AODV Multicast Routing for the Zigbee Heterogeneous Networks in 5G Environment on Wireless Sensor Network

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***Abstract*: A modified AODV routing protocol is adopted as a part of the combined routing strategy in the Zigbee networks. Considering the deploying environment, the emerging 5G technology tends to be ubiquitous in the near future. Aiming to the higher efficiency and the shorter path, an improved Zigbee AODV (Z-AODV) routing protocol using associated gateways for the heterogeneous networks in the 5G environment is proposed in this paper. Besides the regular Zigbee function, by sharing the neighbour and routing information via IP network, the AGs are also responsible for collaboratively finding the optimum path and transmitting the packets to reduce the consumption for Zigbee devices. Moreover, an additional routing information collecting method is developed to further improve the routing performance. The proposed algorithm is evaluated based on simulation results. It is shown that our routing method outperforms the existing ones by higher picketer deliver ratio, shorter path length, lower latency, fewer packets sent per Zigbee node and lower routing overhead.**

***Keywords*: Multicast Routing, Zigbee, 5G, Wireless Dynamic Sensor Networks**

Introduction

Wireless Sensor Networks (WSNs) have been widely considered as one of the most important technologies. Enabled by recent advances in microelectronic mechanical systems (MEMS) and wireless communication technologies, tiny, cheap, and smart sensors deployed in a physical area and networked through wireless links and the Internet provide unprecedented opportunities for a variety of civilian and military applications, for example, environmental monitoring, battle field surveillance, and industry process control. Distinguished from traditional wireless communication networks, for example, cellular systems and mobile ad hoc networks (MANET), WSNs have unique characteristics, for example, denser level of node deployment, higher unreliability of sensor nodes, and severe energy, computation, and storage constraints, which present many new challenges in the development and application of WSNs.A large amount of research activities have be carried out to explore and solve various design and application issues, and significant advances have been made in the development and deployment of WSNs. It is envisioned that in the near future WSNs will be widely used in various civilian and military fields, and revolutionize the way we live, work, and interact with the physical world.

Zigbee wireless technology is specially designed for sensors and control devices that employ low cost connectivity and widely used for several applications. Zigbee is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection. Hence, Zigbee is a low-power, low data rate, and close proximity (i.e., personal area) wireless ad hoc network. Zigbee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Zigbee is typically used in low data rate applications that require long battery life and secure networking (Zigbee networks are secured by 128 bit symmetric encryption keys.) Zigbee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

Literature Survey Work

Izzat Darwazeh et al. [1] proposed End-to-end delay performance is an important Quality of Service (QoS) metric in 5G communication systems and wireless sensor networks (WSNs). This model was developed in the continuous-time domain, which accounts for a discrepancy in digital/discrete-time systems. By using publicly-available real traces from a wireless sensor network, recreate these field experiments in a simulation platform to validate the algorithm. In this paper, they extended the existing multi-hop effective capacity model from the continuous-time domain into the discrete-time domain. Mathematical formulae including tail probabilities of delay, delay mean and jitter over multi-hop wireless paths were derived.

Abdullah Said Alkalbani et al. [2] contributes to provide a simulation-based analysis of the energy efficiency, accuracy and path length of static and dynamic wireless sensor networks for 5G environment. The static networks more accurate than dynamic networks. Data move from source to destination in shortest path in dynamic networks compared to static ones. The tasks of WSNs are functionally influenced by the power source constrains. Minimizing power consumption is very important issue in these networks. In this study, comparison between static and dynamic WSNs conducted for 5G environment. Results prove that dynamic networks are consumes less energy than static networks.

Huertas Martínez et al. [3] proposed to present the integration of Wireless Sensor Networks (WSN), new generation networks or 5G, TCP/IPv6 protocols with the Internet of Things (IoT) that aims to exchange information, applying security, QoS (Quality of

Service) and configuration, these three aspects are the problems in the construction of a network in which confidentiality, integrity, availability, authentication, reconfiguration of topology, improvement, high quality of service, addressing, infrastructure, Network and node construction, for M2M (Machine to Machine) communication or end to end. Because 5G cellular networks, in particular, are attractive technologies to provide Internet connectivity to equipment (UE). It is intended to shed some light on the possible problems of integration that are imposed by the integration of wireless sensor networks and 5G that are manifested in the difference in traffic characteristics. For the development,studied the antecedents that integrate new technologies that integrated with the IoT has a good development. They presented a network model for the purposes of evaluation based on Gauss - Markov network traffic model, in this case we studied variables S (speed), D (direction), L (length), W (width), certainty of uncertainty and c d. With this is generated graphic to compare packages vs nodes, packages vs time of sensing and bytes by unit of time (1s) and consolidate in a table the parameters: rate of loss of errors of packages, budget of delay of the package (ms), priority in range of (1-9) exchanging the order and type of resource (GBR and NonGBR).

Micheals Lee et al. [6] proposed Machine-type communication (MTC) is endorsed in the fifth-generation (5G) networks to realize innovative IoT based applications, such as smart city and intelligent manufacturing. MTC devices with sensing and communication capabilities can monitor the surrounding environment and transmit the collected information back to Base Station (BS) for further data analysis. The dense deployment of sensing devices calls for a clustering structure to preprocess the redundant data to avoid traffic overload. Moreover, due to limited battery capacity, the energy cost remains a critical concern in such IoT systems Moreover, proposed a distributed cluster head (CH) rotation mechanism to balance energy consumption within each cluster. Effective energy utilization is a vital issue in IoT network under 5G scheme.

Problem Statement

The AODV routing protocol is designed for the ad hoc networks, it has a trustworthy performance in various environments. The on demand routing discovery may bring the global shortest path in any time, but the routing overheads and the bandwidth occupation caused by the flooding are the disadvantages. A feasibility analysis of the Zigbee protocol for the wireless dynamic sensor networks (WDSN) applications feasibility of adopting Zigbee in the WDSN is proved and the advantages and limitations are well discussed. It is shown that as the node mobility increases, the Z-AODV routing plays a more and more important role in the data transmission design a multiple feedback policy by processing key messages during route discovery for the AODV routing protocol in the Zigbee specification. Instead of reducing the routing overhead, this work tends to increase the flexibility in the Z-AODV routing. Different from the original algorithm in which the link is decided by the destination node, the sending device would choose the best link based on the multiple replies from each potential path. Although the proposed method may not directly improve the routing, it inspires us to collect the routing information and make other nodes decide the optimal path a compliant new model in OPNET simulator is proposed to resolve the node mobility issue in the Zigbee networks. Furthermore, the authors develop an improved AODV routing method. Although the proposed algorithm is proved more fitting for the mobile nodes, it is only able to benefit the end devices and may occupy much extra bandwidth during route discovery/recovery. An improved routing architecture is developed. The cluster information and network addresses are used to control the transmission range and direction in Z-AODV. Though the routing performance is improved, the routing cost and bandwidth occupation of the algorithm not well considered. The comprehensive evaluation of AODV in different networks is analyzed. As a general testing, it explains the performance degeneration as the mobility increases and the heterogeneous devices introduced. However, the protocol is evaluated when the foreign nodes only interfere the channel. The pivots which are selected by the data sources are the nodes through which the corresponding link must pass. By sending packets in different pivot-determined path, the congestion is reduced. Note that the pivots in this paper are still regular Zigbee devices, which are not able to afford the extra routing overhead. Even foreign nodes with sufficient resources are introduced; the grid-shape deployment is also not practical for most applications. The authors of propose an integrated gateway node control protocol to extend the network life time. Following the initial flooding, clustering, gateway selection, gateway integration and linking procedure, the gateways are created and applied for transmission optimization. The hardware with longer transmitting distance is introduced to extend the coverage of the router device. Thus the routing overhead and the network loads are reduced. Whereas this work is not a typical heterogeneous networks, since it contains different hardwares with only one wireless communication protocol.

Model and Architecture

In this work, we have proposed the improved Z-AODV routing method using the associated gateways (ZAG) for the Zigbee networks in the 5G environment. In ZAG, when the exotic 5G terminals opportunistically move into the coverage of the Zigbee networks, they take part in the existing network to improve the data communication. Each joining AG is assigned a unique AG identifier (AGID) by the ZC for recognizing each other. Because the AGs are connected by IP links, it is rational to consider that the communication between them does not introduce any cost to regular Zigbee nodes. One certain Zigbee device has one of the three roles (ZC, ZR or ZED), the AG is not a new device type in the viewpoint of Zigbee networks, it functions like a ZR in our algorithm. However, an AG needs to be distinguished by the Zigbee nodes for routing improvement. Thus we introduce a one bit field, IsAG, in the neighbor table to indicate whether a device is an AG (1 for yes and 0 for not). Consequently, the Zigbee device is capable of recognizing an AG in its neighborhood. Based on the above discussion, we will describe the improved Z-ADOV routing method using the associated gateways in the 5G environment in detail, including the routing request flooding, determining the optimum path and the additional routing information mining procedures. In the AODV routing, when a sending node cannot find a corresponding entry in the routing table, it may initial a routing discovery procedure by flooding a routing request (RREQ). The command frame includes the command option, route request identifier (RRID), destination address and the path cost Based on the scheme in the last sub-section, the RREQ is forwarded to the destination by flooding. Because the destination replies every

RREQ it receives, the source may get multiple RREPs with different routing costs from different reversed paths within a pre-set waiting duration. Afterwards, it determines the optimum path in the original Z-AODV. Meanwhile, a routing table entry which is identified by the destination address and the path cost is also activated.

Improved Z-AODV Routing

In this method using the associated gateways (ZAG) for the Zigbee networks in the 5G environment. In ZAG, when the exotic 5G terminals opportunistically move into the coverage of the Zigbee networks, they take part in the existing network to improve the data communication. Each joining AG is assigned a unique AG identifier (AGID) by the ZC for recognizing each other. Because the AGs are connected by IP links, it is rational to consider that the communication between them does not introduce any cost to regular Zigbee nodes. One certain Zigbee device has one of the three roles (ZC, ZR or ZED), the AG is not a new device type in the viewpoint of Zigbee networks, it functions like a ZR in our algorithm. However, an AG needs to be distinguished by the Zigbee nodes for routing improvement. Thus we introduce a one bit field, IsAG, in the neighbor table to indicate whether a device is an AG (1 for yes and 0 for not). Consequently, the Zigbee device is capable of recognizing an AG in its neighborhood. Based on the above discussion, we will describe the improved Z-ADOV routing method using the associated gateways in the 5G environment in detail, including the routing request flooding, determining the optimum path and the additional routing information mining procedures. For a lucid explanation, the network shown in Fig. 1 is used as a simple example to illustrate the node behaviours.

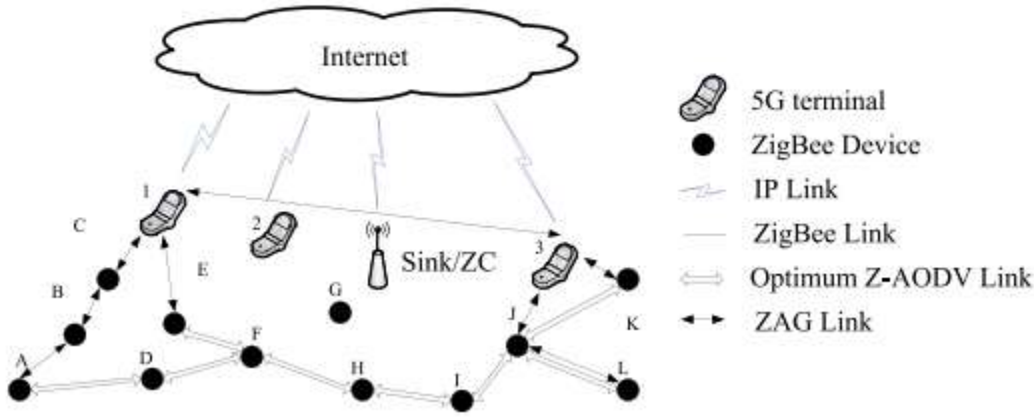

Fig. 1: An example of the Zigbee Link

Routing Request Flooding

In the AODV routing, when a sending node cannot find a corresponding entry in the routing table, it may initial a routing discovery procedure by flooding a routing request (RREQ). The command frame includes the command option, route request identifier (RRID), destination address and the path cost. In this paper, we simply measure the path cost by the hop counts, thus the path cost is equal to the hops from the source to the current device.

On the other hand, when an AG receives a RREQ, beside the compatibility of the marking behaviour, there are 3 reserved bits in the command option filed of the original RREQ, what we need is a one bit Boolean indicator. In the ZAG, we make the Bit 7 (8th bit) to be the Passed AG tag. The default False (0) value means only the Zigbee nodes are included in the path. When an AG receives a RREQ from another one via internet, it sets the value True (1) and rebroadcast the RREQ. Afterwards, if another AG receives this RREQ, it discards this frame since the packet has already passes through AGs. In other words, in the ZAG, when receiving a RREQ, an AG may teleport it only if the PassedAG filed is False. For instance, the Passed AG is set True by AG 2 and 3 before their rebroadcasting. Afterwards the RREQ will be abandoned if it is received by an AG different from identifying an ordinary routing discovery table entry by RRID, a combination of incoming AGID, RRID, and outgoing AGID determines a unique SRDT entry.

Experimental Study

In this section, we evaluate the effectiveness of our proposed method. Node in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. This result shows a simple network configuration on 5G network which consists of 34 nodes as shown in the above figure. A node in NS is network work real-time object made of address and port classifiers. This shows that current network is ready to transfer data between each. Node synchronization in wireless networks is the first most important for basic communication, but it also provides the ability to detect movement, location, and proximity. Here all 34 nodes are synchronized for data transfer and make to participate correctly in routing function. After synchronization the routing protocol was implemented in order to minimize energy usage and speed data delivery with high packet delivery ratio.

Routing is established using AODV protocol, based on the protocol function, the node started to transmit the packet, with packet delivery ratio (PDR) of 98.3% while transmitting, also get throughput of 48,000 packets/sec.

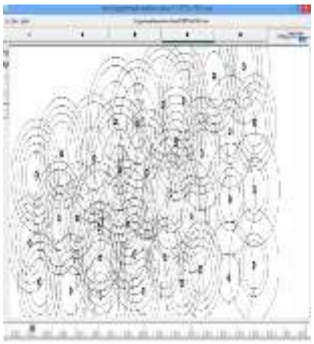

Fig. 2: Node Synchronization

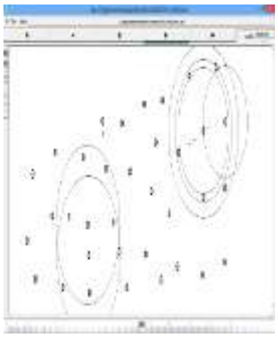

Fig. 3: Packet Transformation

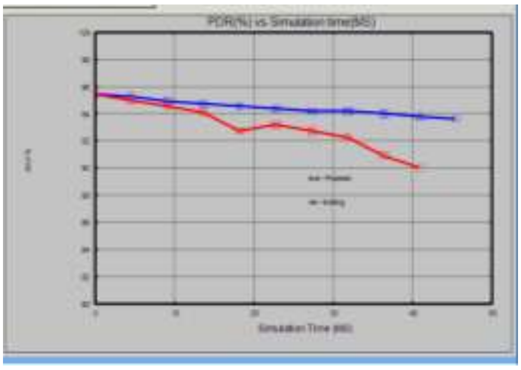

Fig. 4: PDR vs Simulation Time

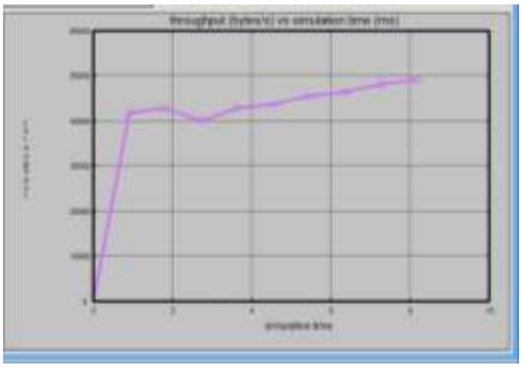

Fig. 5: Throughput vs Time

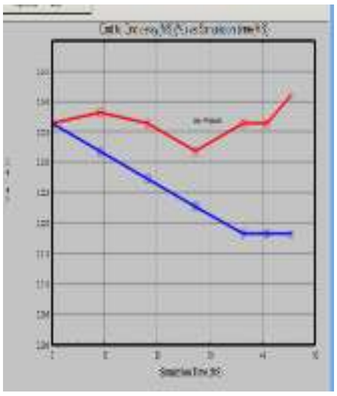

Fig. 6: End to End Delay vs Simulation Time

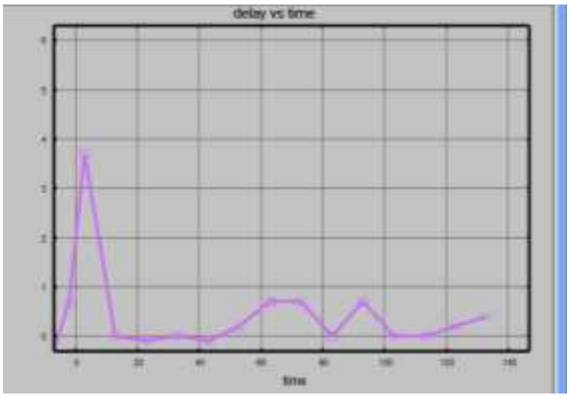

Fig. 7: Overall Delay vs Simulation Time

Conclusion and Future Enhancements

We investigate the on demand routing improvement for Zigbee networks in 5G environments in WSN. Different from regular heterogeneous networks optimization, we only focus on the improvement and efficiency for the Zigbee devices. On the features of native support for M2M communication and smarter device for 5G terminals, we develop the concept and the function of associated gateways. The core idea of our work is to utilize the communication and storage resources on 5G nodes as much as possible to share the loads in Zigbee devices. Thus a Zigbee AODV routing method using associated gateways is proposed. At first, we improve the flooding mechanism in the routing discovery by the RREQ teleporting. Afterwards, we make the source node determine the optimum path. To make our algorithm compatible with the Zigbee specification, the optimum Zigbee path and a routing validation command is designed and introduced. Finally, to fully investigate the routing information in routing discovery, a mining scheme is also discussed to find the segmented optimum paths which can be used in further routing discovery. The simulations show that ZAG achieves better performances with higher packet delivery ratio, less hop counts from Zigbee devices and lower end-to-end delay. Moreover, its overheads are reduced as well, each Zigbee device sends less packet and the normalized routing overheads are also decreased. Besides, the effect of 5G nodes mobility is also investigated. The results indicate that SAR is less sensitive to the mobility because of the AGs share the routing information and the additional routing mining mechanism. The improvements both on the network performances and overheads imply that the 5G devices effectively share the communication in Zigbee networks by ZAG. The hop counts as the only metric considered in path costs in this paper. We plan to extend the metric to the residual energy, network congestion and other parameters which need to be paid attention to in the real world, reliability should be increase in future, fault tolerance should be avoided to minimizing end-to-end latency, Cost of communication will be further decreased in future.

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