ABSTRACT

With increasing usage of mobile digital gadgets, wireless Internet access is a vital part of today’s life. Wireless Mesh Network (WMN) offers high bandwidth Internet access to users via gateway. WMN architecture eliminates need of line of sight communication and suitable for deployment in adverse or dynamic environment. WMN can be characterized as cost effective, easy to maintain and fast to setup. It can be seen as promising technology in future access wireless network. Energy conservation is a key parameter for green and cost effective communication. Energy consumption of WMN is significant portion of that of Internet as a whole. Since energy efficiency has not been given due consideration in WMN by researchers, so, it is very important to analyze parameters impacting energy efficiency of WMN.

From literature survey it is found that, more active collective efforts of standard bodies are required for defining policies to help identify energy efficient technologies. Further, the overall energy consumption is influenced by the functionality of each layer. Number of energy efficient solutions at layers of TCP/IP protocol stack has been highlighted. Cross layer solution with due consideration towards energy consumption of solution itself can be seen as a promising research area. The layers of protocol stack can be adapted by keeping WMN architecture peculiarities in mind. Based on study few thumb rules/generic guidelines have also been identified which may act as initial direction towards achieving energy efficient solution for new researchers.

This work represents importance of wireless mesh network in today’s network. Existing energy aware traditional routing metrics in WMN are more inclined towards battery operated nodes. There are very few researches focusing on network where nodes have sufficient power supply. Moreover, routing metric in standardization area i.e. airtime link metric of IEEE 802.11s also does not consider energy as key parameter. IEEE 802.11s support layer 2 routing. Researchers are required to design enhanced routing protocol for WMN with energy as key design criteria. Keeping this in view, a routing metric by accounting energy consumption due to transmit, receive, discard, link quality and queue stability has been proposed. The proposed metric Energy Aware Path Metric (EAPM) has been compared with airtime link metric. It is
observed that, EAPM measurement is better in terms of network throughput and energy efficiency.  

Until now only few works are found to focus in the area of IEEE 802.11s. Link specific Power Save Mode (PSM) of IEEE 802.11s has not been addressed adequately. Apart from actual data, control data also incur transmission cost, so evaluation of any energy efficient approach should also take control data cost into account. Energy efficiency aspects of IEEE 802.11s have been analyzed and compared with existing test bed observation of other researchers. Numerical results prove that, in spite of no traffic with growth in peer links the energy consumption increases linearly. The increases in beacon size, or decreases in bandwidth also enhances energy consumption. Results for higher value of Delivery Traffic Indication Map (DTIM) period suggests for deep sleep mode of links. By opting deep sleep state for redundant peer links and nodes in WMN energy saving can be improved further. With sufficient queue capacity, the throughput of network does not degrade in light sleep mode. Average delay increases with Beacon Interval. Analysis suggests setting the best possible value for Ad hoc Traffic Indication Message (ATIM) window size, DTIM period, Beacon Interval, Queue Size, Bandwidth, and PSM towards peer links etc. to minimize energy consumption during idle peer listening. Further, by deploying nodes with more battery capacity or increasing density of nodes near gateway node can help prolong overall network lifetime. Proposed model can be a useful tool in scientific field. Frequent switching between sleep and active state may result in more power consumption. According to IEEE 802.11s standard a mesh node may choose to enter in doze state for power saving only if the mesh STA operates in light or deep sleep mode for all of its mesh peering. Keeping above points in view, a detailed nonlinear programming model for optimum PSM for peer links subject to quality constraints has also been proposed. By reducing redundant peer links energy saving can be enhanced in 802.11s. Optimum PSM of peer links can achieve great energy efficiency. But solving the optimization problem can be computationally expensive. An approximation algorithm is required for minimum energy consumption.  

Further, the resources of wireless communication systems are designed in view of peak traffic demands. During low traffic demands the installed capacity of the network resources are underutilized and this results in high energy waste. By
incorporating appropriate mechanism for routing traffic from source to destination with effective utilization of network resources, significant energy savings can be achieved. By switching off underutilized router/idle radio in multi-radio WMN, energy due to circuit power consumption can be saved significantly. But such approaches trigger questions like how to choose the most advantageous set of resources to be switched-off. In this research work, genetic algorithm based traffic consolidation approach has been proposed to identify underutilized nodes and allowed to sleep. By permitting nodes to use elongate path to avoid sleeping nodes in a multi-hop network, can help to achieve a numeral of nodes to stay in the energy efficient state. Unlike previous approaches, this research favors utilization of active network resources to their full capacity by considering communication energy and traffic consolidation. Trade-off in energy saving by switching off underutilized nodes and increases in communication energy cost have been considered. Results prove that significant energy can be saved by traffic consolidation. Such kind of resource management can be incorporated for WMNs, to allow integrated and distant control of all mesh devices and to alter of their configuration as per requirement. The proposed techniques have proved to be highly effective in case of energy saving and providing better network performance as compared to existing techniques.