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

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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

Logical Subnet

Landmark
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 (i.e., transmit same message to all members 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

UAVs:
- equipped with video, chemical sensors
- read data from ground sensors
- “fuse” sensor data inputs
- multicast fused data to other teams
Multicast example

Command Post

Attack!

All Task Force Nodes

Attack!

Attack!

Attack!

Attack!

Attack!
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
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
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 (e.g., 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>

![Diagram showing LANMAR Group ID, Node ID, and Subnet Mask]
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 m² field
  - CBR traffic (512 bytes/packet, 1 packet/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

![Diagram showing mesh structure and delivery ratio graph]
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