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ADOPTIVE PARENT BASED FRAMEWORK FOR ZIGBEE CLUSTER TREE NETWORKS

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Abstract - **ZigBee a unique communication standard designed for low-rate wireless personal area networks, has extremely low complexity, cost, and power consumption for wireless connectivity in inexpensive, portable, and mobile devices. Among the well known ZigBee topologies, ZigBee cluster-tree is especially suitable for low-power and low-cost wireless sensor networks because it supports power saving operations and light-weight routing. In a constructed wireless sensor network, the information about some area of interest may require further investigation such that more traffic will be generated. An adoptive-parent-based framework for a ZigBee cluster-tree network is used to increase bandwidth utilization without generating any extra message exchange. To optimize the throughput in the framework, the process called vertex-constraint maximum flow problem, and a distributed algorithm that is fully compatible with the ZigBee standard is modeled and used for efficient bandwidth and throughput optimization. Finally, the results of simulation experiments demonstrate the significant performance improvement achieved by the proposed framework and distributed algorithm over existing approaches.**

Index Terms— **Zigbee Cluster Tree, WPAN, Beacon and cluster.**

I. INTRODUCTION

Recent advances in wireless communications and micro electro mechanical technologies have had a strong impact on the development of wireless sensor networks (WSNs). The IEEE 802.15.4 protocol is a promising standard for WSN applications because it pays particular attention to energy efficiency and communication overheads. ZigBee technology is a low data rate, low power consumption, low cost, wireless networking protocol targeted towards automation and remote control applications. IEEE 802.15.4 committee started working on a low data rate standard a short while later. Then the ZigBee Alliance and the IEEE decided to join forces and ZigBee is the commercial name for this technology. ZigBee is expected to provide low cost and low power connectivity for equipment that needs battery life as long as several months to several years but does not require data transfer rates as high as those enabled by Bluetooth.

In addition, ZigBee can be implemented in mesh networks larger than is possible with Bluetooth. ZigBee compliant wireless devices are expected to transmit 10-75 meters , depending on the RF environment and the power output consumption required for a given application, and will operate in the unlicensed RF worldwide (2.4GHz global, 915MHz Americas or 868 MHz Europe). The data rate is 250kbps at 2.4GHz, 40kbps at 915MHz and 20kbps at 868MHz. IEEE and ZigBee Alliance have been working closely to specify the entire protocol stack. IEEE 802.15.4 focuses on the specification of the lower two layers of the protocol (physical and data link layer). On the other hand, ZigBee Alliance aims to provide the upper layers of the protocol stack (from network to the application layer) for interoperable data networking, security services and a range of wireless home and building control solutions, provide interoperability compliance testing, marketing of the standard, advanced engineering for the evolution of the standard. This will assure consumers to buy products from different manufacturers with confidence that the products will work together. IEEE 802.15.4 is now detailing the specification of PHY and MAC by offering building blocks for different types of networking known as “star, mesh, and cluster tree”. Network routing schemes are designed to ensure power conservation, and low latency through guaranteed timeslots. A unique feature of ZigBee network layer is communication redundancy eliminating “single point of failure” in mesh networks. Key features of PHY include energy and link quality detection, clear channel assessment for improved coexistence with other wireless networks. Some notable results have been reported for throughput improvement in the routing protocols of ZigBee mesh networks

II. ZIGBEE CLUSTER TREE

ZigBee, which is based on the IEEE 802.15.4 standard, defines the network (NWK) layer and the application layer (APL) in the protocol stack. There are three types of device in a ZigBee network: a coordinator, a router, and an end device. A ZigBee network is comprised of a ZigBee coordinator and multiple ZigBee routers/end-devices. The coordinator provides the initialization, maintenance, and control functions for the network. The router has a forwarding capability to route sensed data to a sink node. The end device lacks such a forwarding capability. ZigBee supports three kinds of network topology, namely, star, cluster-tree, and mesh topologies. In a star network, multiple ZigBee end devices connect directly to the ZigBee coordinator. For cluster-tree and mesh networks, communications can be conducted in a multihop fashion through ZigBee routers. In a cluster-tree network, each ZigBee router with its surrounding devices is regarded as a respective cluster, and each cluster operates individually as a star network. Assume that sensed data in ZigBee cluster-tree networks is delivered by the GTS mechanism because a high-delivery ratio can be guaranteed. Although the ZigBee cluster tree provides an effective solution for low-power and low-cost wireless sensor

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networking, the rigidness of the topology makes it vulnerable to link failures. To resolve such problems, an adoptive-parent-based framework for a ZigBee cluster tree network is used. The framework provides more flexible routing and increases bandwidth utilization without violating the operating principles of the ZigBee protocol.

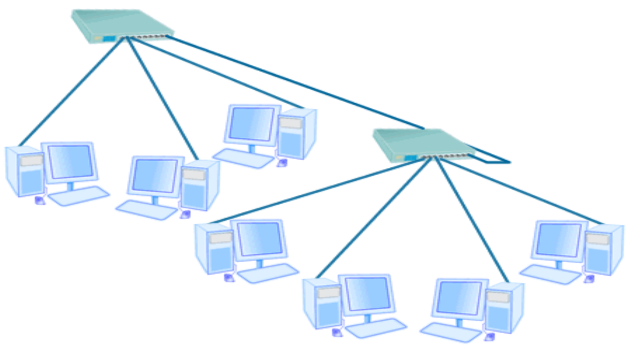

Fig 2.1 The ZigBee cluster tree network

Under the framework, when a ZigBee router suddenly initiates data transmissions that need much more bandwidth than usual, the router is allowed to request bandwidth than usual; the router is allowed to request bandwidth from routers (called adoptive parents) as well as from its original parent router. Additional routing paths are established through the transmission links to the adoptive parents in order to increase the bandwidth between the source and the sink and thereby satisfy the sudden requirement for extra bandwidth.

III. Enhanced System

3.1 EXISTING SYSTEM

Saeyoung et al. proposed a slotted beacon scheduling scheme to reduce power consumption in a hierarchical tree topology; and Yamao and Takagishi presented a novel active-period assignment method to relieve the throughput bottleneck in ZigBee cluster-tree networks. Burda and Wietfeld introduced a distributed beacon scheduling scheme that is suitable for sensor networks, and the robustness and performance are maintained during reconfiguration. Considering the transmission latency, Tseng and Pan defined a minimum delay beacon scheduling problem for quick converge cast in ZigBee tree-based WSNs, and proposed a distributed beacon scheduling scheme with a delay consideration. Although existing works can achieve significant performance improvements in ZigBee cluster tree networks, they do not deal with the restricted routing and poor bandwidth utilization problems.

The common drawback of the existing approaches is that they do not address the poor bandwidth utilization problem in ZigBee cluster-tree networks, so it is difficult to increase the system throughput. Existing works can achieve significant performance improvements in ZigBee cluster tree networks; they do not deal with the restricted routing and poor bandwidth utilization problems.

3.2 PROPOSED SYSTEM

In a wireless sensor network sensors are grouped into clusters, each with its own cluster head (CH). Each CH collects data from sensors in its cluster and relays them to a sink node directly or through other CHs. The *coverage time* of the network is defined as the time until one of the CHs runs out of battery, resulting in an incomplete coverage of the sensing region. The maximization of coverage time can be studied by balancing the power consumption of different CHs.

Using a Rayleigh fading channel model for inter-cluster communications, an optimal power allocation strategies that guarantee (in a probabilistic sense) an upper bound on the end-to-end (inter-CH) path reliability. Allocation strategies account for the interaction between routing and clustering by considering the impacts of intra- and inter-cluster traffic at each CH. Two mechanisms are proposed for achieving balanced power consumption: the routing-aware optimal cluster planning and the clustering-aware optimal random relay. For both mechanisms, the problem is formulated as a signomial optimization, which can be efficiently solved using generalized geometric programming. Numerical examples and simulations are used to validate our analysis and study the performance of the proposed schemes.

IV. Adoptive Parent Based Framework

4.1 Super Frame Structure

The IEEE standard, 802.15.4, defines the physical layer and medium access control sublayer for low-rate wireless personal area networks (LR-WPAN). IEEE 802.15.4 defines a superframe structure that begins by transmitting a beacon issued by a PAN coordinator.

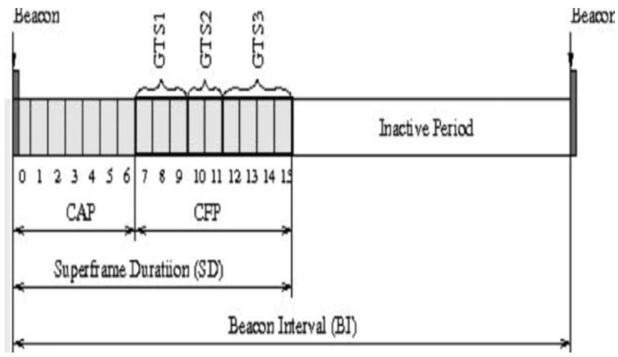

Fig 4.1 Super frame structure

The superframe can have an active and an inactive portion. During the inactive portion, the coordinator shall not interact with its PAN and may enter a low-power mode. The active portion consists of contention access period (CAP) and contention free period (CFP). Any device wishing to communicate during the CAP shall compete with other devices using a slotted CSMACA mechanism. On the other hand, the CFP contains guaranteed time slots (GTSs). The GTSs always appear at the end of the active superframe starting at a slot boundary immediately following the CAP.

4.2 Beacon Generation

Depending on the parameters, the FFD may either operate in a beaconless mode or may begin beacon transmissions either as the PAN coordinator or as a device on a previously established PAN. An FFD that is not the PAN coordinator shall begin transmitting beacon frames only when it has successfully associate with a PAN. This primitive also includes *mac Beacon Order* and *mac Super Frame Order* parameters that determine the duration of the beacon interval and the duration of the active and inactive portions.

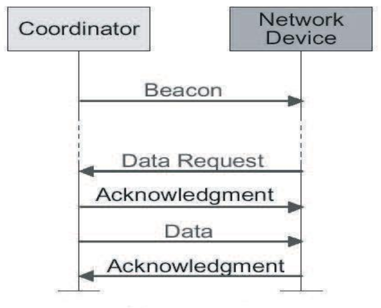

Fig 4.2 Communication in a beacon-enabled network

4.3 Medium Access Control (MAC) Layer
Responsible for providing reliable communications between a node and its immediate neighbors, helping to avoid collisions and improve efficiency. The MAC Layer is also responsible for assembling and decomposing data packets and frames.

4.4 Joining a ZigBee Network
There are two ways to join a ZigBee network: MAC association and NWK rejoin.
4.4.1 MAC Association
MAC association is the bare-bones default, which every ZigBee device must support, since it is actually mandated by and implemented in the underlying MAC layer. In this case, a ZigBee router or coordinator that wishes to allow other devices to join must issue a NLME-PERMIT-JOINING request.

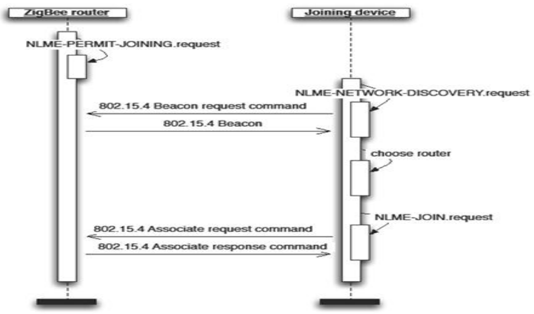

Fig 4.3 MAC protocol

Note that MAC association is an unsecured protocol since all the with that network. Associated frames are sent in the clear (with no security).
4.4.2 Network Rejoin
Network rejoin, which despite the name may also be used to join a network for the first time, is a NWK layer protocol. What this means, first of all, is that it is not subject to the MAC's built-in mechanism for permitting devices to join the network and can be used whether the ZigBee router has issued a NLME-PERMIT-JOINING request or not. Second, it means that the transaction may be secured if the joining device knows the current NWK key. This could be true if the device is actually rejoining the network, or else if the device is joining for the first tim via some out-of-band mechanism. The figure shown below omits the optional network discovery steps shown in the previous case to stress the point that it is not necessary to discover which devices have permitted joining. e but has obtained the NWK key .

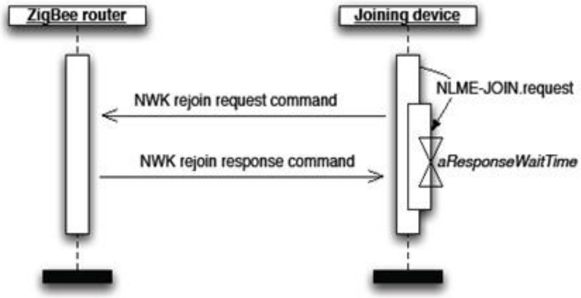

Fig 4.4 Network Rejoining

A high level architecture diagram gives a brief overview of the system at a very high level from an end-user's point of view. It is intended for target audience who may not be interested in knowing the underlying system details.

V. Implementation Results

Figures Fig 5.1 shows that the nodes which are spatially distributed form network by communicating with each other directly or through the other nodes. Fig 5.2 shows that each CH collects data from sensors in its cluster and relays them to a sink node directly or through other CHs. The coverage time of the network is defined as the time until one of the CHs runs out of battery, resulting in an incomplete coverage of the sensing region. Fig 5.3 shows the maximization of coverage time by balancing the power consumption of different CHs.

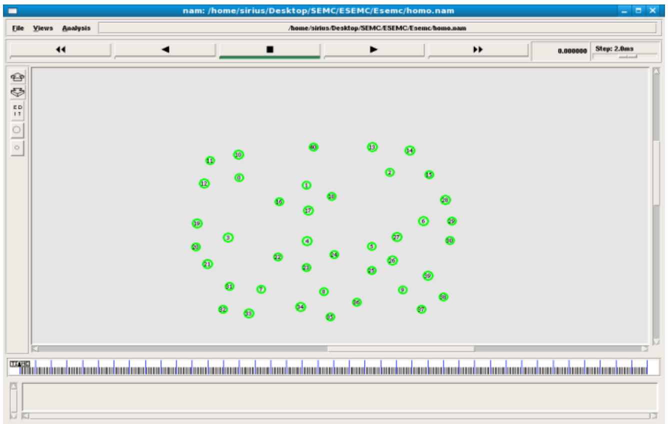

Fig 5.1: Zigbee Clustering Network

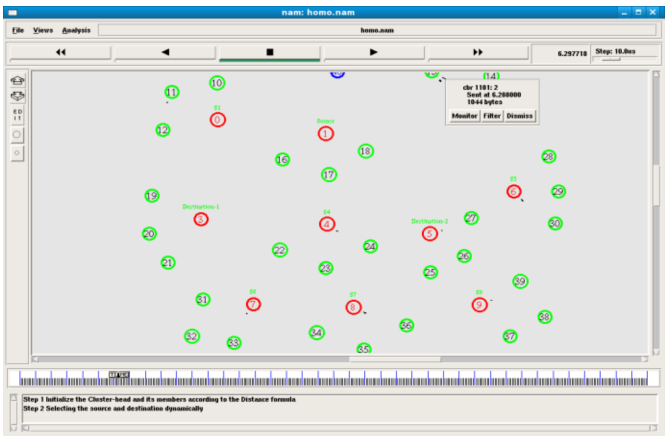

Fig 5.2 Clustering of Nodes

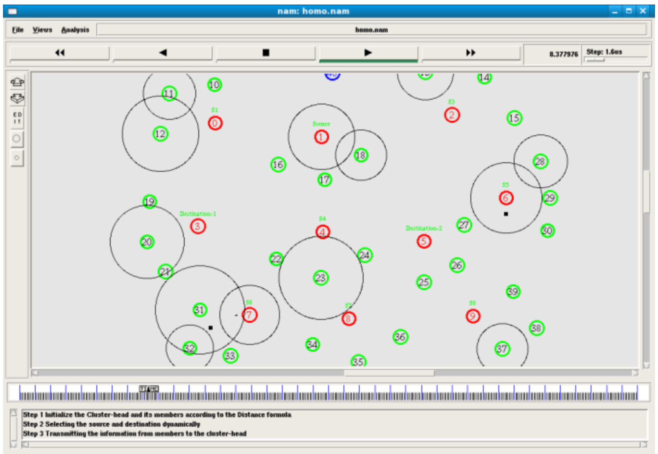

Fig 5.3 Maximization of coverage time

VI. Conclusion

In the constructed WSN, an adoptive-parent based framework for ZigBee cluster tree network is proposed to increase the bandwidth utilization without incurring any extra message exchange. Under the framework, a throughput maximization problem, called the vertex-constraint maximum flow problem, is formulated, and a distributed algorithm that is fully compatible with the ZigBee standard is proposed. The theoretical analysis proves that the proposed algorithm can provide an optimal solution, and the results of simulation experiments demonstrate a significant performance improvement over the original approach.

The coverage time for a clustered wireless sensor network by optimal balancing of power consumption among cluster heads (CHs). Clustering significantly reduces the energy consumption of individual sensors, but it also increases the communication burden on CHs. To investigate this tradeoff, our analytical model incorporates both intra- and inter cluster traffic. Depending on whether location information is available or not, we consider optimization formulations under both deterministic and stochastic setups, using a Rayleigh fading model for inter cluster communications.

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