

# Nextworking 03

## NSF Sponsored Workshop

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Research Issues in Ad Hoc networking

## General research areas: borrowed from Infrastructure Networks, with new “twist”

- **Scalability** (eg, battlefield, thousands of mobile nodes):  
mobility is differentiator
- **QoS** (adaptive, renegotiable)
- **Efficient, fair TCP** in ad hoc mobile nets
- **Routing** – “on demand”
- **Security** (including DDoS, path and motion privacy);  
mobility can help
- **Peer to peer**: natural but more difficult in ad hoc

## New Ad Hoc Research Issues

- Cross Layer design – this is a must in most ad hoc applications
- Fundamental performance models/bounds (following Gupta and Kumar work)
- Energy in portables and sensors
- Mobility exploitation

## My talk

- Scalable routing/forwarding – mobility helps
- “opportunistic ad hoc networking” : the ad hoc, multihop network coexists and augments the conventional, infrastructure type wireless LAN or cellular network.

# Scalable Routing/Forwarding Techniques

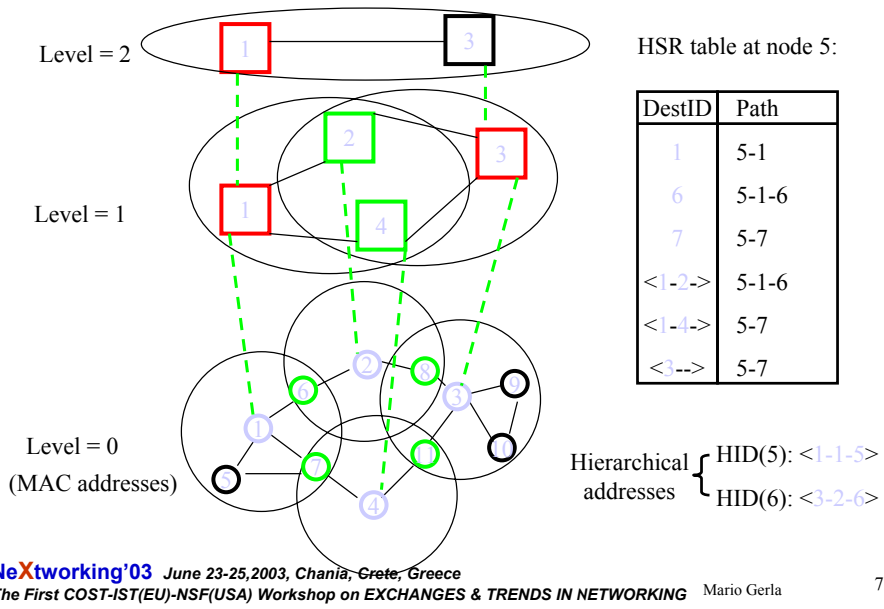
- Hierarchical routing
- Physical hierarchies
- Myopic routing
- Georouting
- Redundant broadcast reduction

Hierarchical routing reduces route table size  
and table update overhead

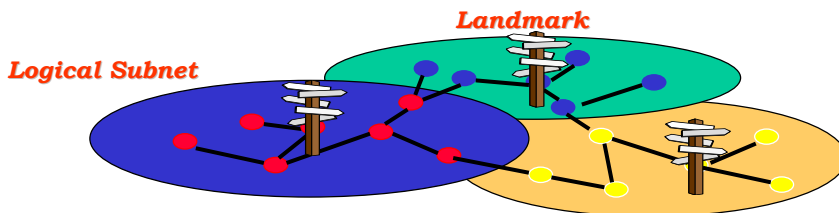
Proposed hierarchical schemes include:

- **Hierarchical State Routing**
- **Zone routing (hybrid scheme)**
- **Landmark Routing**

## HSR - physical multilevel partitions. Why does it not work? Mobility!



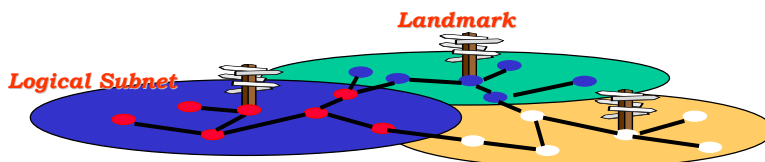
## Landmark Routing: putting mobility to work!



- Logical subnet: group of nodes that move together
- Node logical address = <subnet, host>
- A Landmark is elected in each subnet
- Every node keeps local routes to neighbors up to hop distance N
- Every node maintains routes to all Landmarks

## Landmark Routing (cont'd)

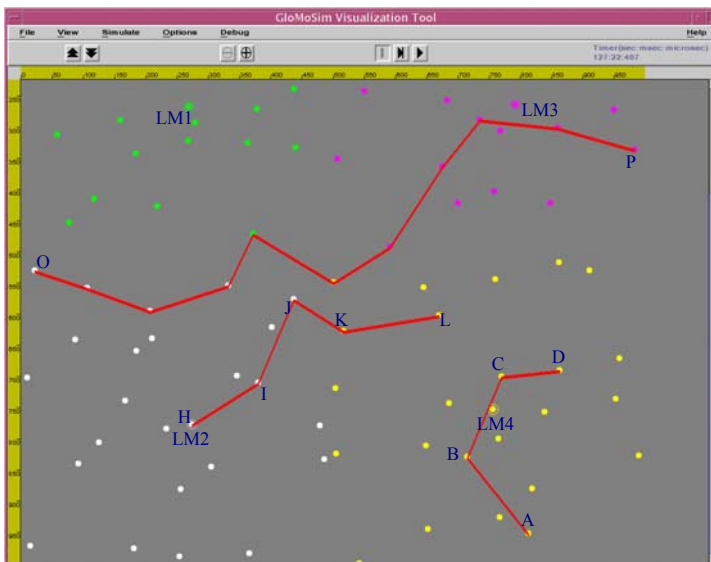
- A packet to **local destination** is routed directly using local tables
- A packet to **remote destination** is routed to corresponding Landmark based on logical addr
- Once the packet gets within Landmark scope, the direct route is found in local tables
- **Benefits:** dramatic reduction of both routing overhead and table size; scalable to large networks



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## Illustration by Example



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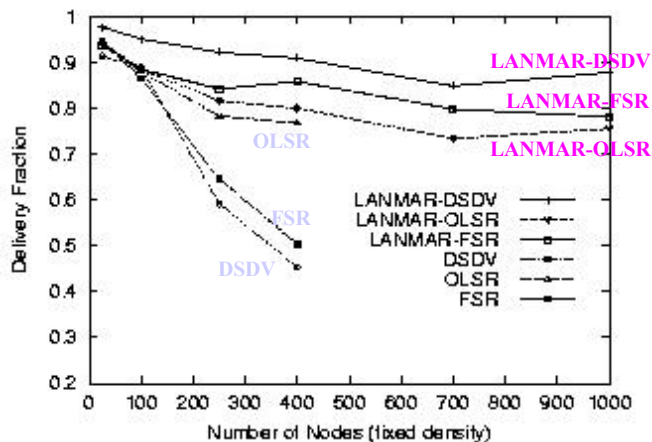
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# How does LANMAR compare with MANET routing schemes?

We compare:

- (a) existing routing schemes DSDV, OLSR and FSR; and
- (b) LANMAR equipped with same schemes as **local scope** routing schemes, ie, LANMAR-DSDV, LANMAR-OLSR and LANMAR-FSR

## 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.

# More on scalable routing: the multilevel backbone (BB) network

## Multihop problem

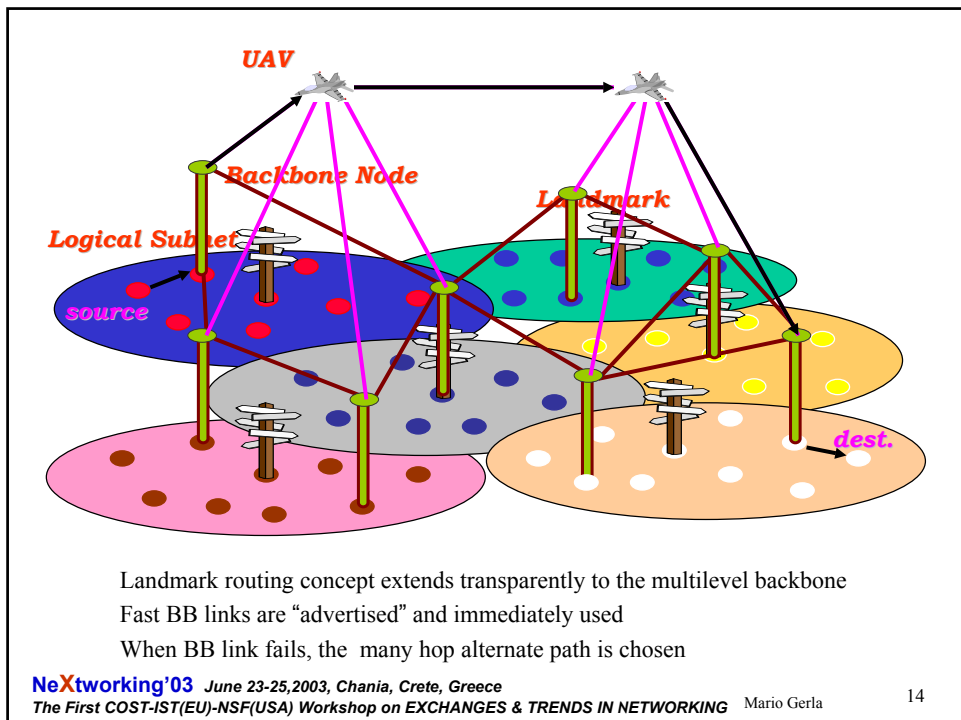
- So far, topology was homogeneous
- But, many hops (say  $> 6$ ) degrade performance

## The Cure:

- physical hierarchy (long range backbone links)

## New challenge:

- Routing must seamlessly extend to high bandwidth BB links
- must degrade gracefully when BB links are lost



# Exploiting Mobility

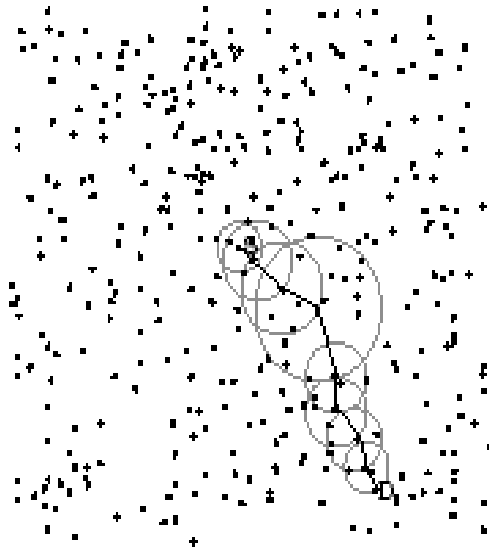
- Mobility (of groups) was helpful to scale the routing protocol
- Can mobility help in other cases?
- (a) Mobility induced distributed route/directory tree
- (b) Using mobility prediction for efficient forwarding/transport

## Mobility Diffusion and “last encounter” routing

- Imagine a **roaming node** “sniffs” the neighborhood and learns/stores neighbors’ IDs
- Roaming node **carries around the info** about nodes it saw before
- If nodes move randomly and uniformly in the field (and the network is dense), there is a **trail of nodes** – like pointers – tracing back to each ID
- The superposition of these trails is a tree – it is a **routing tree** (to send messages back to source); or a distributed directory system (to map ID to hierarchical routing header, or geo coordinates, for example)
- “Last encounter” routing: next hop is the **node that last saw** the destination



## Fresh algorithm – H. Dubois Ferriere, Mobihoc 2003



## Mobility induced, distributed embedded route/directory tree

Benefits:

- (a) avoid overhead of periodic advertising of node location (eg, Landmark routing)
- (b) reduce flood search O/H (to find ID)
- (c) avoid registration to location server (to DNS, say)

Issue:

- Motion pattern impact (localized vs random roaming)

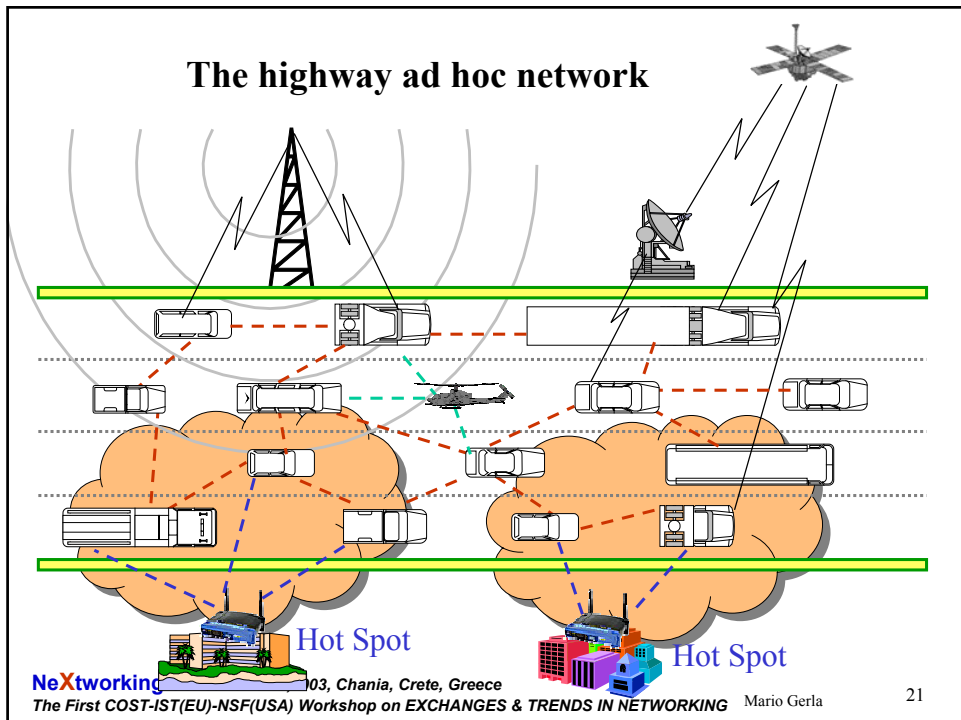
# Mobility increases network Capacity

- Example: highway info-station every 1000 m
- I am driving and I can predict the time when I will connect to the infostation. My intelligent router decides to wait to download a CD
- Latency vs control OH trade offs

# Opportunistic ad hoc nets

- **Fact:** except for military and emergency applications, there has been little penetration of ad hoc nets in the commercial world
- **Probable causes:** ad hoc protocols not compatible with wireless LAN, cellular protocols; no incentive to multihop
- **Proposed solution:**
  - (a) compatible radio and protocol designs
  - (b) intelligent router opportunistically selects best route
- **Examples:** automobile network; Campus student workgroups; conference room networking

## The highway ad hoc network



## The highway vehicle ad hoc network

### The vehicle ad hoc network:

- Provides basic scoped safety info to drivers (accident alerts; collision prevention, etc)
- Represents a large sensor platform (remote viewing of accident scene)
- Relies on friendly cooperation/incentives
- Exploits mobility (groups, last encounter routing, infostations)
- Replaces cellular net when costeffective (eg, P2P CD exchange, netgames); or when necessary because of terrorist attack or congestion

**Needed:** integrated radio approach (eg, soft radios); seamless protocols