Energy Saving For Wireless Mesh Network

State of the art

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Abstract— **Energy consumption of communication systems is becoming a fundamental issue and among all the sectors, wireless access networks are largely responsible for the increase in consumption. With this increasing demand for energy in wireless field related with the increase in carbon dioxide levels in the environment produced by wireless devices in the idle mode, it is very essential to develop the technology that reduce energy consumption. In this context, Wireless Mesh Networks (WMNs) are commonly considered as the most suitable architecture because of their versatility that allows flexible configurations. Different studies have proposed number of protocols in different layers of TCP/IP model to enhance transmission of data. Very few of these protocols envisage node energy. This paper mainly focuses on classification layer of the largest existing approaches dedicated to energy conservation.**

Keywords-WMN; 802.11s; Energy consumption; TCP/IP layers, Topology control; Power control; Sleep.

I. Introduction

As various wireless networks evolve into the next generation to provide better services, a key technology, wireless mesh networks (WMNs) has emerged recently [1, 2]. A WMN is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves. The components of the IEEE 802.11s mesh architecture comprise of the following as shown in Fig. 1 [3]. A mesh point (MP) is a node that has also mesh routing capabilities. Mesh points that also have capability to act as access points are called mesh access points (MAPs). IEEE 802.11 mobile clients are called stations (STA) that do not have mesh capabilities and can connect to MAPs to send their data. An MP that is connected to the wired network is called a mesh portal (MPP) or gateway which enables the integration of WMNs with various existing wireless networks such as cellular systems, wireless sensor networks, wireless-fidelity (Wi-Fi) [4] systems, worldwide inter-operability for microwave access (WiMAX) [5].

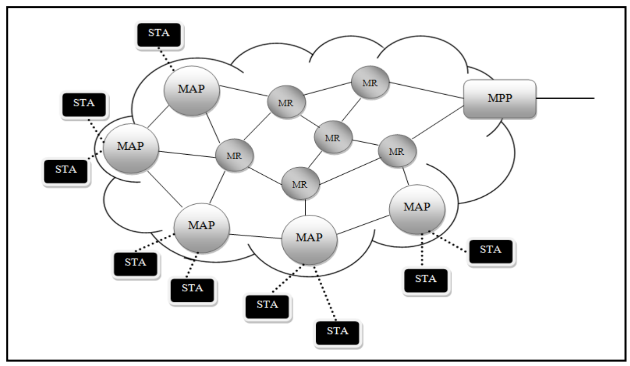

Figure 1. Network architecture of Wireless Mesh Network

Energy consumption is increasing at an exponential rate with heavy growth in the number of access devices. Power management for networks from a perspective that has recently begun to receive attention is targeting the conservation of energy for operating and environmental reasons [6]. Different studies [6, 7] have proposed a rethinking of the way networks are built and operated so that not only costs and performance are taken into account but also their energy consumption and carbon footprint. Significant additional power savings may result by incorporating low-power strategies into the design of network protocols used for data communication.

To reduce energy lost, there are researches that addressed the mechanisms of the Physical Layer to promote energy conservation [9, 10, 12, 13 and 14]. Others work in Data Link Layer is based on IEEE 802.11 standard [15, 16, 17, 18 and 19] that considers energy efficiency. In the Network Layer, studies [30, 31 and 32] have proposed solutions that provide energy saving by using standard routing algorithms with some enhancements.

This paper investigates the state of the art of approaches that reduce energy consumption in different layers of the TCP / IP model. The remainder of this paper is organized as following. Section II explores approaches to energy conservation in Physical Layer. Section III describes different approaches to reduce energy consumption in Data Link Layer. Section IV presents power saving protocols and

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routing protocols within the Network Layer. Finally, the paper is concluded in Section V.

II. APPROACHES TO ENERGY CONSERVATION IN PHYSICAL LAYER

Physical Layer (PHY) implements a network communication hardware, which transmits and receives messages one bit or symbol at a time. In practice, the PHY receives analog symbols from medium and converts them to digital bits for further processing in the higher layers of protocol stack. The PHY functions available in most transceivers are the selection of a frequency channel and a transmit power, the modulation transmitted and demodulation of received data, symbol synchronization and clock generation for received data [8]. The researches that involve the Physical Layer of WMNs are pointed out in this Section.

A. The LM-SPT (Local Minimum Shortest Path-Tree)

LM-SPT is a fully scalable power-efficient localized distributed topology control algorithm [9], proposed to effectively construct for a meshed backbone network of access points. The approach taken in this work is to construct an overlay graph topology of the WMN this concept is based on information of the local neighborhood that is confined to one hop from the logical visible neighborhood for calculating the minimum power transmission. The LM-SPT algorithm is shown to lead desirable features as reduced physical node degree, increased throughput, increased network lifetime and maintenance of connectivity by varying the transmission power at each node. The main contribution of this work consists in the ability of the algorithm to balance energy efficiency and throughput in WMNs and without loss of connectivity. In this approach Aron et al.[9] proposed to calculate minimum transmission power and require only an optimal value to maintain an optimal connectivity and decrease the interference and collision which save energy and achieve a good throughput.

B. CNN (Critical Number of Neighbors)

Santi [10] used CNN refers to the minimum number of neighbors that should be maintained by each node in order for the network to be asymptotically connected. This approach to maintain connectivity is adopted for use in the proposed scheme because only knowledge of the network size is required to determine the CNN. This information can be easily obtained from a proactive routing protocol such as OLSR [11]. The CNN may also result in heterogeneous transceiver power outputs, potentially maximizing power savings and interference gains. The CNN is also less affected by the distribution and position of the network nodes and there is no need to assume a GPS enabled router. It’s also increases gradually with network size and is thus able to tolerate delays in the propagation of topology updates and network size (if a proactive routing protocol is used). Thus, maintaining connectivity via a CNN will reduce human intervention (if a proactive routing protocol is employed).

The same idea like Aron et al. [9] approach, Santi [10] proposed to calculate minimum number of neighbors that should be maintained to be connected to conserve energy.

C. Minimum-energy topology

Aron et al. [12], considered the problem of topology control in a hybrid WMN of heterogeneous and presented a localized distributed topology control which pointed to calculate the optimal transmission power to maintain connectivity and reduce the transmission power to cover only nearest neighbors and save energy and extend lifetimes of the networks. In this work, the main objective is to generate a minimum-energy topology G graph. Taking an arbitrary node $u \in V$ in the network G, a three phased topology control algorithm that runs in each node. In the first stage, node *u* broadcasts a “hello” message using its full power, $P^{max}{}_{u}$. The nodes that receive the “hello” message form the set of accessible neighborhood of node *u*. The “hello” message contains the id of u, the location information of *u*, (x (u), y (u)) and the value of the $P^{max}{}_{u}$. After there exist a weighted directed graph topology G, $u \in V$. Node *u* has knowledge of the edge weights and path weights, where path weight of a directed path. Finally, in this phase, node *u* determines its own transmission power and the powers on the accessible edges of all the nodes in the accessible neighborhood. Node *u* takes as its power, the largest one-hop edge weight among the edges obtained in the minimum-energy local topology view G, after node u adopts its minimum-energy level; it propagates this minimum power value to the other neighbors in the accessible neighborhood with the current Transmission power. Aron et al. [12] developed a minimum-energy distributed topology control that ensures a reduction in the amount of energy consumed per node during transmissions and without loss of connectivity.

D. PlainTC

Mudali et al. [13] investigate the feasibility of power control in a popular WMN backbone device and design and evaluate an autonomous, light-weight TC scheme called PlainTC. Two main approaches may be used in this regard, either maintaining the Critical Transmission Range (CTR) or the Critical Neighbor Number (CNN). In this work, Mudali et al. [13] presented a TC scheme for a WMN backbone comprising of commercially available Linksys WRT54GL routers (which are popular WMN backbone devices). The proposed scheme is designed to maintain network connectivity by relying on data collected by a proactive routing protocol. Three types of information can be collected and used as the basis of a TC scheme: location information, direction information and neighbor information. The Linksys WRT54GL device contains neither a GPS nor the native ability to determine the relative direction of incoming and outgoing transmissions. The device does however possess the ability to collect low-quality, neighbor-based information by inspecting the routing table built by the proactive routing protocol being employed. Determining the logical node degree is easier because the number of HELLO messages received from unique sources can be determined if a reactive routing protocol is employed. If a proactive routing protocol is employed, then the routing table can be inspected for the number of one-hop (or n-hop) neighbors. The approach proposed by Mudali et al. [13], is designed for a specific device (Linksys WRT54GL) and it contains a GPS to define the direction. Unfortunately, generally the devices are not specific and they are not equipped with a GPS generally.

E. Virtual WLAN

Coskun et al. [14], proposed the switching scheme which aims to powering on the minimum number of devices (or the combination of devices that consume the least energy) that can jointly provide full coverage and enough capacity. Basically, this approach corresponds to having a minimum set of devices that provide coverage and an additional set of devices that are powered on to provide additional capacity when needed. By consolidating hardware, some hardware can be put in low-power mode and energy consumption can be reduced, saving the difference in energy consumption per low-power node when compared to an active node and adding the amount of energy consumed by hosting more networking processes just on fewer network nodes. Depending on the type of device, different amounts can be saved. Using virtual 802.11 interfaces to connect to multiple networks simultaneously, instead of using multiple network interface cards, enables savings in energy costs, minimizes the physical space, and provides the capability to build large and small wireless mesh networks.

Summary

Topology control algorithms have largely been proven to be one way of achieving energy efficiency in MWNs. The main goal of a topology control algorithm is to select appropriate logical neighbors of a node (from a given physical topology network) according to some specified rules (average node degree, throughput, energy consume, network lifetimes). Each node should be able to apply the rules to adjust its transmission power accordingly so that only the necessary logical neighbors are covered. Several contributions have been tailored towards studying power control problems in energy-constrained conventional IEEE 802.11 wireless network standards; little attention has been drawn to the power control problems in WMNs.

Control of topology and control of power transmission are a good ideas, simple but very effective for saving energy, while keeping maximum connectivity and the extending of network lifetime. Some of these studies are summarized in the previous Section. Another trend in research is the mechanisms of the Data Link Layer that promote energy conservation will be present in the next Section.

III. APPROACHES TO ENERGY CONSERVATION IN DATA LINK LAYER

In the previous section, we showed approaches that conserve energy in Physical Layer. We now discuss some of the key issues relating to the implementation of power saving at MAC Layer sub layer of Data Link Layer, which provide a fair mechanism to share access to medium among other nodes. The MAC sub layer determines how and when to utilize PHY functions. Hence, MAC plays a key role in the maximization of node's energy efficiency. We first briefly review power saving in conventional IEEE 802.11and discussion of recent work that has started to address them.

A. PSM (Power Saving Mode) IEEE 802.11 Protocol

The MAC layer specification in IEEE 802.11 [15], defines two diverse power management modes a station can operate in one of them: active mode and Power Saving Mode (PSM). In active mode, a station is fully powered and is able to exchange frames at any time. While in Power Saving mode, a station is permitted to be in one of two different power states, either in awake state or doze state. An AP in a wireless network observes the mode of each station. A station must first inform its AP about changing its power management mode using Power Management bits within the Frame Control field of the frame used as a power saving request. A station should not enter PSM before it receives an acknowledgement from the AP. During the association procedure, a station informs the AP about its listen interval, which is used to indicate a period of time for which a station in PSM may choose to sleep. Its aim is to reduce energy consumption in conventional IEEE 802.11 standard.

The IEEE 802.11 standard defines power saving for clients devices, by allowing the nodes to switch between the Awake and Doze states. But the standard does not provide mechanism for placing APs into power saving mode and requires that the access point be continuously powered, and this requirement can lead to lost energy.

B. APSD (Automatic Power Save Delivery)

Various enhancements to the above scheme have been included in some of the follow-on standards. For example, IEEE 802.11e defines Automatic Power Save Delivery (APSD) [16]. This includes both contention-based operation (referred to as EDCA) and a polling-based option (called HCCA). In the latter case, the AP functions as a hybrid coordinator (HC), and defines periodic service intervals that allow the synchronous delivery of traffic using Scheduled Automatic Power Save Delivery (S-APSD). In the former case the unscheduled APSD (U-APSD) mechanism permits the station to initiate communication activity by transmitting trigger frames on the uplink in EDCA contention mode. These mechanisms provide for improved flexibility and power saving compared to the original procedures.

C. PSMP (Power Save MultiPoll)

IEEE 802.11n has introduced further enhancements to the U-APSD and S-APSD protocols, referred to as power save multipoll (PSMP) [17]. As in its predecessors, there are scheduled (i.e., S-PSMP) and unscheduled (i.e., U-PSMP) versions. S-PSMP provides tighter control over the AP/station timeline by having the AP define a PSMP sequence that includes scheduled times for downlink and uplink transmissions. The ability to do this allows (non-AP) stations to remain in Doze mode during the times when other stations are scheduled to be using the channel and reduces AP/station interaction overheads. U-PSMP is similar to U-APSD in that it supports both triggered and delivery enabled modes.

D. NAV (Network Allocation Vector) And NAM (Network Allocation Map)

The AP uses network allocation vector blocking to prevent channel access to the AP when it is in Doze mode [18]. In conventional IEEE 802.11, a NAV is used at each station to implement a virtual carrier sense mechanism and to block stations from transmitting in cases where the channel has been reserved for some other purpose.

The IEEE 802.11 NAV mechanism is generalized, and a power saving AP includes a network allocation map (NAM) in its beacon broadcasts [19]. The NAM specifies periods of time within the super frame when the AP is unavailable, and during these periods the AP is assumed to be inactive and conserving power.

E. PAMAS (Power-aware Multi Access Protocol with Signaling)

Singh et al. [20], proposed to conserve battery energy by turning off nodes not transmitting or not receiving. It is a combination of original MAC protocol [21], and using a separate channel for a busy signal. By using the busy signal, the terminals are able to determine when and how long they should turn off their radio interfaces. In this protocol, if a node has no packet to transmit, then it should turn off its radio interface if one of its neighboring nodes begins transmitting. Similarly, if at least one neighboring node transmits and another receives, the node should also turn off power because it cannot transmit or receive packets (even if its transmission queue is not empty). This approach uses a separate channel for a busy signal. Each node listens to channel to see when it becomes free to transmit (idle-listening). So it leads to important energy consumption.

F. STEM (Sparse Topology and Energy Management)

Schurgers et al. [22], used a separate control channel to avoid clock synchronization required by IEEE 802.11 PSM. STEM is based on asynchronous beacon packets in a second control channel set to wake receivers. After finishing a transmission, the node turns off its radio interfaces in the data channel. STEM does not provide mechanisms to indicate the status of energy management of a node. Instead, the power management state is only maintained on a database by linking the nodes participating in data communication. Therefore, it is possible that a third source node experiences a significant delay to wake up a receiver node, while the receiver is already awake to the recent communication with other nodes. In this approach Schurgers et al. [22] have used a separate control channel to send packets, asynchronous beacon receivers to wake up. Then the use of these control packets (control overhead) can achieve crucial consumption of energy.

G. S-MAC

S-MAC [23] is an energy efficient MAC protocol for wireless sensor networks. Unlike PAMAS, S-MAC uses the model of periodic listen and sleep to reduce energy consumption by avoiding listening to empty. However, this requires synchronization between neighboring nodes. Latency is increased since a sender must wait for the receiver that it is wake up before starting transmission. But SMAC uses synchronization to form virtual groups of nodes on the same list of sleep. This technique coordinates the nodes to minimize additional latency. In [23], nodes lose some of their energies during the exchange by diffusion of SYNC packets.

H. Admission Control in Power Constrained OFDM/TDMA

Niyato and Hossain [24] proposed an analytical model is developed to investigate the packet-level and the connection-level performances as well as the energy-efficiency in a solar-powered wireless mesh network using OFDM/TDMA transmission. The energy-saving mechanism is implemented through a sleep and wakeup process and is integrated with a round-robin scheduling and an admission control mechanism in the mesh routers. Without an admission control mechanism at a mesh router, packet-level performances as well as the energy saving performances may degrade. Again, if a mesh router spends too much time in the sleep mode, packet-level performances will degrade.

I. Virtualization of NICs

Al-Hazmi and Hermann [25], suggest one of the possible ways to save energy is to shutdown some of the APs, which serve a specific area of interest, if the number of the served stations are decreased in off-peak hours (e.g. at night, weekend, holidays). This could lead to the fact that some locations in the interested area are not covered, and stations located within these locations will not have connections. These can get connectivity by using Network coverage extension/ Relaying capability. In addition to the energy saved by shutting down some APs, NIC virtualization plays a role in reducing energy consumption. But the usage of multiple network interface cards (NICs) demands higher cost, large physical space and more energy consumption.

J. LEACH(Low-Energy Adaptive clustering Hierarchy)

LEACH is scheduled MAC protocol with clustered topology [26]. The nodes organize themselves into local clusters with one node acting as the local cluster head. The cluster heads are chosen randomly according to a specific algorithm based election a probability function which takes into account various criteria such as energy available nodes. To distribute energy consumption evenly, LEACH propose to rotate cluster heads randomly. Each node determines a cluster to associate with by choosing the cluster head that requires minimum communication energy. Once all the nodes are organized into clusters each cluster head creates a schedule for the nodes in the cluster. This allows that each cluster member node can switch to sleep mode at all times except during it transmit time; thus, minimizing its energy consumption. The disadvantage of this protocol [26] is that some nodes operate much more than other nodes and especially the Cluster Head the disadvantage is that these nodes die much faster than other.

Summary

The power saving protocols of MAC sublayer presented in this section is summarized in this Table I.

TABLE I. SUMMARY OF MAC PROTOCOLS

Protocol	Network	Topology	Channel	Synchronization	Contribution
Admission Control in Power	802.11s	Flat	1	No	a round-robin scheduling and sleep/wakeup mechanism
APSD	802.11e	Flat	1	Yes	Active/sleep schedules
LAECH	802.15.4	Clustered	1	Yes	Low energy clustering
NAM	802.11	Flat	1	Yes	Map of active/sleep period
NAV	802.11	Flat	1	Yes	Active/sleep with blockage of transmission when channel is reserved
PAMAS	Ad hoc	Flat	2	No	Wake up radio scheme
PSM	802.11	Flat	1	Yes	Active/sleep period
PSMP	802.11n	Flat	2	Yes	Active/sleep schedules with reducing overheads
SMAC	802.15.4	Flat	1	Yes	Active/sleep schedules
STEM	802.11	Flat	2	NO	Wake up radio with periodic sleep
Virtualization of NIC	802.11	Flat	1	Yes	NIC virtualization

Different mechanisms of MAC sub layer have been presented that allow substantial energy savings in this Section. We have noted that a large majority of work in Mac layer, was based on the proposal of the 802.11 standard, in this case the protocol PSM (Power saving mode) and extended it to improve the functioning. The next Section we will discuss approaches that conserves energy in the Network Layer.

IV. APPROACHES TO ENERGY CONSERVATION IN NETWORK LAYER

Different technique of power saving for multi-hop ad hoc wireless networks that reduces energy consumption have been proposed without diminishing of the capacity or connectivity of the network. As WMNs share many common features with ad hoc networks. Thus, the approaches of energy conservation for ad hoc networks can usually be applied to WMNs. In the Network Layer, power management can benefit from information on the topology; we find essentially the following approaches:

A. The CDS (Connected Dominating Set)

The CSD use information of neighborhood or topology to determine the set of nodes which form a connected dominating set (CDS) for the network where all nodes are either a member of the CDS or a direct neighbor of at least one member [27]. Nodes in the CDS are considered the pivotal routing and remain active all the time in order to maintain global connectivity. All other nodes can choose to sleep if necessary.

B. The SPAN

SPAN is distributed algorithm, each node in the network running Span makes periodic, local decisions on whether to sleep or stay awake as a coordinator and participates in the forwarding backbone topology [28]. Each node decides to be a coordinator may have two criterions. The first is selection of the nodes with the higher energy to be a coordinator. The second criterion is the value that a node adds to the overall network connectivity. A node connecting more nodes will be more likely to be chosen as coordinator. Span uses broadcast messages to discover and react to changes in the network topology. Finally span integrates with 802.11 power saving mode nicely, non-coordinate can still receive packets when operating in power saving mode. This algorithm can be applied to WLAN mesh network with changes in selection of coordinator in the criterion of energy for example we can choose the access points which are connected with power in the place of those are powered with battery.

C. The GAF

The GAF scheme of Xu et al. [29] has similar goals to Span. In GAF, nodes use geographic location information to divide area to cover into fixed square grids. The size of each grid stays constant, regardless of node density. Nodes within a grid switch between sleeping and listening, with the guarantee that one node in each grid stays up to route packets.

One main disadvantage of the three previous approaches [27, 28 and 29] is that it is inherently dependent on node density for energy savings. The basic premise is that there are enough nodes that only a small number of them are needed at any one time. In low density networks, almost no power can be saved using these approaches because almost every node must stay active. Another main disadvantage of these approaches is the overhead required to maintain an effective subset. Since nodes are mobile, the subset must be continually updated in order to provide complete coverage. Even if nodes were not mobile, the subset must be rotated in order to avoid completely draining the resources of a few nodes. Since coordination is required every time the subset changes, this can cause significant amounts of

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communication traffic which both limits scalability and reduces good-put by cutting into available medium time.

D. The Pulse

The Pulse protocol design is centered on a flood we refer to as a pulse, which is periodically sent at a fixed pulse interval [30]. This pulse flood originates from infrastructure access nodes (pulse sources) and propagates through the entire component of the network. This rhythmic pulse serves two functions simultaneously. It serves as the primary routing mechanism by periodically updating each node in the networks route to the nearest pulse source. Each node tracks the best route to the pulse source by remembering only the node from which it received a flood packet with the lowest metric. If a node needs to send and receive packets, it responds to the flood with a reservation packet. This reservation packet is sent to the pulse source. The reservation packet contains the address of the node making the reservation, and is used to setup reverse routes at all nodes on the path between the pulse source and the sending node. A node that does not send or forward a reservation packet will have no packet forwarding responsibilities until the next pulse occurs, it may place its radio in sleep mode until the next pulse period begins. This node deactivation is what allows the Pulse protocol to conserve power. This protocol [30] has significant disadvantages in the routing information that is essentially the problem of flooding packets and the problem of Overlap delay or it can result in a significant consumption of energy.

E. EMM-DSR protocol

Bouyedou et al. [31], suggest a new mechanism that allows making a trade-off between energy efficiency and the shortness of a selected path for forwarding data packets. In other word, this mechanism tries to minimize the energy consumption and, at the same time, maintain a good end-to-end delay and throughput performance. The solution proposed by Bouyedou et al. consists in extending the Max-Min algorithm to support the cited trade-off. Thus, they incorporate this extension, among other options, to the existing on-demand dynamic source routing protocol (DSR), and the resultant version takes the name of EMM-DSR (Extended Max-Min DSR).

F. Power-Aware Routing

Lin et al. [32], present a power-aware routing algorithm for wireless networks with renewable energy sources. The proposed algorithm is shown to be asymptotically optimal when compared to the full knowledge case. No information is assumed regarding the arrival process and it is assumed that the node has full knowledge of the energy it will receive until the next renewal point by looking at previous data. The proposed routing algorithm uses a composite cost metric that includes power for transmission and reception, replenishment rate, and residual energy. The work also includes non-uniform energy replenishment rates and introduces a battery energy threshold scheme to decrease overhead.

G. The green-clustering

The green-clustering algorithm was developed to enable the central controller in a WLAN to make certain decisions to power on and off portions of it based on certain pre-defined criteria like deployment, location of access points, and locally derived information. Hence, this algorithm was designed with respect to the centralized network infrastructure and its devices [33]. The basic idea was that if access points are close enough in the cluster, a single one would fulfill the needs of users, even those in the vicinity of other APs in the same cluster. This clustering concept was designed with respect to large organizations with high-density WLANs because access points are placed very close to each other to provide overlapping coverage and high bandwidth.

Summary

The discussed routing protocols are summarized and classified in Table II. As routing protocols may use hybrid techniques to achieve their intended target application, some of the protocols are classified to several categories.

Mobility support is evaluated according to the amount of the nodes that can move and the effort required for route reconstruction.

TABLE II. SUMMARY OF ROUTING PROTOCOLS

Routing Protocol	Network	Topology	Classification	Mobility
CDS	Ad hoc	Flat	Node centric routing	---
EMM-DSR	Ad hoc	Flat	Node centric	---
GAF	Ad hoc	Grid	Location based	Partial
Green-clustering	WLAN infrastructure	Clustered	Node centric	---
Power-Aware routing	Multi-hop Wireless	Flat	Cost field based	Partial
Pulse	multi-hop wireless infrastructure	Tree	Cost field based	---
SPAN	Ad hoc	Grid	Location based	Partial

In the network layer, we think that the tendency of clustering is a good approach because it has already proven itself in the MANET as shown in the large numbers of items.

V. CONCLUSION

Reducing power consumption can be achieved on a larger scale by introducing intelligence into the network infrastructure at various levels by employing different kinds of algorithms. This research tends to discuss the best designs for maximum efficiency in terms of power while retaining the best user experience. This paper has reviewed recent work on energy saving in networks WMN, who treated both routing algorithms energy saver, the mechanisms of energy conservation in the MAC layer and finally some topology control methods and the means developed to put in to sleep

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some routers at certain times. After studying of these works, we reached some conclusions. First, if we want to optimize the problem of energy conservation in WMN, we can intervene on the three lower layers of the OSI model, trying to combine the advantages of the proposed solutions in the state of the art in each layer using the proposal most advantageous in terms of energy savings. In terms of routing, we think that the tendency of clustering is a good approach because it has already proven itself in the MANET as shown in the large numbers of items. We have noted that a large majority of work in Mac layer, was based on the proposal of the 802.11 standard, in this case the protocol PSM (Power saving mode) and extended it to improve the functioning. The works done in the physical layer, all have either used the notion of CNN (Critical Number of Neighbors), or CTR (Critical Transmitting Range), to control the topology of WMN network, in order to optimize consumption of energy. Another trend plays on optimizing the transmission power of nodes, which must be sufficient, and never maximal to keep connectivity without interferences. So we can try to verify if the use of these three ideas together can improve the performance of network, and also saving power, with simulation in future work.

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