

**ARPA Mobile Information Systems Applications Workshop
December 7-8, 1995**

Mobile Networking

**Randy H. Katz
CS Division
EECS Department
University of California, Berkeley**



Mobile Networking

Middleware

Mobile Applications

Mobile Applications Support

Reliable Transport

TCP
IP
Mobile End-to-End Networking

Mobile Networking

Radio Channel

Wireless Communications Nodes

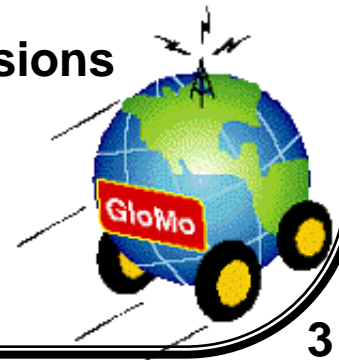
“Sophisticated network mgmt and routing algorithms suitable for the dynamic, multi-hop, wireless networking environment of the tactical battlefield”

Mobility Services
Subnetwork Control
Link Control
Media Access



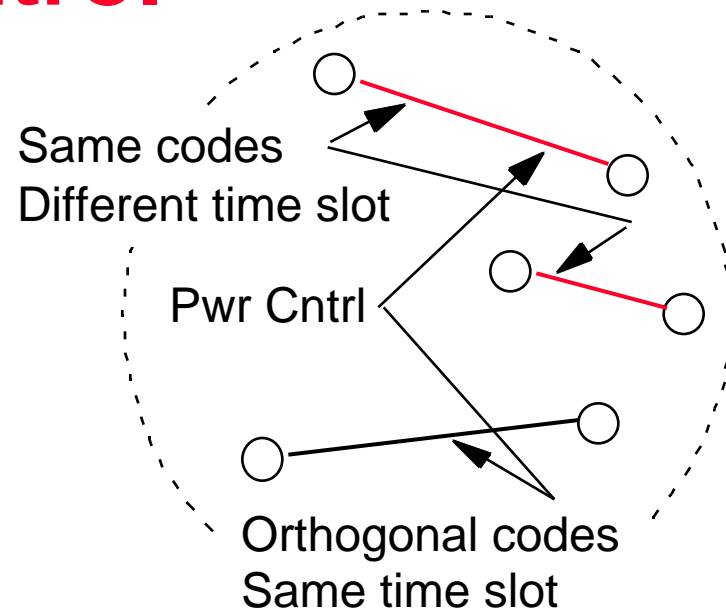
Media Access

- **Cluster-Based CDMA/PRMA (UCLA)**
 - Packet reservation techniques for slots
 - Multiple conversations per slot through code division
- **Floor Acquisition Multiple Access (UCSC)**
 - Combines features of Carrier Sense Multiple Access (carrier sensing) and Multiple Access Collision Avoidance (collision avoidance dialog) schemes
 - Achieves higher throughput than MACA by permitting bursts for each successive RTS/CTS handshake (i.e., “floor acquisition”)
 - Sufficient conditions for completely avoiding collisions



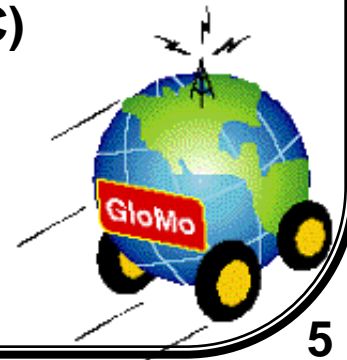
Link Control

- **Link Establishment**
 - Code and slot assignment to minimize interference (KU, UCLA)
 - Power control
- **Adaptive Link Performance**
 - Bandwidth vs. Reliability
 - Link level error correction and retransmission
 - Power control
- **Support for upper layer QoS requirements based on lower layer SIR constraints**



Subnetwork Control & Routing

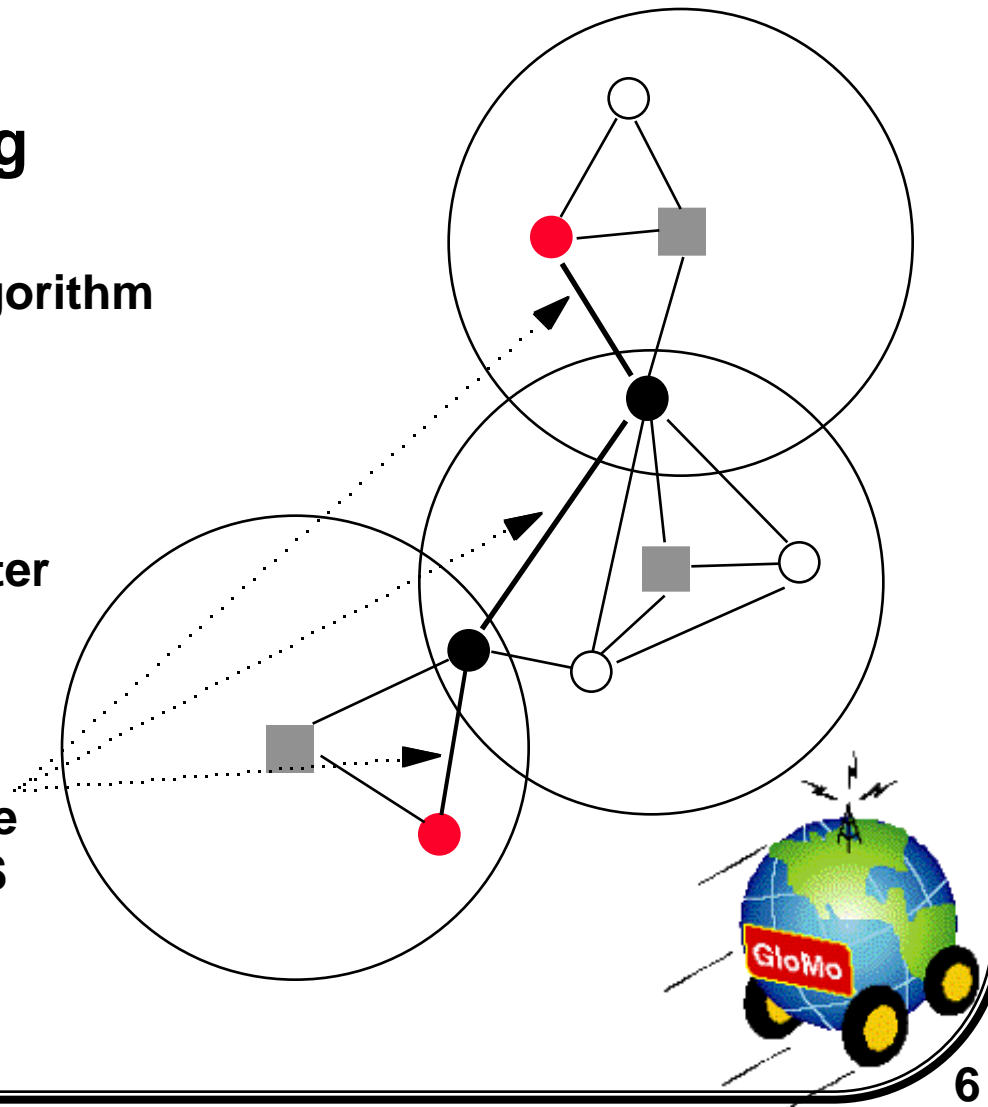
- **Topology Creation/Reconfiguration**
 - Hierarchical/Cluster-based Schemes (UCLA)
 - Rapidly Deployable Radio Network (KU)
 - Reliable/survivable network topology (Stevens)
- **Routing**
 - Multihop Routing (UCLA, UCSC)
 - Mobile IP (UCB, Others)
 - Switch Mobility (KU, Stevens)
 - QoS Driven Path Assignment (Stevens, UCLA, UCSC)
 - Subnet Support for Multicast (Stevens, UCB, UCSC)
 - Subnet Support of VCs with QoS Negotiation (Stevens, UCLA)
 - GPS Integration with Routing (KU, UCSC)
 - Wireline-Wireless ATM Integration (KU, Stevens)



Topology Creation

- **Hierarchical/Clustering Algorithms (UCLA)**
 - Distributed Clustering Algorithm
 - Time Division Slotting
 - Slot Reservation
 - VCs for R/T; DGs for data
 - Code Separation per cluster

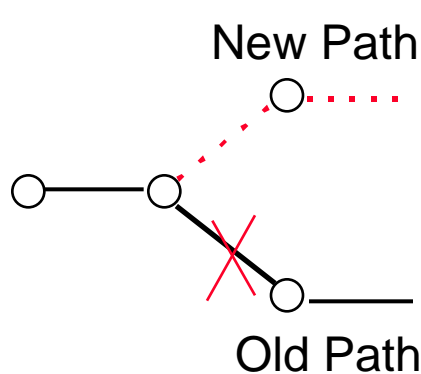
**Multihop Route
subject to QoS
Constraints**



Topology Creation

- **Dynamic Topology Reconfiguration (UCLA)**
 - Cluster merge/split under mobility
 - VC reconfiguration in presence of mobility

» **Fast Reservation** Scheme

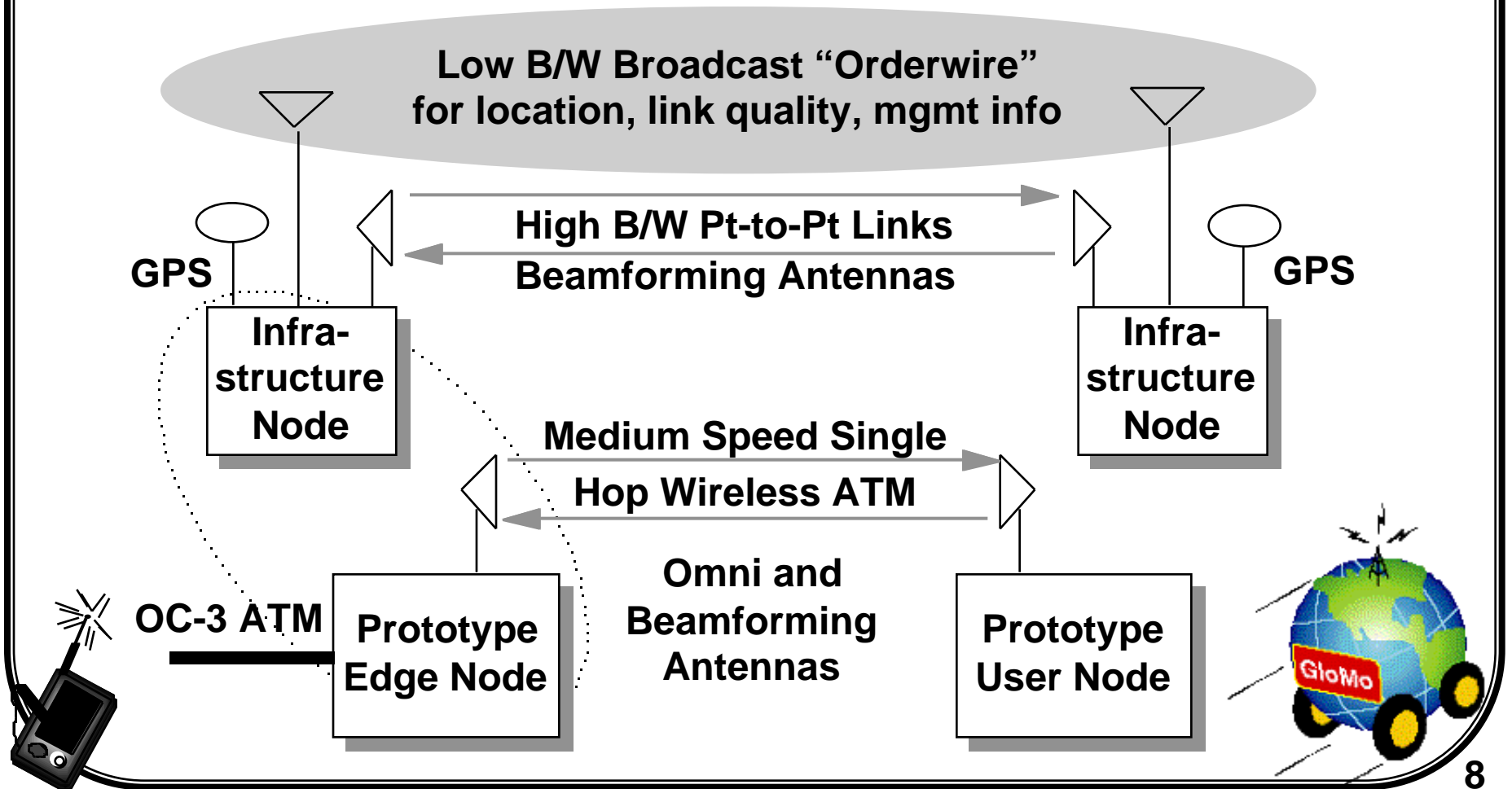


- R/T packets follow shortest path
- Rate adjustment based on advertised QoS
- First packet reserves slot on path
- First packet competes for slot on new path
- May be dropped if no path
- Low priority voice/video components dropped during switchover
- Reservation released if slot unused



Topology Creation

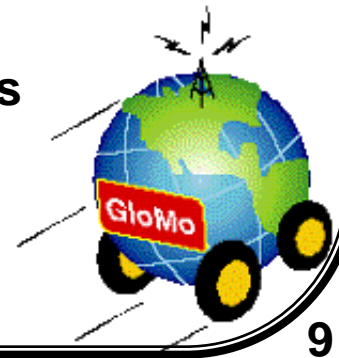
- RDRN Configuration (KU)



Multi-hop Routing

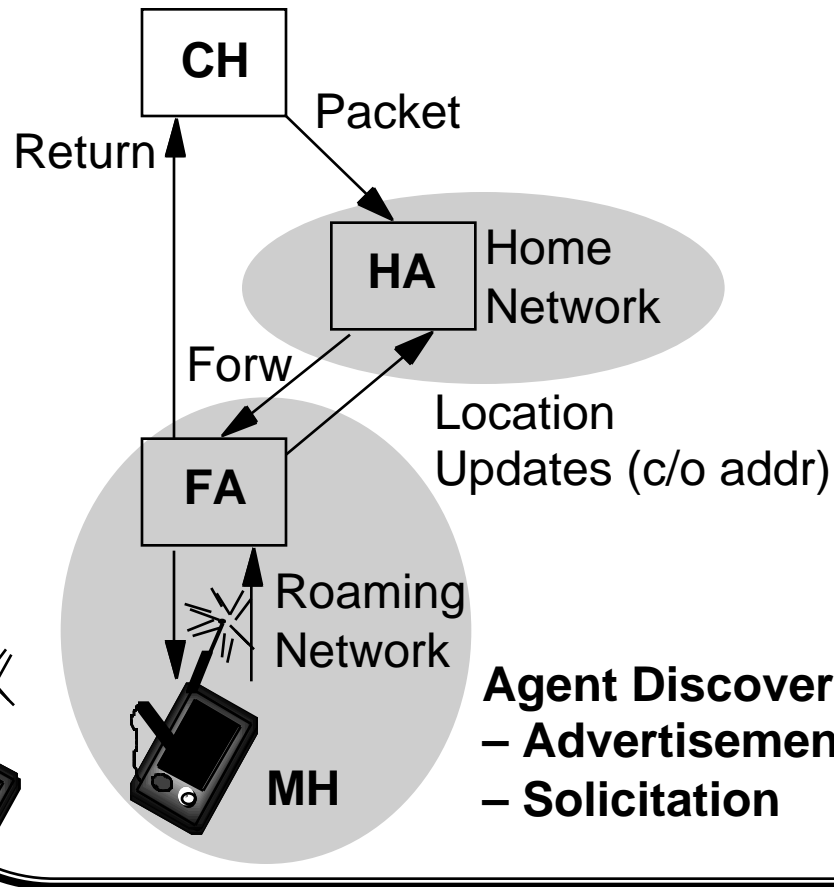
- **Routing Algorithms (UCSC)**

- **Link Vector:** New routing algorithms based on distribution of link information, used to reach destinations, to neighbors thru **preferred paths**
- **Path-Finding:** New **loop-free** distributed shortest-path algorithm utilizing length and second-to-last hop of shortest path
- Yield better behavior than flooding and Distributed Bellman-Ford, especially in presence of link or node failure
- Multiple successors from any node to any successor; Choice of route can reduce congestion
- Integration of **GPS** information in routing algorithms



Mobile Routing

- **Mobile IP (IETF + Many Groups)**



Schemes to reduce dog leg routes, and location updates:

- **Caching MH location at CH**
- **Dynamic source routing / CH directly tunnels to MH**
- **Local multicast groups**
- **Hierarchical foreign agents**

Agent Discovery & Registration
– Advertisement
– Solicitation

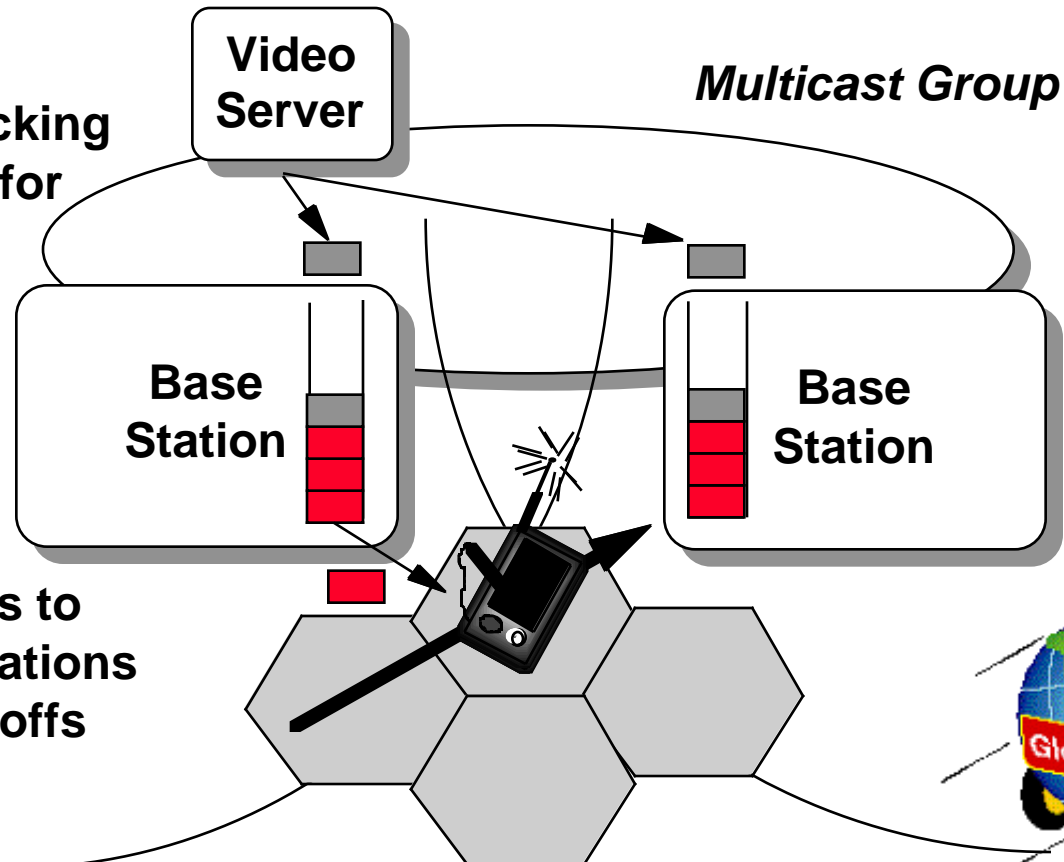


Mobility Services: Handoff

- Multicast-based Low Latency Handoff (UCB)

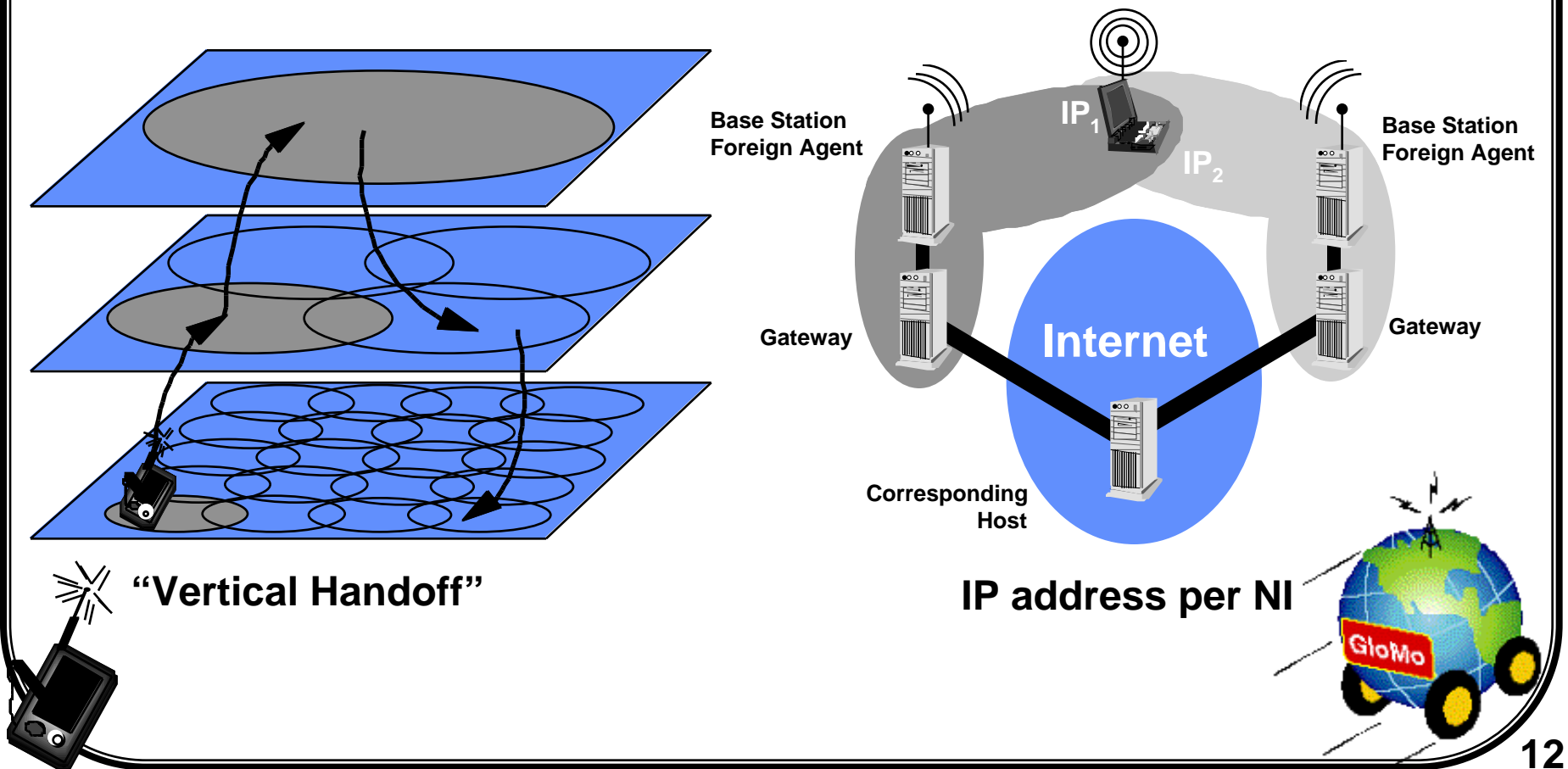
Use terminal tracking to assist in HOs for R/T streams

Multicast packets to adjacent base stations to smooth hand-offs



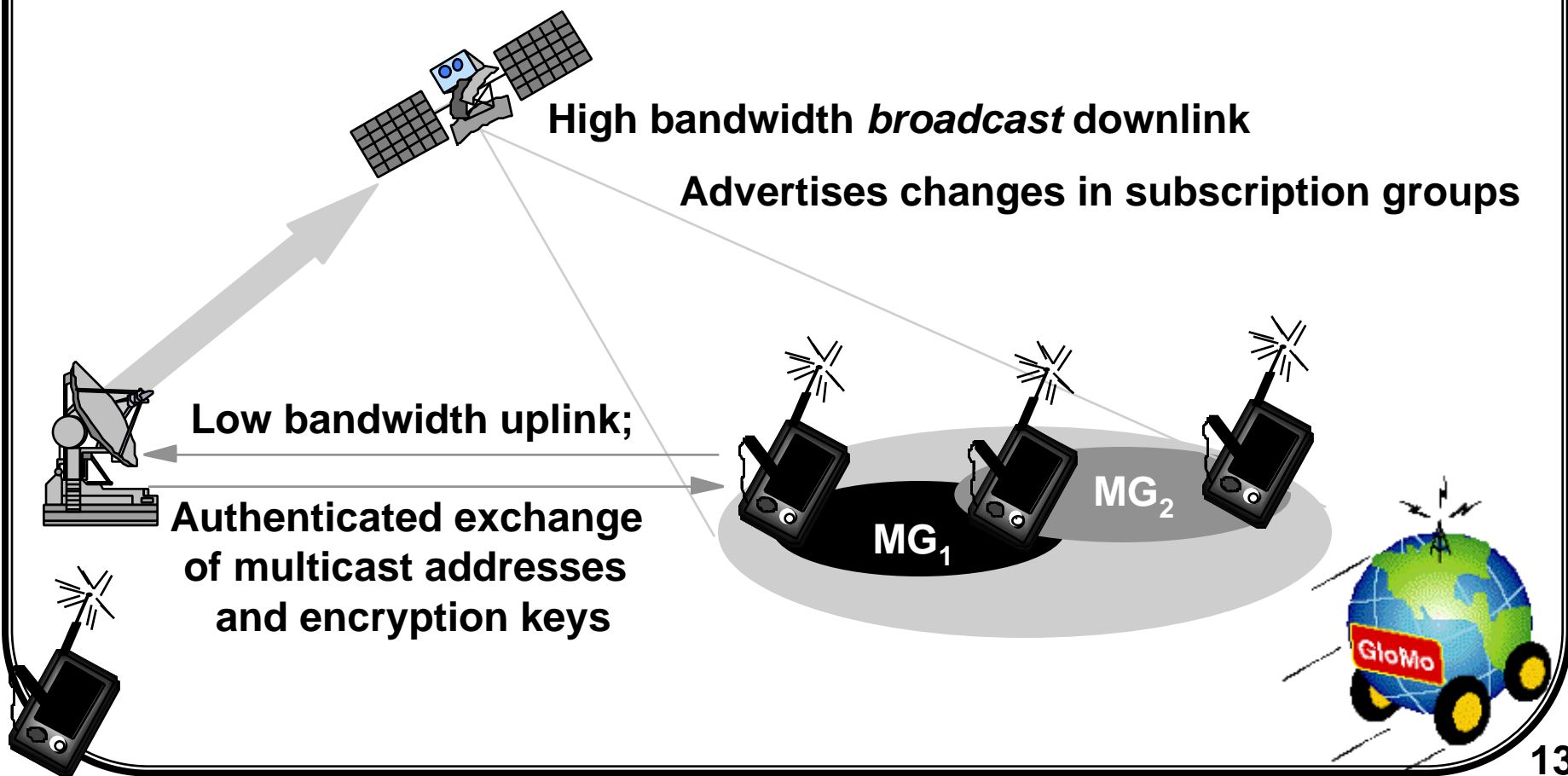
Mobility Services: Handoff

- Handoff between wireless subnets for connectivity;
Load balancing/different traffic across subnets (UCB)



Multicast Routing

- DBS Support for “Secure” Multicast (Hughes & UCB)



Mobility Services: Tracking

- **Virtual Network Configuration Algorithm (KU)**
 - Mobile tracking
 - » Track direction, velocity, bandwidth, # connections, past history, etc.
 - » Use to predict future network state
 - Use to control antenna beamforming, topology changes, switch/routing tables, resource allocation, etc.
 - » Predict forward/roll back if in error
 - » Allows fast reconfiguration
 - Orderwire “virtual messages” estimate future behavior
 - Accurate, synchronized timing through GPS crucial



Common Themes

- **Given**
 - Quality of Service requirements imposed from above
 - Signal-to-Interference Ratio constraints from below
- **Exploit local knowledge**
 - Cluster/Hierarchical Schemes (UCLA), LV Algorithm (UCSC)
 - Mobile Tracking (KU, UCB)
- **Find “best” routes subject to QoS constraints**
 - Multi-hop (UCLA), Multi-path (UCSC), Virtual Path (Stevens)
 - Best overlay (UCB)
- **Retaining connectivity while moving**
 - Beam steering (KU)
 - Changing route (UCLA, UCSC)
 - Changing overlay (UCB)
 - Reliable/Survivable Topology (Stevens)

