to leave the current static Internet in the dust by utilizing open-source wireless technologies like Bluetooth, radio frequency identification (RFID), WiFi, and embedded sensor and actuator nodes [3].

Smart objects are defined as Internet of Things (IoT) devices that communicate and interact with each other.Due to its technological advancements, IoT has numerous implementation challenges. Sensed data can be sent either in a query format or as a continuous format. For this to work, the sensor nodes must communicate efficiently. IoT deploys more objects, which results in increased power consumption as a result, so green networking is a crucial component of the IoT to reduce consumption and operational costs, reduce emissions and pollution, and improve surveillance and environmental conservation [4-8]. Having all the WSNs in one network, integrated with each other, would enable objects and devices from every environment (network) to have an active role in interacting with one another and communicating, exchanging data, monitoring various areas all around the world, recording and understanding events and actions, and reacting autonomously and accordingly when changes occur (sensing). With the help of standard interfaces, these smart objects can be accessed and configured via the Internet, allowing clients to query and change their states, as well as retrieve their associated data while considering security issues [9].

IoT depends on wireless sensor networks and it consists of a large number of energy-constrained devices that autonomously form networks through which sensed information is transported from the place covered by the sensor to the central control station (known as a sink) [10,11]. The major purpose of sensor networks is to gather regional/local information to participate in the global decision about the physical environment [10, 12]. Magnetometers, visual sensors, infrared sensors, thermal sensors, acoustic sensors, seismic sensors, and radars are some of the most common sensors present in communication networks that enable a wide range of applications such as traffic control, environmental monitoring, precision agriculture, weather forecasting, military surveillance, and industrial sensing [10, 13]. Wireless sensor networks have a wide range of applications, but they are plagued by design and architectural issues [10, 14]. The sensor nodes' energy consumption while communicating is one of the main problems. Energy-constrained sensors hamper communication. A reduction in the overhead communication requirement can decrease the energy requirement of sensors in networks [10].

A routing system aims to reduce latency, maximize network lifetime, and address resource awareness, topological changes, location awareness, and scalability. The most important issue is network lifetime. The lifespan of a network is dependent on the energy consumption of the nodes, which in turn is dependent upon the tasks the nodes perform. As each node maintains its own topology information, FSR is similar to link-state-based routing protocol. However, routing information is disseminated differently in the two systems. In link-state routing, the link state messages are generated and disseminated into the network whenever a node detects a topology change. FSR, however, does not flood the network with link state messages. Each node maintains a link-state table based on the most current information it receives from its neighbors, and it periodically exchanges this information only with its local neighbours. Message flooding is not carried out by neighbours. This process exchanges a small number of entries with a small sequence number for a large number of entries with a larger sequence number in the topology table. In this way, nodes will always have the most current information.

The article investigates the optimization of node connectivity to ensure energy-efficient IoT and proposes an innovative deployment scheme. First, a framework model of Fisheye is developed for the deployment of the IoT. The IoT becomes more extensible with this updated scalability feature. On the basis of the proposed framework, an optimization model is presented, and this model is energy efficient, easing the path to a green IoT. We are trying to identify a minimum energy consumption-based topology and a novel transmission algorithm for the optimization of IoT devices. We prove that this scheme is more flexible and efficient compared to other approaches for WSN and IoT connectivity and it can be easily implemented in an energy-efficient IoT.

BACKGROUND STUDY

Shio Kumar Singh, M P Singh, D K Singh (2010) discussed Sensing devices and environmental-related with the availability of low-cost sensor nodes in advanced wireless sensor network technology. A lot of technical methods are required to increase the potentiality of wireless sensor networks for data forwarding and processing. There are certain limitations in WSN utilization such as transmission range, processing storage capabilities, and energy resources. This research article surveyed several classification measures, including location information and many more [15].

Changle Li, Hanxiao Zhang, Binbin Hao, Jiandong Li (2011) The nature of routing protocols is to increase its scale property in terms of increasing density. Its energy consumption is an important effect on the scales as the node is uncharged. The primary task of nodes at the hierarchical level is to perform data aggregation and management. The hierarchical routing protocol includes large-scale WSN to solve the problems. In this research, routing protocols are implemented for large-scale WSNs. In their work, they used various criteria to classify the protocols [16].

Harish Kumar, Harneet Arora, R.K. Singla, (2013) In WSN, energy consumption pays close attention in order to consume more energy. This would happen during the inter-communication among multiple sensors. The authors proposed a routing scheme using route selection algorithms named fisheye state routing. This algorithm aims to reduce the energy consumption in the network. This proposed algorithm has been examined over the different state-of-the-art algorithms including end-to-end delay average, energy consumption, and throughput [14].

N. Pushpalatha, Dr.B.Anuradha (2014) Wireless sensor networks determine probable in military, environments, health and commercial applications. Using remote sensor nodes to transform information is a challenging task. New research environment trying to identify best routing protocol. Simulation results were executed using the NS2 tool and the results were obtained to discuss the role of transferring information through the shortest path. This scheme needs a particular justification and testing before applying to accomplish practical results pertaining to such types of deployments [17].

Abdullah I. Alhasanat, Ahmad Ali Alhasanat, Khitam M. Alatoun, Aws AlQaisi (2015) discussed energy consumption of Wireless Sensor Networks (WSNs). Data aggregation is one of the significant issues which cause energy consumption in WSN. New algorithm focusing on minimizing the transmission path between sensor nodes and cluster heads. Also, important given to omit the overhead of dynamic clustering, minimize the transmission path between sensor nodes and cluster head nodes, and reduce the direct communication between the sink node and cluster heads. Results in their work showed a better performance.

Shalli Rani, Rajneesh Talwar, Jyoteesh Malhotra, Syed Hassan Ahmed, Mahasweta Sarkar, Houbing Song (2015) provides a novel scheme to propose energy efficiency issues. This method introduces a hierarchical network design, a model for the energy-efficient and minimum energy consumption. This method works in a defiant manner and communication [19].

Amit Sarkar, T. Senthil Murugan (2016) discussed the significant role of WSN in the field of environmental monitoring, traffic monitoring etc. They propose a categorization model for routing problems. Their main objective is working towards various features that are related to energy, security, speed, and reliability problems. In addition, the optimization of the routing algorithms and the study of routing optimization are explored [20].

ROUTİNG ISSUES ON IOT APPLİCATİONS

As the Internet of Things connects massive devices, it was created on the fly by multiple nodes cooperating without the involvement of central access points or fixed frames. Each node of the network can operate individually and independently. Node movement causes route changes. The nodes themselves are responsible for dynamically discovering other nodes to communicate with. Nodes are interconnected. If a node wants to communicate outside its transmission range, a multi-hop routing strategy is used with intermediate nodes. Numerous IoT applications need multiple communication channels across various networks. In most cases, nodes or networks have many limitations, such as limited energy supply, limited computing power, and limited bandwidth of wireless links connecting the nodes. By employing aggressive energy management techniques, routing schemes try to maximize the lifetime of networks and prevent connectivity degradation by carrying out data packets while extending the lifetime of the network. IoT application design becomes a very big issue when it comes to connecting with the routing protocol. Various factors must be overcome before efficient communication can be achieved in WSNs. The following section highlights some of the issues related to routing and design that affect the routing process in IoT applications.

3.1 Data Aggregation

Commonly a sensor node generates data redundancy; it forwards similar packets from multiple nodes that can be aggregated so that the number of transmissions is controlled. This technique has been used to reach energy efficiency and optimization of data transfer in routing protocols.

3.2 Scalability

Huge sensor nodes deployed in the sensing area for the purpose of the routing scheme must be able to connect and communicate with neighboring nodes. Most of the sensor nodes are in a sleep state until an event occurs.

3.3 Communication links

Some communication links between sensors may not be symmetrical, that is, it may not be possible for a pair of sensors to communicate with each other in both directions. This should be addressed in routing protocols.

3.4 Limited energy capacity

Since the battery-powered techniques used in **S**ensor nodes have limited energy capacity. Therefore, it causes node connectivity failure or data transmission delay.

3.5 Unreliable environment

Sensor network depends on the dynamic and unreliable environment. The network topology, which is defined by the sensors and the communication links between the sensors, variation occurs frequently due to sensor addition, deletion, node failures, damages, energy reduction, noisy channel and error-prone etc.,

3.6 Node connectivity

Implementing new structures and devices on existing sensor nodes raises many routing issues. Some of the applications might require a different combination of sensors for monitoring the surrounding environment and moving objects.

3.7 Data generating process

Observation of data sensing and reporting in a wireless network is reliant on the application and the time-criticality of the data reporting. Data reporting methods are classified into time-based, event-based, query-based, and hybrid combinations. The routing protocol is extremely influenced by the data reporting method with regard to route stability and energy consumption.

3.8 Different sensing application requirements

Wireless **s**ensor networks have a wide range of diverse applications and it is difficult to meet all the requirements of various applications on a single network model. Hence, the routing protocols should promise data delivery and its accuracy.

3.9 Sensor locations

Managing sensor location is another significant challenge. Most of the sensor models are prepared with a global positioning system that can be implemented on different network protocols.

3.10 Fault Tolerance

Due to environmental interference sensor nodes may fail or be blocked due to lack of power and physical damage. The task of the sensor network should not affect single node failure. In hard situations due to many nodes failing, the Network model requires rerouting packets through regions of the network. Therefore, multiple levels of redundancy may be needed in a fault-tolerant sensor network.

RESEARCH SIGNIFICANCE

Currently, routing algorithms don't perform well in the scenarios mentioned above. Therefore, it is necessary to construct an effective routing algorithm that adapts most of the components of IoT architecture. IoT applications are real-time applications interacting with humans and digital and electronic devices on network-based communication systems. Networks are connected with many sensor nodes, all the nodes are not capable of handling data packets from different users and various access points. Some sensor nodes fail to receive/send packets due to lack of power, flooding, physical damage and environmental interference etc., In this circumstance IoT applications need to serve human society without any communication barrier and all possible smart services. Therefore, we have chosen the FSR routing algorithm to connect wireless sensor networks.

FSR routing protocol is capable of communicating packets to the nearest node 360 degrees. So, if any node fails to communicate due to the above mentioned problem, the FSR routing protocol is capable to make connectivity to the nearest node. FSR routing protocols are intentionally designed in order to improve not only the reliability of event detection but also to play an important role in both gathering and disseminating data. Since the IoT architecture is a connected wireless network with a few constraints on throughput, energy, and storage capacity, the approach should preferably transfer messages etc., The reason for choosing the FSR algorithm, it communicates the nearest wireless sensor point, Neighbor list, Topology table, next-hop table and distance table. It maintains accurate routing information for immediate neighbors. Progressively details as distance increases Link state of immediate neighbors are exchanged more frequently. The exchange frequency decreases proportionally to the distance and the packet gets closer to the destination, the accuracy increases.

IOT ARCHITECTURE OF THE FSR PROTOCOL USING SENSOR NETWORKS

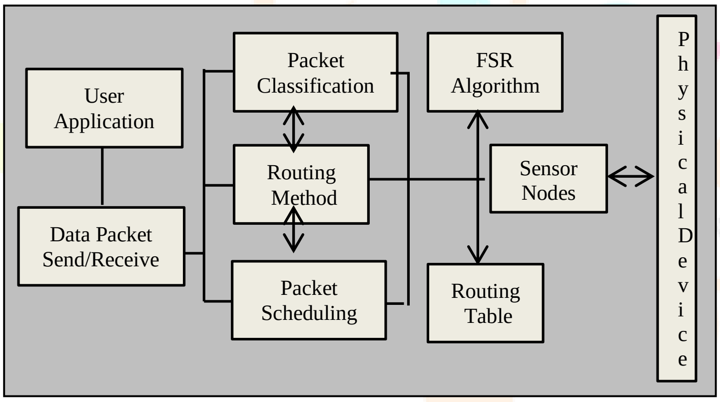

Fig. 1. IoT architecture model

The reason for choosing the FSR routing protocol was used to reduce the size of the information required to represent the efficient connectivity of nodes in an IoT application. In routing, the fisheye approach renders to maintaining an accurate distance and packets can be transmitted to the neighborhood node without any failure. Here we proposed a model of IoT application connecting with the fisheye technique. Figure1 illustrates the connectivity model of the Internet of Things application implemented on the application of fisheye in a mobile, wireless network. Internet of Things physical devices communicates and transmit the signal to wireless sensor nodes. Then the signals transmit through the FSR algorithm with the help of a routing table to identify the destination address. Next, packet classifieds and scheduling to the receiver end. Most IoT objects have moving features. Therefore, it is essential to avoid node failure and effective packet transmission. The FSR algorithm uses 360-degree rotation capabilities and is capable of managing node failure.

IMPLEMENTATION PLAN

Figure 2 illustrates the application of fisheye-based routing in IoT devices and wireless networks. There are different shades of grey in the circles that show the position of the fisheye scopes relative to the center. The scope of a network is defined as the set of nodes that are reachable within a given number of hops. With more levels and radius for each scope, the routing table overhead for routing updates decreases. In that case, entries associated with nodes in the smaller scope are propagated to their neighbors with the highest frequency. As a result of this strategy, near stations receive timely updates, while far stations experience large latencies. Although the packet's route remains imprecise until it reaches the destination, as it gets closer to it, the route becomes increasingly accurate. It is suitable for IoT devices as the network size always grows and is connected with a large number of devices.

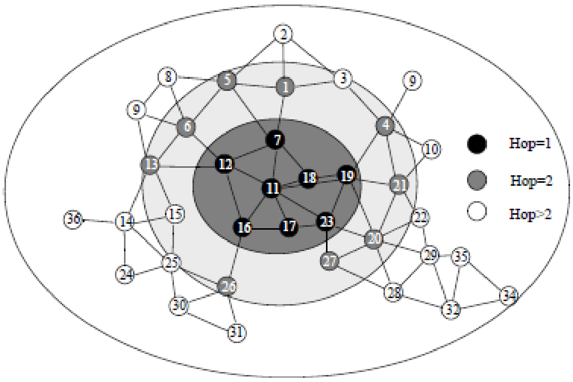

Fig. 2. Fisheye node connectivity
Sources: https://www.slideshare.net/YoavFrancis/fisheye-state-routing-protocol-overview

The concept of FSR basically derived from Global State Routing. Global State Routing can be observed as a special case of FSR, that there is only one fisheye scope level and the 360-degree radius level. It covers the entire topology table that is exchanged between neighbors nodes. Clearly, this consumes a considerable amount of bandwidth when the network size becomes large and this method is suitable for IoT applications. A proposed model scale well to large network size and keeps overhead low without compromising route computation accuracy when the different destination of nodes and it retaining a routing entry for each destination node. The object's mobility feature increases, routes to remote destinations become less accurate. When a packet connects to its destination, it finds accurate routing directions as it enters sectors with a higher refresh rate.

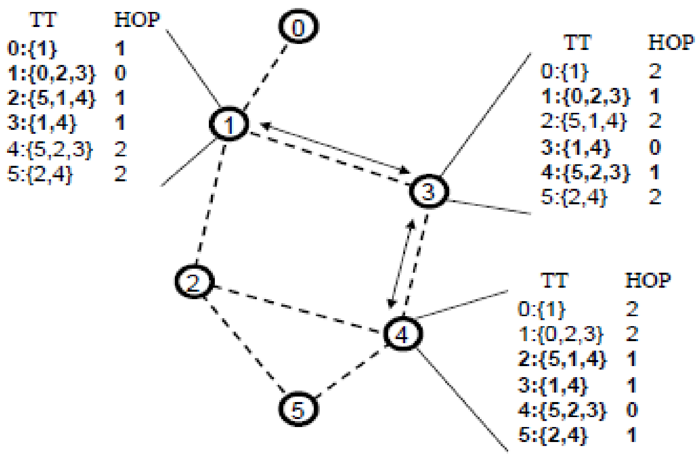

Fig 3. Node connectivity scheme using fisheye
Sources :https://www.slideshare.net/YoavFrancis/fisheye-state-routing-protocol-overview

PERFORMANCE EVALUATION

The performance evaluation was calculated and compared with GSR, DBF, CBRP routing protocol. We concentrate on three segments analysis which has computation complexity time complexity and data complexity. The formulation of complexity measures mentioning in the following table 1.

Table 1. Complexity formulation

protocol	CC	TC	DC
GSR	$O(N^2)$	O(D.I)	O(|E|)/I
DBF	$O(N^2)$	O(N.I)	O(N)/I
CBRP	O(N)	O(2d)	O(2x)
FSR	$O(N^2)$	O(D.I)	$O(\Sigma\ n_i d/w_i)/I$

SIMULATION RESULT

We implement a proactive FSR algorithm simulated by the static network with a higher link failure rate, we used a truly mobile environment in our simulator to determine the connectivity among wireless hosts. The simulation is programmed in GNS2 tool used to simulate an environment of 100 nodes roaming randomly in 500 x 500 meter square_ Then the arbitrary numbers of nodes, representing the wireless hosts, move independently on their own routes within randomly chosen 100, 200, 300 square meters. For the simulation model, we consider the following assumptions for the experimental purpose such as no node failure, constant runtime, fixed time system, fixed frequency range and node transmission range. In this simulation setup, a node selects a destination randomly within the roaming area and moves towards that destination at a predefined speed. Once the node arrives at the destination, it pauses at the current position for 3 seconds. The node then selects another destination randomly and moves towards it, pausing there for 3 seconds, and so on. In addition to that we compared three routing schemes such as DBF, LS and GSR is executed in the simulation model with the following parameters mentioned in table 2.

Table 2. Simulation parameters for node connectivity in IOT using FSR

Simulation parameters	Assessment
Network	UDP
Packet size	250 bytes
Connectivity	UDP/Random
Duration	75s
Pause time	3s, 30s, 60s
Simulation area	100, 200, 400, 500m.sq
Number of nodes	100

For the experimental simulation, we have chosen a different number of nodes and the result of the packet transmission duration mentioned in table 3. Figure 4 mentioned the packet distribution ratio of various numbers of nodes and its average mentioned in figure 5.

Table 3. Node connectivity duration

Nodes	GSR	DBF	CBRP	FSR
1 (100)	1.1	1.08	1.05	1.02
2 (200)	1.6	1.52	1.5	1.42
3 (300)	1.9	1.82	1.84	1.72
4 (400)	2.2	2.12	2.08	2.05
5 (500)	2.4	2.28	2.29	2.18

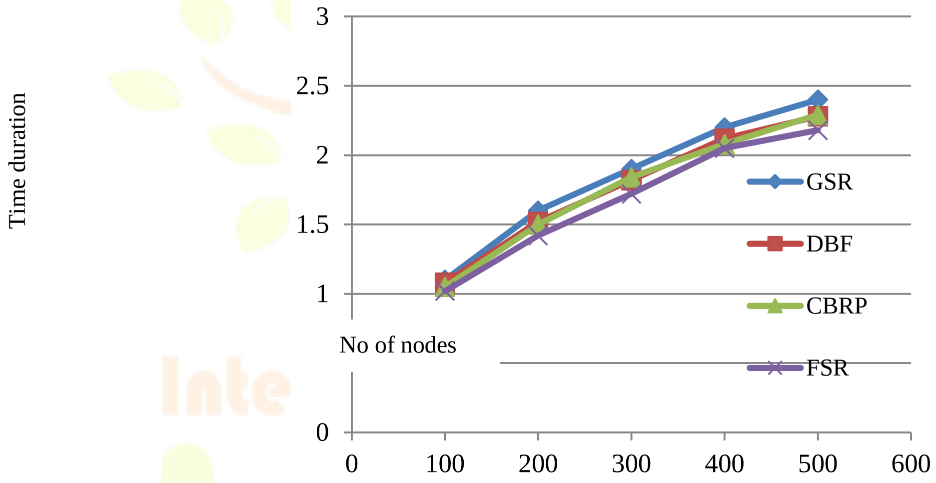

Fig 4. Packet distribution Ratio

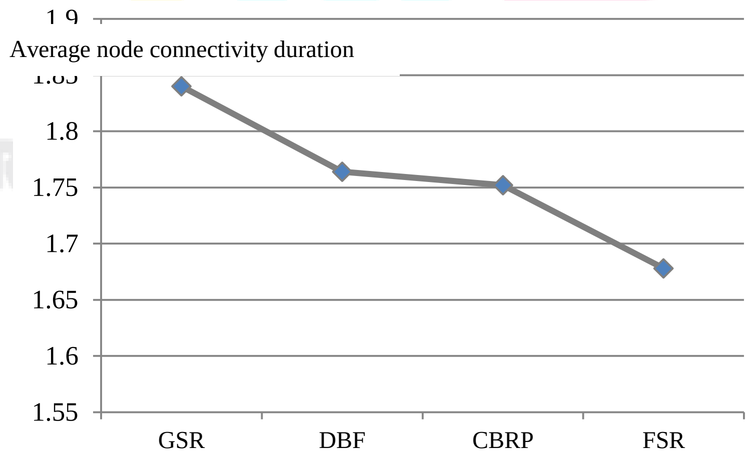

Fig 5. Average time duration of node connectivity

CONCLUSION

This paper is motivated by the real-world application of smart devices which are interconnected by modern-world sensor network systems. Existing routing algorithms cannot perform well on connecting real-world application devices with wireless sensor networks. IoT applications are always connected with real-world applications. Flexible network connections are needed to support a wide range of network environments. There is no specific algorithm to solve all kinds of data transfer between nodes. Therefore, this work proposes the FSR routing algorithm that builds on the advantages of existing algorithms to obtain better performance of packet delivery capability. We evaluated the packet distribution duration performance with a different number of nodes and the different sizes of networks. From the simulation results shown in section 5, we concluded that the FSR protocol is the most efficient in terms of average packet distribution duration. As a result of the vast network, mobility, and condition of nodes, FSR offers a better packet delivery ratio than other protocols. We performed different network ratios, in that the FSR protocol communicated with neighboring nodes effectively. In the future, the implementation of these works will be focused on implementing them in a smart city environment.

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