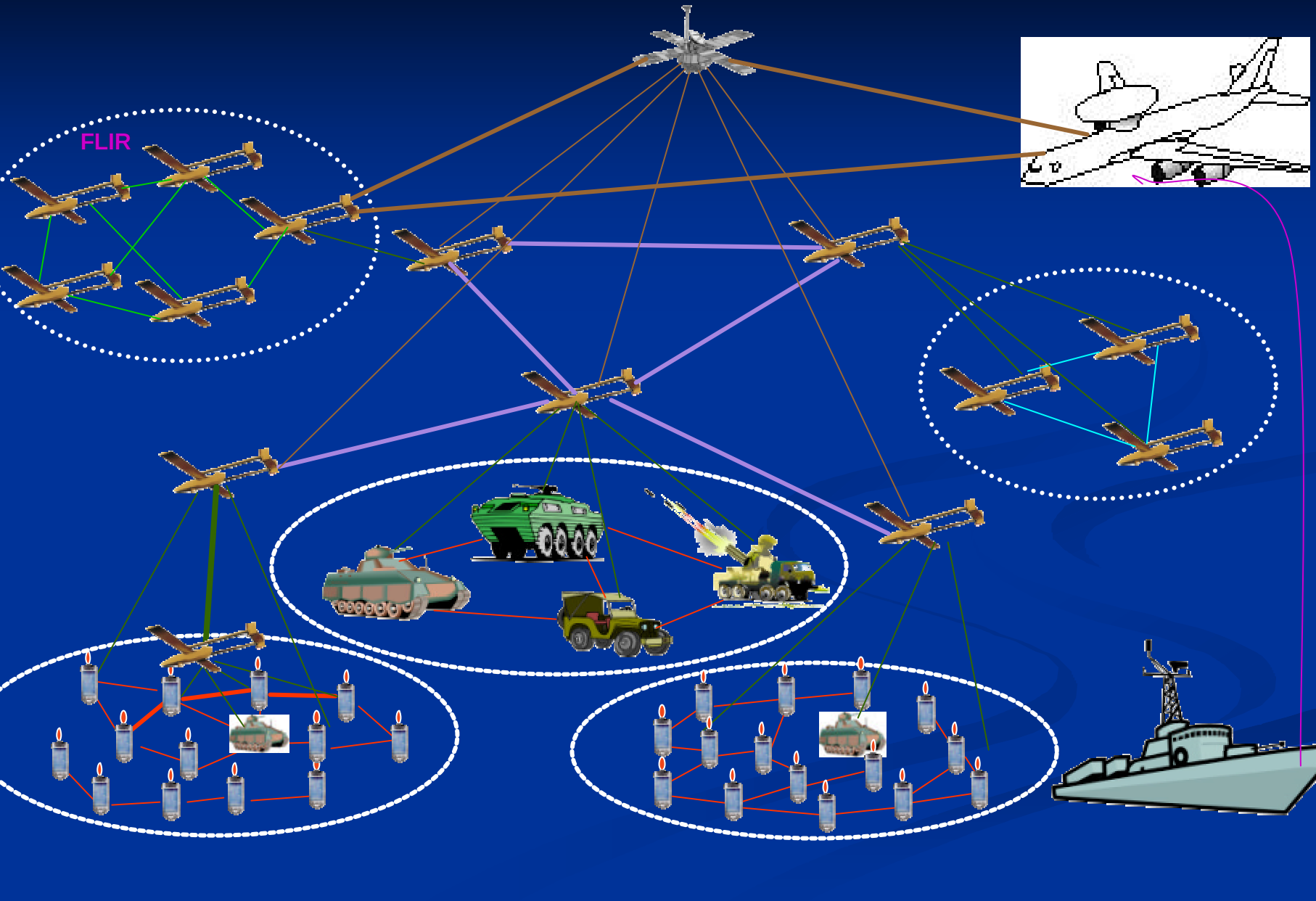
Multicast-Enabled Landmark (M-LANMAR) : Implementation and scalability

YunJung Yi, Mario Gerla, JS Park, Yeng Lee, SW Lee

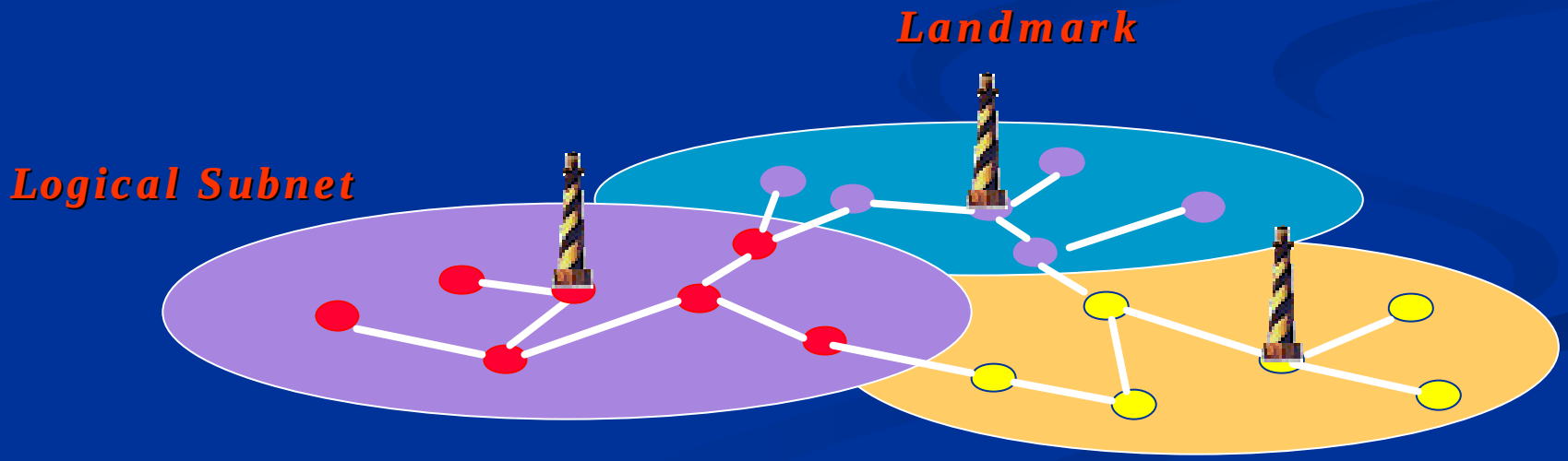
Computer Science Dept
University of California, Los Angeles

The AINS Scenario



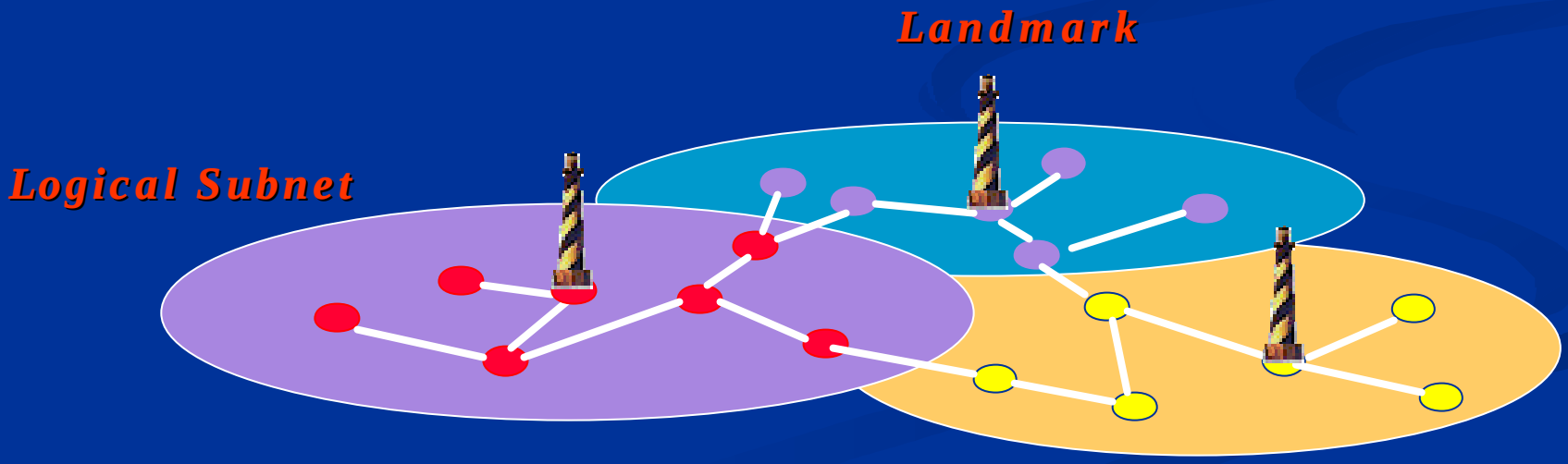
LANMAR

- Key insight: nodes move in teams/swarms
  - Each team is mapped into a logical subnet
  - IP-like Node address = <subnet, host>
  - Address compatible with IPv6
  - Team leader (Landmark) elected in each group



LANMAR (cont)

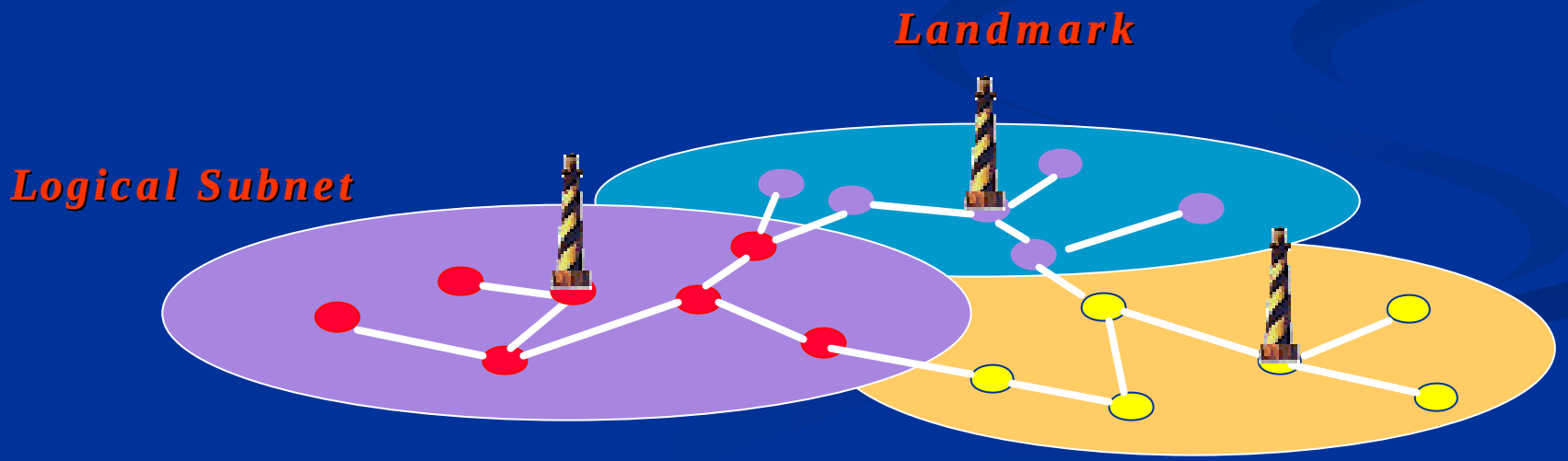
- Three main components in LANMAR:
  - **(1) "local " routing algorithm that keeps accurate routes within local scope < k hops (e.g., Distance Vector)**
  - **(2) Landmark selection within each logical group**
  - **(3) Landmark routes advertised to all nodes**



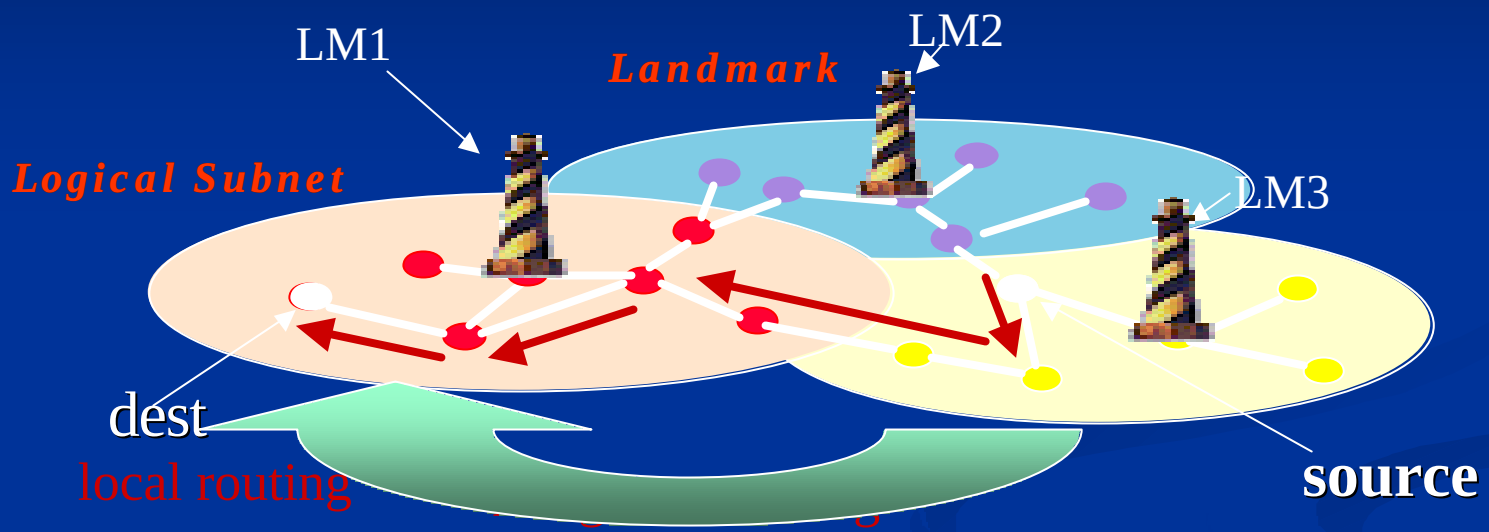
LANMAR (cont)

- A packet to "local" destination is routed directly using local tables
- A packet to remote destination is routed to corresponding Landmark
- Once the packet is "in sight" of Landmark, the direct route is found in local tables.

Main benefit: routing O/H reduction => scalability



LANMAR Review



1. Node address = {subnet ID, Host ID}
2. Lookup local routing table to locate dest → fail
3. Look up landmark table to find destination subnet → LM1
4. Send a packet toward LM1

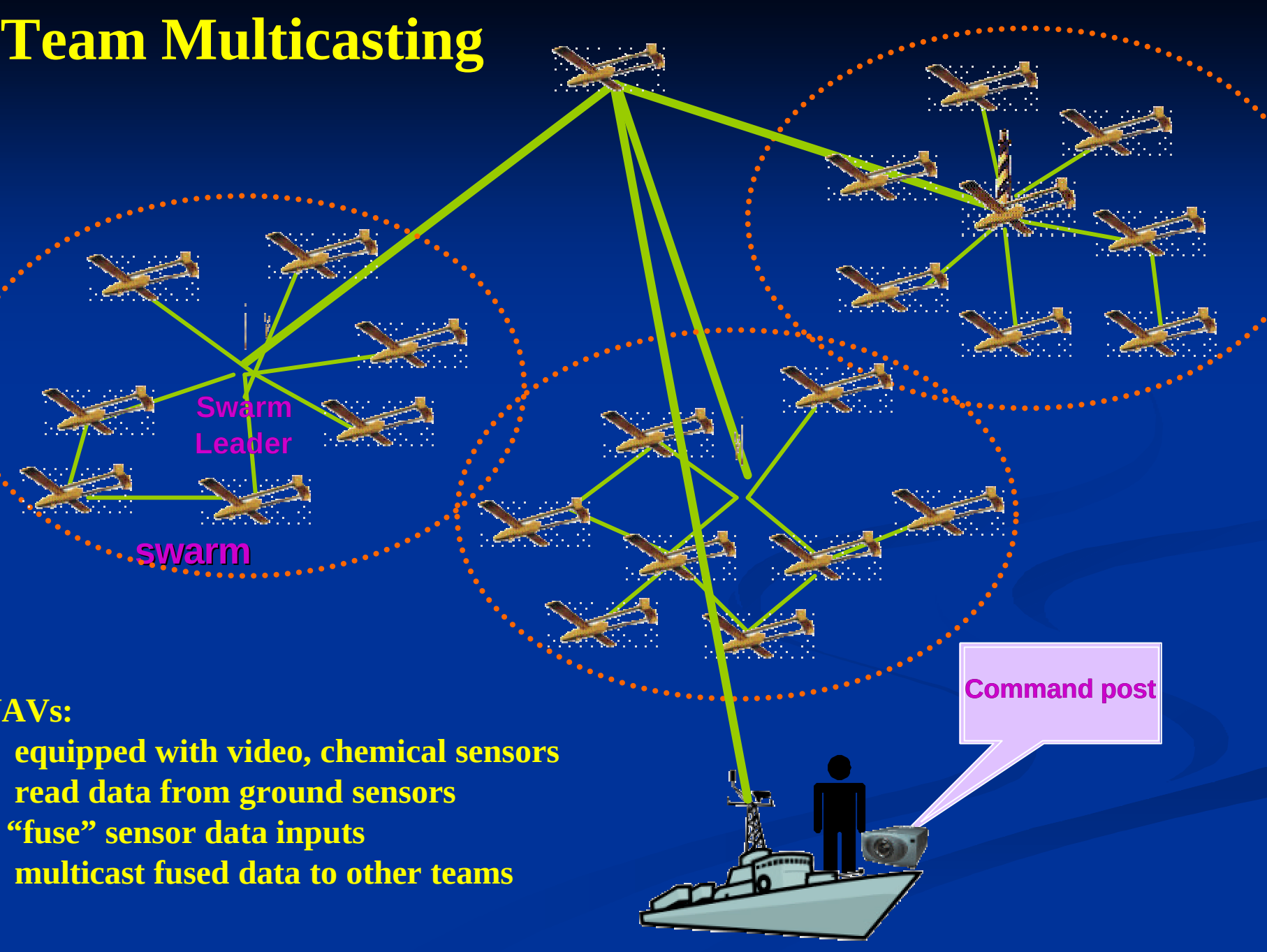
Scalable Ad hoc multicasting

- Multicast (ie, transmit same message to all member of a group) critical in battlefield

- "Multiple unicast" does not scale
- Current ad hoc multicast solutions: inappropriate
  - They do not exploit affinity team model
  - multicast tree approach is "fragile" to mobility;
  - no congestion control; no reliable end to end delivery

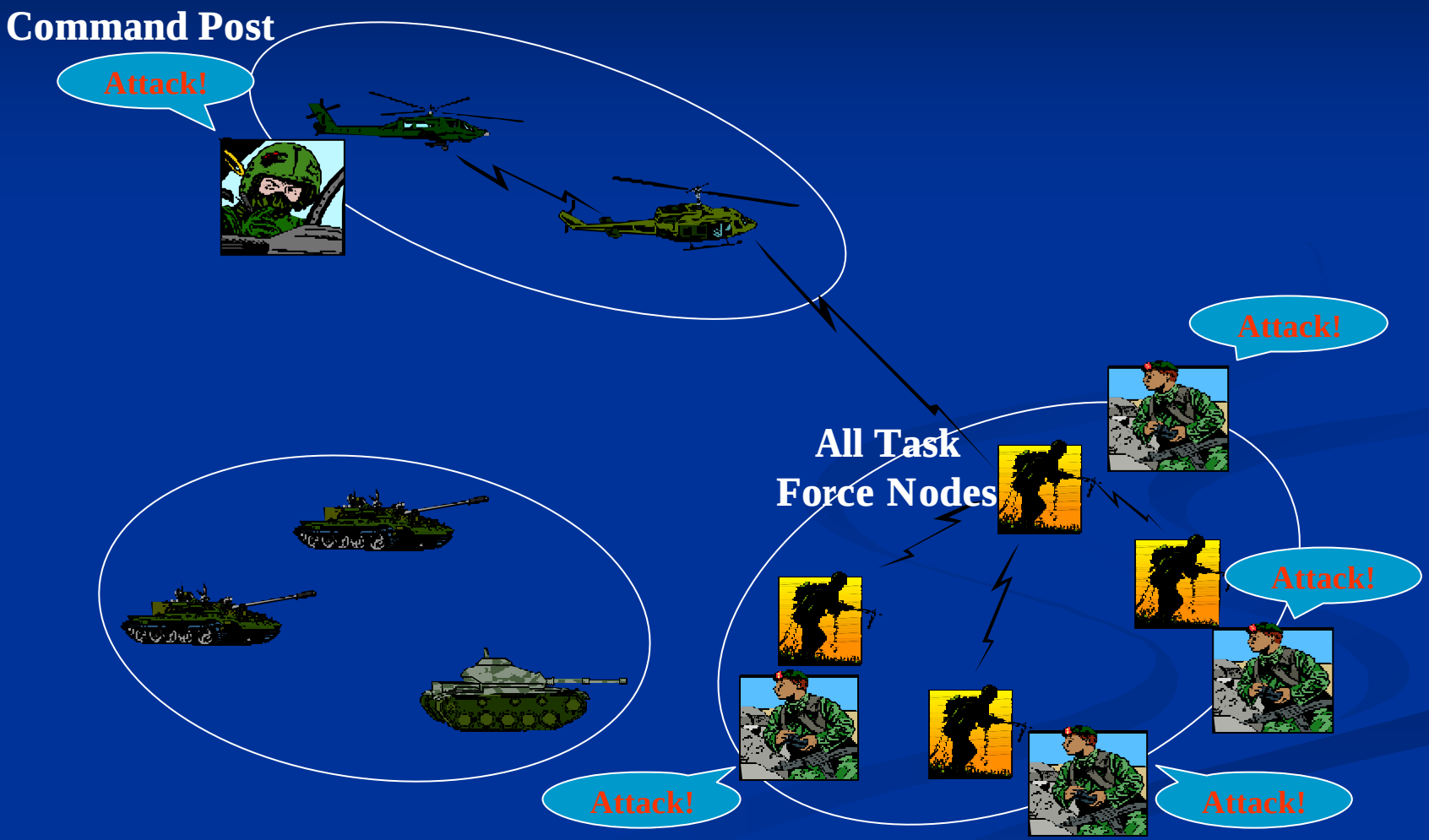
- Proposed approach:
  - **TEAM Multicast**

Team Multicasting



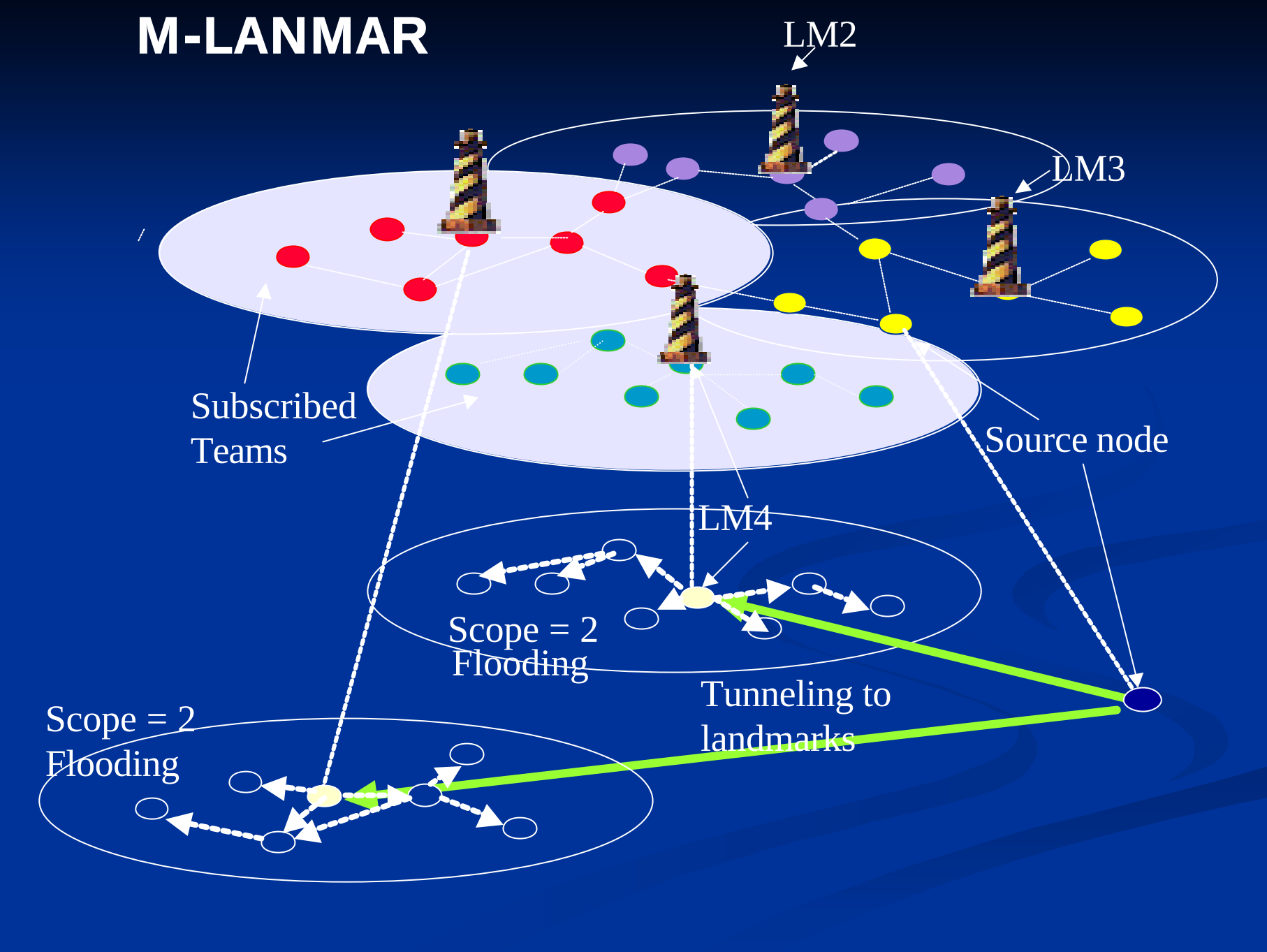
AVs:
- equipped with video, chemical sensors
- read data from ground sensors
- "fuse" sensor data inputs
- multicast fused data to other teams

Multicast example



Two-tier team multicast: M-LANMAR

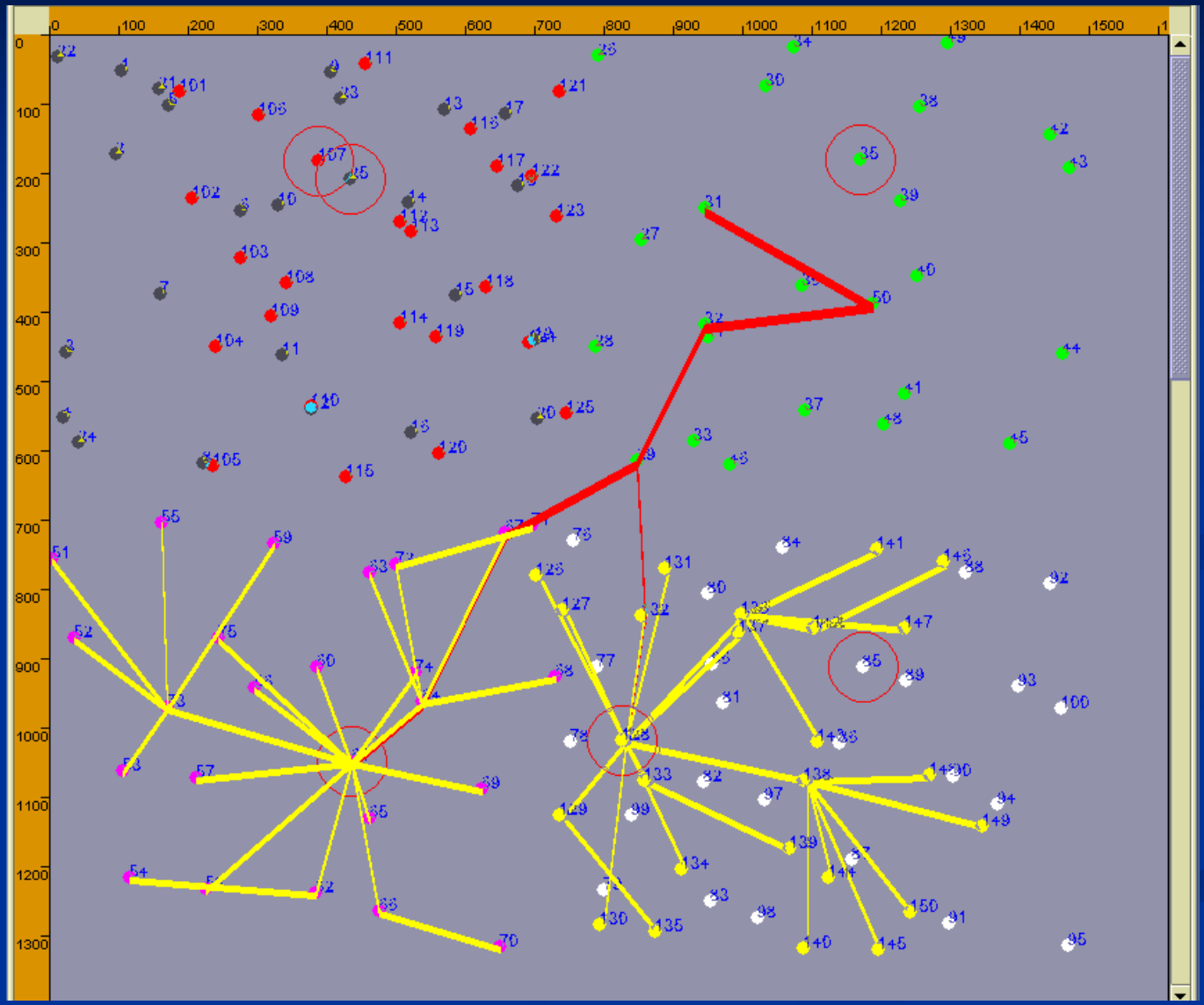
- Extension of LANMAR enabling multicast
  - Inter-team communication: unicast tunneling from the source to the representative of each subscribed team
  - Intra-team communication: scoped flooding within a team

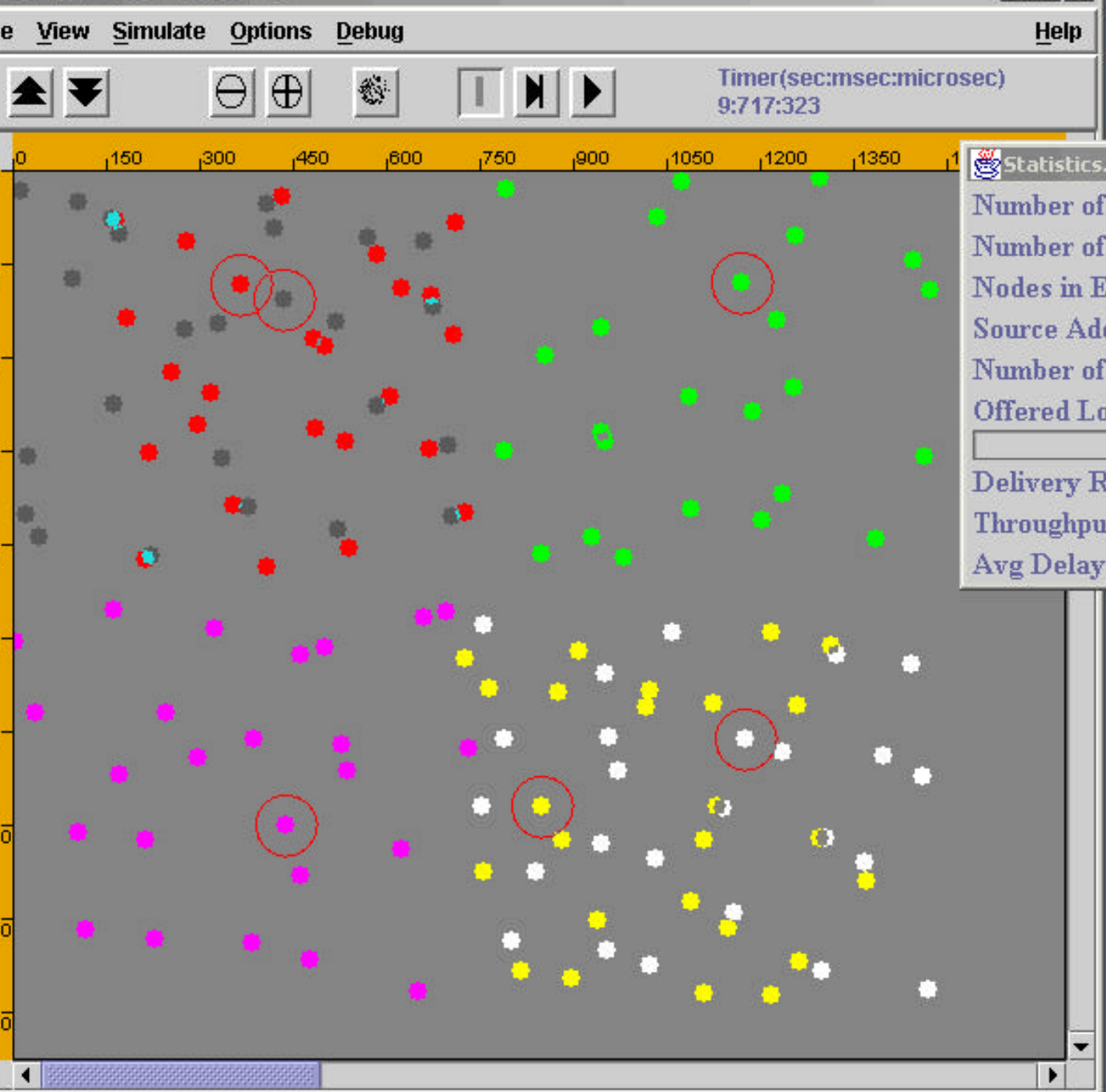

M-LANMAR
LM2
LM3
LM4
Subscribed
Teams
Source node
Scope = 2
Flooding
Tunneling to
landmarks
Scope = 2
Flooding

Advantages of M-LANMAR

- Reduced control traffic overhead
- Scalable to thousands of nodes
- Enhanced Congestion control and Reliability (because of TCP control on unicast tunnels)

M-LANMAR multicast



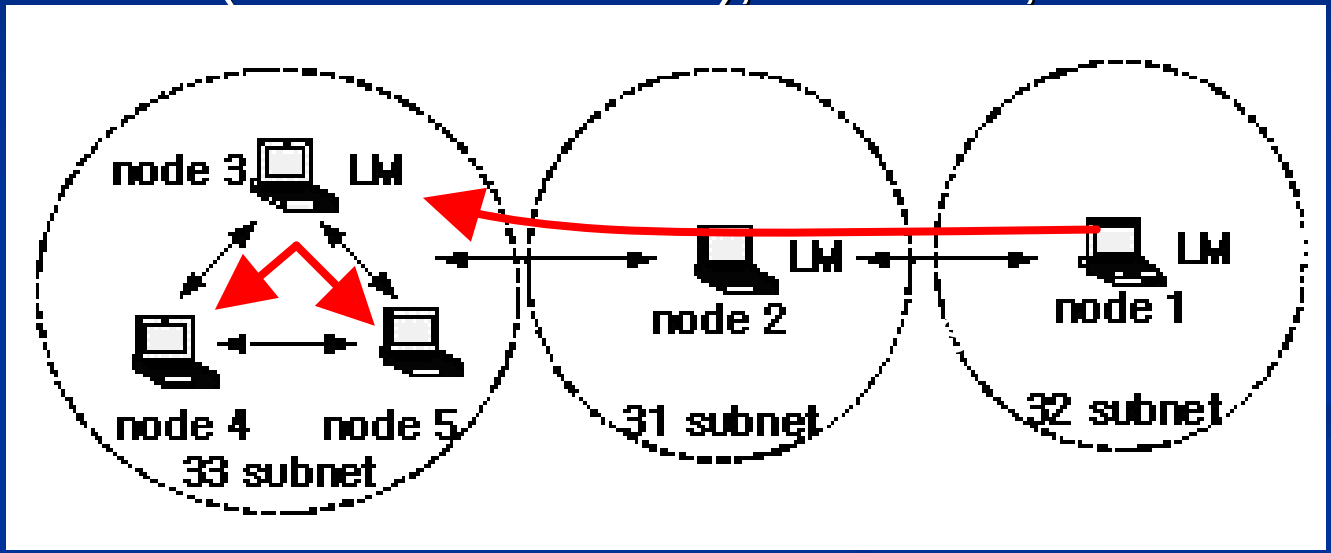

e View Simulate Options Debug Help
Timer(sec:msec:microsec)
9:717:323
0 150 300 450 600 750 900 1050 1200 1350
Statistics...
Number of Nodes 150
Number of Subnets 6
Nodes in Each Subnet 25
Source Address
Number of Members (#)
Offered Load bits/s
Delivery Ratio %
Throughput bits/s
Avg Delay msec

M-LANMAR Implementation

- User level M-LANMAR daemon on Linux
- M-LANMAR daemon functions:
  - LANMAR routing
  - Group membership management
  - Packet forwarding engine for tunneling and scoped flooding
- Compatible with any conventional multicast application (eg, vic = video conferencing tool from UCB)

Testbed configuration

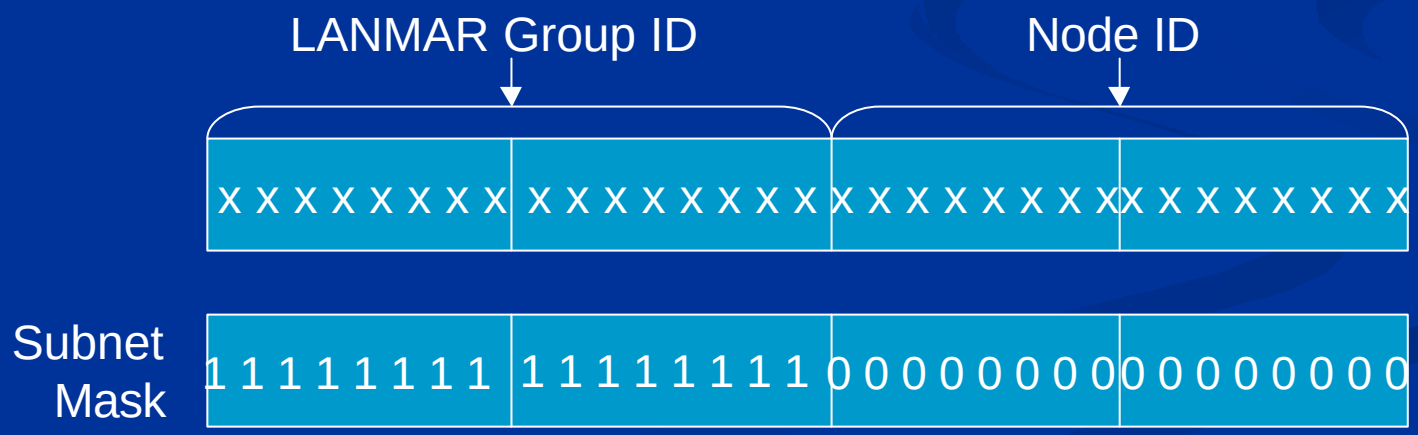
- 3 teams (= 3 IPv4 subnets), 1 sender, 3 receivers



- Dell P4 laptop with Lucent Orinoco 802.11b pcmcia card
- CBR traffic (512B/packet, 5~15 packets/sec)
- Protocols: **ODMRP; M-LANMAR**

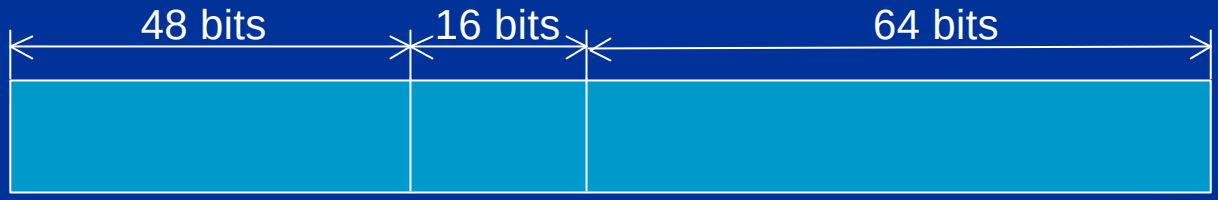
LANMAR Addressing in IPv4

- Each LANMAR group is an IPv4 subnet
- The address of a node then has format as <group-ID, node-ID>

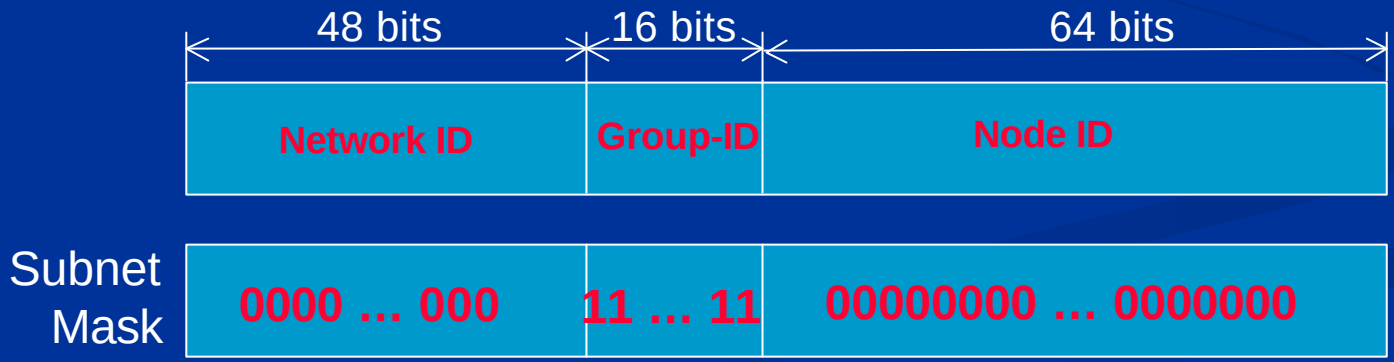


LANMAR Addressing in IPv6

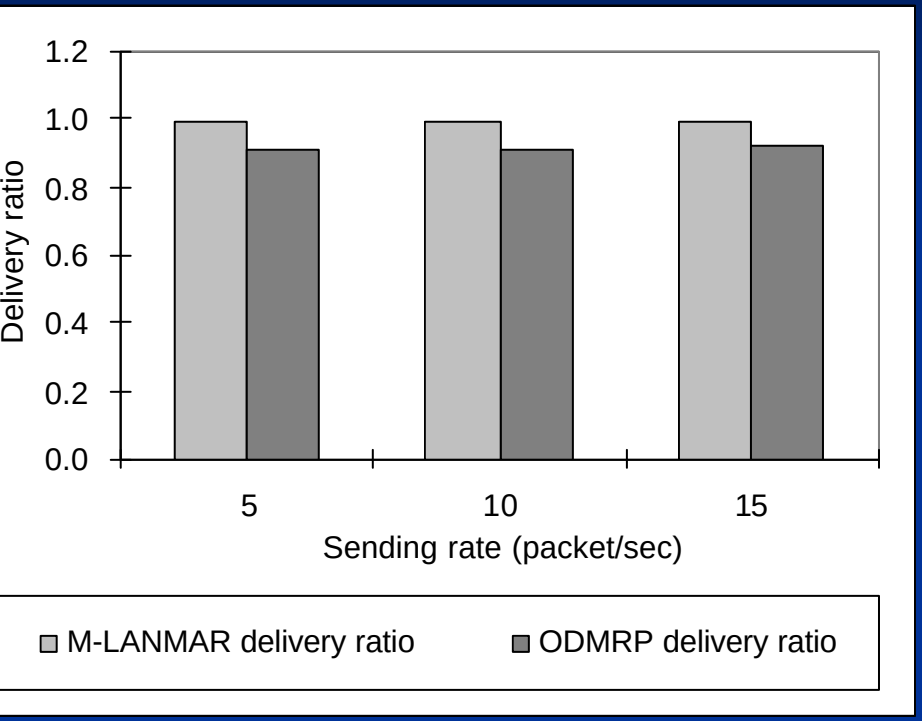
- "Limited-Scope" IPv6 address format proposed in IETF Internet draft (<draft-templin-lsareqts-00.txt)

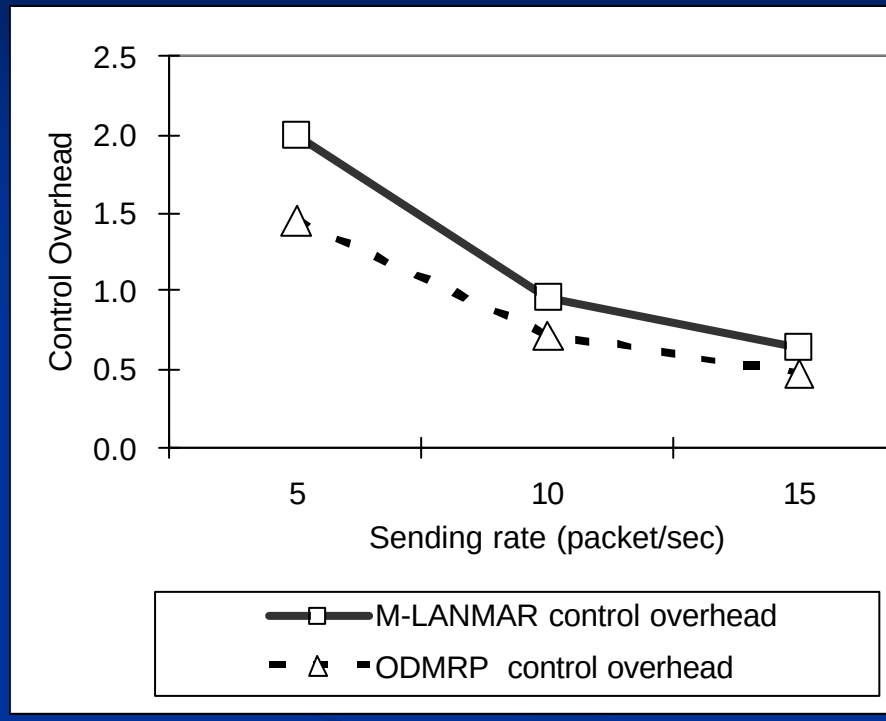


- LANMAR addressing: Keep the unique network ID field as it is. Use the middle 16 bits to store group IDs.



Experimental Results: Delivery Ratio and Control Overhead



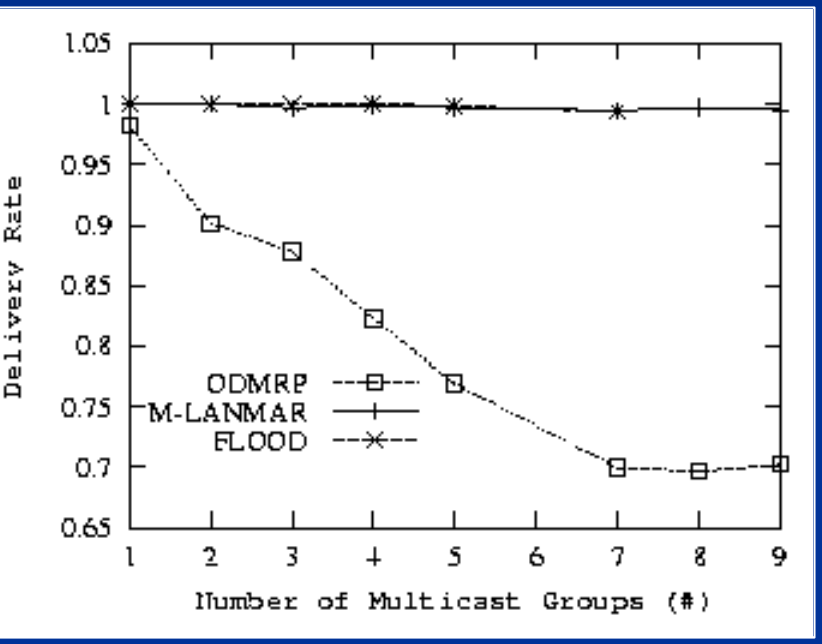


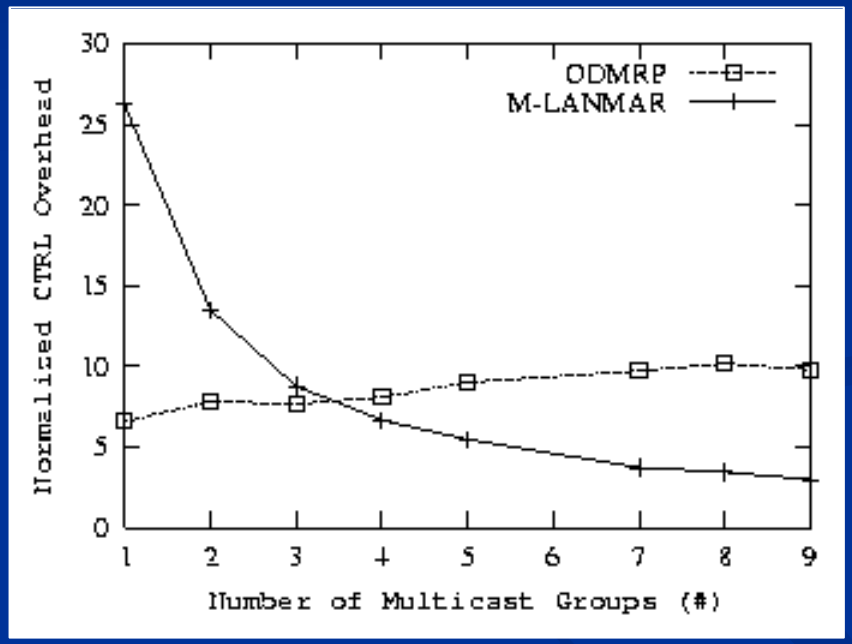
- M-LANMAR has higher Delivery Ratio than ODMRP: unicast tunneling helps reliable data delivery as it incorporates RTS/CTS/ACK)
- M-LANMAR has higher control overhead

Scalability

- Objective: test M-LANMAR scalability
- Compared with
  - ODMRP
  - Flooding
- Simulation Environment
  - QualNet
  - 1000 nodes forming 36 teams on 6000 x 6000 m^2 field
  - CBR traffic (512 bytes/packet, 1packet/sec)

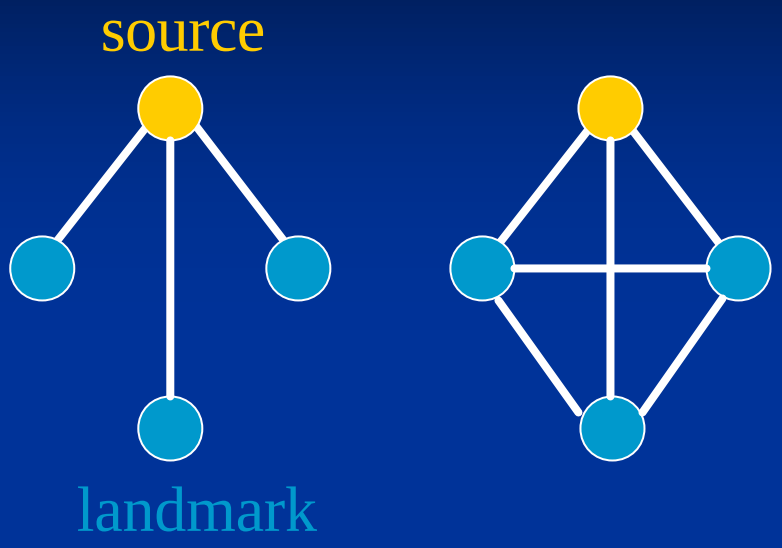
Simulation Results

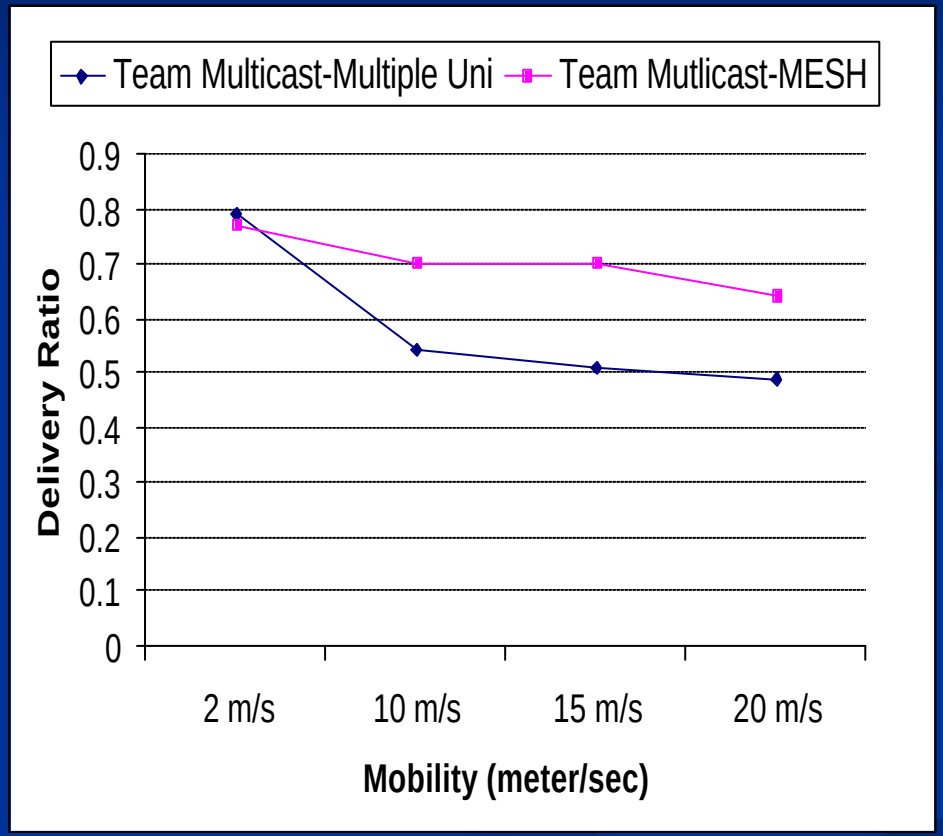




- As the number of multicast groups increases
  - ODMRP suffers from large control overhead and collisions
  - M-LANMAR achieves high delivery ratio (by unicast tunneling and flooding)

Multiple Unicast v.s. Mesh Structure





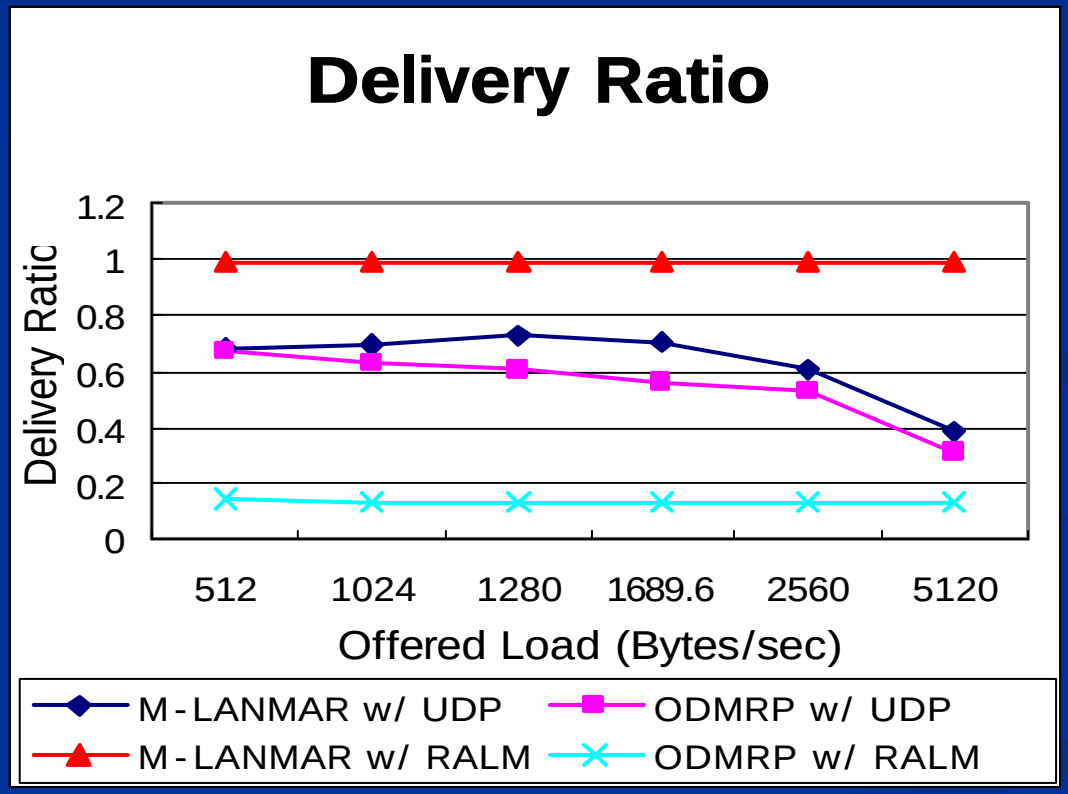
- Builds a mesh between landmarks
  - Load Balancing
  - Better Reliability

Reliable Multicast Support

- **Reliable Adaptive Lightweight Multicast (RALM)**
  - **Source continually monitors the channel condition**
  - No congestion: the source transmits at “native” rate
  - Congestion detected (i.e., packet loss feedback via NACK): the source falls back to “send-and-wait” mechanism (source stops upon receiving a NACK; it resumes when it receives an ACK)
- **Combining with M-LANMAR**
  - Only landmarks return feedback (e.g. NACK/ACK) to the source
  - Prevents unnecessary feedback implosion

Simulation Results with RALM "Reliable Multicast"

(1000 nodes, 3 teams for each group, 5 multicast groups)



ODMRP suffers from feedback implosion; congestion is unacceptable

Conclusions and Future Work

- M-LANMAR is a scalable multicast protocol designed for large ad-hoc networks with affinity team model.
- M-LANMAR implemented in LINUX.
- M-LANMAR improved reliability in data delivery shown in experimental results.
- M-LANMAR scalability in large-scale networks shown via simulation
- Related study in progress
  - Reliability issues in regular and team multicast
  - Team dynamics: inter-team, intra-team scenarios