Project Vision

• Digital inclusion of remote villages
• Providing data, voice and video connectivity with QoS guarantee
• Cost effective solution by using off the shelf hardware and open source driver
Wired or Wireless

• Huge investment in laying wires compared to setting up directional antennas for wireless coverage
• Inexpensive Wi-Fi hardware operating in unlicensed spectrum
• Considerable human effort in setting up wired backbone compared to ease of deployment of wireless network
Challenges in Wireless

• Issues in using 802.11 Wi-Fi protocol
  – Unnecessary back-off in absence of external interference
  – Severe decrease in throughput in multi hop network due to self interference
  – Difficult to assure QoS guarantees

• How about using TDMA?
  – Communication with precise slot boundaries; no CSMA
  – Minimum collision due to synchronous operation
  – Guaranteed fulfillment of QoS requirements due to centralized scheduling

• TDMA more suitable than CSMA for our requirements
Problem Statement

• Design and implementation of multi-hop wireless TDMA system
  – Dynamically adapting the schedule in response to change in network load and topology
  – Should support best effort (HTTP, FTP) and real time (Voice, Video) traffic
Related Work

• Existing protocols provide hook into madwifi drivers for
  – stripping off CSMA mechanism (SoftMAC)
  – using multiple MAC based on network conditions (MultiMAC)
  – precise time synchronization (MadMAC)
  – control over radio configuration and time critical functions (FreeMAC)

• Till date there is no implementation and evaluation of multi-hop TDMA system
Our Approach

• Centralized TDMA scheduler
  – root node creates the schedule and disseminates it across the network
  – new node join and exit mechanism
  – adaptive schedule based on bandwidth requests
  – synchronization of nodes
Hardware and Software

• 233 MHz soekris board with 256MB HDD and 64MB RAM running voyage Linux
• Atheros Wi-Fi chipset AR5213A
• Open source Madwifi 0.9.4 wireless driver
• Directional Antennas
FRACTEL

ISP

Root Node

Directional Antenna

Soekris Board

Wi-Fi node and antenna
Local Access network
Omni directional local access point
End User

Sector Antenna

Directional Antenna

Soekris Board

Wi-Fi node and antenna
Local Access network
Omni directional local access point
End User
Modifications to Madwifi

• Disabled MAC level acknowledgments
• Disabled random back-off mechanism
• Tweaked CCA mechanism to always sense channel clear
• No RTS/CTS
• Raw packet transmission; no 802.11 frame
• Generating hardware time stamped packets for synchronization
Monitor mode send-receive

Network Layer

Mac Layer

2 bytes added at position 31,32
2 bytes added at position 23,24

ARP Packet
Other Packets

Madwifi HAL

Bytes 31, 32 are modified
Sequence # stamped at 23,24

Network Layer

Mac Layer

Bytes 31, 32 are removed before input_monitor()
Bytes 23, 24 removed in input_monitor()

ath_intr() \rightarrow rx_tasklet()

Madwifi HAL

INTR generated
Packet received \rightarrow rx_timestamp
Synchronization and clock drift

- Variation in drift observed
- Drift compensation mechanism
- Drift dependent resynchronization strategy
- Possible use of guard band
Future Work

• Algorithm
  – Design of centralized TDMA scheduler

• Implementation
  – Generation and processing of control packets at MAC layer
  – Sending packets at precise slot timings

• Testing
  – Indoor benchmarking
  – Outdoor benchmarking