



Helsinki University
of Technology

**T-79.7001 Postgraduate Course in
Theoretical Computer Science
T-79.5401 Special Course in Mobility Management:
Ad hoc networks
(2 - 10 cr) P V**

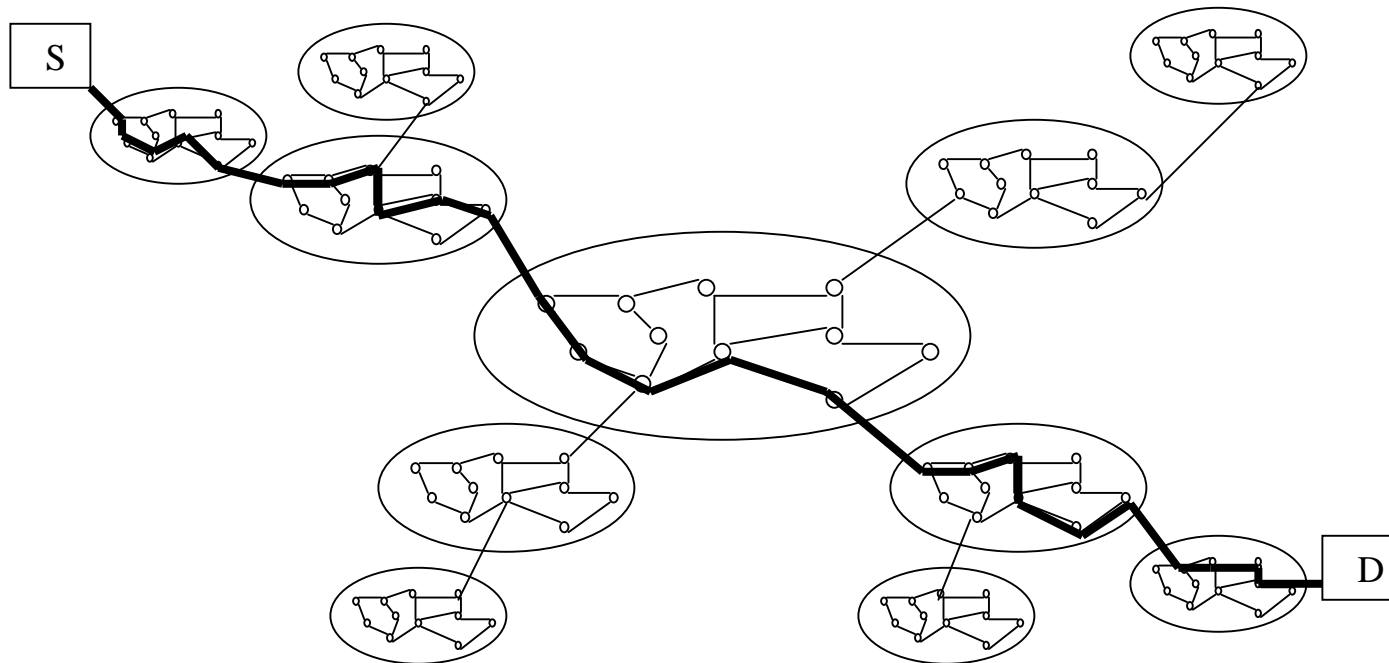
**professor Hannu H. Kari
Laboratory for Theoretical Computer Science
Department of Computer Science and Engineering
Helsinki University of Technology (HUT), Espoo, Finland
email: Kari [at] tcs [dot] hut [dot] fi**



- **Material based on**
 - **C. Siva Ram Murthy and B. S. Manoj: "Ad Hoc Wireless Networks: Architectures and Protocols"**
 - **Hannu H. Kari, Ville Nuorvala, Ville Salmensuu: "Efficient utilization of ad hoc network technologies in wireless access networks in providing reachability for mobile nodes in a military environment", project report, 2004**
 - **(+Old slides of HHK)**

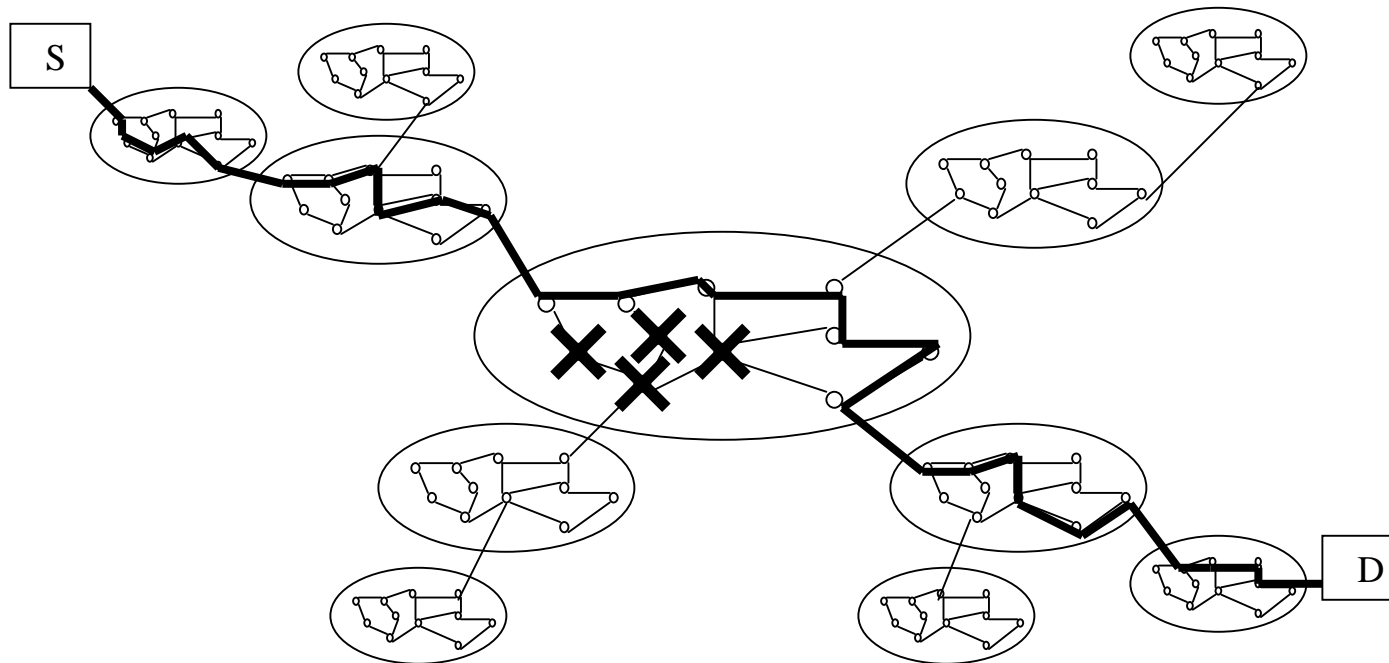


- **Internet was designed to survive nuclear war**



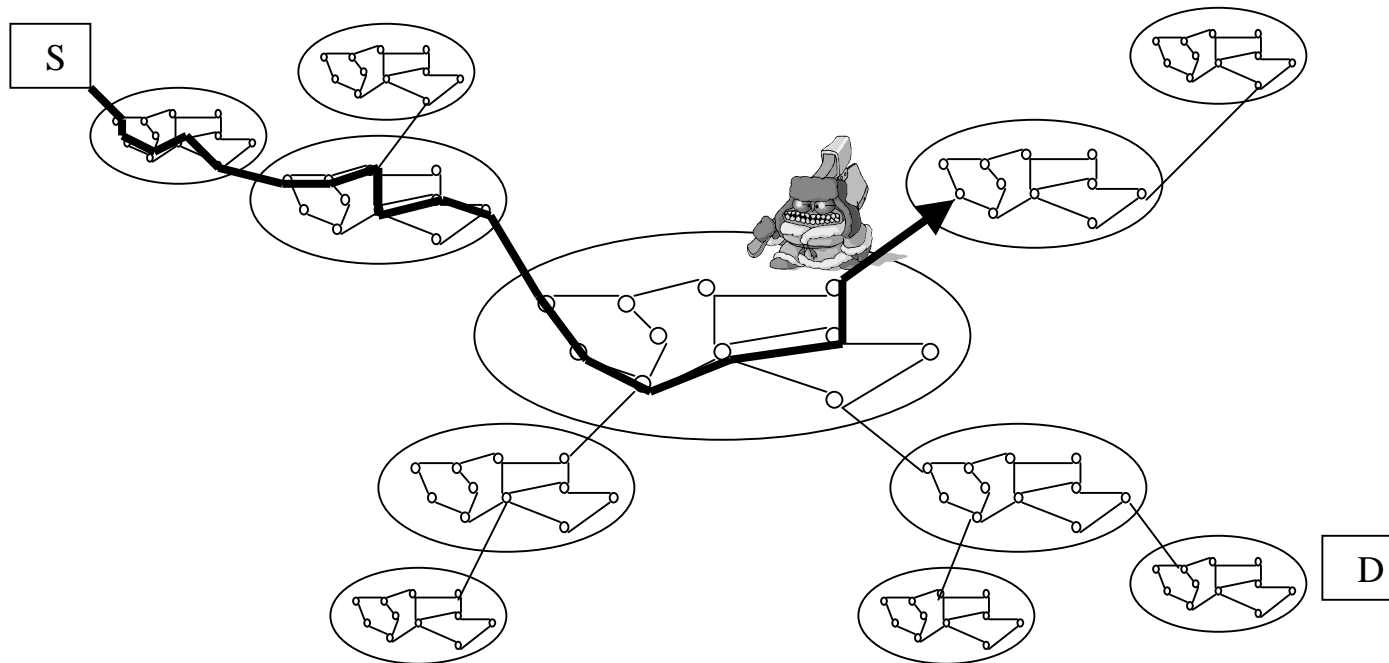


- Packets can be rerouted quickly



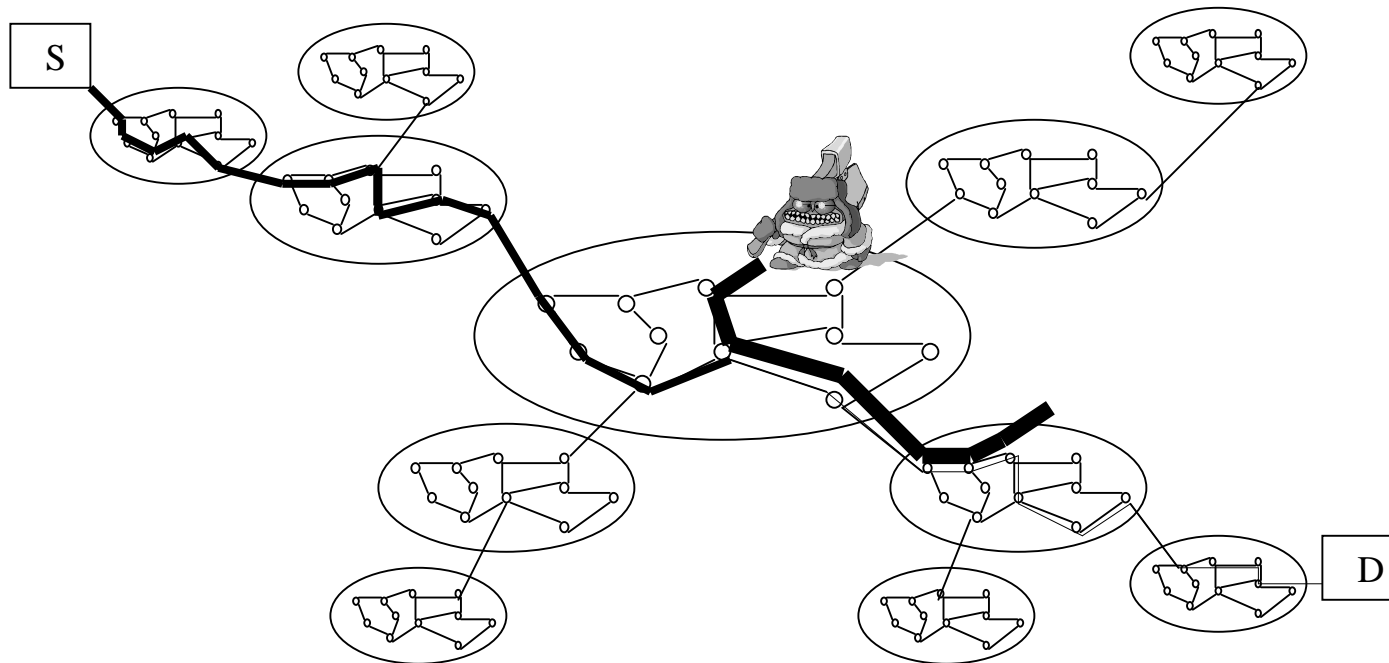


- ...but one mole can damage the routing



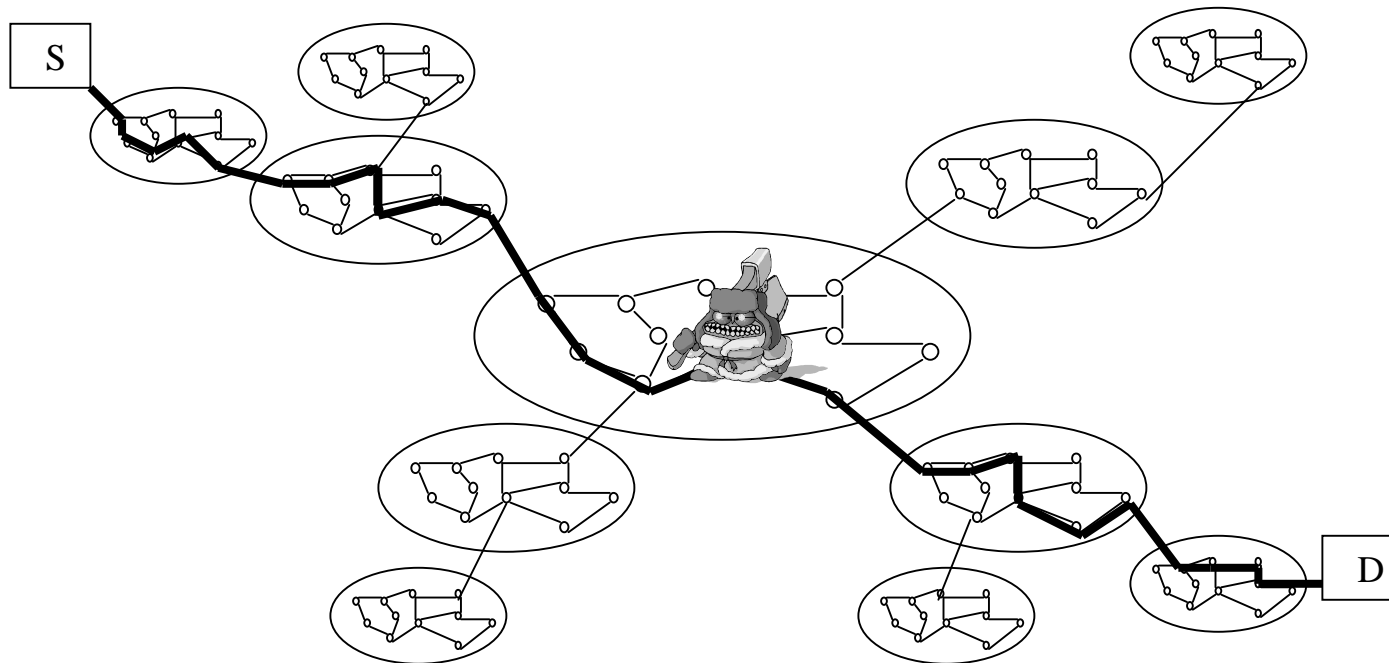


- ... or fill network with garbage ...





- ...or corrupt transmitted data





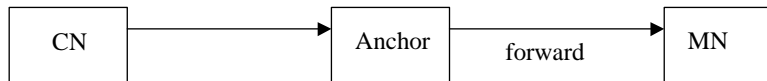
- **Problems are dramatically getting worse, when**
 - **wireless networks are used instead of wired links**
 - **dynamic network infrastructure is used instead of static**
 - **nodes are mobile**
 - **environment is hostile**
 - **nodes may become compromised**
 - **strict Quality of Service requirements are needed**
 - **transmission channel has very limited capacity**

=> All these are present at wireless ad hoc networks

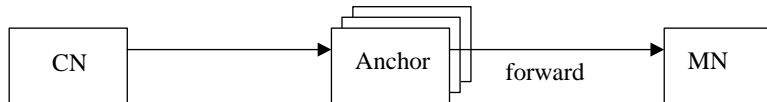


- It's all about reachability...

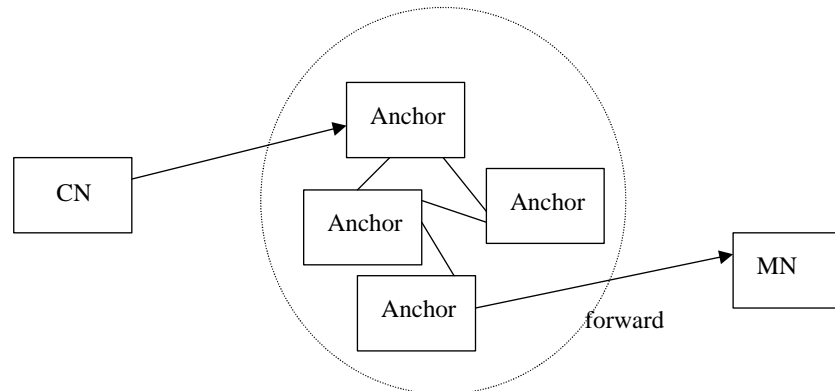
2a) Simple forwarding case



2b) Fault tolerant anchoring point



2c) Distributed anchoring point

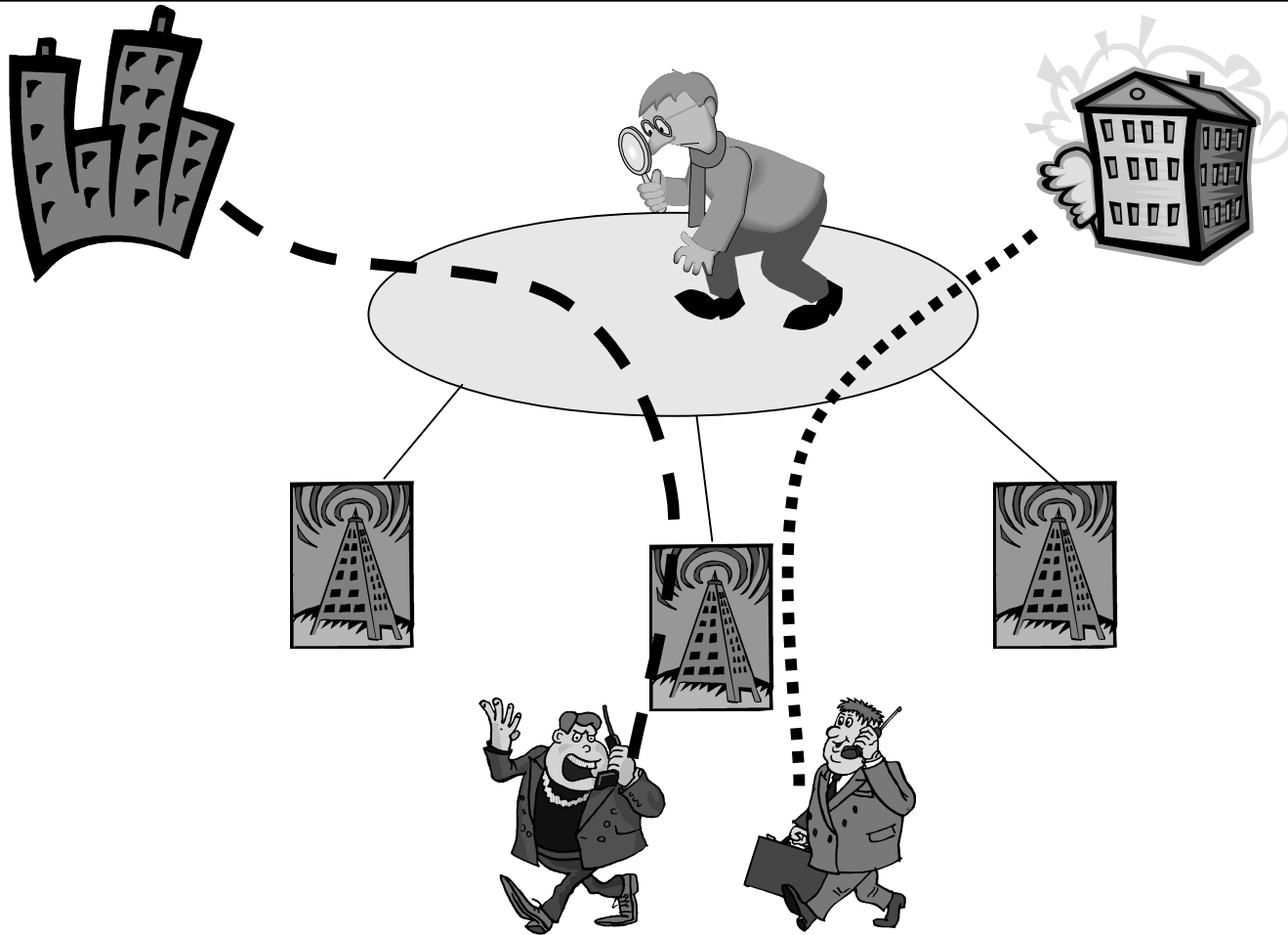




- **...and privacy**
 - **6 classes of privacy:**
 - **Data privacy (content)**
 - **Identity privacy (source/destination)**
 - **Location privacy (place)**
 - **Time privacy (when)**
 - **Transaction (what)**
 - **Privacy of existence (does it exist)**
 - **Security solutions should protect us**
 - **... but still wireless networks leak critical information**
-
-



Example: Who are pals?





Example: Who are pals?

Cell 1: 

Cell 2: 

Cell 3: 

...

...

At same cell 

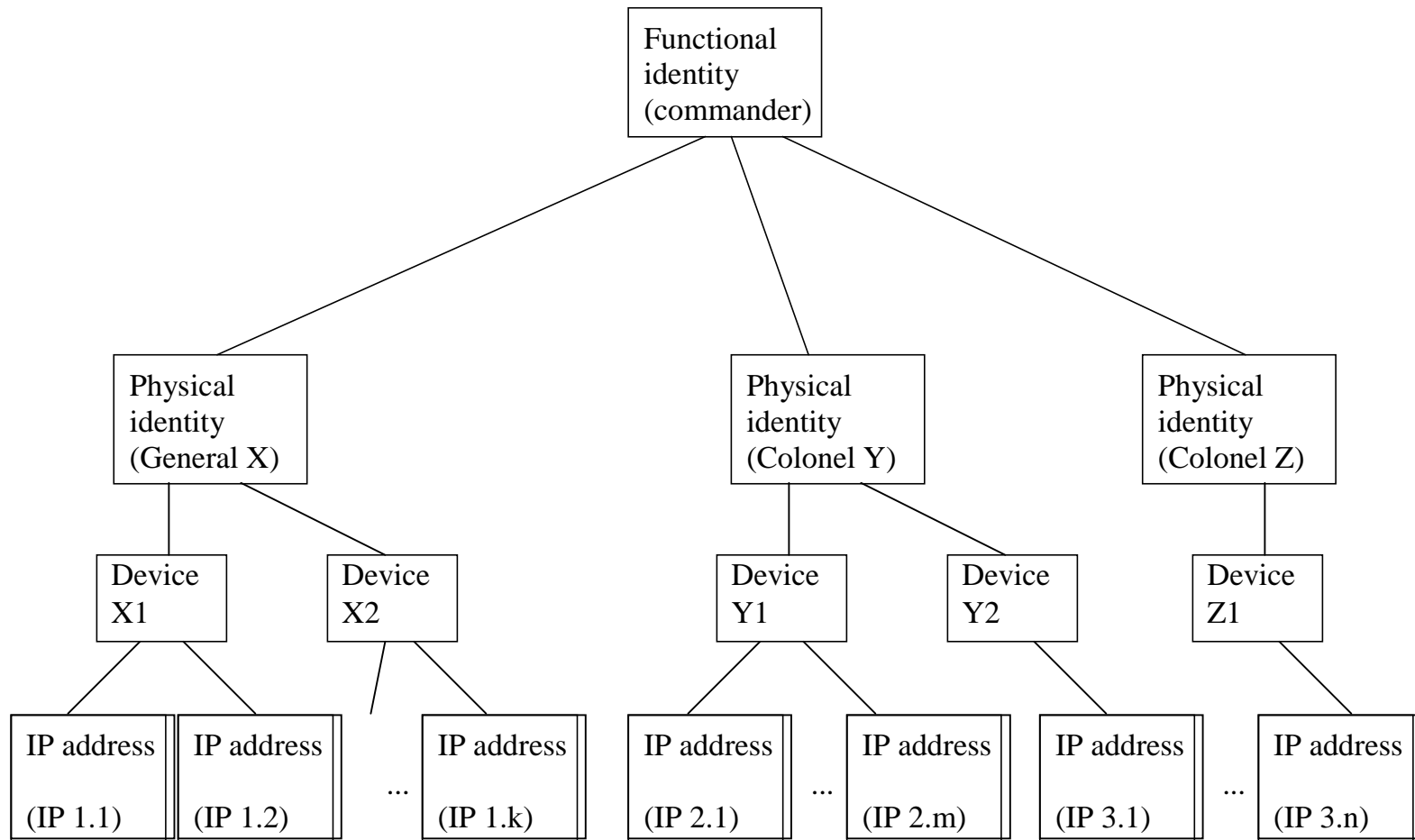
...



- **Terminal mobility**
 - Mobile IP
 - HIP (Host Identity Protocol)
 - Network mobility
 - Ad hoc routing protocols
- **Identity mobility**
 - SIM-card
 - SSH connection
 - HST-card
- **Session/program mobility**
 - Programs migrate from one computer to another...

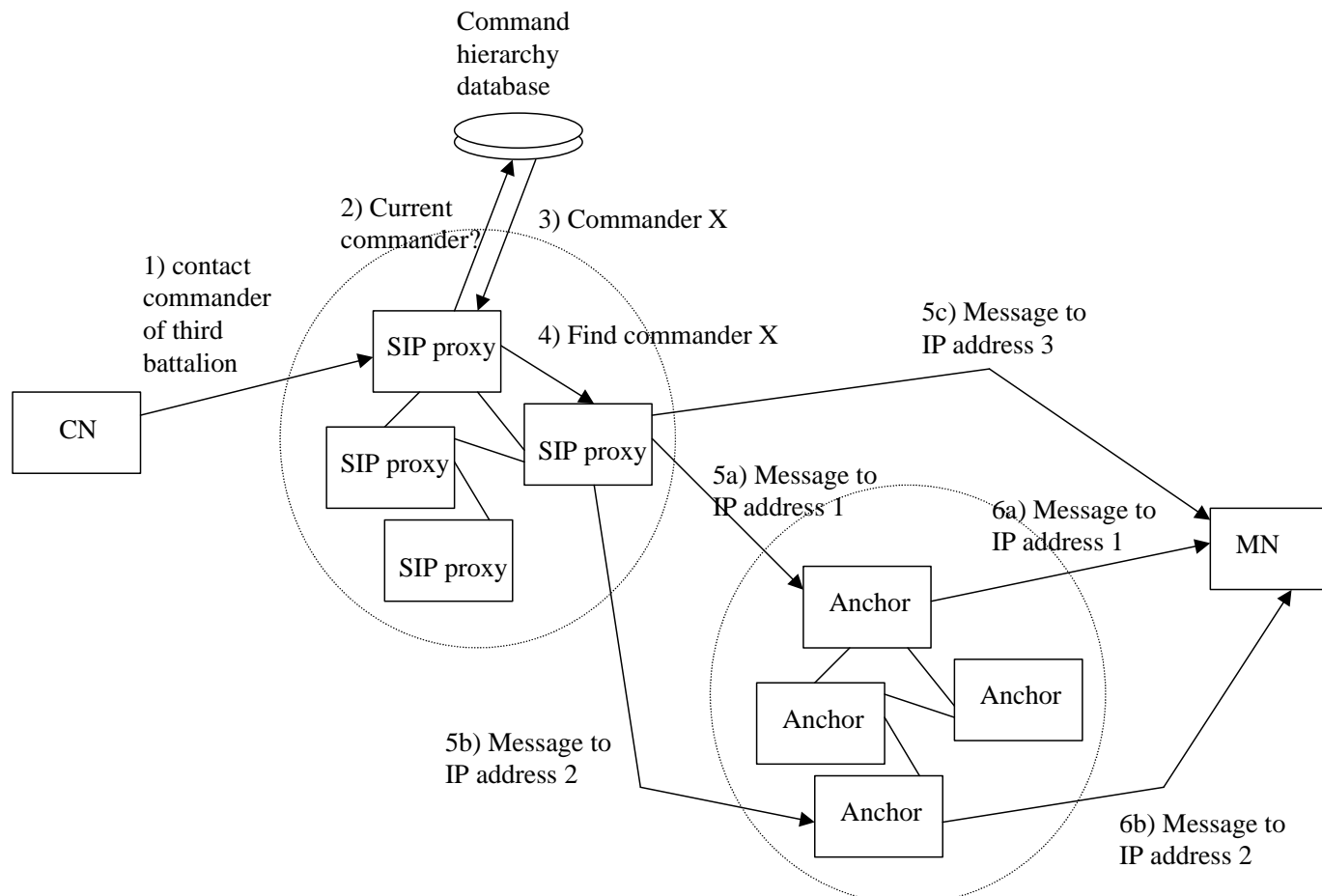


Mobility management: Different level identities





Hierarchical mobility management



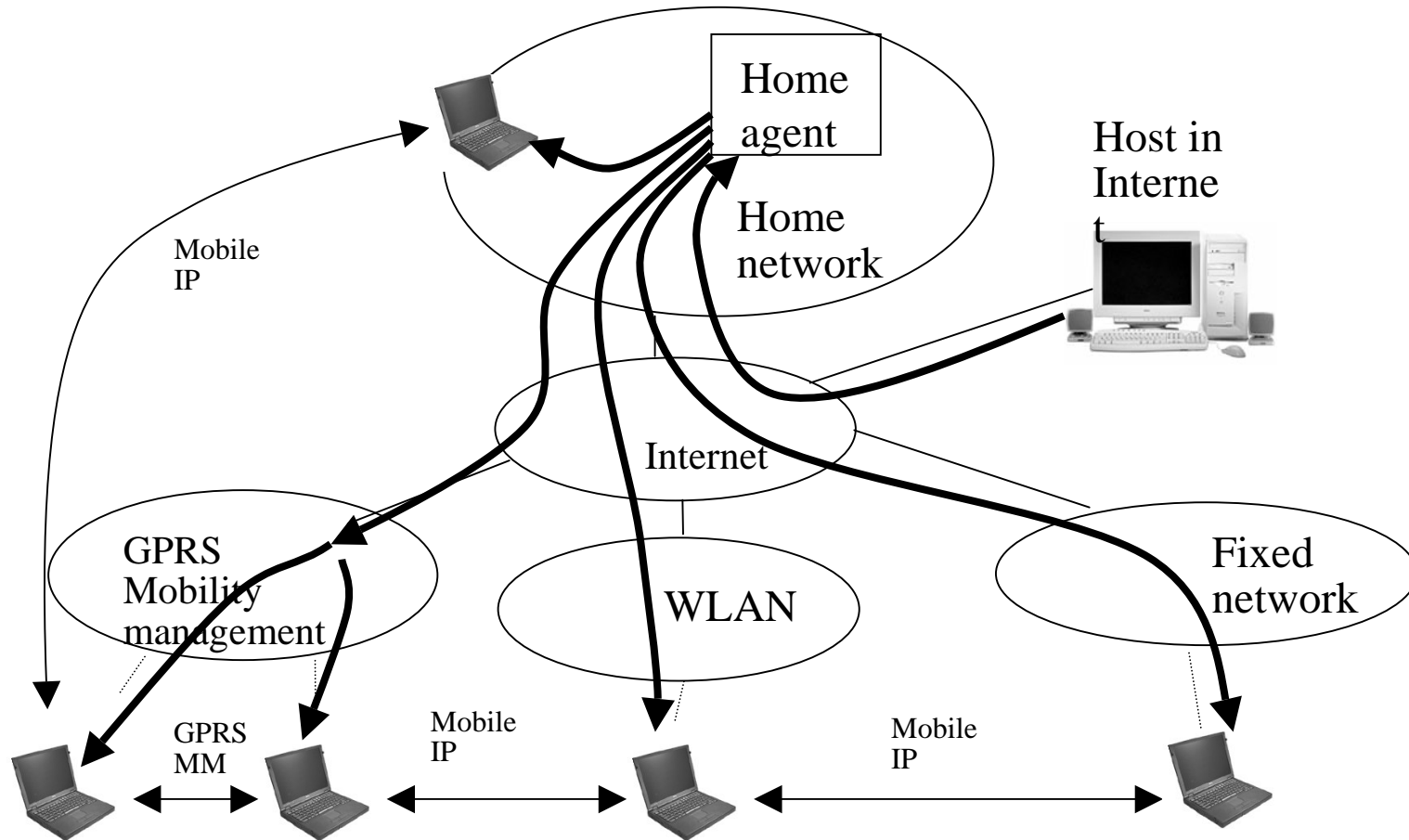


Address mobility: IP address is typically used as

- **identifier:www.foo.bar => 131.228.214.11**
- **location indicator: from subnetwork1 => subnetwork2 ... => subnetworkN**
 - **traceroute www.google.fi ...has multiple addresses; using 64.233.183.103**
 - **traceroute to www.l.google.com (64.233.183.103)**
 - 1 130.233.215.4 (130.233.215.4) 0.134 ms 0.099 ms 0.096 ms
 - 2 130.233.215.1 (130.233.215.1) 0.358 ms 0.300 ms 0.293 ms
 - 3 gw-2-v98.hut.fi (130.233.231.83) 1.545 ms 0.620 ms 0.573 ms
 - 4 funet-ge-1-1.hut.fi (130.233.231.233) 1.182 ms 0.764 ms 0.736 ms
 - 5 helsinki0-g2100-csc4.funet.fi (193.166.187.182) 1.232 ms 14.069 ms 0.856 ms
 - 6 fi-gw2.nordu.net (193.10.68.97) 8.148 ms 9.010 ms 7.861 ms
 - 7 s-b4-link.telia.net (213.248.97.93) 8.141 ms 7.829 ms 7.883 ms
 - 8 s-bb1-pos7-1-0.telia.net (213.248.66.5) 8.430 ms 8.084 ms 8.025 ms
 - 9 hbg-bb1-link.telia.net (80.91.249.220) 25.382 ms 25.063 ms 25.014 ms
 - 10 hbg-b2-link.telia.net (80.91.249.198) 21.536 ms 20.675 ms 25.080 ms
 - 11 google-110073-hbg-b2.c.telia.net (213.248.96.102) 32.476 ms 32.624 ms 32.522 ms
 - 12 66.249.95.133 (66.249.95.133) 32.394 ms 32.117 ms 32.032 ms
 - 13 72.14.233.79 (72.14.233.79) 36.886 ms 36.542 ms 32.132 ms
 - 14 216.239.43.34 (216.239.43.34) 32.818 ms 39.972 ms 36.077 ms
 - 15 nf-in-f103.google.com (64.233.183.103) 33.039 ms 32.388 ms 36.782 ms

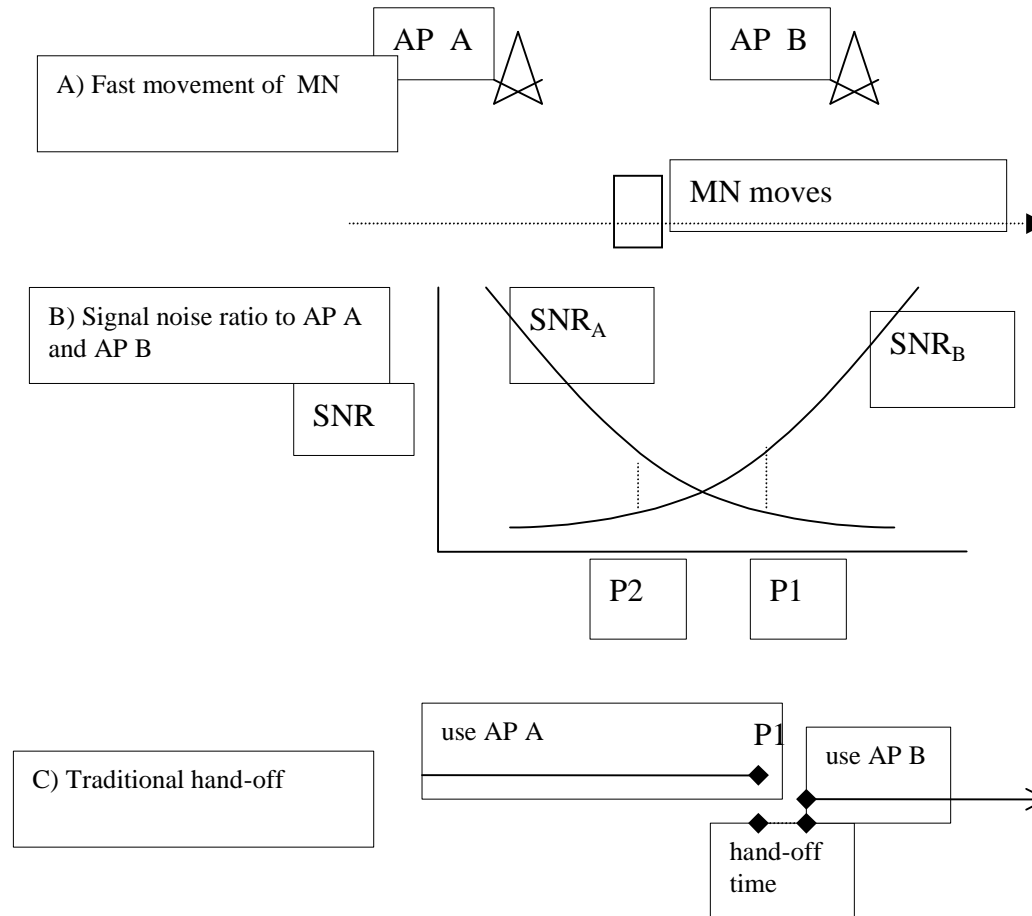


Mobile IP and various access networks



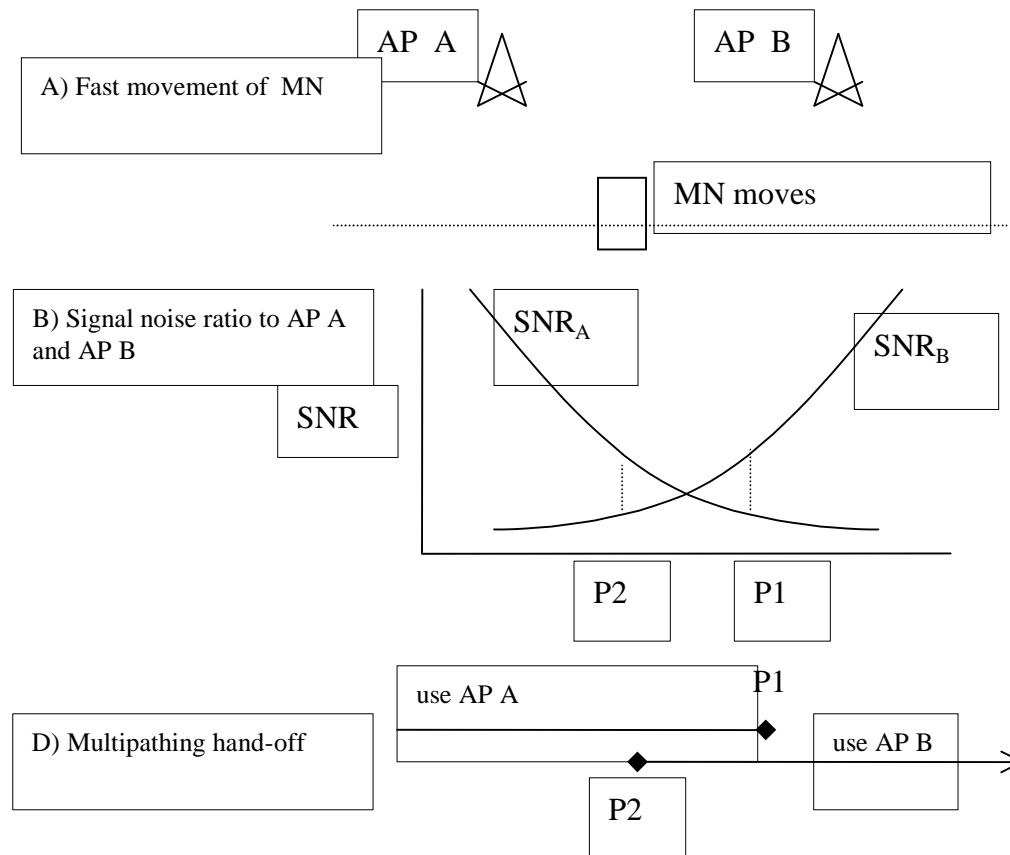


Mobility management: traditional change of access point



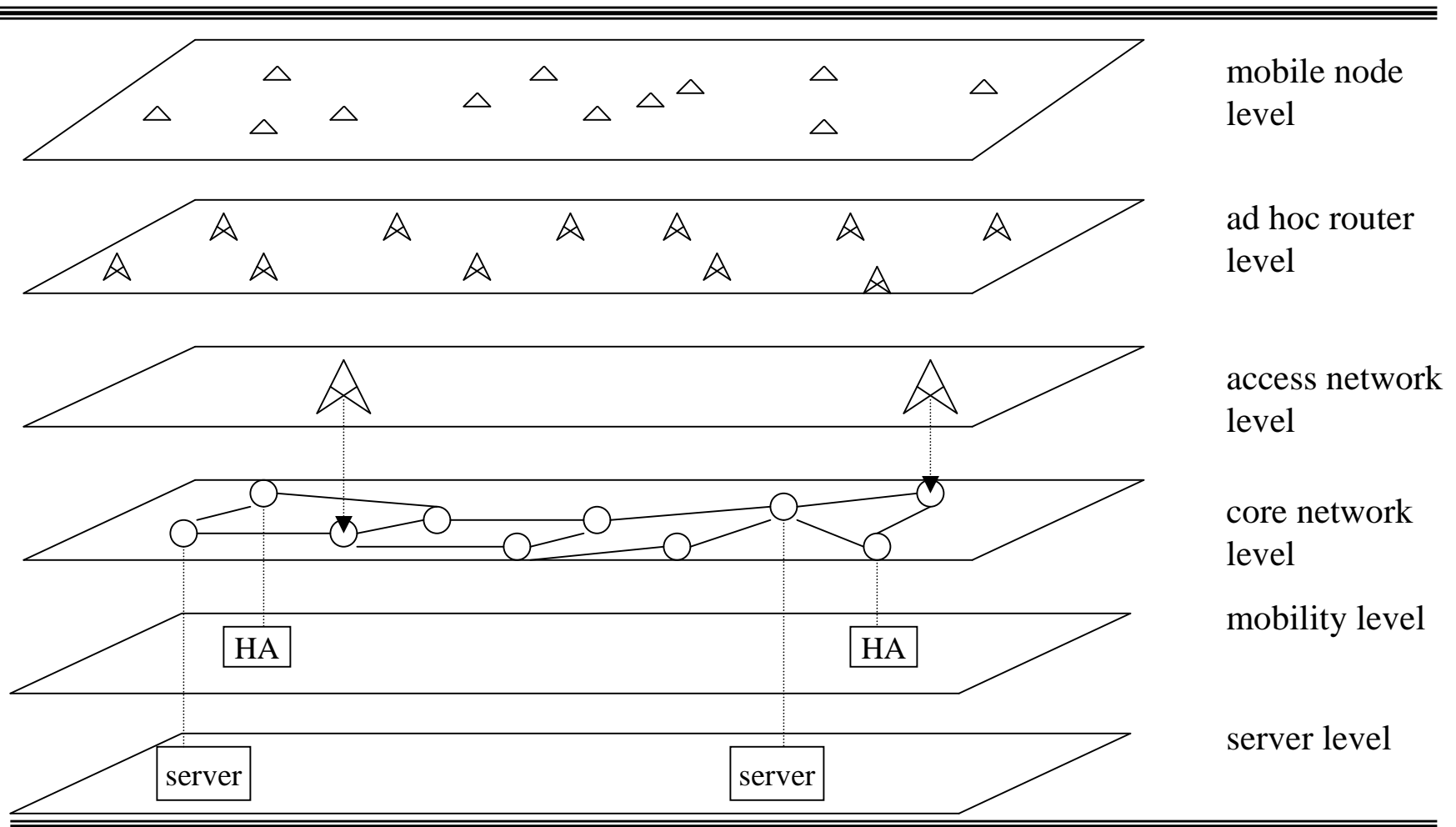


Mobility management: enhanced change of access point



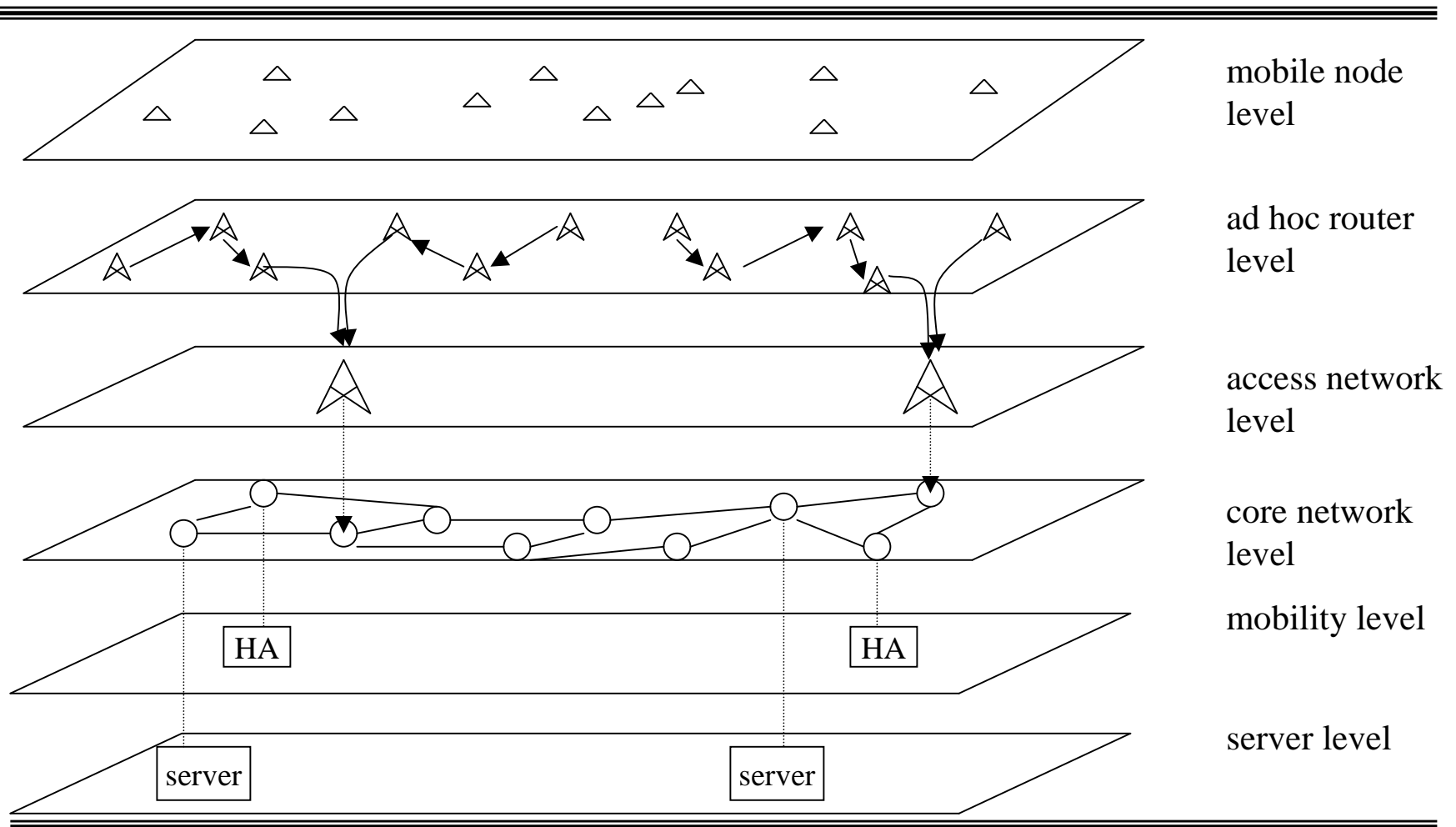


Layered model for wireless networks



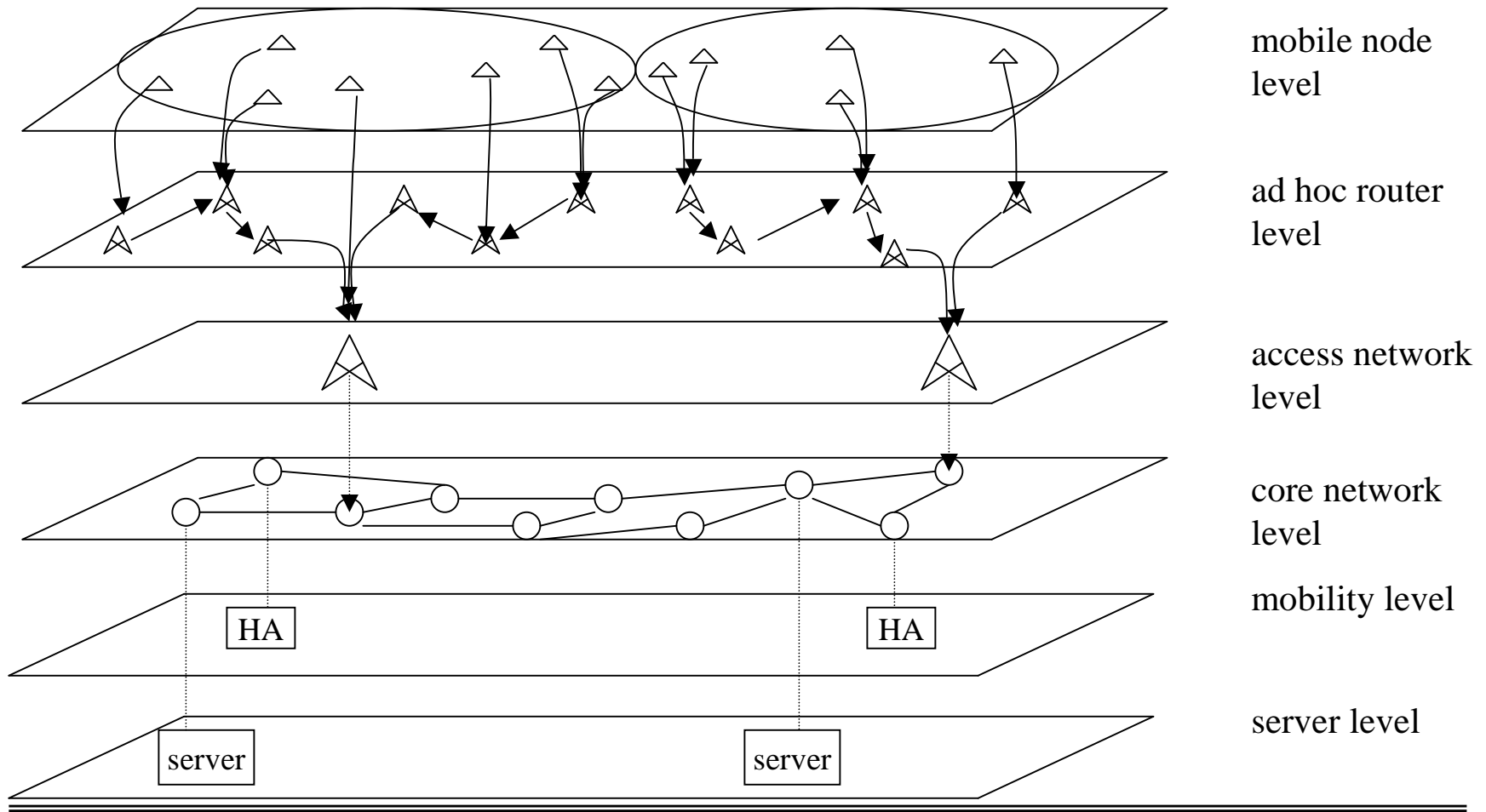


Layered model for wireless networks: ad hoc routers



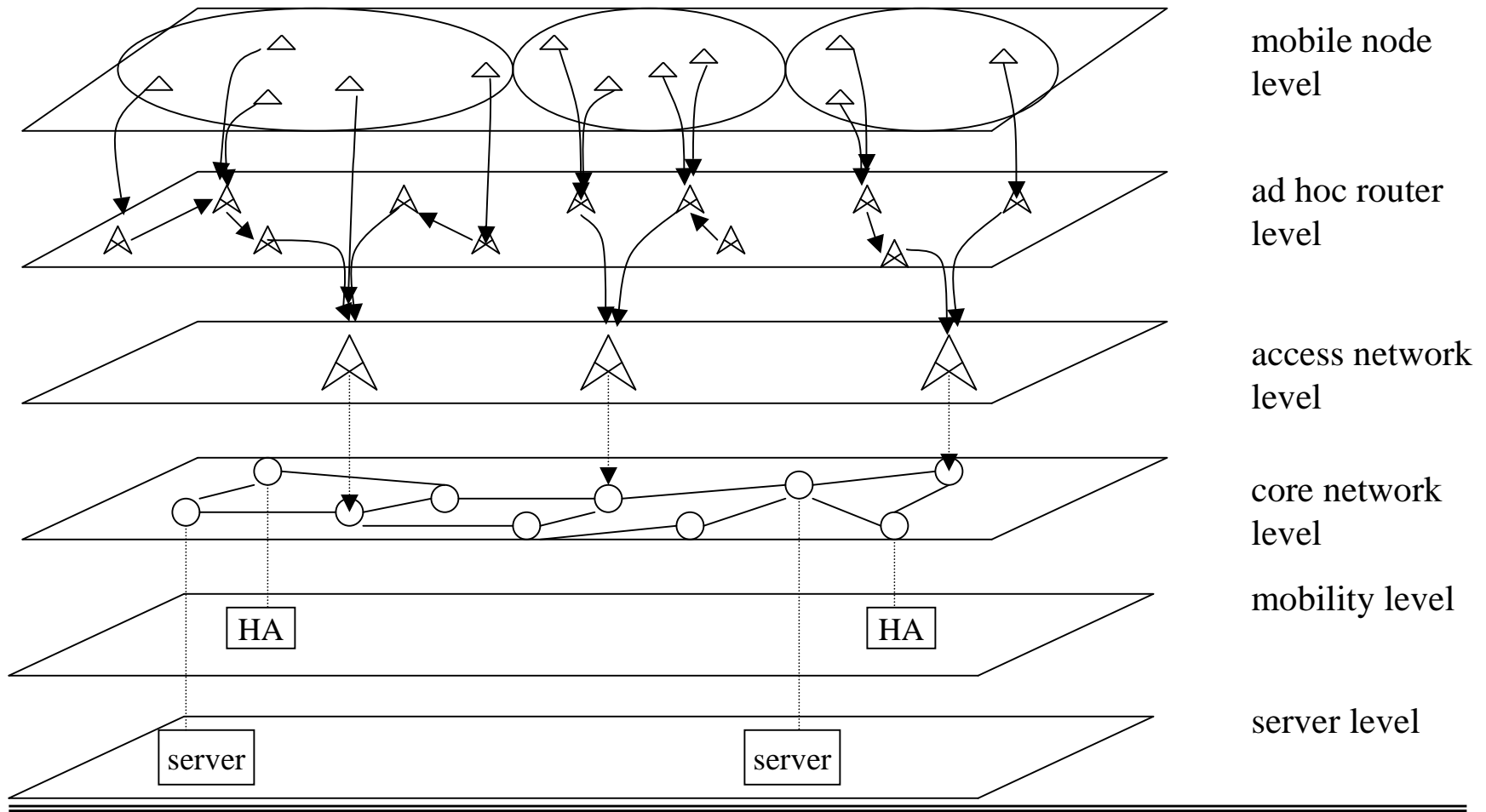


Layered model for wireless networks: mobile nodes



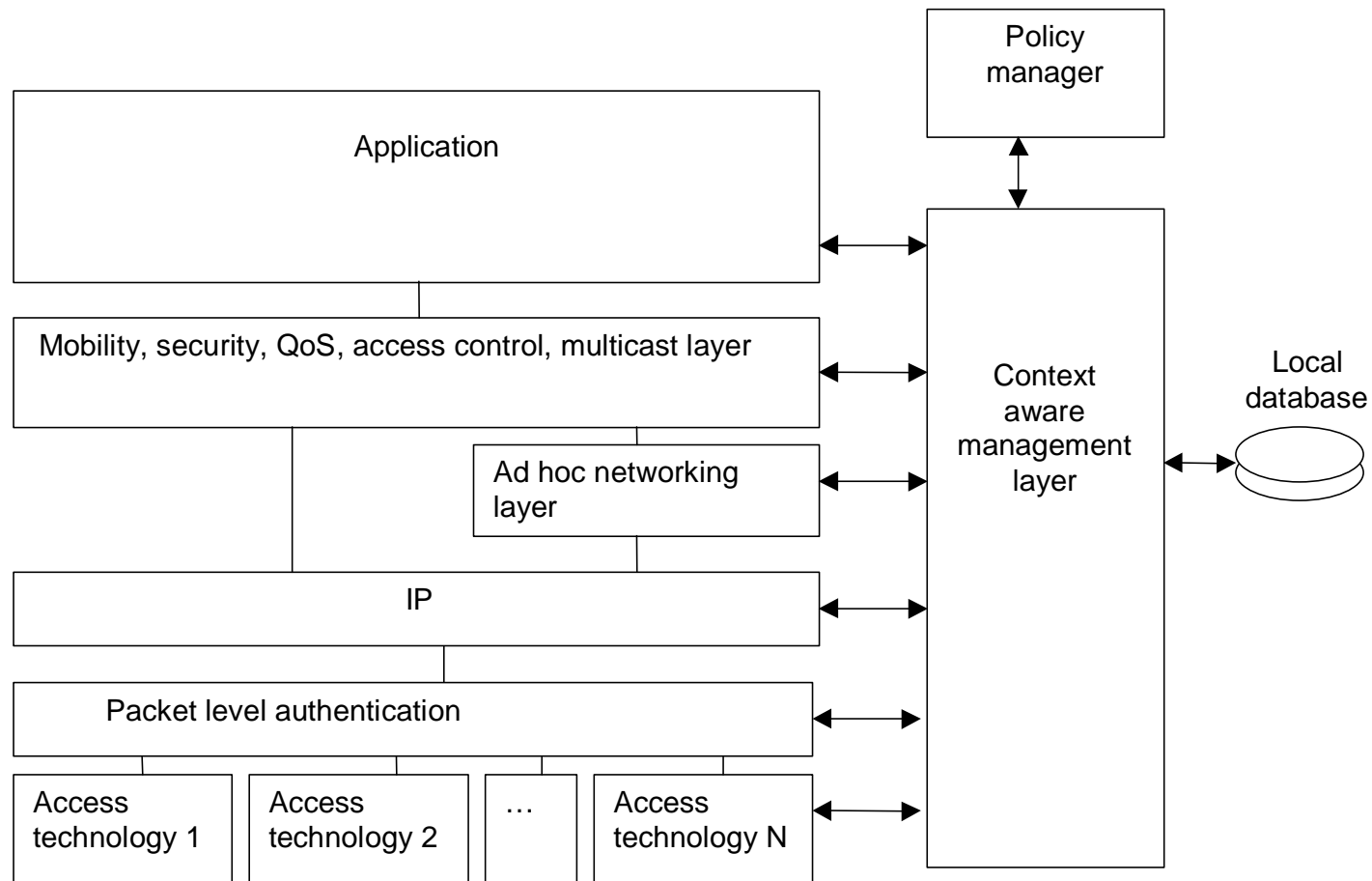


Layered model for wireless networks: new access point



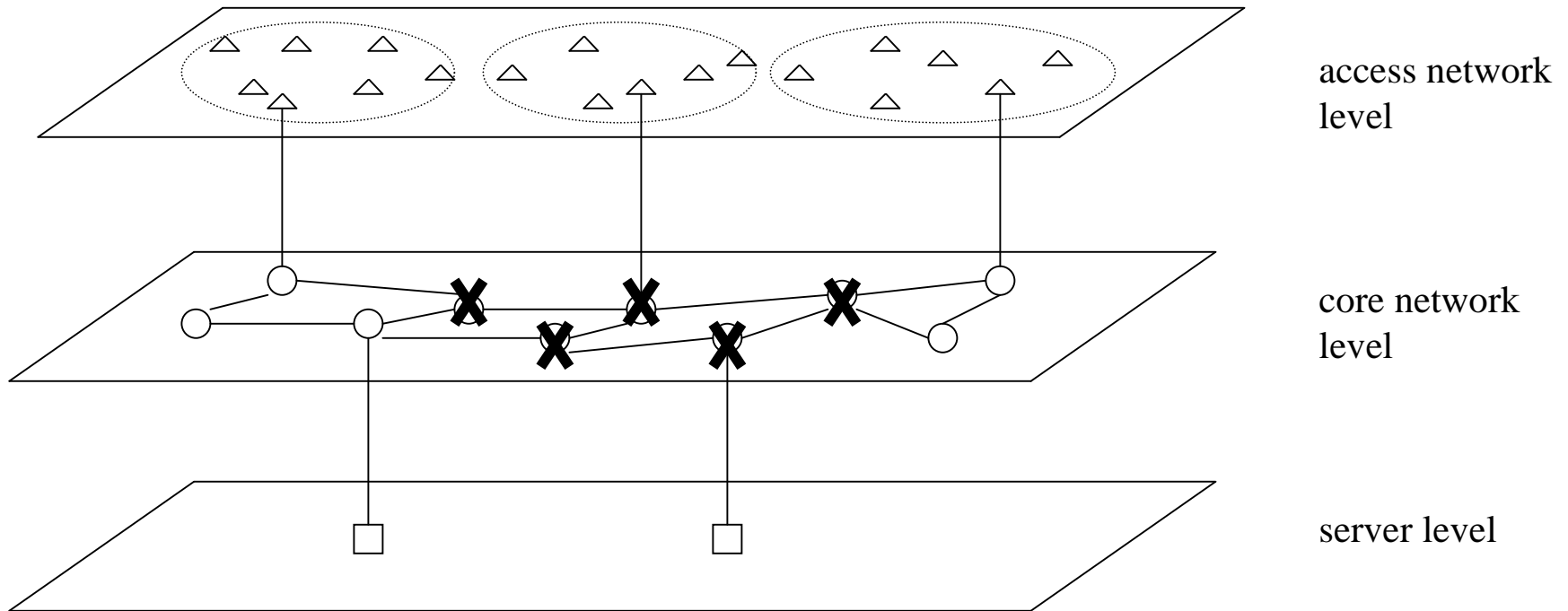


Context Aware Management/ Policy Manager



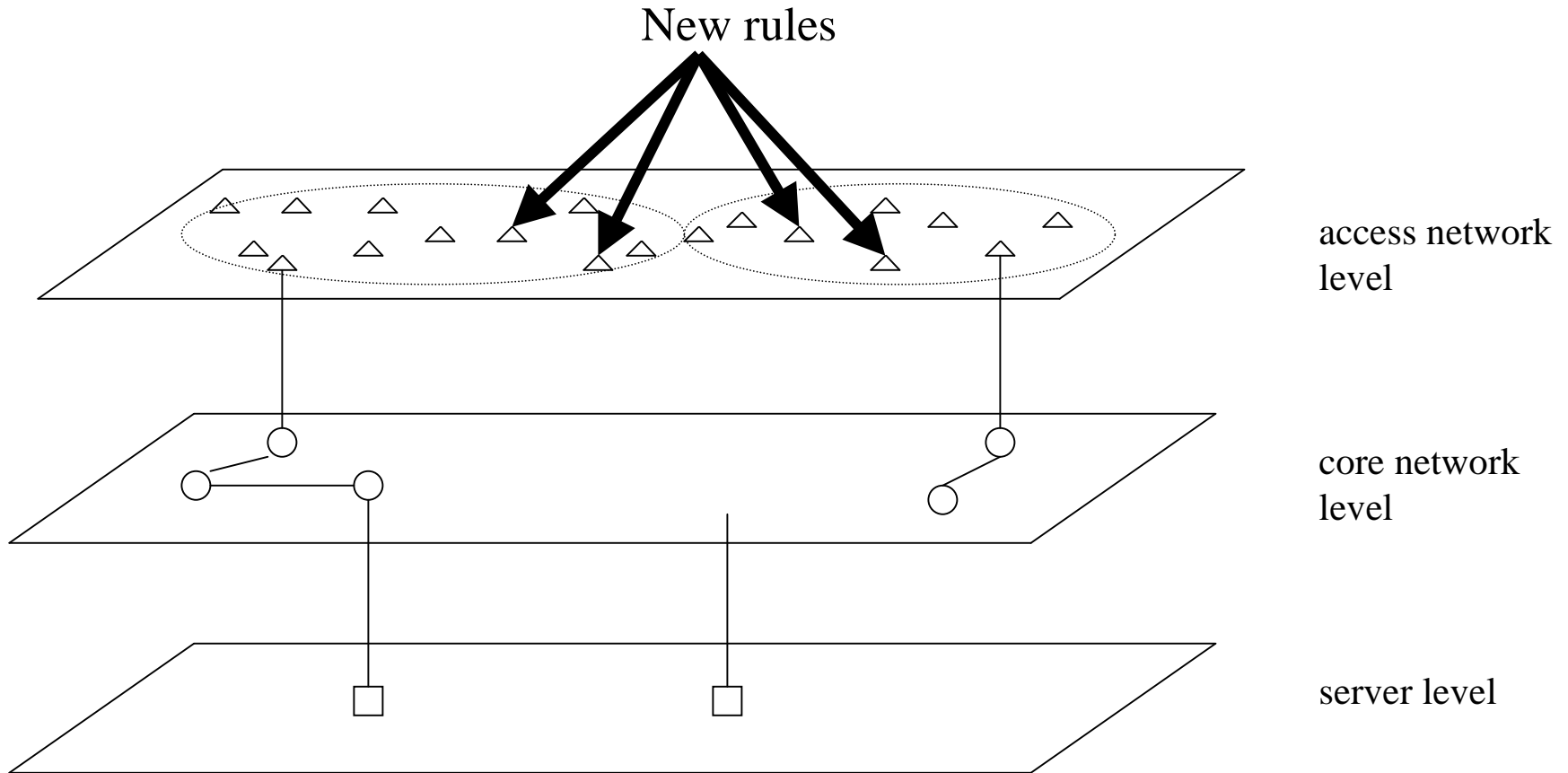


Application: New core network: Military strike



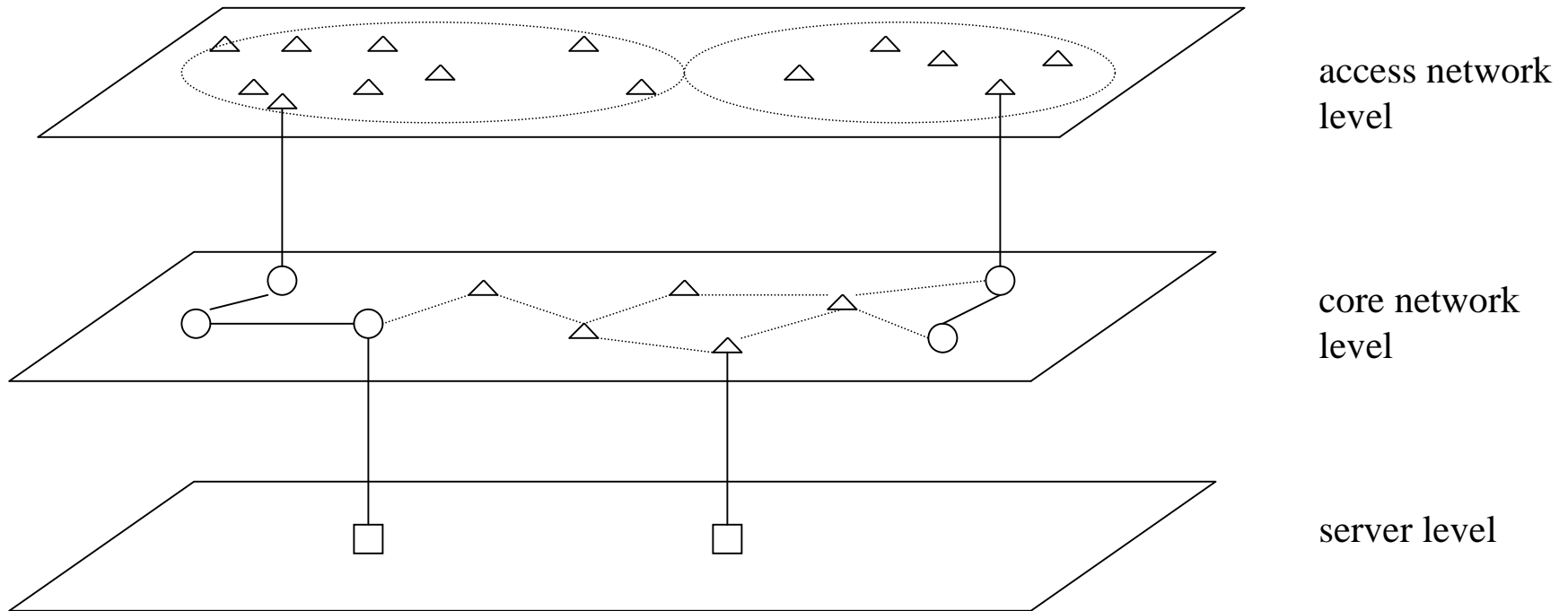


Application: New core network: Reconfiguration





Application: New core network: After military strike





Mobility management functions

	MN-AN	E2E
• Initial setup (e.g. subscription)	(X)	X
• Registration (e.g. attaching to the system)	X	(X)
• Mobility management (e.g., location update)	X	X
• Normal operation (sending/receiving data)		X
• Deregistration (e.g. detach)	X	(X)
• Closing down (e.g. terminating subscription)	(X)	X

**(MN-AN = mobile-access network
E2E = End-to-end)**



- **Decision making:**
 - **By mobile:**
 - **Mobile initiated handoff**
 - **By network**
 - **Mobile evaluated handoff**
 - **Network initiated handoff**
 - **Mobile assisted handoff**



- **Benefits of route optimization?**
 - E.g., in Mobile IP
- **Benefits of multipathing?**
- **Mobile or network initiated handoffs?**