

Wireless TDMA Mesh Networks

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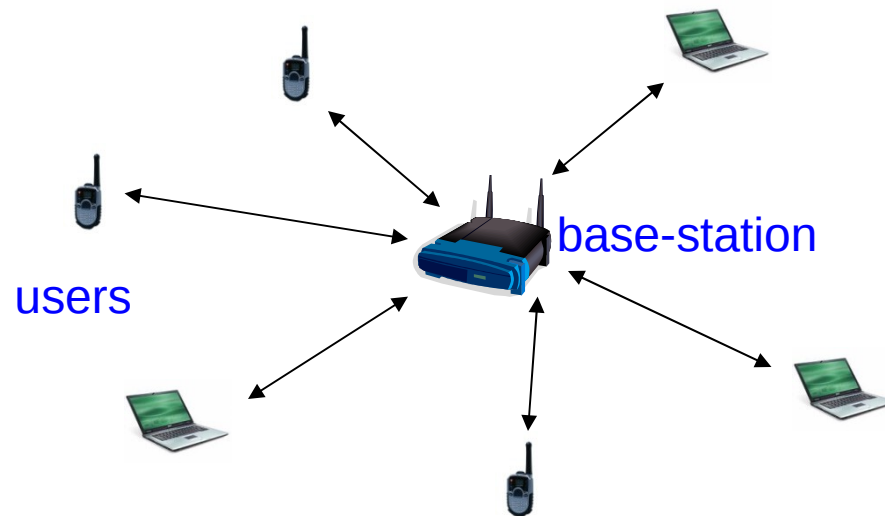
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Outline

- What are mesh networks
- Applications of wireless mesh
- Quality-of-service
- Design and development of a TDMA mesh

Point to Multipoint

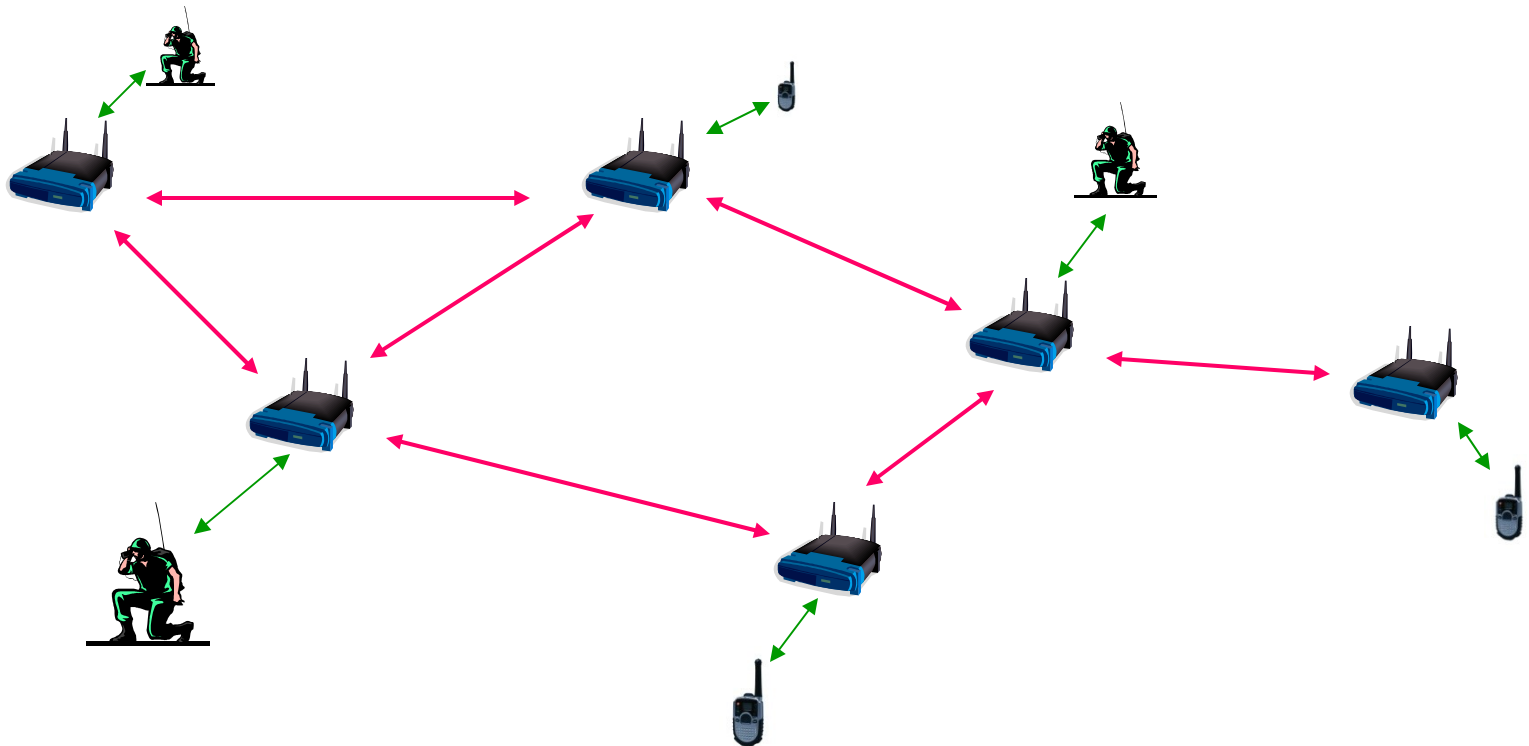
- WiFi
 - single base-station/access point
 - users associate with base-station



- Drawback: covers small area

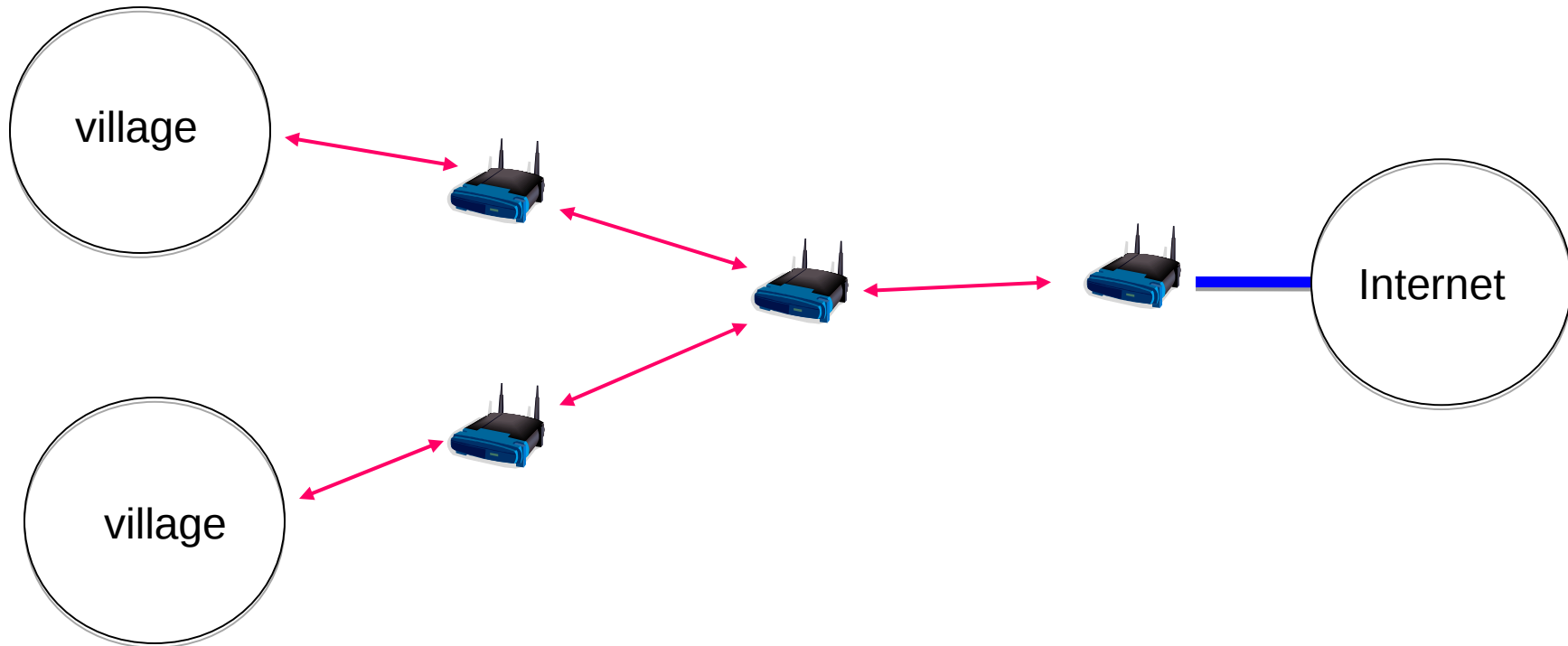
Wireless Mesh Networks

- Multi-hop wireless
- Large coverage area
- Unlike MANETs, base-stations are static (limited nomadic capability)



Applications of Mesh Networks

- Internet connectivity to areas lacking wired connectivity
 - rural areas, disadvantaged urban communities



Disaster Management

- Cyclones, tsunamis, earthquakes can destroy communication infrastructure

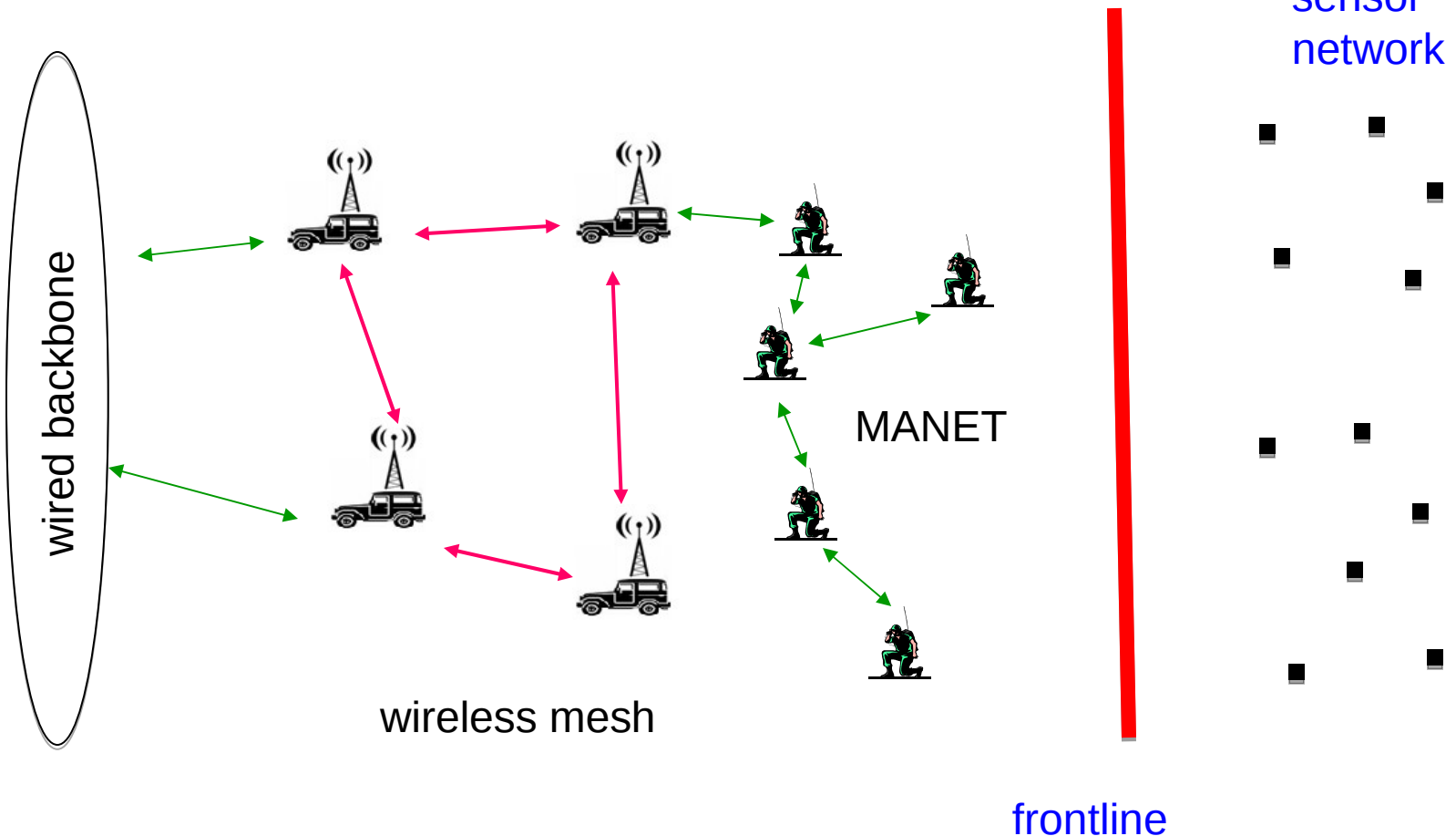


Tsunami devastation

(source: yenisafak.com.tr)

Military Battlefield

- Mesh connects frontline to wired backbone
- MANET and WSN at battlefront



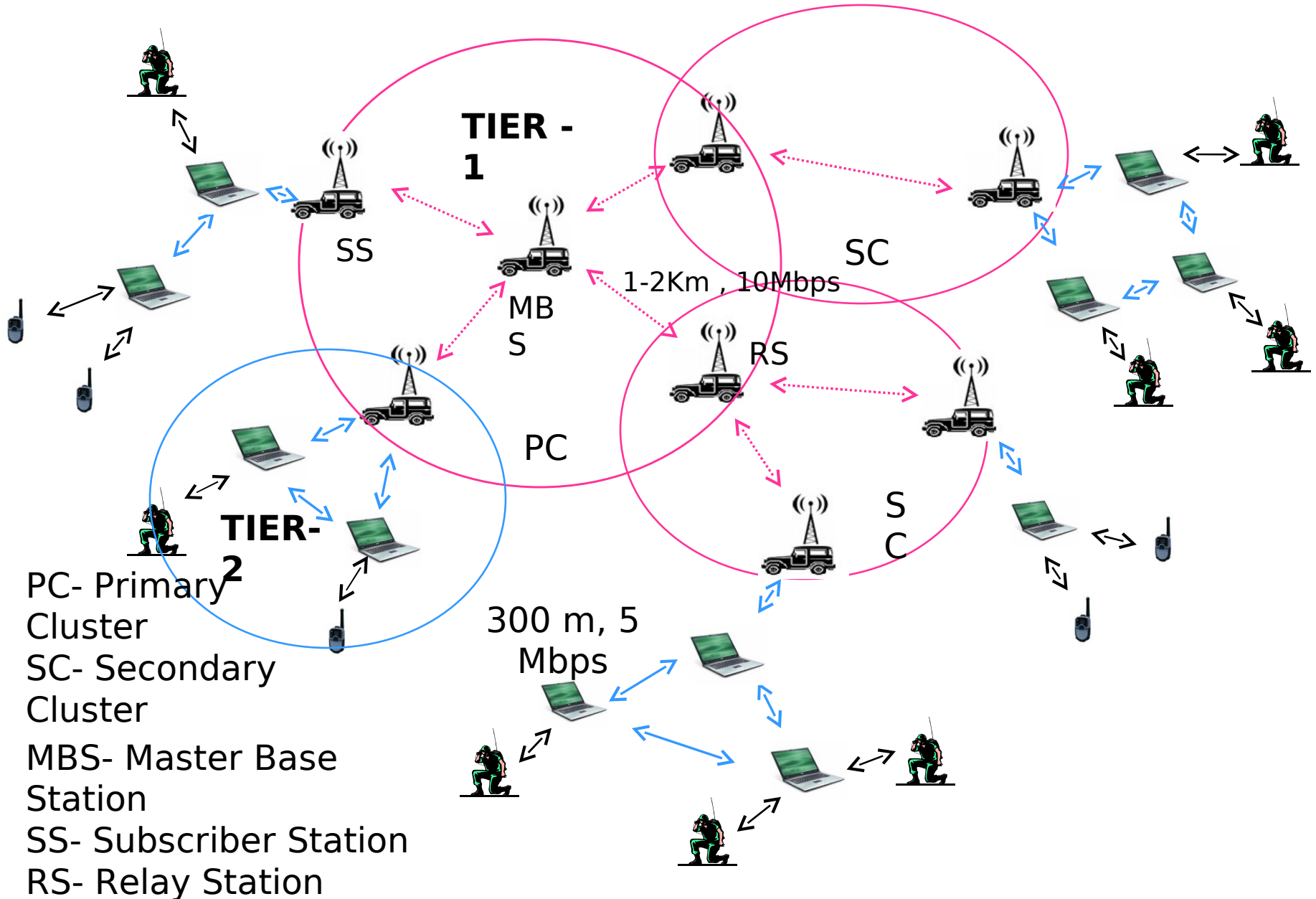
Application Requirements

- Long range (10km diameter)
- Quality-of-service
 - triple play (voice, video, data)
 - high bandwidth (several Mbps), low end-to-end delay (20ms)
- Rapid deployment (minutes)
 - disaster management, military
- Robustness to node failure

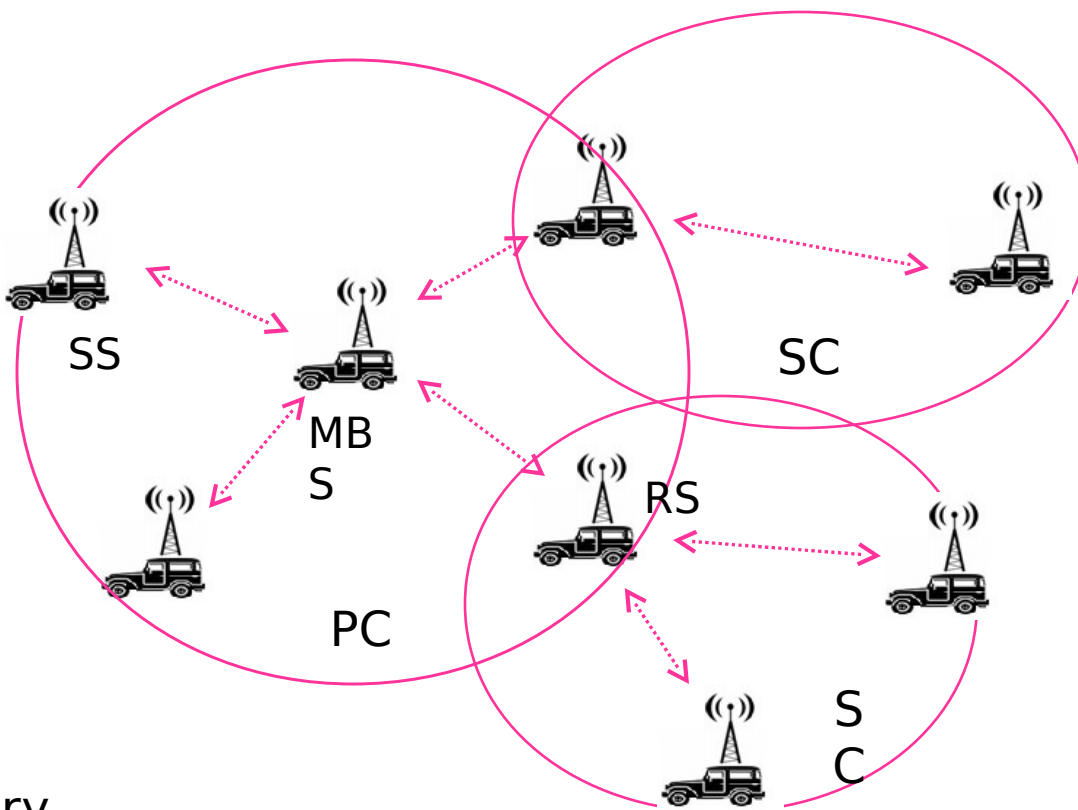
Ongoing DIT Project

- Title: “Design and development of a rapidly deployable WiMAX-based mesh network”
- Investigators: Huzur Saran, Vinay Ribeiro, B. N. Jain, Kolin Paul (CSE dept, IIT Delhi)
- Focus on disaster management and military scenarios
- Build prototype mesh node

Two Tier Network Planned



Tier-1 Topology



PC- Primary
Cluster

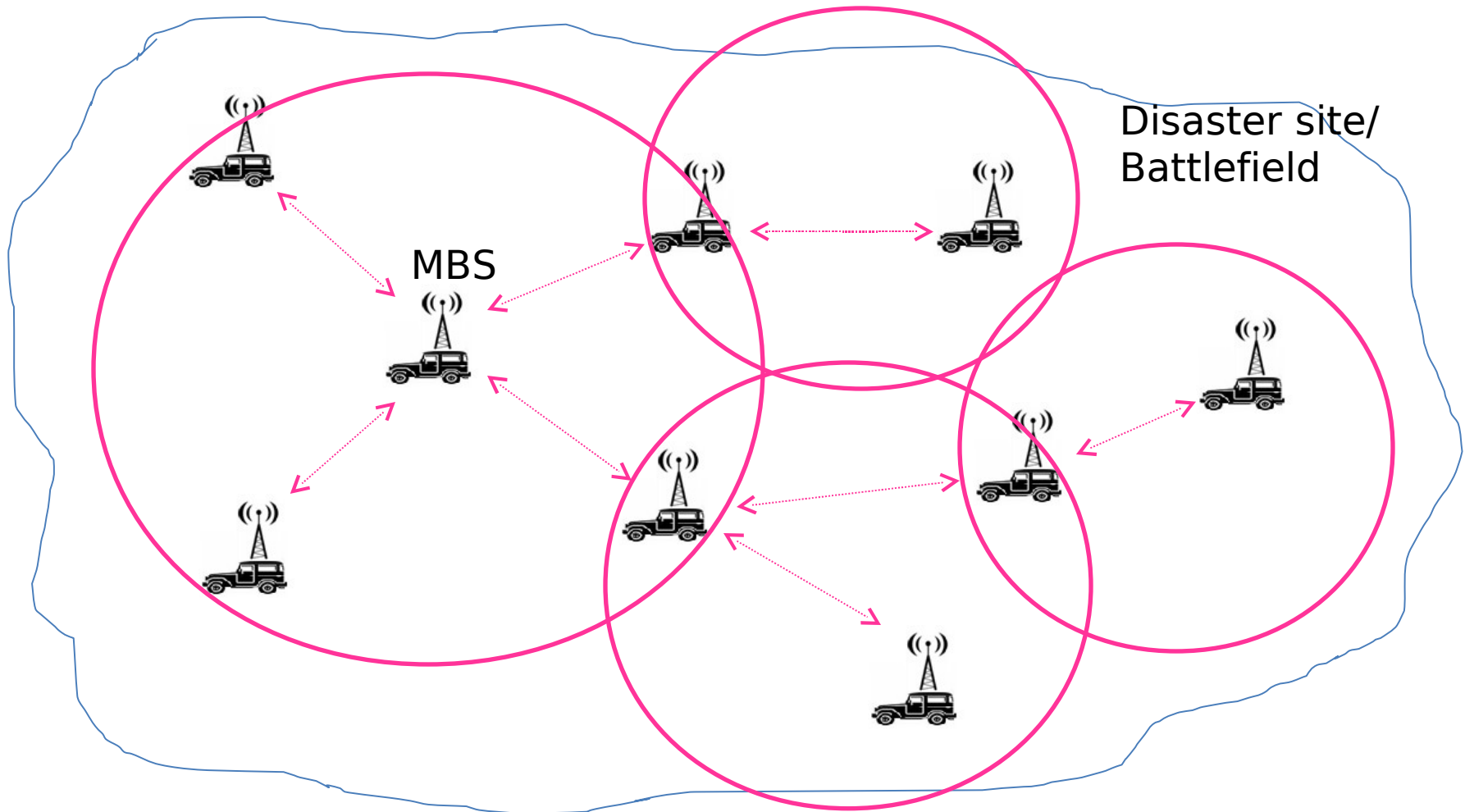
SC- Secondary
Cluster

MBS- Master Base
Station

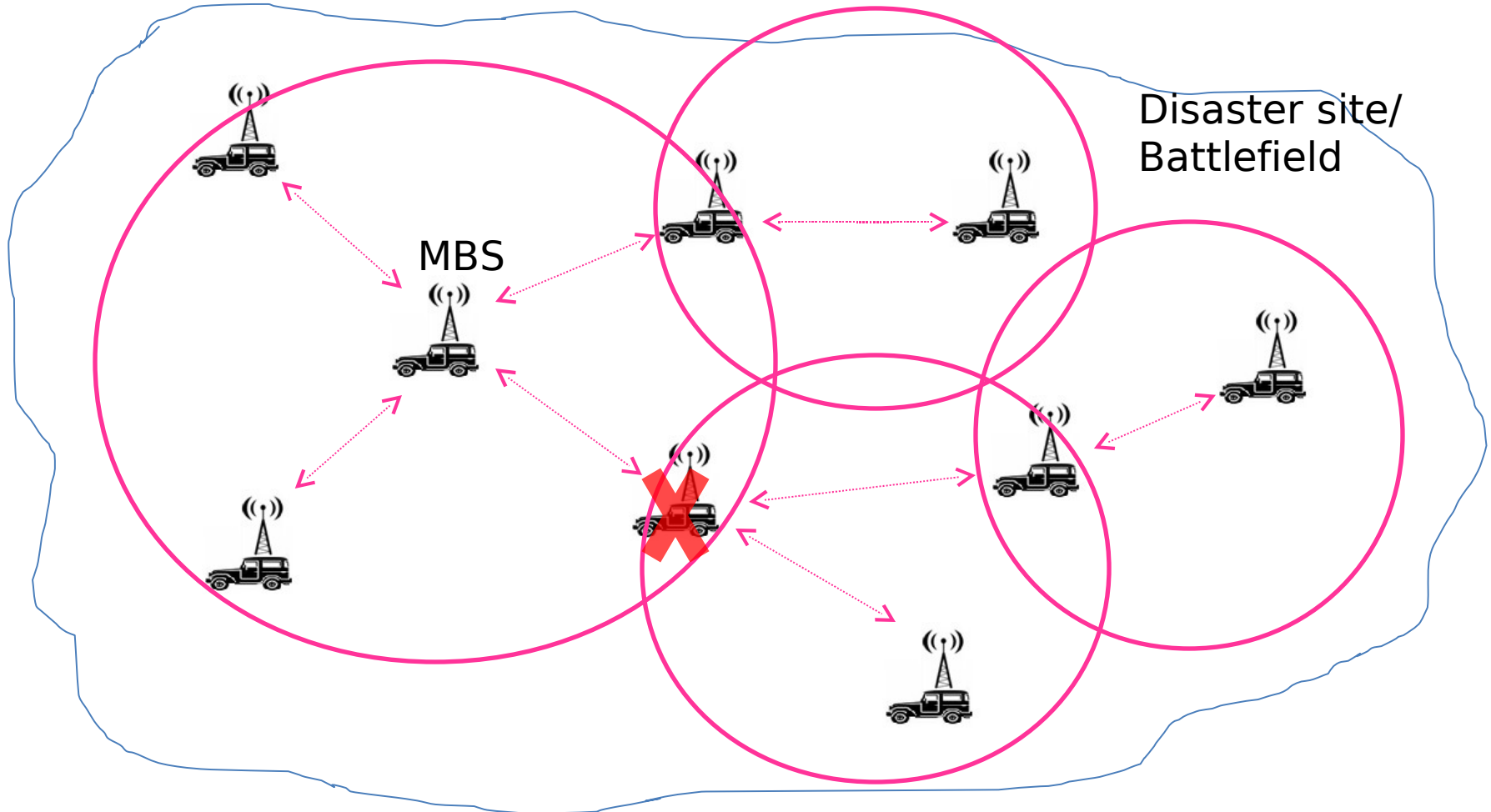
SS- Subscriber Station

RS- Relay Station

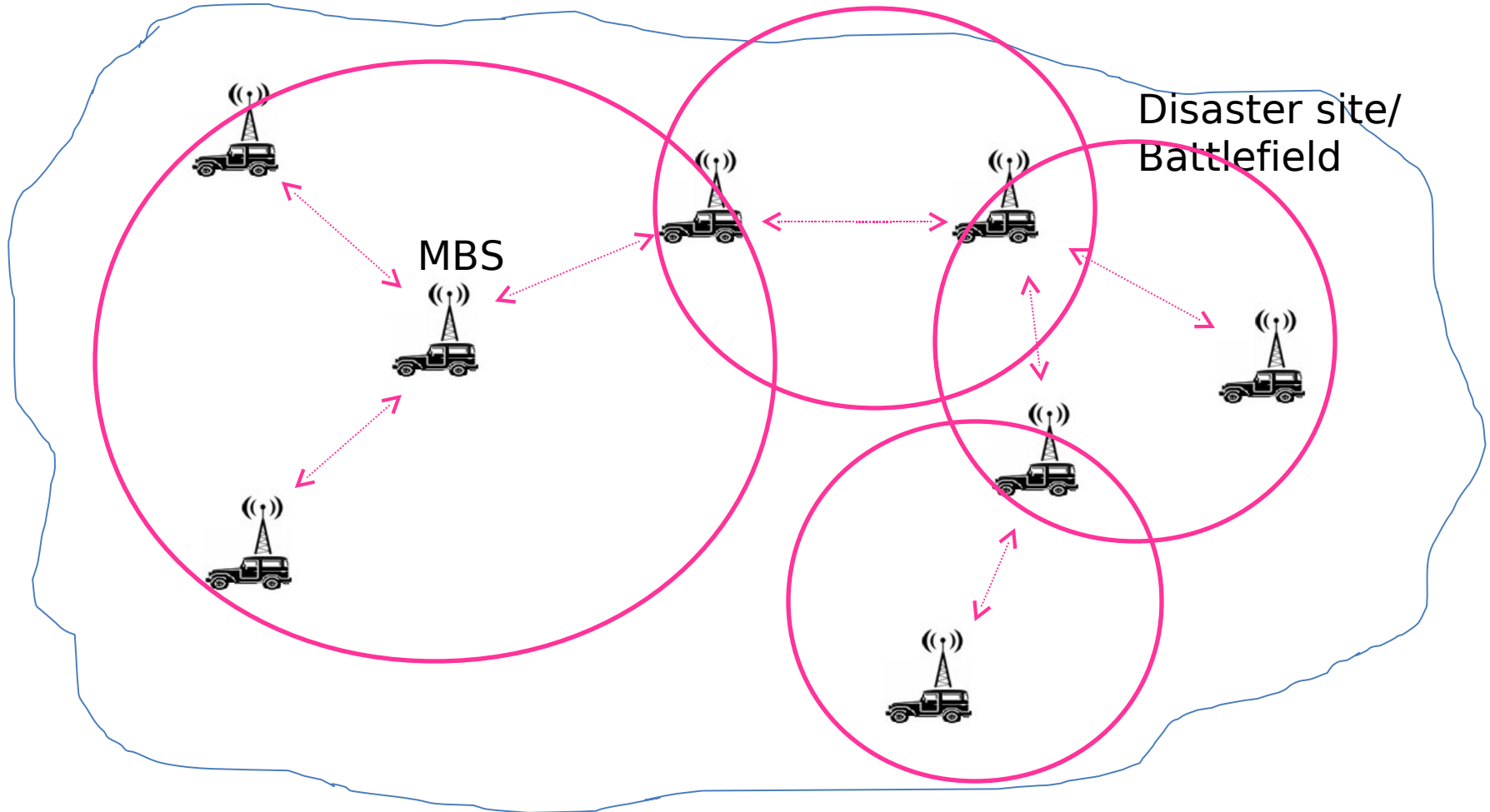
How Rapidly-Deployable and Self-configurable?



How Robust to Node Failure?

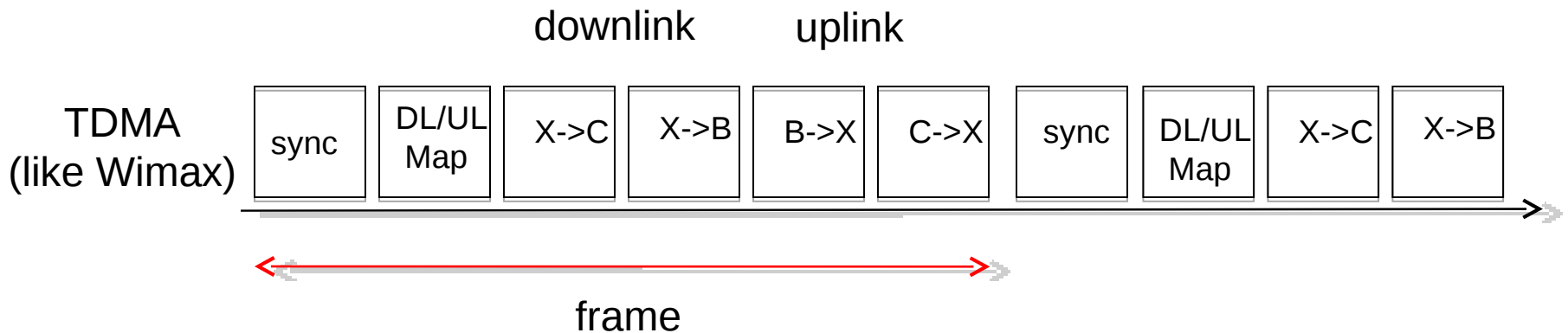
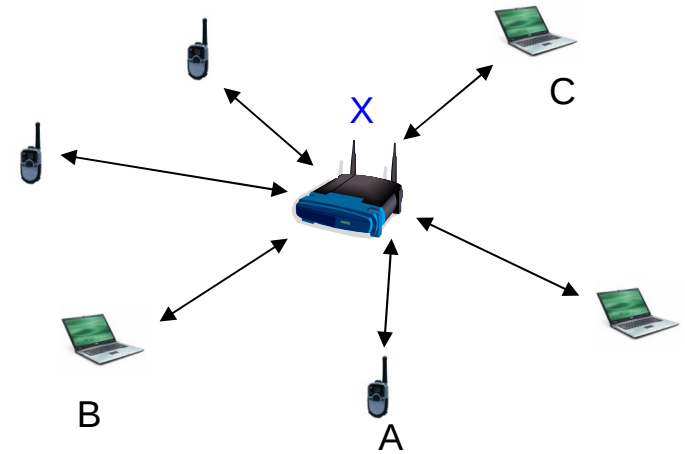
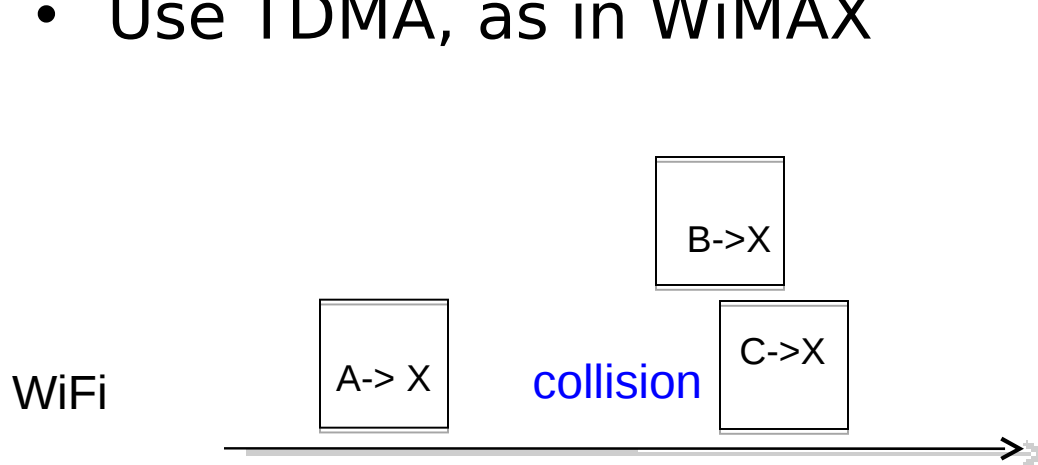


How Robust to Node Failure?



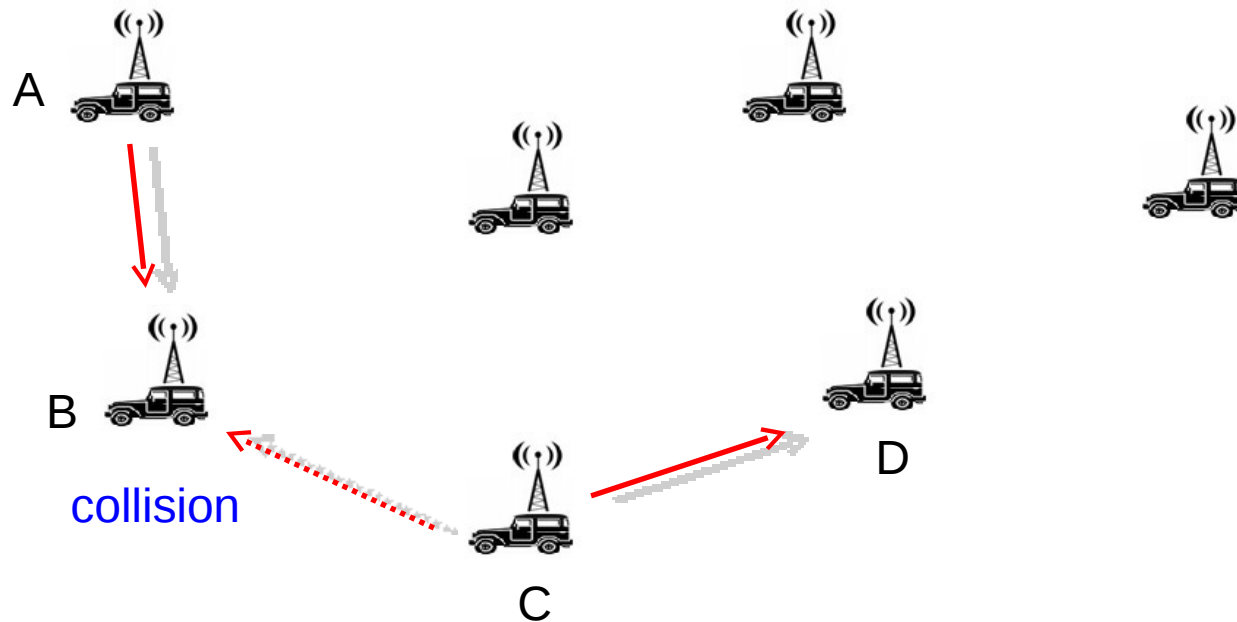
Quality of Service

- Use TDMA, as in WiMAX



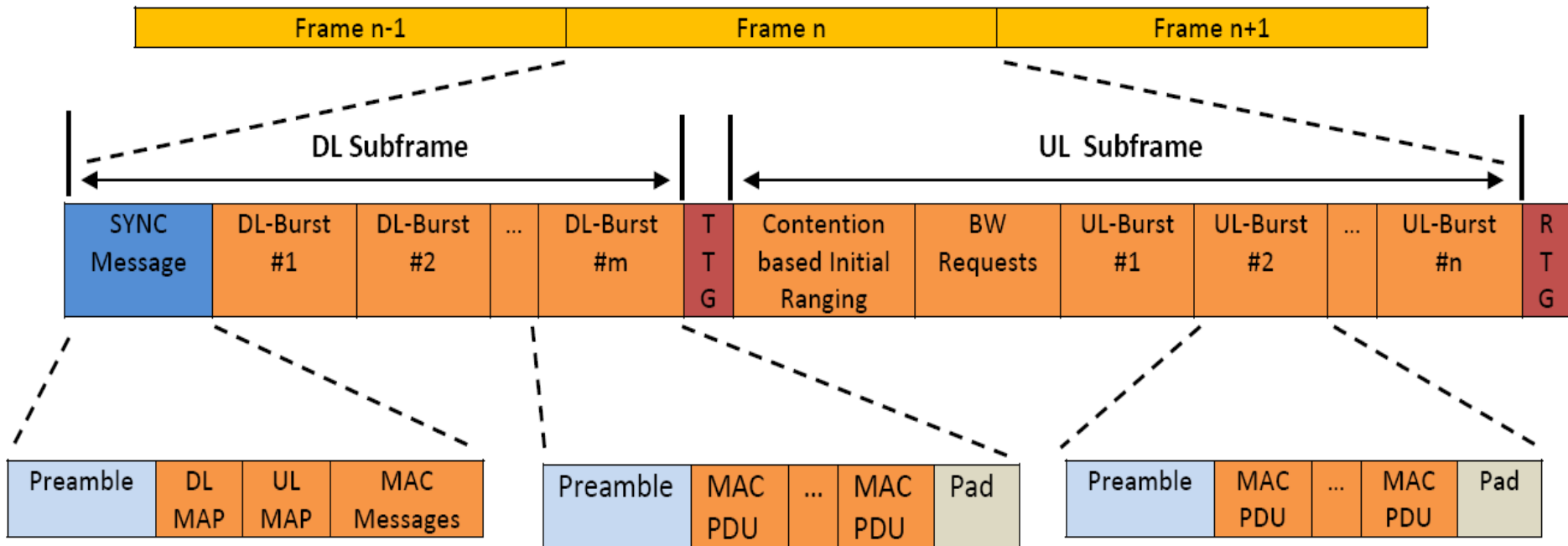
Scheduling in Mesh is Non-Trivial

- Interference, hidden terminal problems
- joint scheduling and routing

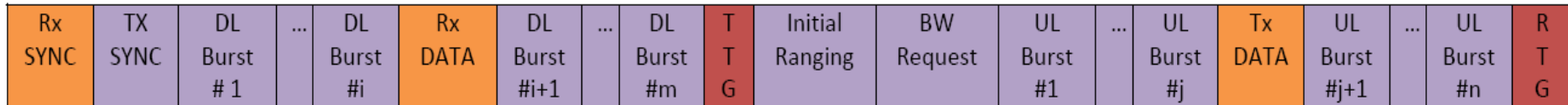


- need spatio-temporal scheduling

Frame Structure of MBS



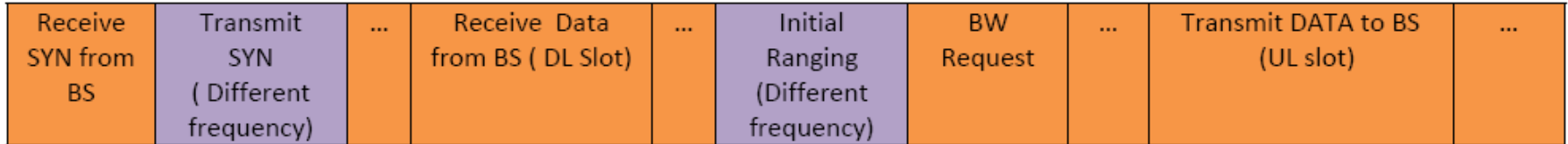
Frame Structure of RS



- Frequency f_0 Where RS is acting as a SS
- Frequency f_1 Where RS is acting as a BS
- Tx/Rx transition gap, Rx/Tx transition gap

Relay uses different frequency channel in its own cluster

Frame Structure of SS

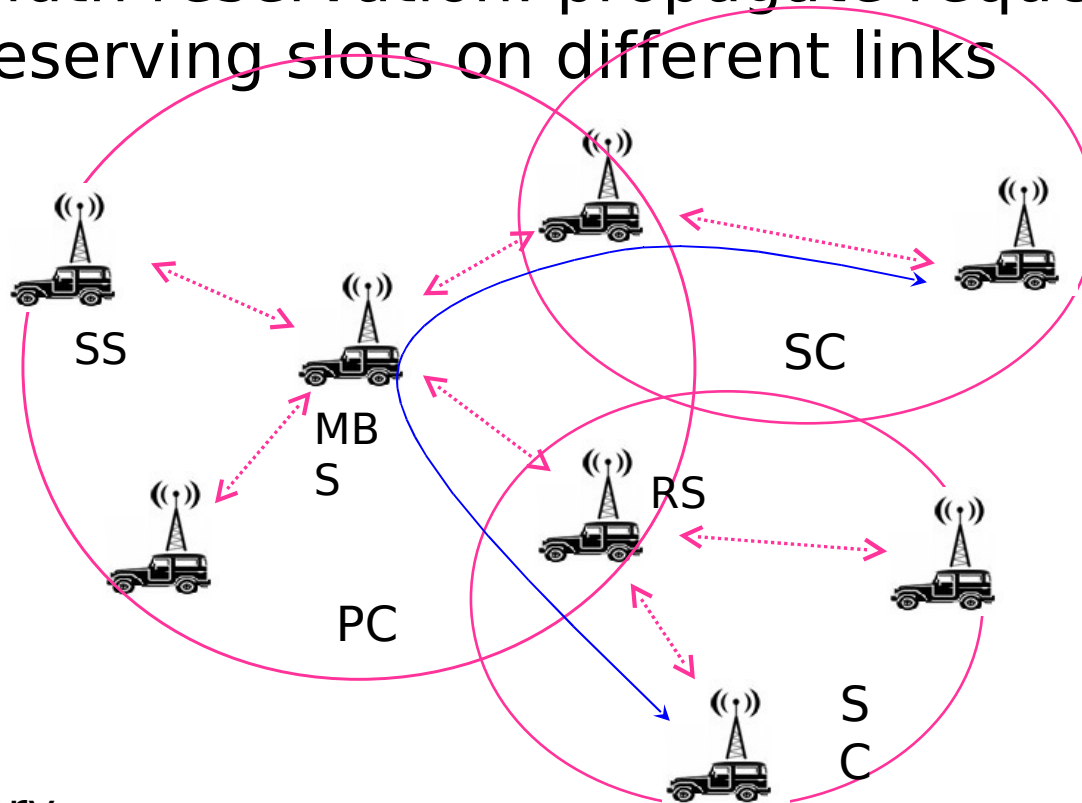


■ Sent in each i th frame where i is a configurable parameter.

- SS can act as a relay for other nodes
- each cluster uses different frequency band
- when SS not communicating with MBS, switch to own frequency and transmit SYN

Scheduling and Routing

- Tree structure: only one routing path between pair of nodes
- bandwidth reservation: propagate request over tree, reserving slots on different links



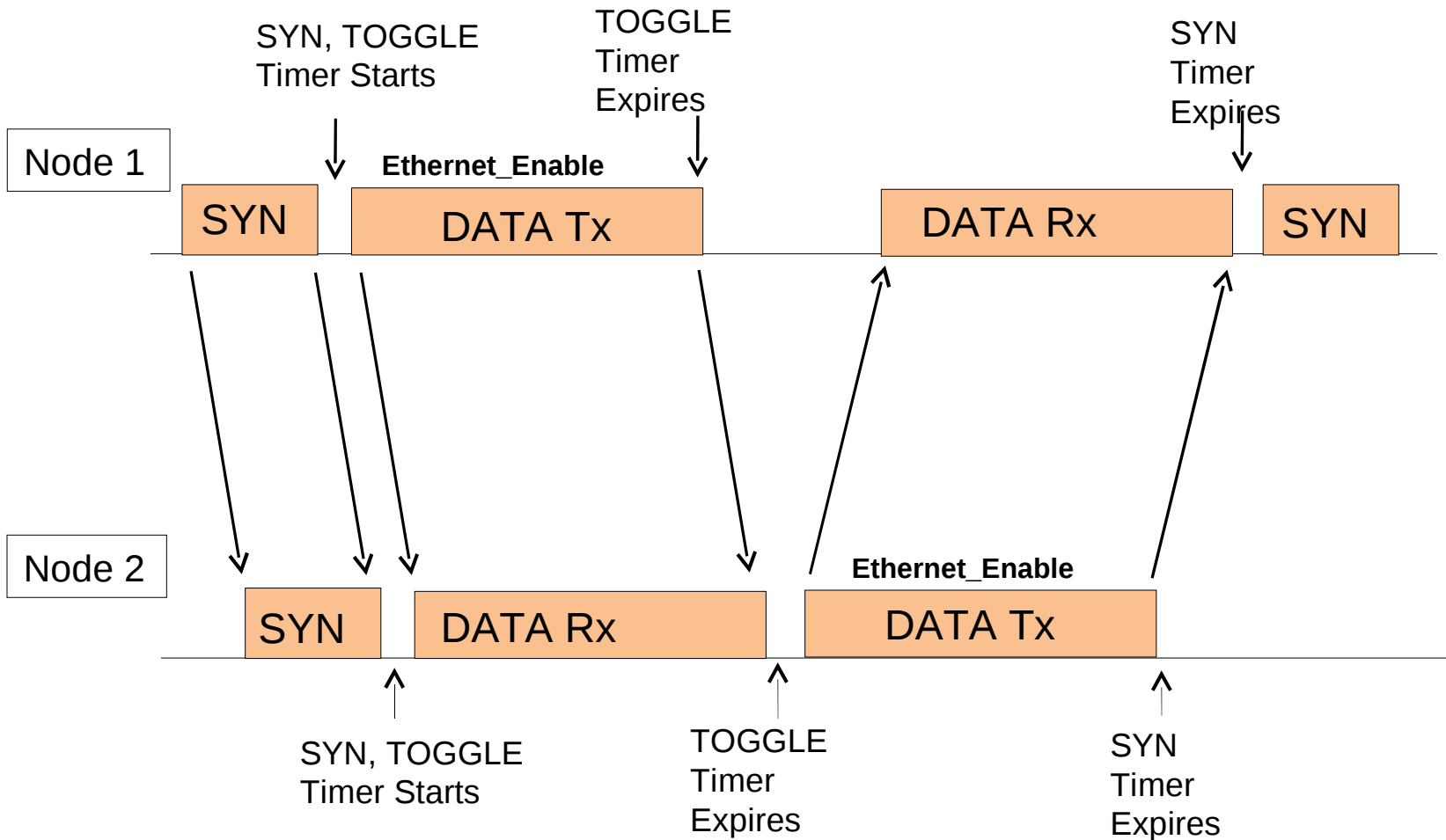
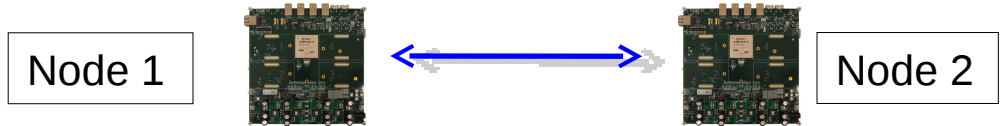
PC- Primary
Cluster
SC- Secondary
Cluster

Hardware Platforms

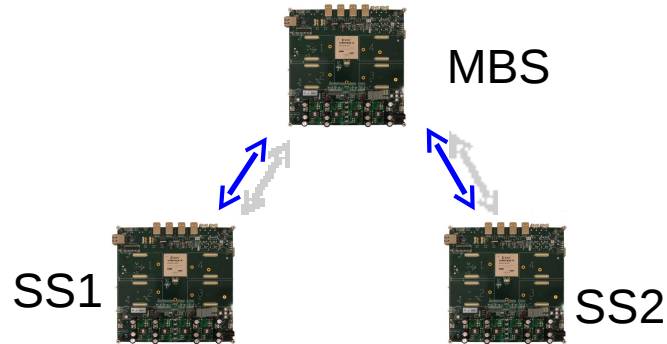
- Wireless open Access Research Platform (WARP)
 - tier-1 mesh node, FPGA-based, RF daughterboards (WiFi chipsets)
 - standalone board, 2.4GHz ISM band
- Runcom technologies WiMesh node
 - tier-2. PCMCIA cards, WiMAX self-configurable, multihop,



Two Node TDD



Three Node TDMA

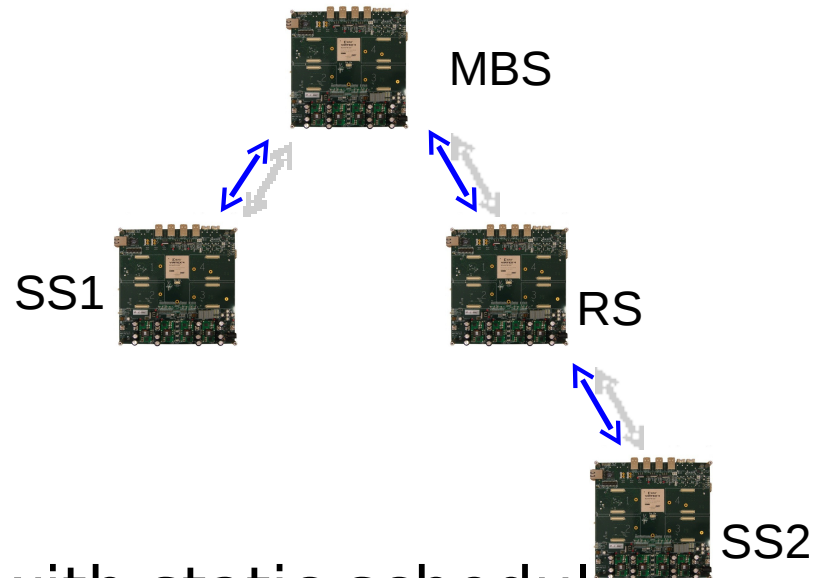


At MBS



- SS1 → MBS → SS2 throughput (iperf UDP): **8 Mbps**
- Fixed schedule, no application specific QoS yet
- PHY: SISO, 10MHz chl, OFDM, 2.4GHz band, QAM-16
- MAC: frame length 4.8ms, slot duration 1ms

Four Node Mesh



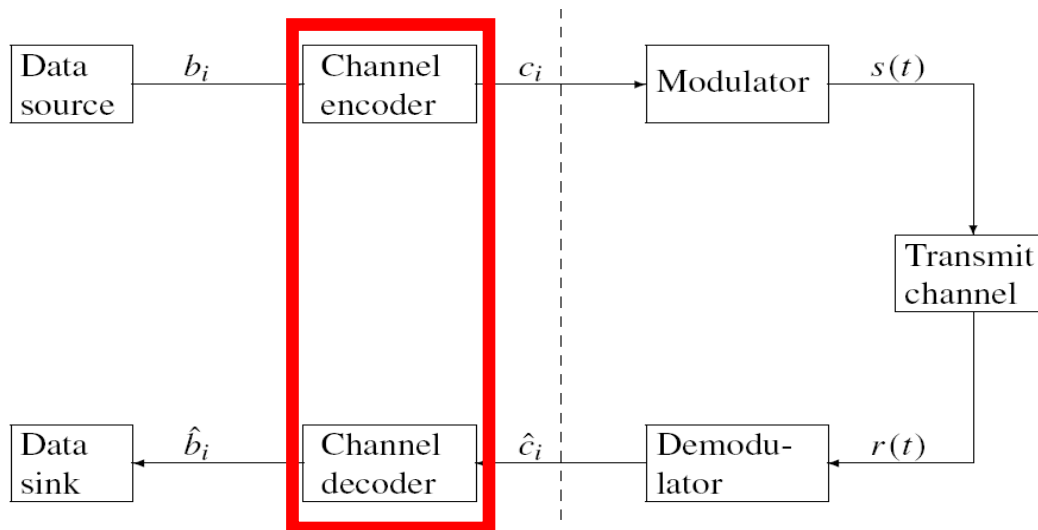
- Implemented with static scheduling
- Frame size: 7ms, slot size 1ms
- Experimentation ongoing

Achieving Long-Range

- directional antennas (not good for rapid deployment)
- Increase transmit power
- increase antenna height
- improve coding, use MIMO
- use lower center frequency

Reducing Packet Loss

- Type-1 Hybrid ARQ
 - If no. of errors is within the error correcting capability of the FEC code then decoded message saved
 - Else received message is discarded and retransmission requested



- Result: Packet loss decreased by 4x for CSMA MAC, SISO, LOS
- FEC used: convolutional code used in 802.11a

Runcom WiMesh Experiments

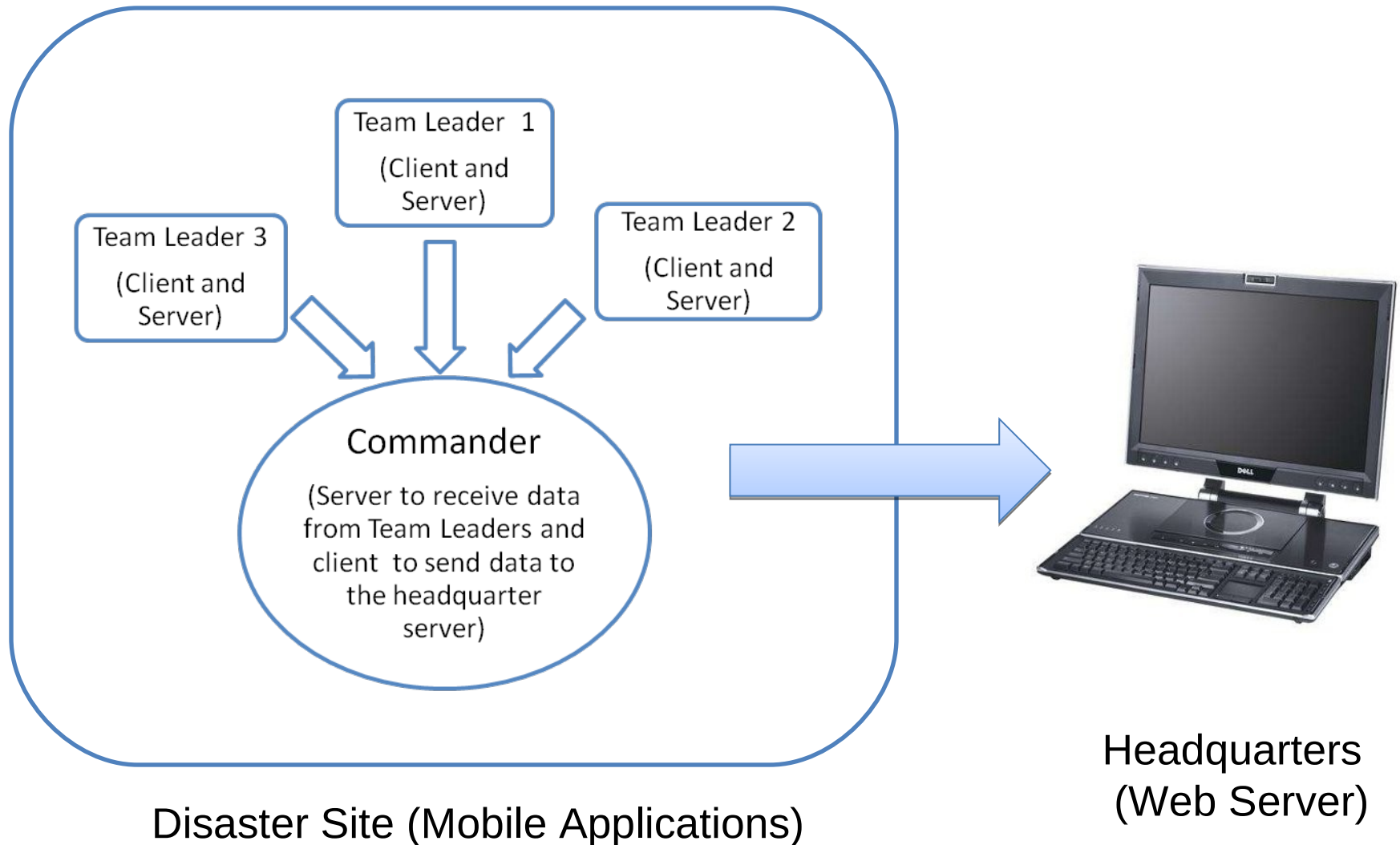
- Preliminary results (may improve with upgraded firmware)



- Two node experiment, transmit power: 15dBm
- Outdoor NLOS: range 53m, 6 Mbps data rate
- Outdoor LOS: range 120m, video streaming
- uses two bands 2.3GHz and 2.7GHz
- two transceivers (uplink/downlink simultaneously)
- Future: Handoff experiments, directional antennas

Disaster Management Applications

- Android based, hands-free, voice-based activation



Conclusions

- TDMA wireless meshes can provide QoS over large spatial area, all-wireless
- Design of a rapidly deployable mesh for disaster management
 - two tier network
- Platform choice WARP, Runcom WiMesh
- 4-node tier-1 network developed, applications on Android
- Future: implementation of dynamic node joining, QoS/bandwidth reservation