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SURVEY ON SCHEDULING IN WIRELESS SENSOR NETWORKS

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Abstract—Wireless Sensor Networks (WSNs) have become a most important solutions for many applications.Usually WSN consists of large number of sensor nodes in the wide area to gather the data.For a WSN to serve in energy-efficient nature, lot of scheduling protocols like Dynamic Multilevel Priority (DMP) packet scheduling, Sleep-wake scheduling, artificial bee colony algorithm are developed.Based on priority, more number of real time and non-real time scheduling mechanisms were followed.Generally developers concerned on delay and energy consumption.At present, new protocols are being developed to achieve energy and scheduling.This survey shows the scheduling of data packets based on priority in three different ways:node scheduling,link scheduling and packet scheduling.These ideas are particularly for the ene-to-end delay of packets, scheduling and energy consumption.In this paper we highlight the importance of node scheduling, link scheduling and packet scheduling protocols and discuss the challenges posed by them.The performance of these protocols could be increased in future works by taking the pros of recent methods and some demands.

Index Terms—*Wireless sensor networks, Sleep-wake scheduling, artificial bee colony.*

I. INTRODUCTION:

Wireless sensor network have used in many applications like forest fire detection, earth monitoring, military surveillance, emergency disaster relief and environmental monitoring etc. Generally WSN consist of a large number of battery-powered sensor nodes in the large area to transfer and receive the data to fusion center or gateway.Energy consumption, latency, delay constraints are some of the issues that takes place while maintaining the normal functions of WSNs.These applications needs delay control,scheduling schemes, network life time to provide long duration and some latency controls.Protocols are also implemented for critical event monitoring for the WSN where many times small number of packets are transmitted.TDMA-based MAC protocols are used to avoid collisions, overhearing and idle listening and also it is energy efficient. Multi-hop TDMA scheduling is more challenging than one-hop scheduling because spatial reuse of a time slot may be possible. DMAC provides significant energy savings and latency reduction which ensures high data reliability. Among all these issues, scheduling at sensor nodes is most important since it ensures delivery of different types of data packets based on their priority and fairness with a minimum latency**.**

Data aggregation is a basic operation to conserve energy by reducing the number of packet transmissions through the network.It is also used to avoid data redundancy of data and time efficient method to gather data, hence solving the end-to-end delay.In [17] In-network estimation has performed for delay constraints in multi hop networks.Scheduling of data sensed for real time applications have higher priority than for non-real time ones. In this paper, the primary objective is minimizing the energy consumption, ene-to-end delay,broadcasting delay,latency by using different scheduling techniques.Data aggregation scheduling is also considered.The data scheduling is based on three catogories:packet scheduling, link scheduling, and node scheduling. We first emphasize on the taxonomy of scheduling schemes. Then we concentrate on brief definitions of packet scheduling, link scheduling, and node scheduling.Next section we describes aggregation of data in sensor nodes.Survey on MAC also dealt here.Finally, the survey of our protocol is concluded with future directions for researchers and developers with regard to issues that have not been come-up thoroughly.

TAXONOMY:

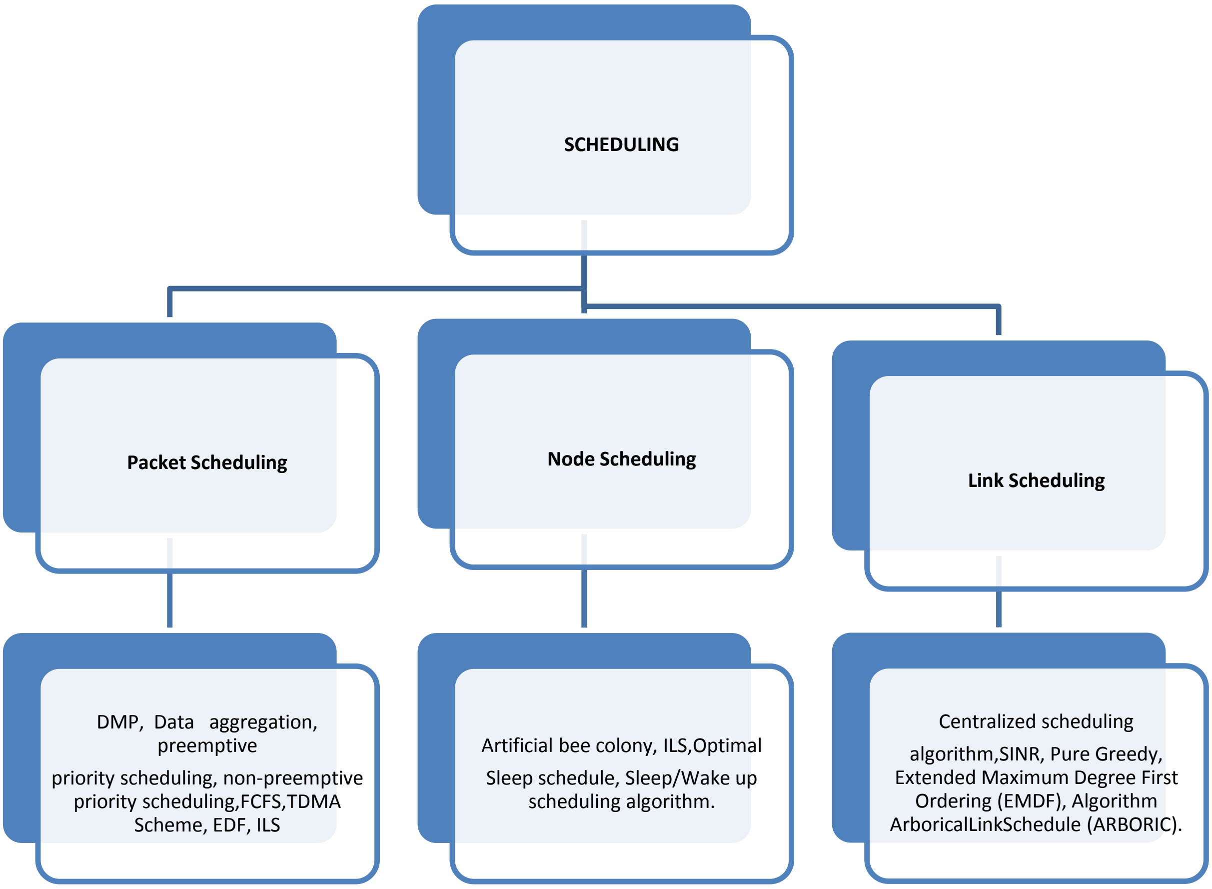

Figure.1 Taxonomy of Scheduling

II. TYPES OF SCHEDULING

SURVEY:

Scheduling methods and characteristics	Packet scheduling	Node scheduling	Link scheduling
Platform	Sleep scheduling methods	Sleep scheduling methods	Sleep scheduling methods
Limitations	The other tasks need to wait for an undefined period time, causing the occurrence of a deadlock	This is hard to avoid in a distributed fashion since the global topology information is required to know whether the interfering nodes have any packets.	Adjusts the duty cycles adaptively according to the traffic load in the network
Future work	To reduce processing overhead and save bandwidth.	General problem of optimal resource allocation in wireless networks	Only Latency is reduced. Not tested with Mote-based sensor platform.

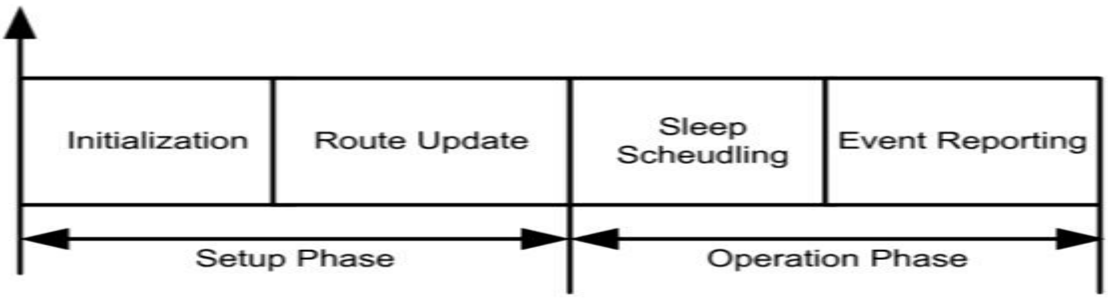

Figure.2 The flow chart and the
Interaction among different phases

Scheduling is grouped into three categories namely packet,node and link based on the sensor node and data situated in network.

The Complete Overview:

1.) Packet Scheduling:

Packet-scheduling is an important mechanism for energy consumption of sensors, end-to-end data delay transmissions and delivery ratio requirements of flows. Dynamic Multilevel Priority (DMP) packet scheduling scheme is proposed where three levels of priority queues except those at the last level of virtual hierarchy in zone based topology. Real time packets are placed in higher priority queues and non-real time packets are placed in other two queues. Distributed scheduling policy for multihop transmissions, and the unreliable nature of wireless transmissions. In-network data aggregation is mainly used to reduce the transmission delays.

2.) *Node Scheduling:*

Distributed inverse-log protocol that is applicable to networks with a large number of nodes were derived. Dynamic Voltage Scaling (DVS) for tasks and Dynamic Modulation Scaling (DMS) for messages are employed for interference constraints in large WSN.These techniques tradeoff energy with latency. However, in dense deployments of WSN with small transmitter receiver distances, DMS does not monotonically reduce the energy consumption.If packets arrives continyesly at the node's buffer during the sleep periods, the node cannot transmit them until it wakes up.Anycast is a technique where each node forwards a packet to the first neighboring node that wakes up among multiple candidate nodes called forwarding node set.

3.) Link Scheduling:

The challenges in adopting a TDMA MAC protocol for sensor networks is in allocating timeslots for each pair of neighboring nodes is one problem which is referred to as link scheduling. If all the links incident to one node are assigned consecutive time slots then contiguous link scheduling is said to be correct. Link layer scheduling is used to minimize end-to-end delay through optimizing routing. We present two cross-layer schemes, a loosely coupled cross-layer scheme and a tightly coupled cross-layer scheme. Link scheduling also depends on the service required by the network layer hence links between the stations are scheduled.

AGGREGATION SCHEDULING:

In [26], Data aggregation aims to eliminate redundant packet transmission by filtering repeated and unnecessary data readings and thus cut on the energy used in communication. In WSN, Data aggregation is a task where the intermediate node collects data from its children nodes. Then process the received data to get an aggregated value and forward it to its corresponding parent nodes [12].It is mainly used in the data gathering applications.

OVERVIEW OF SCHEDULING TCEHNIQUES:

PACKET SCHEDULING:

Packet-scheduling is an important mechanism for energy consumption of sensors, end-to-end data delay transmissions and delivery ratio requirements of flows. Dynamic Multilevel Priority (DMP) packet scheduling scheme is proposed where three levels of priority queues except those at the last level of virtual hierarchy in zone based topology. Data packets are sensed by using TDMA schemes with variable-length timeslots.Real time packets are placed in higher priority queues and non-real time packets are placed in other two queues.Since FCFS approaches leads to overhead and long end-to-end data transmission delay.Nodes that have same hop distance from BS are placed at the same hierarchical level. Based on hop distance priority is given.Real time packets are processed in FCFS basis.Non real time packets are sensed byblocal nodes. Nodes that are located at the lowest level and one level upper to the lowest level can be allocated timeslots 1 and 2. Each and every node maintains three levels of priority queues.In [15], Namely (i) real-time (priority 1), (ii) non-real-time remote data packet that are received from lower level nodes (priority 2), and (iii) non-real-time local data packets that are sensed at the node itself (priority 3). In [15], in non-preemptive packet scheduling schemes,real-time data packets have to wait for completing the transmissions of other non-real-time data packets.In preemptive priority scheduling, lower-priority datapackets can be placed into starvation for continuous arrival of higher-priority data.Considering delay transmissions and delivery requirements, in [22], a model is proposed that jointly considers the end-to-end delay constraints and delivery ratio requirements of flows, the need for multi hop transmissions, and the unreliable nature of wireless transmissions CONSIDERING TWO SENSORS:The first type of sensors, the *orthogonal relay sensors*, which transmit and receive packets, while the second type of sensors, the *halfduplex sensors*, which cant.A framework was also constructed for designing feasibility-optimal policies.For real-time applications it eliminates task waiting time and end-to-end delay.To reduce overhead save bandwidth, we consider removing tasks with expired deadlines from the medium.DMP requires more processing cycles since it has three levels of queues.Hence it is less energy efficient.It does not supports for the aggregation.

NODE SCHEDULING:

The nodes in the WSN must quickly report the results to access point, since the nodes are battery-powered, the medium access control (MAC) protocol is critical in determining network lifetime.TDMA scheduling algorithms for WSN by **Sinem Coleri Ergen Æ Pravin Varaiya** proposed the smallest length conflict-free assignment of slots in which each link
or node is activated at each node reach their destination.Two heuristics algorithms:

- Node based scheduling:

Node based from ad hoc networks for scheduling many non-conflicting nodes in each time slots.

- Level based scheduling:

It is based on scheduling the levels.In the routing tree before scheduling the nodes for many-to-one communication in sensor networks. This algorithm eliminates collisions.time slots and latency. **Hady S. AbdelSalam** proposed sllep-schedule approach in order to conserve energy among sensors and improve the functional longevity of sensors.Entire life time of sensor is between sleep mode and awake mode where it consumes high energy. ESD is a parameter used when a minimum number of awake sensors are needed to satisfy QoS requirements. [30], For conserve energy the sleep control laws is designed to minimize the expected value of a cost function both energy consumption costs and holding costs for backlogged packets.Discrete time system with a Bernoulli arrival process is dealt. For this optimal control laws under the finite horizon expected cost and infinite horizon expected average cost criteria is followed. For the infinite horizon average expected cost problem,the optimal control at each state in the state space is viewed. For the finite horizon expected cost problem, the optimal policy for all states except the boundary state is described. The difference from the infinite horizon was the existence of a “shutdown” period at the end of the time horizon in which the queue stops serving packets, regardless of the queue size. For a single-server queue that acceptspacket arrivals and transmits them over a reliable channel.To conserve energy, the node goes to sleep from time to time. While asleep, the node is unable to transmit packets; however, packets continue to arrive at the node.For having a good sleep policy:

- minimize the packet queueing delay
- conserve energy in order to continue operating for an extended amount of time.

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Considering the network lifetime and delay constraints [29], sleep-wake scheduling is proposed where delay occurs due to transmitting node needs to wait for its next-hop relay node to wake up.To reduce this Anycast packet forwarding schemes is developed. Anycast packet forwarding scheme is used to reduce the event reporting delay to sink node and thus minimize the delay. This technique shows delay-minimization problem to construct an optimal solution to the lifetime-maximization problem for a specific definition of network lifetime.But end-to-end delay occurs since packets relayed through time-consuming routing path by determining how each node should choose its anycast forwarding policy. Every node broadcast the message to the neighboring nodes.This process continues in operation when desired destination is reached. In synchronized sleep–wake scheduling protocols,sensor nodes periodically or aperiodically exchange synchronization information with neighbouring nodes.Such synchronization procedures could cause additional communication overhead and consume a considerable energy.Performance is little tricky. Data are gathered from several source nodes where scheduling algorithms view on the traffic load to reduce the interruption problem.Sleep delay and latency in multi-hop sensor networks is reduced by TDMA diffusions for conflict-free assignment of slots. MAC protocols in sleep duty cycles reduces the interruption problem.

LINK SCHEDULING:

In [12], The challenges in adopting a TDMA MAC protocol for sensor networks is in allocating timeslots for each pair of neighboring nodes is one problem which is referred to as link scheduling. Link layer scheduling is used to minimize end-to-end delay through optimizing routing. Two layer schemes cross-layer schemes, a loosely coupled and a tightly coupled cross-layer scheme. In the loosely coupled cross-layer, routing is computed first and then the information of routing is used for link layer scheduling. In the tightly coupled scheme, routing and link scheduling are solved in one optimization model. The transmission of a station is intended for a particular near node and there must be no collision at this receiver. Two links may not be assigned to the same slot, if either they are adjacent or there exists third link from the transmitter of one link to the receiver of the other links.Here delay is minimized using routing path algorithm and MAC layer.

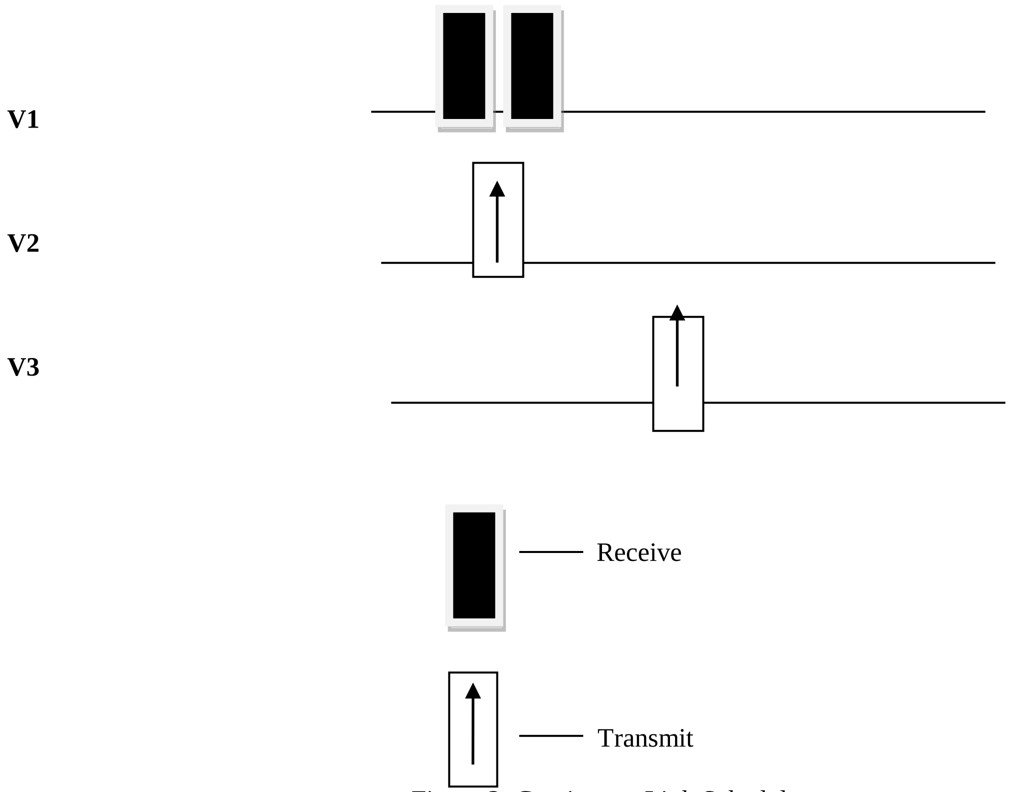

Figure 2: Contiguous Link Schedule.

In Fig 2, Link scheduling is done without interference, where a node starts up many times in a period.

Contiguous link scheduling is used to aggregation of data.Centralized and distributive scheduling has performed for contiguous link scheduling. In centralized approach the link incident for a node is scheduled consecutive time slots.Each node can start only once to receive entire data from its nearby nodes.In distributed scheduling random order is used instead of global decreasing order and contention based MAC is used here.[13] for data aggregation scheduling, SINR constraints is used with link scheduling for delay efficient process.Here nodes are distributed in a plane, each node contains data to report.Data aggregation with minimum delay is considered as NP-hard.

- Long life time and performance is good for multiple hop radio networks due to efficient link schedule techniques.
- Bandwidth is also preserved.

AGGREGATION TECHNIQUES:

In [10], Data aggregation is a fundamental operation aiming to conserve energy by reducing the number of packet transmissions through the networkto minimize the latency efficient collision free aggregation scheduling called FAST is proposed with less time slots for tree-based structures.FAST is a balanced Connected 3-hop Dominating Sets (C3DS)-based structure. In [13] Data aggregation [5], [12] is a process in which information can be gathered and expressed in a summary form according to some aggregation function such as maximum, and sum. Data aggregation introduces a possibility of a new energy or time efficient method to gather data, in contrast to raw data gathering in [13].

CONCLUSION:

WSN has major role in all the applications but due to small sensor nodes which are less energy, hence battery powered leads to many problems. For solving wastage of energy, latency, reduced time slots, increased life time and to improve throughput of network nodes some scheduling techniques are used.The scheduling of packets has done using DMP, where three-level of priority queues to schedule data packets based on their types and priorities was employed. Hence feasibility-optimal scheduling policies is also applied for eliminate delays. For node scheduling based on TDMA scheduling algorithms, node-based scheduling and level based approaches are followed to bring scheduling. Energy is conserved here by using sleep schedules and sleep-wake approach for network life time and delay constraints. Survey on Latency Issues of Asynchronous MAC Protocols in Delay-Sensitive Wireless Sensor Networks.Centralized scheduling algorithm, SINR, Pure Greedy, Extended Maximum Degree First Ordering (EMDF), Algorithm Arborical Link Schedule (ARBORIC) are the main scheduling algorithms for the link scheduling. In-network data aggregation removes as redundancy as well as unnecessary data forwarding, and hence cuts on the energy used in communications, in addition to energy efficiency and data latency.SINR constraints and in-network is viwed which eliminates the delay.

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