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Monitoring of Indoor CO_2 through Proactive and Reactive routing with Cognitive Wireless Sensor Networks

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Abstract: As we know, many air buildings are built and the ventilators are not work in timely manner and also less. Indoor air quality become an issue in recent years because it directly relates to human health. Therefore the clean air is essential especially when it comes to indoor air. To mitigate this worriment, the wireless sensor networks (WSNs) have the dormant. Wireless sensor networks are easy to afford and implement. Indoor Carbon Dioxide measuring is very necessary because at inside environment, its concentration is more than outside environment due to limited space. As the number of the nodes that join the network increases the need for energy-efficient, spectrum-efficient and resource-constrained protocol also increases. In this paper, two routing protocols proactive and reactive are introduced. The Destination-Sequenced Distance-Vector routing (DSDV) protocol is proactive protocol and Ad Hoc on-demand Distance vector routing (AODV) protocol is reactive protocol. Firstly we monitored the carbon dioxide gas through simple wireless sensors network with proposed protocols and then monitored through cognitive network with proposed protocols. Then the performance results has been carried out in terms of throughput w.r.t time which shows that by using cognitive properties on monitoring system performs better than simple wireless sensor network system. Secondly, the performance of AODV, DSDV and existing (CNOR- cognitive networking with opportunistic routing) protocol in terms of throughput, total energy consumption and average end-to-end delay through cognitive wireless sensor networks has been compared. The AODV performs better than DSDV and existing (CNOR- cognitive networking with opportunistic routing) protocol.

Keywords: Indoor air quality (IAQ), CO_2, Cognitive wireless sensor networks (CWSNs), AODV, DSDV,CNOR, proactive, reactive.

1.INTRODUCTION

IAQ (indoor air quality) relates to the condition of the air inside the buildings as represented by thermal (temperature and relative humidity) conditions and concentration of pollutants that affects the performance and health of occupants. It would be a great work to know the air quality because it directly relates to the health and comfort of building inhabitants. According to the lung association of America, an estimated 40 million individuals have respiratory illness affects and allergies in the U.S. An estimated 7.1 million children under the age of eighteen have these affects .There are number of gases, chemicals and living organisms that can bring air quality down, including dust mites(from carpets, fabric),asbestos, radon, carbon dioxide and mold. Pesticides Cleaning supplies, and other airborne chemicals can also pollute the air. Poor temperature control, inadequate ventilation and too low or too high humidity also impact the quality of air. Tobacco products and deteriorating insulation can be

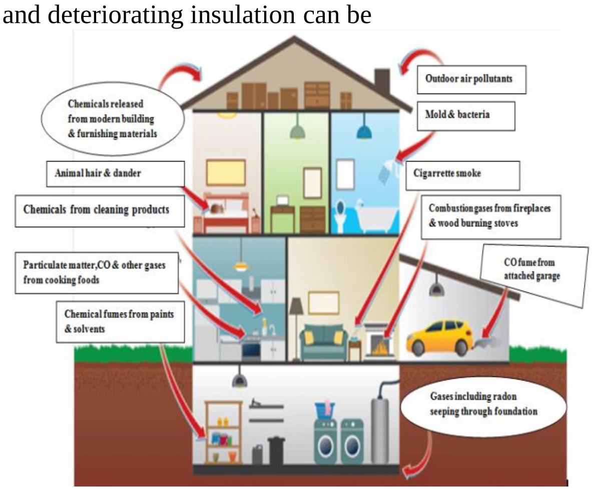

Figure 1: Reasons of Poor Air Quality

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considered pollutants as well as renovation or construction activities make negative effects on air quality.The significant amount of time spend in indoors from most of us, it's crucial that the air as clean as possible that we breathe. The problems like fatigue, headaches and irritation of the eyes, throat and nose creates by poor IAQ.Some pollutants can cause or deteriorate the indications of allergies, asthma or respiratory illness. Consequently, the development of an accurate system for IAQ monitoring is of great interest.

Wireless sensor networks (WSNs) can be quintessential solution to handle this worriment. They consist of inch scale and low cost sensing nodes that can integrate sensing, data processing, packet formation and wireless transmission. Each node has typically several parts: an electronic circuit for interfacing with sensors, a radio transceiver with an internal antenna or with an external antenna, a microcontroller and energy source; an embedded form of power harvesting or normally a battery. With the rapid development of communication technology, remote sensing technology and network technology, there is a necessity that air pollution monitoring system is often designed in wireless form. At present, the GSM, GPRS etc. are wireless mode in air pollution monitoring system. But if we think about installation and maintenance, and complexity, both modes are expensive. On the other hand, WSN have been rapidly developed during recent years. Initially it was for military and industrial controls. Its advantage may include the liability, low cost and simplicity. Due to these advantages, it is now being tested in experimental monitoring issues. Additional benefits include minimizing the need for battery replacements, enlarging coverage of large spatial areas and adding weather proof containers which reduce maintenance. It would allow the monitoring of remote or dangerous environments as well as providing warnings for situations such as earthquakes, floods and inclement weather.

2. CARBON DIOXIDE

Carbon dioxide is colorless, odorless, non-combustible greenhouse-gas that contributes to global warming. It is composed of one carbon and two oxygen atoms and formula is CO2. It is present in the earth's atmosphere at low concentration and acts as a greenhouse gas. In its solid state, it is called dry ice.
The multiple natural sources of carbon dioxide in atmosphere are the combustion of organic materials, volcanic outgasing and the respiration processes of living aerobic organisms. The man-made sources of carbon dioxide come mainly from the burning of various fossil fuels (charcoal, coal, petroleum, natural gas) for power generation and transport use. It is also produced by various micro-organisms from cellular respiration and fermentation.

Figure 2. Carbon dioxide structure

It is the one of the greenhouse gases and, since over the last 200 years its concentration in upper atmosphere has increased from 270 parts per million (ppm) to 350 parts per million (ppm).

2.1.INDOOR CO_2 CAUSES

Earth's atmosphere contains only 0.033 percent of carbon dioxide, but within the home this level can increase, since all humans and animals exhale it as a waste product of respiration. At low levels carbon dioxide is harmless to humans, but when exceed the limit can lead to a range of health problems like headaches, fatigue and breathing difficulties. Some main sources are:
a. Overcrowding: Normally CO_2 levels at outdoors found to be 250 to 350 ppm. Occupied spaces with good air exchange have co2 levels between 350 and 1000 ppm. Since humans exhale carbon dioxide as a part of respiration, overcrowded houses may lead to elevated carbon dioxide levels.
b. Combustion: fossil fuel combustion of wood, coal, oil, charcoal and gas lead to the production of carbon dioxide. The kilogram of coal burnt on a fire can creates 2.86 kilogram per cubic meter of carbon dioxide. Therefore it is important to keep the areas well ventilated where combustion takes place.

2.2. IMPACTS ON HUMAN HEALTH

Carbon dioxide in its gas form is poison, which cuts off the oxygen supply for breathing, especially in limited areas. Exposure to concentrations of carbon dioxide to 10 percent or more can cause unconsciousness, death or convulsions. Exposure may harm a developing fetus.
Carbon dioxide can cause vision damage, central nervous system injury, elevated blood pressure, abrupt muscle contractions, lung congestion, hyperventilation and shortness of breath. Excess carbon dioxide can also cause dizziness, fatigue, sweating, numbness, headache and memory loss, nausea, tingling of extremities, vomiting, depression,

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confusion, skin and eye burns and ringing in the ears. A person more affected by exposure to carbon dioxide if he have a cardiac, lung or blood disease.

3. COGNITIVE WIRELESS SENSOR NETWORKS

Recently, cognitive technology have been used in wireless networks to avoid the limitations imposed by wireless sensor networks. When we integrate cognitive radio with wireless sensors, then it is called cognitive wireless sensor networks. The cognitive technique is the process of knowing through planning, perception, acting, reasoning and continuously updating and upgrading with a history learning. Cognitive radio is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones. This raise the use of available radio-frequency (RF) spectrum while minimizing interference to other users.

There are main two types of cognitive radio, full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all parameters that a wireless node or network can be aware of. Spectrum –sensing cognitive radio detects the possible channels in the radio frequency spectrum. A WSN comprised of sensor nodes equipped with cognitive radio may benefit from the potential advantages of the salient features of dynamic spectrum access such as:

a.Opportunistic channel usage for bursty traffic: Upon the detection of an event in WSN, sensor nodes generate a traffic of packet bursts. At the same time, in densely deployed sensor networks, a large number of nodes within the event area try to acquire the channel. This increases probability of collisions, and hence, decreases the overall communication reliability due to packet losses leading to excessive power consumption and packet delay. Here, sensor nodes with cognitive radio capability may opportunistically access to multiple alternative channels to alleviate these potential challenges.

b. Using adaptability to reduce power consumption: Time varying nature of wireless channel causes energy consumption due to packet losses and retransmissions. Cognitive radio capable sensor nodes may be able to change their operating parameters to adapt to channel conditions. This capability can be used to increase transmission efficiency, and hence, help reduce power used for transmission and reception.

c. Dynamic spectrum access: In general, the existing WSN deployments assume fixed spectrum allocation. However, WSN must either be worked in unlicensed bands, or a spectrum hire for a licensed band must be obtained. Generally, high costs are associated with a spectrum lease, which would, in turn, amplify the overall cost of deployment. This is also contradictory with the main design principles of WSN. On the other hand, unlicensed bands are also used by other devices such as IEEE802.11 wireless local area network (WLAN) hotspots, PDAs and Bluetooth devices. Therefore, sensor networks experience crowded spectrum problem. Hence, in order to maximize the network performance and be able to co-operate efficiently with other types of users, opportunistic spectrum access schemes must be utilized in WSN as well.

4. ROUTING PROTOCOL

Designing a routing protocol for wireless sensor network is a difficult task as compare to traditional networks. There is a strict energy saving increasing network lifetime requirement in the case of WSN. The main function of the routing is route selection and data forwarding. The packet forwarding in the traditional routing approaches for multi hop wireless networks is done by selecting the node proactively at the sender side before transmission.

4.1 Proactive (table-driven) Routing Protocol

Destination-Sequenced Distance-Vector (DSDV) Protocol is proactive. The proactive routing is table-driven routing protocol. In this routing protocol, routing information is broadcasted by mobile nodes to the neighbours. Each node needs to keep their routing table which contains the information of neighbourhood nodes, reachable nodes and the number of hops. In other words, all of the nodes have to find their nodes in the neighborhood as there is change in network topology. Therefore, the disadvantage of this protocol is when size of network increases, then overhead increases. The most familiar proactive type is destination sequenced distance vector (DSDV) routing protocol.

Destination-Sequenced Distance-Vector (DSDV) Protocols i.e. Table-driven DSDV protocol which is a modification in the Distributed Bellman-Ford (DBF) Algorithm which was used successfully in many of the dynamic packet switched networks. In case of DSDV, every node in the mobile network is required to send a sequence number, which is periodically increased by two and it is transmitted along with other routing update messages to all other neighboring nodes.

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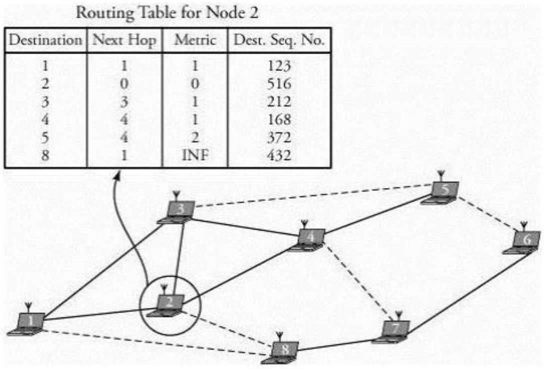
Routing Table for Node 2

Destination	Next Hop	Metric	Dest. Seq. No.
1	1	1	123
2	0	0	516
3	3	1	212
4	4	1	168
5	4	2	372
8	1	INF	432

Figure 3: A DSDV routing table.

4.2Reactive (on-demand) routing protocol

Ad Hoc On-demand Distance Vector Routing (AODV) protocol is reactive protocol. This type of protocol finds routes by using the route request packet. It is a bandwidth efficient on-demand routing protocol for Mobile Ad-Hoc Networks. The protocol deals with two main functions of Route Discovery and Route Maintenance. The discovery of new route is decided by Route Discovery function and the detection of link breaks and repair of an existing route is decided by Route Maintenance function. Reactive or on-demand routing protocols route is discovered when required. Distribution of information is not required in reactive protocols. These protocols do not maintain permanent route table. Instead, routes are built by the source on demand.

In AODV, route establishment takes place only when there is a demand for new route. AODV is capable of unicast, broadcast and multicast routing. AODV is able to react quickly to the changes in the network topology and it updates only the hosts that may be affected by the changes in the network by using the RREQ message. The RREQ and RREP messages are responsible for the route discovery.

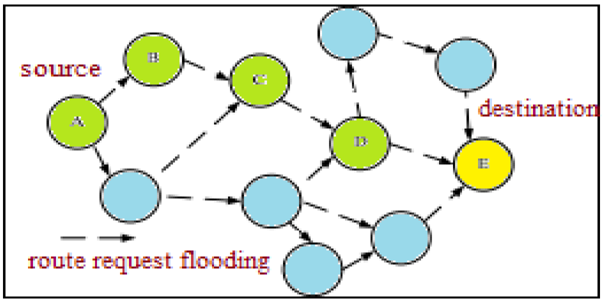

Figure4: Route Request (RREQ) flooding.

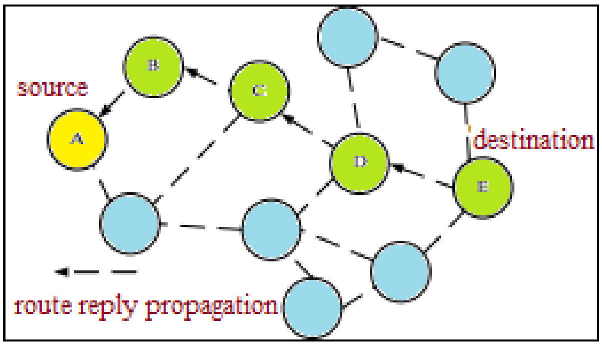

Figure5: Route Reply (RREP) propagation.

5. PERFORMANCE EVALUATION AND SIMULATION RESULTS

Throughput is the number of bits divided by the time needed to transport the bits. The figure 6 shows the performance results of AODV routing in terms of throughput [kbps] w.r.t. time with cognitive properties which combined with monitoring system and simple monitoring system.

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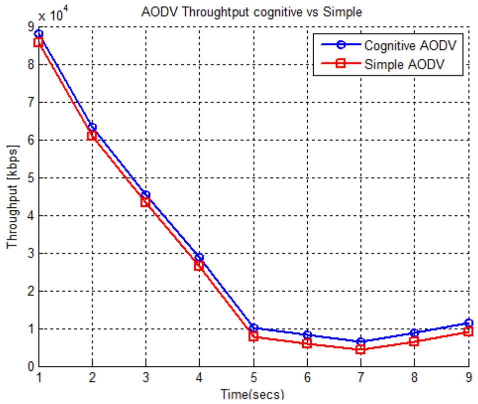

Figure 6: Throughput of AODV with cognitive and simple monitoring network.

The comparison of result shows that AODV routing with cognitive network performs better than AODV with simple wireless sensor network. Throughput [kbps] of AODV with simple network is between 8.572e+04(27.30)-9189 and AODV with cognitive is between 8.807e+04(27.93)-1.154e+04(7.13).

The figure 7 shows the performance results of DSDV routing in terms of throughput [kbps] w.r.t. time with cognitive properties which combined with monitoring system and DSDV with simple wireless monitoring system. The comparison of result shows that DSDV routing with cognitive network performs better than DSDV with simple wireless sensor network. Throughput [kbps] of DSDV with simple monitoring is between 6.113e+04(20.60)-1872 and DSDV with cognitive is between 6.467e+04(21.57)-5404.As throughput depends on time and as DSDV is the table driven protocol, it requires extra time to set up routing tables before delivering packets to the next node. Its throughput becomes less than that of AODV. On analyzing figure 6 and figure 7, it shows that AODV routing protocol gives better result than DSDV routing protocol with cognitive wireless sensor network.

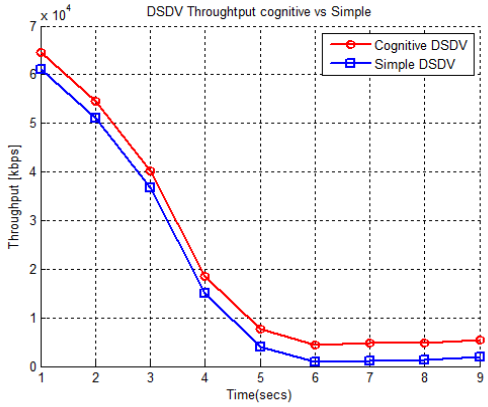

Figure 7: Throughput of DSDV with cognitive and simple monitoring network.

5.1 Throughput: Throughput is the number of bits divided by the time needed to transport the bits. From each of the 10 different source nodes 1000 packets were transmitted towards the destination. The network density was increased from 50 to 400 nodes leading to an average of 3 to 8 neighbor nodes. As the network density increases, the number of the active nodes that can transmit data increases. The figure shows the results.

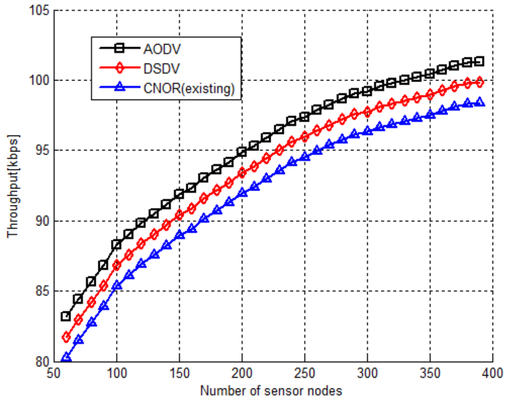

Figure 8: Throughput under different network density.

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The figure 8 shows the comparison between AODV, DSDV and CNOR (existing) with cognitive wireless sensor network. The AODV performs better than DSDV and CNOR. Throughput [kbps] of AODV is between 83.17-101.3, DSDV is between 81.71-99.83 and existing protocol i.e. CNOR is between 80.26-98.37. The two proposed protocols better than existing protocol is because of mobile nodes static position. The DSDV gives less throughput than AODV because DSDV requires extra time due to proactive nature to set up routing tables before delivering packets to the next node.

5.2 Packet end-to-end delay: End-to-end delay of a packet in the network is the time it takes the packet to reach the destination after leaving the source. Each of the 10 different source nodes sends 1000 packets toward the destination, in a network with 200 randomly distributed nodes and with 5 average neighbour nodes and a transmission time of 6.4ms. Each node can store up to 5 packets in its buffer while if the buffer of a node is full, it cannot participate in any packet transmission. The average end-to-end delay of the packets under different packet arrival rates is shown in figure. When the packet rate is higher than the buffer size, the average end-to-end delay in all the three approaches is increased. The buffer of many nodes tends to be full, decreasing the number of the available relay nodes.

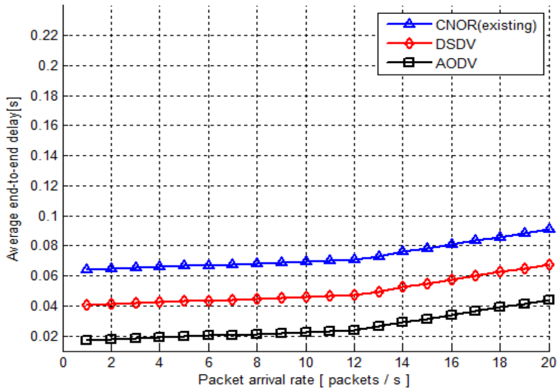

Figure 9: Average end-to-end delay under different packet arrival rates.

The figure 9 shows comparison results of performance of AODV, DSDV and CNOR (existing). The AODV gives less end to end delay. The average end-to-end delay of AODV is between 0.01696-0.04417, DSDV is between 0.04041-0.06762 and CNOR is between 0.06386-0.09107.

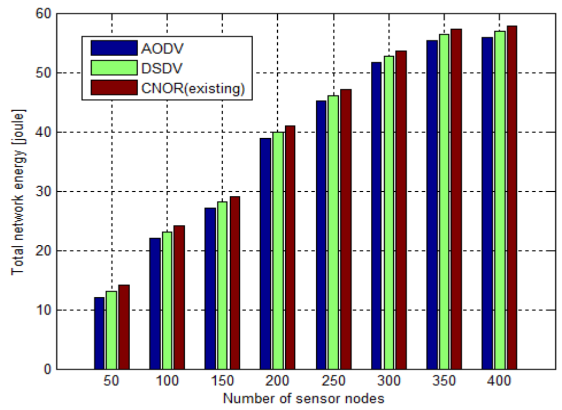

Figure10: Total Energy consumption under different network density.

5.3. Network energy consumption: Network energy consumption is the amount of energy consumed from all the nodes in the network. Every source node sends 100 packets towards the destination while the network density was increased from 50 to 400 nodes. As the number of the nodes in the network is increased the total energy consumption is increased.

The figure 10 shows comparison between two proposed routing protocols and existing routing protocol in terms of total energy consumption. The CNOR is between 14.0506-57.8481, DSDV is between 13.0664-56.8639 and AODV is between 12.0822-55.8797. On comparison it shows that AODV consumes less energy by combining cognitive properties with simple monitoring system.

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6. CONCLUSION

A lot of research has been conducted to measure the indoor gases. The paper shows Carbon Dioxide monitoring through wireless sensor networks. Firstly implemented both proposed reactive (AODV) protocol and proactive (DSDV) protocol with system which follows cognitive techniques and simple monitoring system. Then there results has been compared in terms of throughput [kbps] and both shows high throughput as compared to simple monitoring system. Finally proposed routing protocols with cognitive techniques compared with existing protocol. In DSDV routing protocol, mobile nodes periodically broadcast their routing information to the neighbors. Each node requires to maintain their routing table. AODV protocol finds routes by using the route request packet and route is discovered when needed. The comparison of these protocols has been done through parameters that are throughput, average end-to-end delay and Total energy consumption. AODV performs better than DSDV and CNOR (cognitive networking with opportunistic routing) routing protocol for all these parameters.

7. FUTURE SCOPE

As we know the Indoor Air Quality is big issue in recent years because it directly relates to human health. There are another more poisonous gases which exists in the surrounding and also we cannot sense. Our future work add Carbon monoxide gas sensor. Addition of sensor may cause of load of data on packets and we will also try to find solution. Moreover, we will compare proposed protocols with cognitive network in terms of routing overhead, packet delivery ratio etc.

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