# LANMAR+OLSR: A Scalable, Group Oriented Extension of OLSR

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# OLSR

- **Link State routing with *Multipoint Relays* (MPRs)**

- **Efficient in two ways:**
  - **reduces the number of "superfluous" forwardings.**
  - **reduces the size of LS updates.**
  - **reduces table size**

- **Reductions are most effective with high nodal density**

# The AINS (Autonomous Intelligent Networked Systems) Program at UCLA

- 5 year research program (Dec 2000 – Dec 2005) sponsored by ONR

- 7 Faculty Participants: 3 in CS Dept, 4 in EE Dept

- Goal: design a robust, self-configurable, scalable network architecture for  intelligent, autonomous mobile agents

# SWARM-enabled communications network



Autonomous Perching
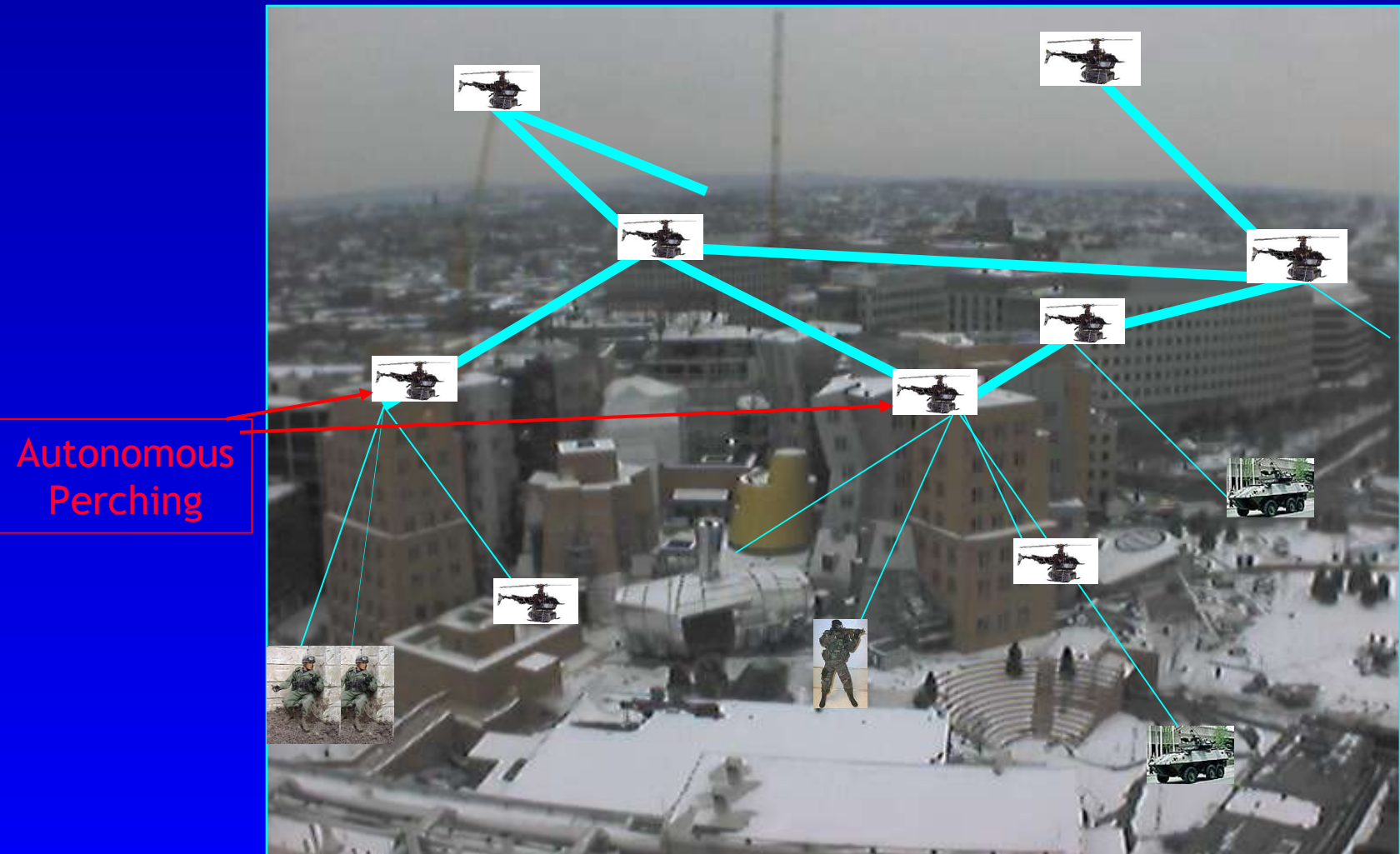
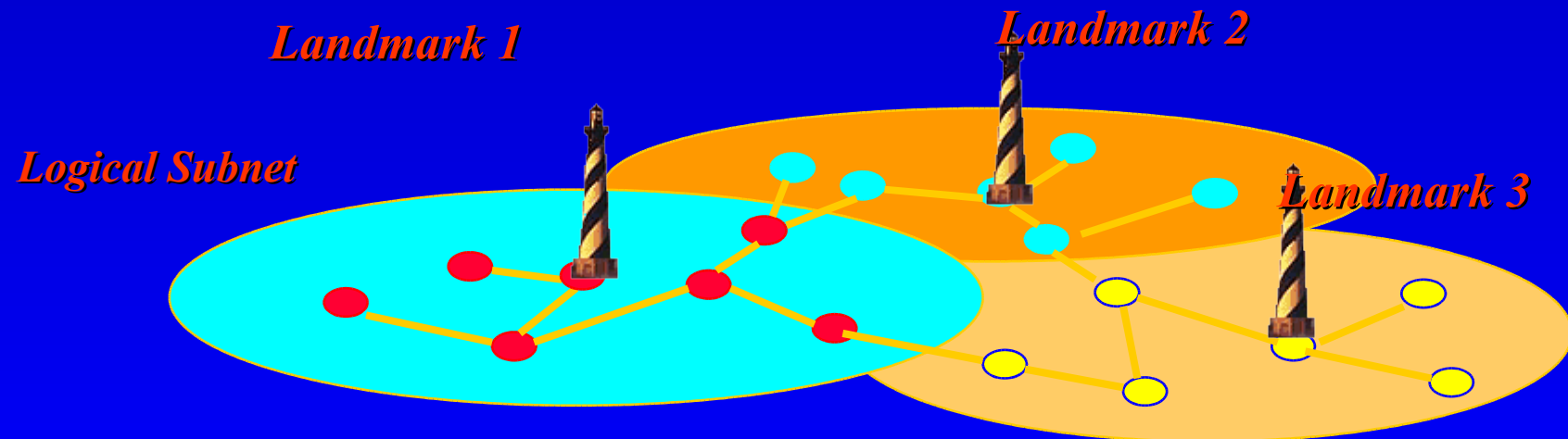# Example of Group Motion Oriented MANET



FLIR
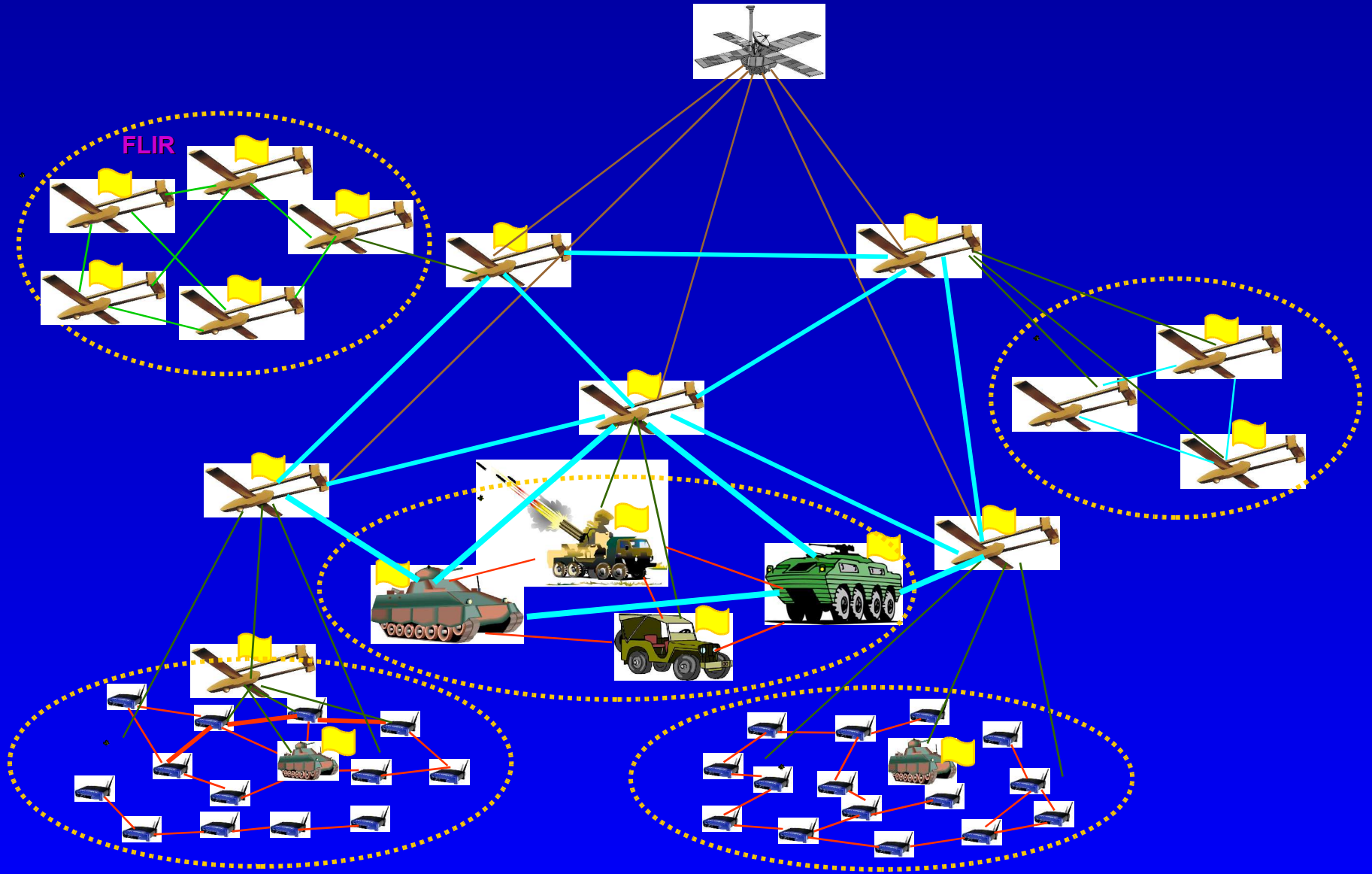
# UCLA Field Test May 2004
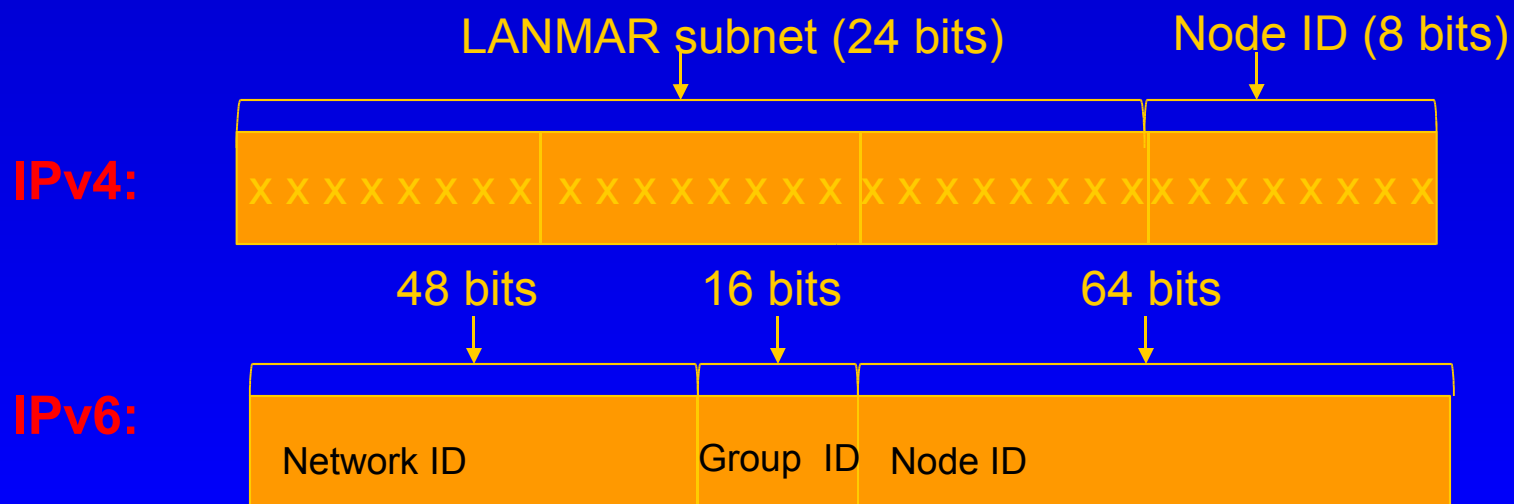
# Group Oriented Routing - LANMAR

## Rationale:

- **keep loose track of groups (logical subnets)**
  - *Landmarks*
- **while keeping an accurate view of vicinity (N hops)**
  - *Local Scope*



*Landmark 1*

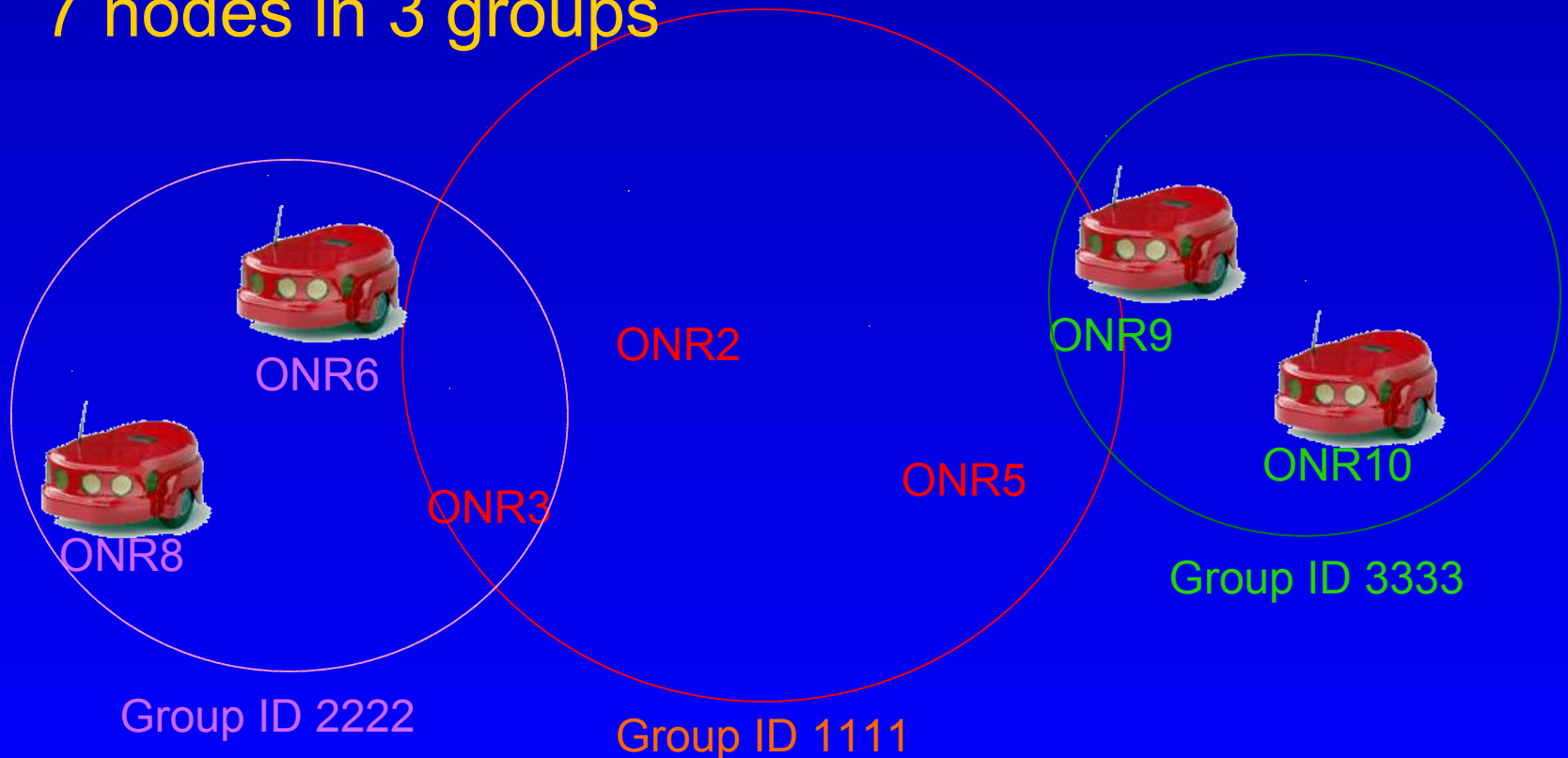*Landmark 2*

*Logical Subnet*

*Landmark 3*

# LANMAR for IPv6 environment

- **Features:**
  - Use IPv6's Group ID to distinguish groups
  - Support many more members in each group (than IPv4)

LANMAR subnet (24 bits)      Node ID (8 bits)

**IPv4:** x x x x x x x x  x x x x x x x x  x x x x x x x x  x x x x x x x x

48 bits      16 bits      64 bits

**IPv6:**

Network ID      Group ID   Node ID

# Phase 1: LANMAR IPv6 Testbed Demo

7 nodes in 3 groups

ONR2

ONR6

ONR8

ONR3

ONR5

ONR9

ONR10

Group ID 2222

Group ID 1111

Group ID 3333

# Snapshot of LANMAR IPv6 Routing Tables.

## Local routing table

| Dest. | Prefix | Next Hop | Metric |
|---|---|---|---|
| fe80:0:0:1111::dad6 | 128 | :: | 0 |
| fe80:0:0:1111::4352 | 128 | fe80:0:0:1111::cf49 | 2 |
| … ….. | 128 | … ….. | … … |

## Landmark routing table

| Landmark Address | Prefix | Next Hop | Metric |
|---|---|---|---|
| 0:0:0:1111:: | 64 | fe80:0:0:1111::cf49 | 1 |
| 0:0:0:2222:: | 64 | fe80:0:0:1111::cf49 | 2 |

# LANMAR+OLSR

- **Three components:**
  - **(1) OLSR as a local proactive routing: accurate routes from a source to all destinations within a limited scope N**
  - **(2) LANMAR as a "long haul" distance vector routing: maintain accurate routes to landmarks from all mobiles in the field**
  - **(3) LANMAR runs Landmark election based on local routing table in each logical subnet**

- **Benefits:**
  - **IP-like route aggregation (CIDR)**
  - **Routing information is suppressed for remote groups.**

# LANMAR+OLSR cont'd

- **Routing:**
  - A packet to "local" destination is routed directly using OLSR
  - A packet to remote destination is routed to Landmark corresponding to group addr. Once the packet approaches the Landmark, the direct route is found in OLSR table.

# Increasing region size: Routing Table Storage
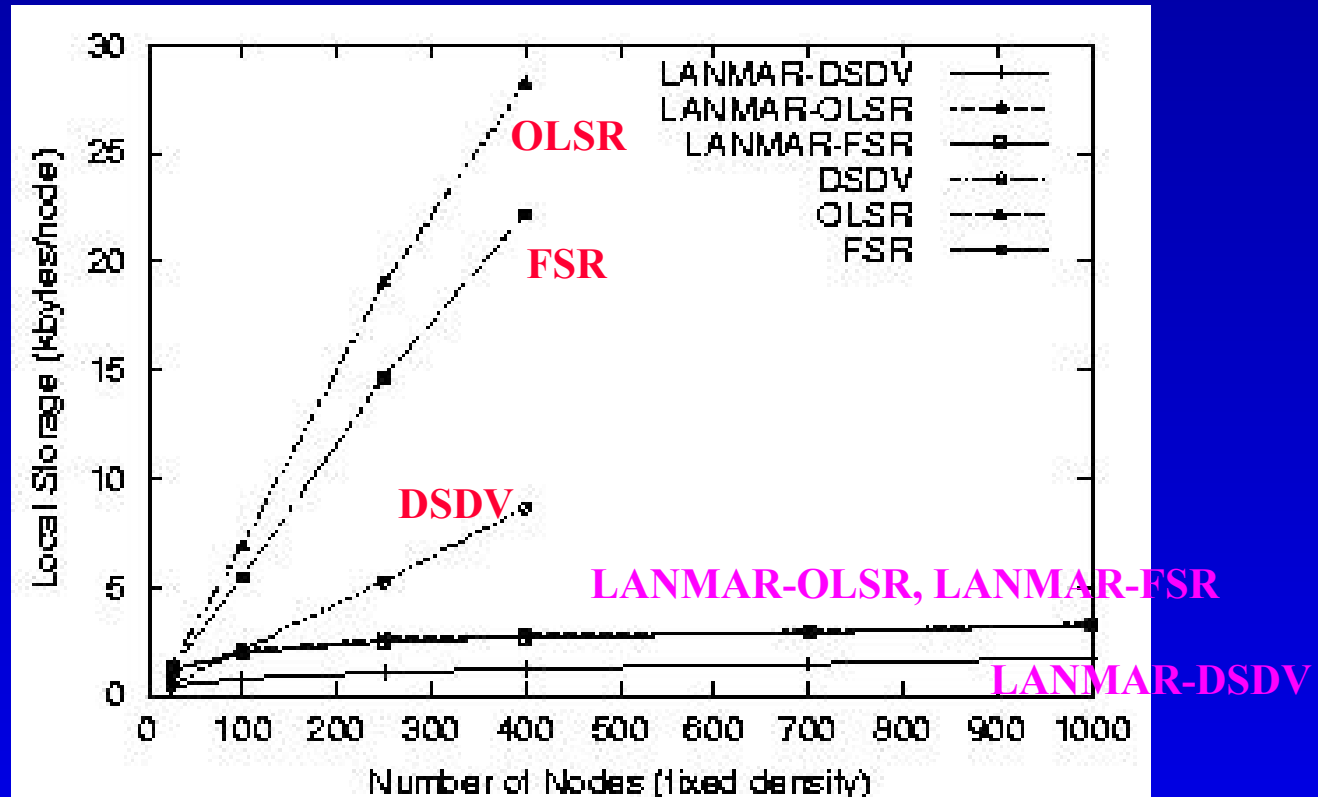


- LANMAR variants remain low storage.
- Their original counterparts  increase storage linearly.
  Among them, DSDV increases slow than OLSR and FSR.

# Increasing region: # of Control Packets
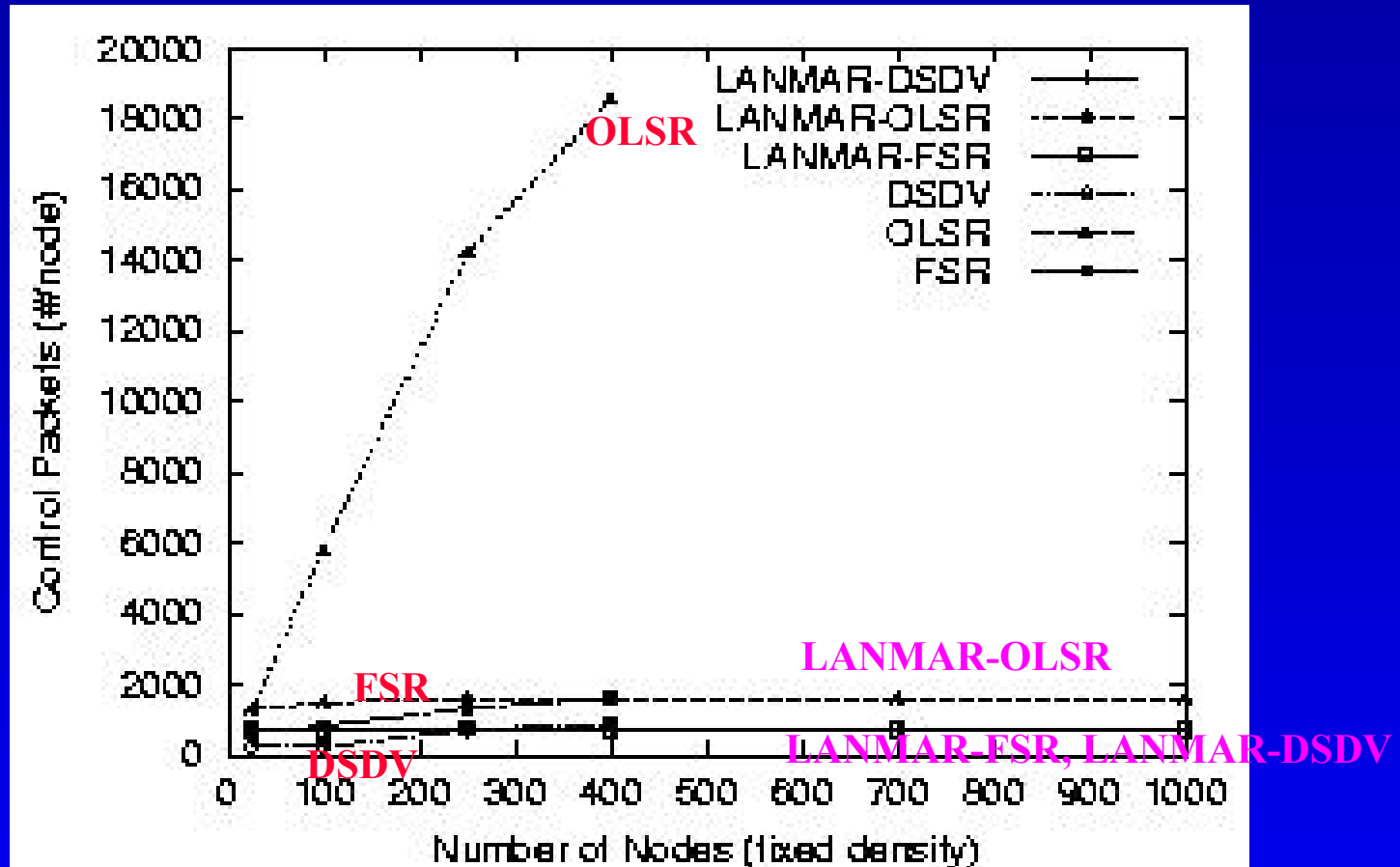


- Control packets not affected by # of nodes (periodic updates), except for OLSR, it uses triggered updates, so increase linearly.

# Increasing region: Delivery Ratio
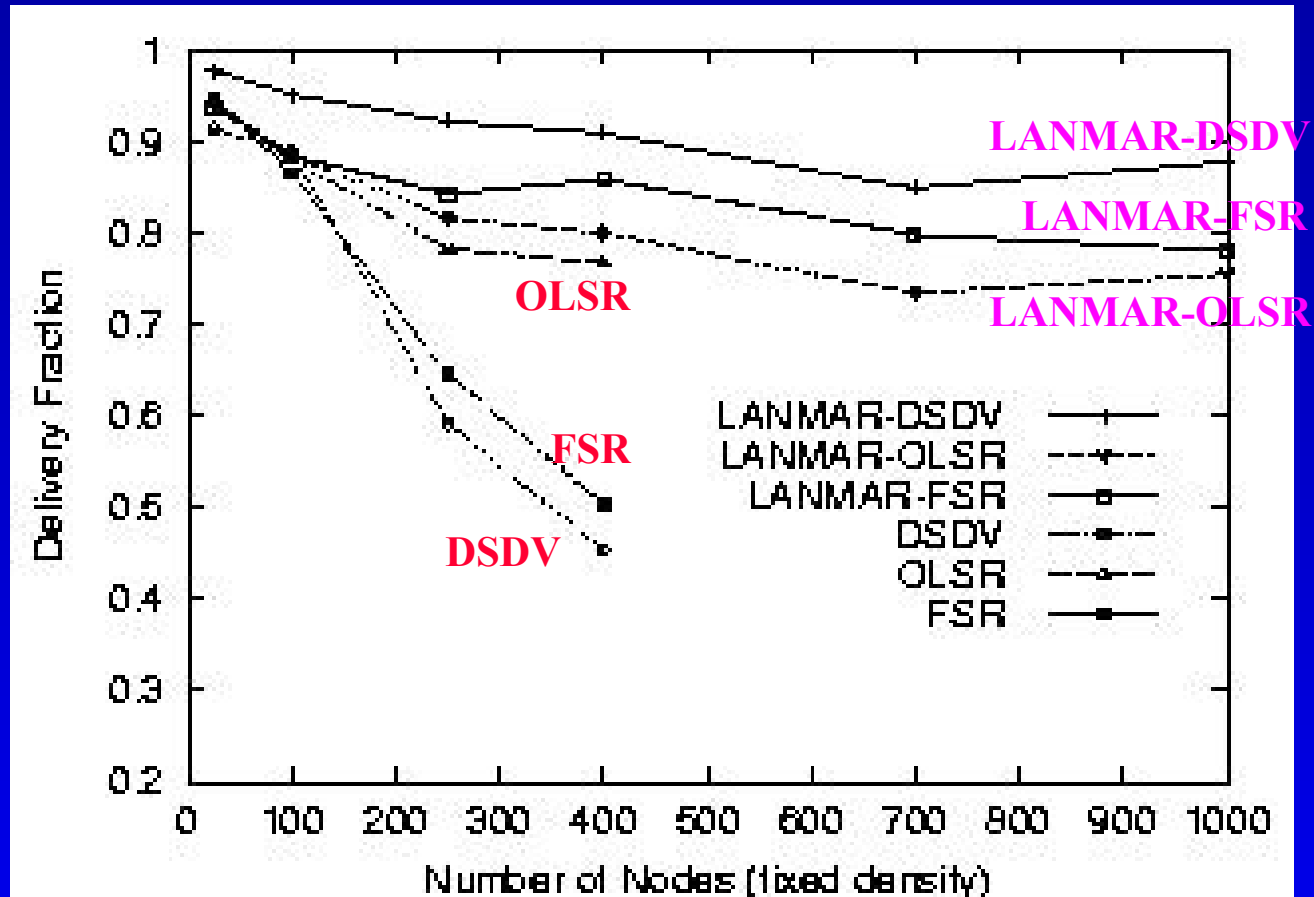


- DSDV and FSR decrease quickly when number of nodes increases.
- OLSR generates excessive control packets, cannot exceed 400 nodes.
- All LANMAR variants work fine.

# OLSR + Fisheye

- **LANMAR works well with group mobility**
- **What if the motion is random - each node on its own?**


- **Enter OLSR + FSR**
  - Combines OLSR and FSR


- **Key Features**
  - Different frequencies for broadcasting Link State packets different hops away (FSR)
  - Scalable to large number of nodes: progressive O/H reduction
  - Scalable to mobility:
    - Short update interval to keep accurate routing information of local nodes
    - Longer update interval to roughly trace remote nodes

# Scalability to Network Size

– Fixed node density as # of nodes increases

– OLSR configuration: hello interval = 2S, TC interval = 4S

– OLSR + FSR configuration: 4 scopes, each scope is 2 hops except last one
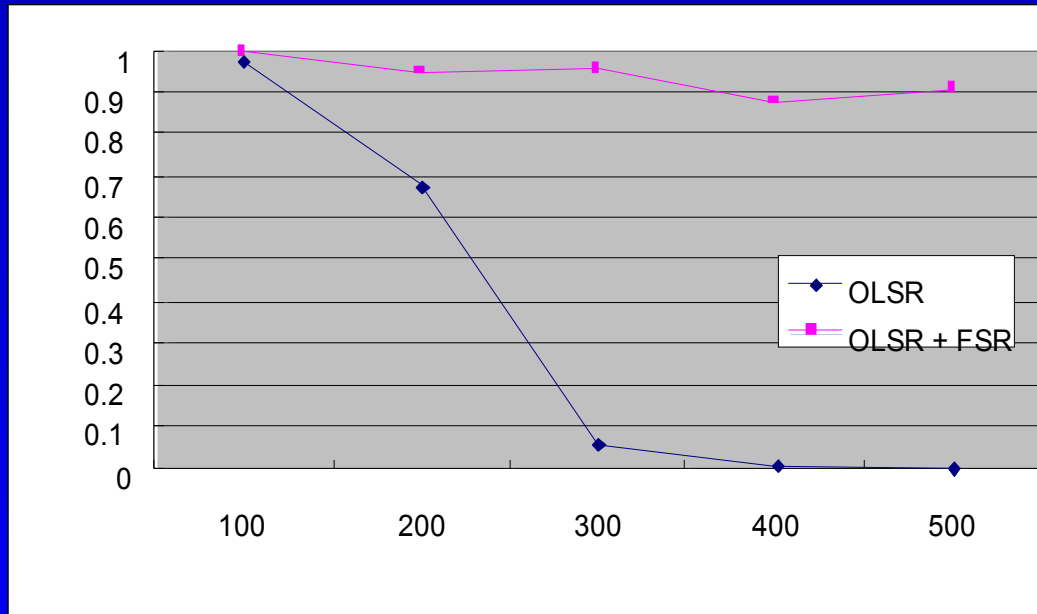


Packet Delivery Ratio vs. Network Size

# Physical, Mobile Backbone Overlay

- **Landmarks provide routing scalability**
- **However the network is still flat - paths have many hops → poor TCP and QoS performance!!**
- **Solution: Mobile Backbone Overlay**
- **MBO is a physical overlay**
- **MBO provides performance scalability**
- **LANMAR + OLSR extends "transparently" to the MBO**

# Backbone Node Automatic Deployment

- **Objectives**
  - Robust and autonomous backbone network maintenance
  - Uniform distribution to cover the field

- **Approach**
  - Dynamic backbone node election: Deploy redundant backbone capable nodes and select a few
  - Backbone node automatic placement: Relocate backbone nodes from dense to sparse regions

# Mobile Backbone Reconfiguration

QuickTime™ and a
Microsoft Video 1 decompressor
are needed to see this picture.

# LANMAR+OLSR Implementation Details

- **Landmarks are translated into subnet entries in kernel routing table**

  - entry match with most specific subnet mask

- **Multithreads**

  - OLSR send, LANMAR send, listen

- **Two ports**

  - OLSR and LANMAR use different ports

- **OLSR and LANMAR communicate through kernel routing table**

  - Protected by a semaphore

# Demo Scenario of LANMAR+OLSR Implementation

- **Scope: 2 hops**

- **Landmarks: ONR1 and ONR9**

- **Observe**
  - Kernel IP routing tables
  - Protocol dumps of its internal tables



ONR9: 131.179.32.9

ONR3: 131.179.33.3

ONR1: 131.179.33.1

ONR11: 131.179.32.11

*LM Group 2 (131.179.32.xx)*

*LM Group 1 (131.179.33.xx)*
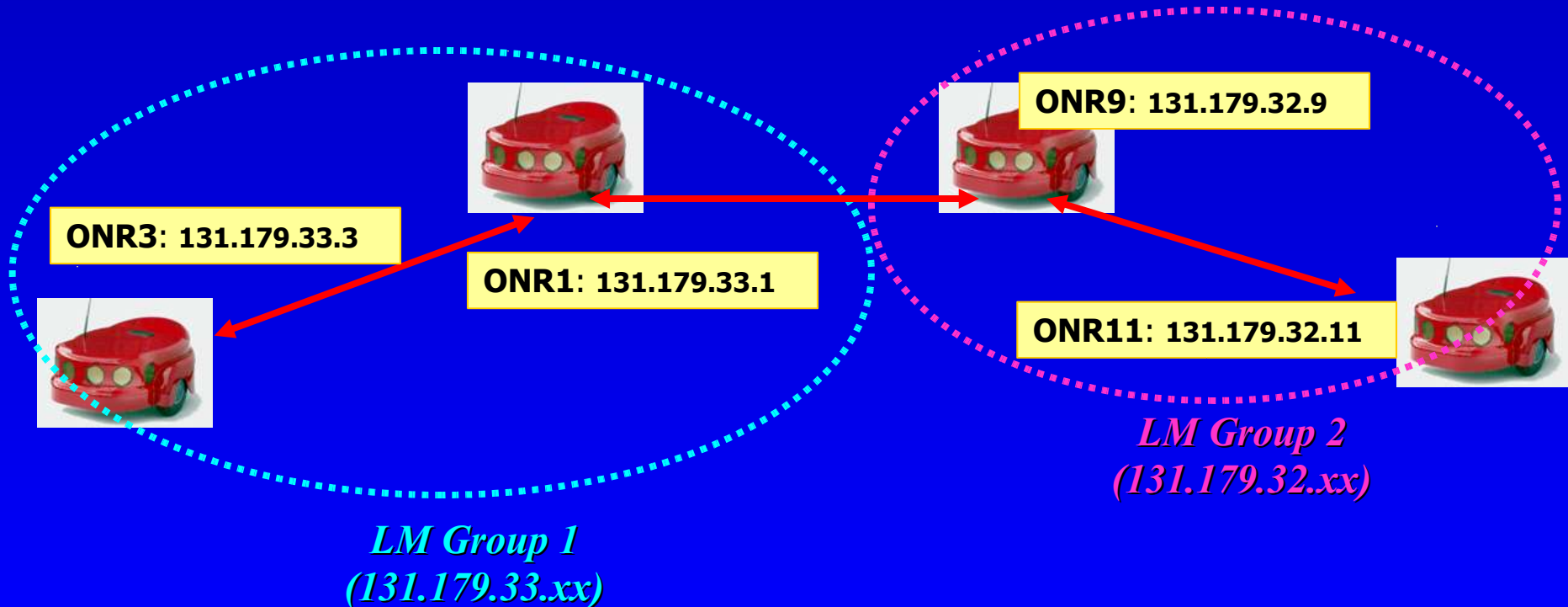
# Implementation of LANMAR+OLSR in Linux

- **Kernel Routing Table**
  - For a host address, Linux sends directly.
  - For a landmark, Linux routes to node with most specific subnet mask entry

- **Routing protocol maintains**
  - OLSR tables and LANMAR tables

```
              Kernel IP routing table
```

| Destination   | Gateway       | Genmask         | Flags | Metric | Ref | Use | Iface |
|---------------|---------------|-----------------|-------|--------|-----|-----|-------|
| 131.179.33.3  | 131.179.33.3  | 255.255.255.255 | U     | 1      | 0   | 0   | eth0  |
| 131.179.32.9  | 131.179.32.9  | 255.255.255.255 | U     | 1      | 0   | 0   | eth0  |
| 131.179.32.11 | 131.179.32.9  | 255.255.255.255 | U     | 2      | 0   | 0   | eth0  |
| 131.179.33.0  | 131.179.33.1  | 255.255.255.0   | U     | 1      | 0   | 0   | eth0  |
| 131.179.32.0  | 131.179.32.9  | 255.255.255.0   | U     | 1      | 0   | 0   | eth0  |
| 127.0.0.0     | *             | 255.0.0.0       | U     | 0      | 0   | 0   | lo    |
| default       | 131.179.33.1  | 0.0.0.0         | UG    | 0      | 0   | 0   | eth0  |

# Testbed at WAM

# Conclusions and Future work

- **LANMAR integration extends OLSR scalability in group oriented MANETs**
- **Fisheye integration helps when motion is random**
- **Both Compatible with mobile backbone**

- **Future work**
  - Move to IPv6 environment
  - More testbed experiments with larger number of nodes
  - Compare OLSR+FSR and OLSR + LANMAR
  - OLSR + LANMAR + FSR?
  - Mobile Backbone experiments
  - QoS extension

# The End

# Thank You!