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IMPROVISATION OF MESH NETWORK WITH WIDEBAND CODE DIVISION MULTIPLE ACCESS

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Abstract: Mesh Networks are employed in various applications despite issues relevant to interference and network capacity. These networks also impose delay in routing and reconfiguration. Traditionally, TDMA and FDMA techniques have been used in these networks. This paper proposes wideband code division multiple access (WCDMA) technique for enabling maximum power transfer, low energy consumption, interference free and plug-and-play feature enabling easy implementation of the technology. The spatial configuration and node count bounds are stated ensuring continuous satisfaction of quality of service by the communication link. Additionally, dynamic parallel orthogonal transmission and turbo coding schemes are used in combination to improve the efficiency of the network even for large hop counts.

Keywords: Mesh Network, WCDMA, wireless communication, energy efficiency, turbo coding

1. INTRODUCTION

Code Division Multiple Access (CDMA) is a mode of communication that uses multiple access technique. It allows simultaneous transmission of varied data through the same channel. A unique code containing information regarding the signal source and destination is assigned to each transition using speed spectrum. Wideband Code Division Multiple Access (WCDMA or W-CDMA), launched in Japan in 2001 is the communication standard that is frequently used in third generation (3G) cellular networks. It enables high-speed data transfer along with the basic MMS, text messaging and voice services. It facilitated mobile devices to access Internet broadband services.

Due to its high transmission rate, WCDMA is used for improving QoS. It can allocate multimedia traffic and handle services with large data rates. 144kbps to 2Mbps of data is supported by WCDMA technologies. Despite the primary use of WCDMA in mobile communication, the technology has found widespread application in the domain of wireless multiple access ranging from high-end computer networks to low-end wireless sensor networks. Communication networks called wireless mesh networks are composed of radio nodes that are organized in a mesh topology. The connectivity and speed of mesh networking can be enhanced by adopting WCDMA technology by interconnecting the users in the network without base stations.

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Using peer nodes, data packets are hopped to the destination in multi-hopping network. This helps reducing the inter-channel interference in mesh networking technologies used in wireless sensor networks. Modulation and demodulation of multiple packets can be done in parallel. Cautious power control algorithm are required for conservation of limited energy reserves in the nodes. In case of communication in areas with high density obstructions like high-rise buildings and trees, it is difficult to serve most of the customers due to line of sight (LOS) requirements. These drawbacks can be overcome by wireless mesh networks (WMN) as they provide wireless broadband internet facility.

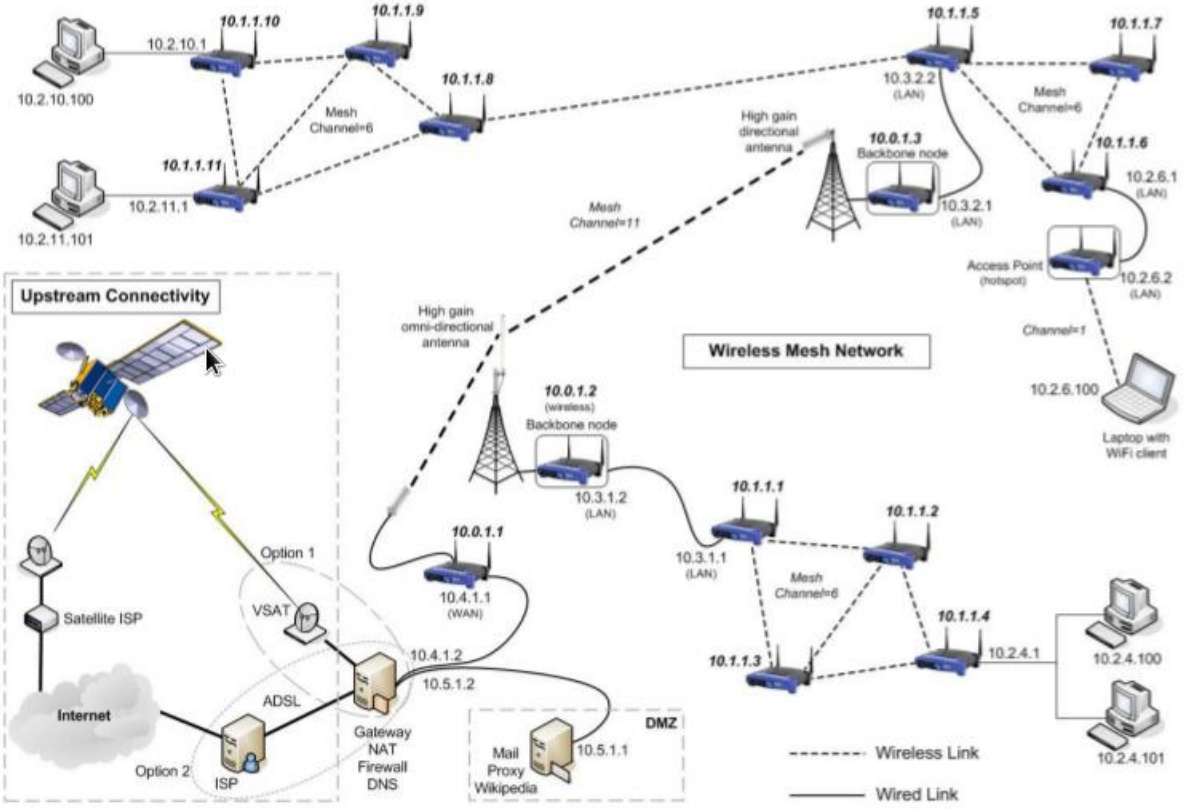

Figure 1: Wireless Mesh Network [22]

Figure 1 represents a wired-wireless mesh network configuration which has an upstream connection through a VSAT (Very Small Aperture Terminal) link. Details of the related work is provided in section 2. Section 3 provides information regarding the proposed work and Section 4 provides the simulation results. Finally, the conclusion and future work is briefed in section 5.

2. EXISTING LITERATURE

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Mihail et al. [21] presented the opportunities and challenges of wireless mesh networks and performed a study on the applications of WMN such as broadband internet access, indoor WLAN coverage, mobile user access and connectivity. This technology can successfully compete with traditional systems like WLAN, 3G, and WMAN. Woojoon Lee et al. [20] proposed a novel CDMA based multicast able switch and the hybrid NoC associated with it based on star and 2D-mesh topologies. This approach helped improve the efficiency of the network and to overcome the hotspot problem.

Leonardo Badia et al. [19] investigated optimization and management strategies for radio resources in WCDMA systems. The trade-off amongst price and utility is also considered. Utility functions are employed for accountability of added features characterized by traffic elasticity and further consider price effects in order to have accurate portrayal of economic quantities. Jagadeesh et al. [18] published a paper titled "Multiple Descriptions and Path Diversity for Voice Communications over Wireless Mesh Networks". The authors perform the average distortion comparison in packetized communication per symbol using multiple description and path diversity for transmission of memory-less Gaussian source through additive white Gaussian noise channels. Further, the delivered voice quality is evaluated and compared with the existing methods.

Roman et al. [17] suggested the usage of wireless mesh networks in areas with infrastructure deficiency for providing internet access. The paper highlights the drawbacks of WCDMA networks that are based on 3G technology. Qualnet simulator is used for analysing the architectural capacity and reliability of the system. The macro diversity and interference between the base stations in WCDMA is discussed by Sana Ben et al. [14] for analysis of quality indicator matrices and their influence on the network design. The high data transfer rate of WCDMA improves the QoS in cellular networks [12]. The paper proposes improving signal strength with a power control scheme and connection admission control scheme for resource allocation.

Sihan Fan et al. [11] used orthogonal frequency division multiple access (OFDMA) for virtualization of resources in wireless mesh networks. Proportional fairness principle based physical resource allocation and load balancing based on virtual link multi-path mapping are the sub-problems of the system model. Mark Nixon et al. [10] studied the wireless mesh network that are used in real-time industrial field deployment. The WirelessHART mesh network that is used in research facility is explored in depth.

3. PROPOSED WORK

A wireless mesh network with N nodes that is inter connected is considered. Communication takes place between the nodes with the help of WCDMA spread-spectrum multiple access protocol. Here data is continuously broadcasted in place of node to node communication link maintenance. The mesh nodes consists of modulating

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and demodulating units in the form of transmitter and receivers. The architecture of the network, constraints in control, capacity of the network and the behaviour of the intended controller is described in this section. Figure 2 represents a simple architecture of multiple hop mesh network with multiple users.

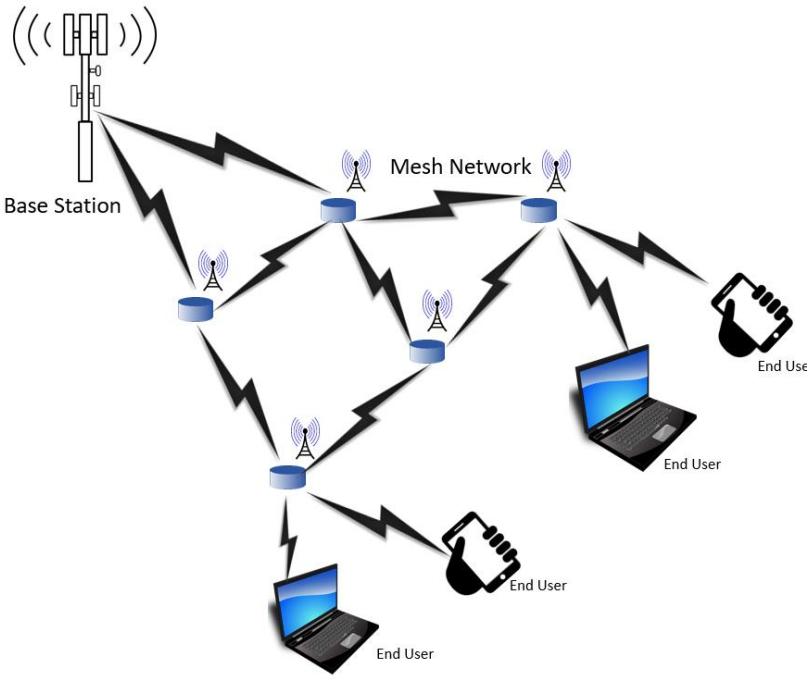

Figure 2: Multiple hop mesh network with multiple users

$$\gamma_{ij} = \frac{P_i G_{ij}}{\sum_{k \neq i, k \neq j}^{N} P_k G_{kj}} \geq \gamma_t, \forall i, j, k \in \Omega \text{ ---------- (1)}$$

Equation 1 represents the CIR constraint where i, j and k are the nodes in the network. The transmission power levels of i^{th} and k^{th} nodes are P_i and P_k, the link gains between the nodes are G_{ij} and G_{kj}.

$$P_i G_{ij} \geq R_{min}, \forall \text{ i, j } \in \Omega \text{ ---------- (2)}$$

Equation 2 represents the received power condition. In the above mesh network, the energy critical nodes perform power minimization using power control algorithm. This protocol can be very efficient for the end users since modulation and demodulation of multiple packets can be done in parallel. The signal to noise ratio of the system can be calculated with the following formula

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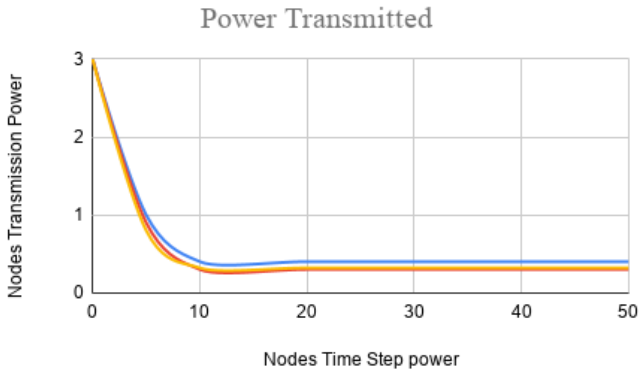
$$(SNR_n)^{-1} = \left[\frac{1}{\frac{E_b}{N}} - \frac{n-1}{PG}\right]$$

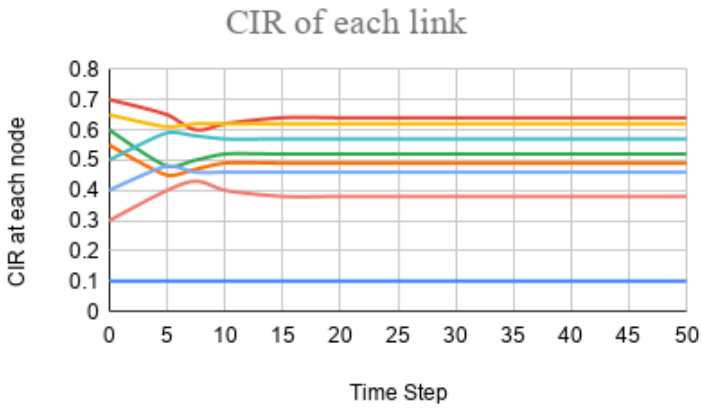
Where n is the number of spread packets, PG is the processing gain and E_b/N is the thermal noise. The delay jitter, average delay, bandwidth, bit rate and other major factors can be analysed.

4. SIMULATION RESULTS

With increasing node count, the behaviour of the Career-to-Interference Ratio (CIR) and the simulation results at every node is represented in Figure 3. The transmitted power across the node transmission power and node time step power.



(a)



(b)

Figure 3: Transmission power control effects

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Form these graphs, it is evident that controller congregates to the minimum transmission power that satisfies all the restrictions defined in the previous section.

5. CONCLUSION AND FUTURE SCOPE

This paper proposes the implementation of wireless mesh networks with Wideband CDMA technique. A comparison with the traditional techniques like FDMA and TDMA is performed. The QoS criteria is also analysed for data and control packets as well as power saving aspects. This network is extremely suitable for consumer based applications. In case of use of narrowband CDMA, it can be used in defence and military applications. Low energy consumption, maximum power transfer, plug-and-play and interference free features has enabled easy implementation of this technology. Turbo coding and orthogonal transmission schemes are used for improved efficiency. Future work involves further reduction of power and improvement of efficiency. Application specific research is also proposed as future work.

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