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Efficient broadcasting and routing to minimize transmission delay for critical event monitoring

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ABSTRACT

Sensor nodes are expected to work for a long time for event monitoring without recharging their batteries. So sleep scheduling method is always used during the monitoring process. But it cause transmission delay because sender nodes should wait until receiver nodes are active and ready to receive the message. The Existing Sleep scheduling methods are employed to prolong the network life time which in turn broadcast the alarm message to the entire network within stipulated time. Thus delay-efficient sleep scheduling method needs to be designed to ensure low broadcasting delay from any node in the WSN. It is designed with two determined traffic paths such as Path for transmission of alarm message and Level-by-level offset based wake-up pattern according to the selected path. Although the existing system avoids delay there are still few challenges. So the proposed topology of a wireless network should be efficiently designed to achieve high network performance. Thus remove useless topology information such as collision, redundancy and transmission delay from a network to dramatically improve a network's broadband utilization, delivery ratio, network lifetime and packet retransmission. This is called as topology control management. Thus Connected Dominating Set (CDS) is regarded as an effective approach to hierarchical topology organization.

1. INTRODUCTION

In mission-critical applications, such as battlefield reconnaissance, fire detection in forests, and gas monitoring in coal mines, wireless sensor networks (WSNs) are deployed in a wide range of areas, with a large number of sensor nodes detecting and reporting some information of urgencies to the end-users. As there may be no communication infrastructure, users are usually equipped with communicating devices to communicate with sensor nodes. When a critical event (e.g., gas leak or fire) occurs in the monitoring area and is detected by a sensor node, an alarm needs to be broadcast to the other nodes as soon as possible, which is shown in Fig. 1 as an example. Then, sensor nodes can warn users nearby to flee or take some response to the event.

However, it is still a challenge for us to apply the level-by-level offset to alarm broadcasting in the critical event monitoring. First, the order of nodes' wake-up should conform to the traffic direction. If the traffic flow is in the reverse direction, the delay in each hop will be as large as the length of the whole duty cycle. Second, the level-by-level offset employed by the packet broadcasting could cause a serious collision. Finally, the transmission failure due to some unreliable wireless links may cause the retransmission during the next duty cycle, which also results in large delay equaling the whole duty cycle.

The novel sleep scheduling method which is still based on the level-by-level offset schedule to achieve low broadcasting delay in a large scale WSN. As the alarm message may be originated by any possible node, we set two phases for the alarm broadcasting in the proposed sleep scheduling method. First, when a node detects a critical event, it originates an alarm message and quickly transmits it to a center node along a predetermined path with a level-by-level offset way. Then, the center node broadcasts the alarm message to the other nodes along another path also with a level-by-level offset way. Through designing a special wake-up pattern, the two possible traffics could be both carried by a node and the node just needs to be awake for no more than time in each duty cycle to transmit an alarm packet.

For the critical event monitoring in a WSN, sensor nodes are usually equipped with passive event detection capabilities that allow a node to detect an event even when its wireless communication module is in sleep mode. Upon the detection of an event by the sensor, the radio module of the sensor node is immediately woken up and is ready to send an alarm message

2. Objective of this paper

Sleep scheduling methods are employed to prolong the network life time which in turn broadcast the alarm message to the entire network within stipulated time. Thus delay-efficient sleep scheduling method needs to be designed to ensure low broadcasting delay from any node in the WSN. The objective is to reduce the delay of alarm broadcasting from any sensor node in WSNs

It is challenging to achieve energy-efficient, low latency and reliable multihop broadcast over asynchronous dutycycling. For example, the neighbors of a transmitter wake up asynchronously, requiring the transmitter to stay active long enough so that each neighbor has a chance to receive the broadcast packet, resulting in increased energy consumption. In addition, transmission attempts over poor quality links can significantly decrease delivery ratio and increase delivery latency and energy consumption. When a transmission fails and the intended receiver goes to sleep, if the transmitter is to retransmit, it must wait until the receiver wakes up in next cycle. A transmitter may also substantially delay forwarding by other neighbours, if the transmitter occupies the medium while waiting to reach all of its neighbors. Finally, information about the progress of a broadcast is important for a node to avoid redundant transmissions, but a node that has just taken up has no up-to-date progress information. The node cannot simply use overhearing to learn this information as the progress may change while the node has its radio off.

3. Method and Procedure

A novel sleep scheduling method in the existing system is designed with two determined traffic paths. They are:

1. A Path for transmission of alarm message.

2. Level-by-level offset based wake-up pattern according to the selected path.

When a critical event occurs, an alarm is quickly transmitted along one of the traffic paths to a center node and then it is immediately broadcast by the center node along another path without collision. Thus broadcasting delay is independent of the density of nodes and its energy consumption is ultra low. Exactly, the upper bound of the broadcasting delay is only 3D + 2L, where D is the maximum hop of nodes to the center node, L is the length of sleeping duty cycle.

3.1 Level-by-level offset schedule:

The packet can be delivered from **node a to node c** via node b with minimum delay. Hence it is possible to achieve low transmission delay with the level-by-level offset schedule in multi-hop WSNs. But sending alarm broadcasting in the critical event monitoring is difficult.

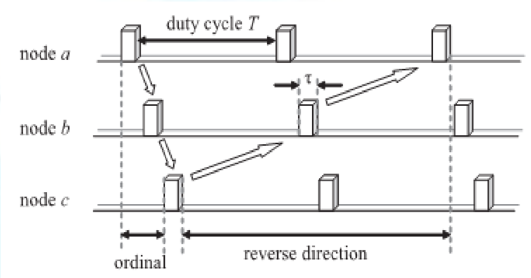

Fig.1 : The level-by-level offset schedule.

3.2 Issues in level-by-level offset to alarm in the critical event monitoring:

1. The order of nodes' wake-up should conform to the traffic direction. If the traffic flow is in the reverse direction the delay in each hop will be as large as the length of the whole duty cycle.
2. The level-by-level offset could cause transmission failure due to some unreliable wireless links. So

retransmission during the next duty cycle results in delay.

It is known that the alarm could be originated by any node which detects a critical event in the WSN. To essentially reduce the broadcasting delay, includes two phases:

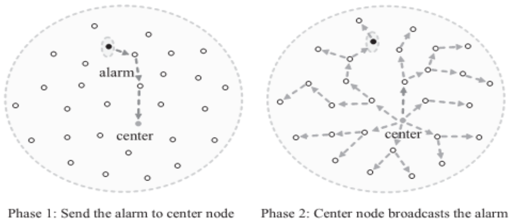

Fig 2: Illustrates two phases of the processing.

1) Any node which detects a critical event sends an alarm packet to the center node along a predetermined path according to level-by-level offset schedule.

2) The center node broadcasts the alarm packet to the entire network also according to level-by-level offset schedule.

3.3 Minimize the Broadcast Delay- special wake up pattern

In the scheduling scheme each node needs to wake up properly for both of the traffics in two parts:

1) Establish the two traffic paths in the WSN

- The traffic path from node to the center node is defined as uplink- breadth first search (BFS) tree.
- The traffic path from the center node to other nodes is defined as downlink-colored connected dominant set via IMC algorithm is established. Each node transmits or receives packets in a specific channel according to the color assigned. Thus eliminate the collision in broadcasting.

2) Calculate the wake-up parameters (e.g., time slot and channel) for all nodes to handle all possible traffics.

1. If size of time slot is enlarged, the performance of the existing scheme could not be further encouraged.

2. Enlargement of time slot increases energy consumption of sensor nodes. This is because nodes have to keep awake during the whole of the synchronous time slot.

3.4 Routing to minimize transmission delay for critical event monitoring

The topology of a wireless network should be efficiently designed to achieve high network performance. Thus remove useless topology information such as collision, redundancy and transmission delay from a network to dramatically improve a network's broadband utilization, delivery ratio, network lifetime and packet retransmission. This is called as topology control management. Thus Connected Dominating Set (CDS) is regarded as an effective approach to hierarchical topology organization.

Topology control includes power control and hierarchical topology organization. The target of power control is to adjust nodes' transmission range to achieve balanced connectivity while hierarchical topology organization aims to find a communication backbone from the original network in charge of all forwarding's in the network. Routing information is only kept in the virtual backbone, so that routing path search time and communication cost will decrease greatly.

3.4.1 Connected Dominating Set (CDS):

A network can be modeled as a bidirectional graph denoted as G= (V, E) where V represents the set of nodes in the network while E represents the set of all links. When CDS is constructed, only nodes in CDS may forward data whereas broadcasting nodes in CDS can help spread data to the whole network. In routing, data

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will be sent to CDS and be delivered via nodes in CDS.

Larger CDS, increases redundancy and interference. On the other hand smaller CDS some characteristics in original networks may be missing. In Fig. 1a, nodes (D, E, F) construct a minimum CDS. The shortest path between A and C in the original network is $\mathbf{p_{AC}}$= {A, B, C} of length 2. However, routing path between A and C through the minimum CDS will become $\mathbf{p'_{AC}}$= {A, D, E, F, C} of length 4 which is twice as that of $\mathbf{p_{AC}}$. Hence $\mathbf{p_{AC}}$ is used for routing between A and C.

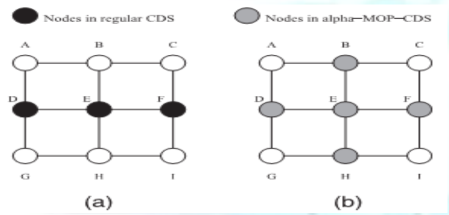


Fig 3: (a) A minimum Regular CDS. (b) A minimum 1-MOC-CDS.

Efficient broadcasting and routing**:**

CDS's size should be as small as possible while the routing paths' length does not increase a lot through the nodes in CDSs. The concept of diameter was defined to evaluate the length of the longest shortest path between any pair of nodes in a network. A special CDS named as ∝-Minimum rOuting Cost-Connected Dominating Set **(∝-MOC-CDS)**.

(∝-MOC-CDS) has a special constraint—for any pair of nodes, there is at least one path all intermediate nodes on which belong to **(∝-MOC-CDS)** and the number of the intermediate nodes is smaller than ∝ times of that on the shortest path in the original network. Thus, routing hops will not increase too much.

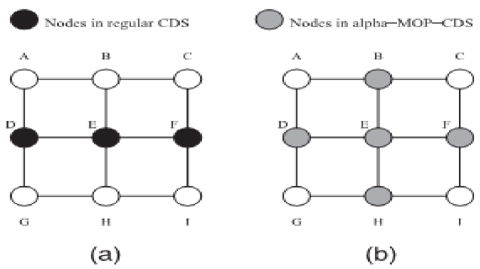


Fig 4: (a) A minimum Regular CDS. (b) A minimum 1-MOC-CDS.

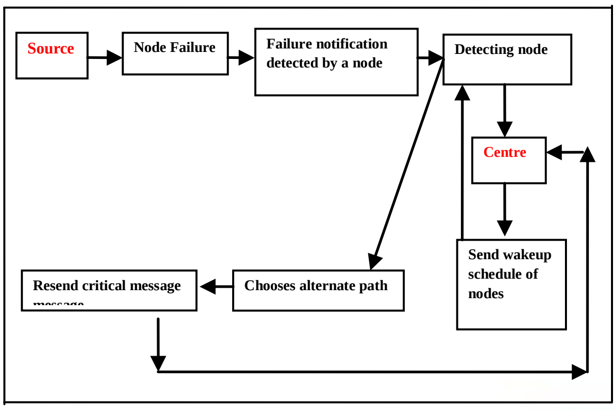
Heuristic localized algorithm is proposed to construct **∝-2hop-DS which is equivalent to (∝-MOC-CDS)**. A network can be modeled as a bidirectional graph denoted as G= (V, E) where V represents the set of nodes in the network while E represents the set of all links. The path between any pair of nodes u and v as **p (u, v)** = (**u,** w1, w2,… wk, **v**) where $\mathbf{W_i}$ (1≤ i ≤k) represents the intermediate node on p (u, v). The shortest path between u and v is the path with the smallest number of intermediate nodes, represented by $\mathbf{p_{shortest}}$ **(u, v)** and the distance between u and v is equal to the hop count on the shortest path between u and v, denoted as **Dist (u, v) = |** $\mathbf{p_{shortest}}$ **(u, v) | - 1** If the distance between the source and the destination is 1, then the messages can be delivered directly. To simplify the problem of ∝-MOC-CDS**,** an equivalent problem of ∝-2hop-DS is defined. It is used where the intermediate nodes distance is 2.

4. ADVANTAGES OF ALPHA-MOC-CDS

- Efficient routing cost influences the performance of the network in terms of broadcasting, scheduling of transmission and routing.
- Designed high efficient topology construction reduces transmissions delay at times of critical event which broadcast to the entire network as soon as possible.

5.SYSTEMATIC REPRESENTATION

5.1. Alpha-Moc-CDS



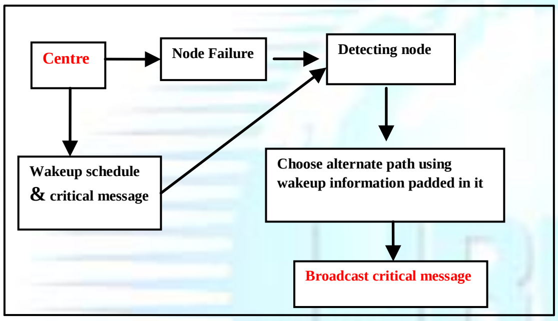


Fig 5: Alpha-Moc-CDS

6. CONCLUSION AND FUTURE WORK

The sleep schedule scheme could essentially decrease the delay of alarm broadcasting from any node in WSN. Moreover, the alarm broadcasting delay is independent of the density of nodes in WSN. The topology influences the performance of the network in terms of broadcasting, scheduling of transmission and routing. When a critical event occurs, an alarm message should broadcast to the entire network as soon as possible. If such topology construction is poorly designed causes transmissions delay. To achieve efficient routing, minimum routing cost preserving CDS is proposed. Hence we can achieve efficient routing even through CDS.

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