Mobile Networking

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outline

- introduction
  - problem space
- Mobile-IP - RFC 2002
- problems/solutions &&
- PSU solutions for some problems
  - security/redundancy
- one whacky idea
- research areas

but 1st - a commercial

- PSU/DARPA project
  “Secure Mobile Networks”
- try to combine Mobile-IP/IPSEC network security/Wavelan wireless LAN
- focus on **security** and **survivability**
- e.g., MIP has single point of failure in Home Agent, therefore developed
- HARP - Home Agent Redundancy Protocol

project home page

- http://www.cs.pdx.edu/research/SMN
- includes FreeBSD based
  - FA-oriented Mobile-IP
  - IPSEC integrated with Mobile-IP
    - » HA/MN 2-way ESP tunnels
  - Wavelan drivers: ISA/PCCARD
    - » old and IEEE 802.11
  - simple less insecure ad hoc routing protocol
    - » replacement for ARP

problem space

- mobile systems as opposed to fixed systems
- wireless or multi-interface as opposed to wired infrastructure
- current systems designed to stay put from OS up/down
- applications/transport/network/link layer
  - assumptions favor wired/fixed systems

some problems - net stack POV

app layer: dns* works at boot/rich bandwidth
transport layer: TCP disconnect=congestion
network layer: IP address -> subnet locality, network design
link: wireless metrics/bandwidth/reachability

*and manual configured?!

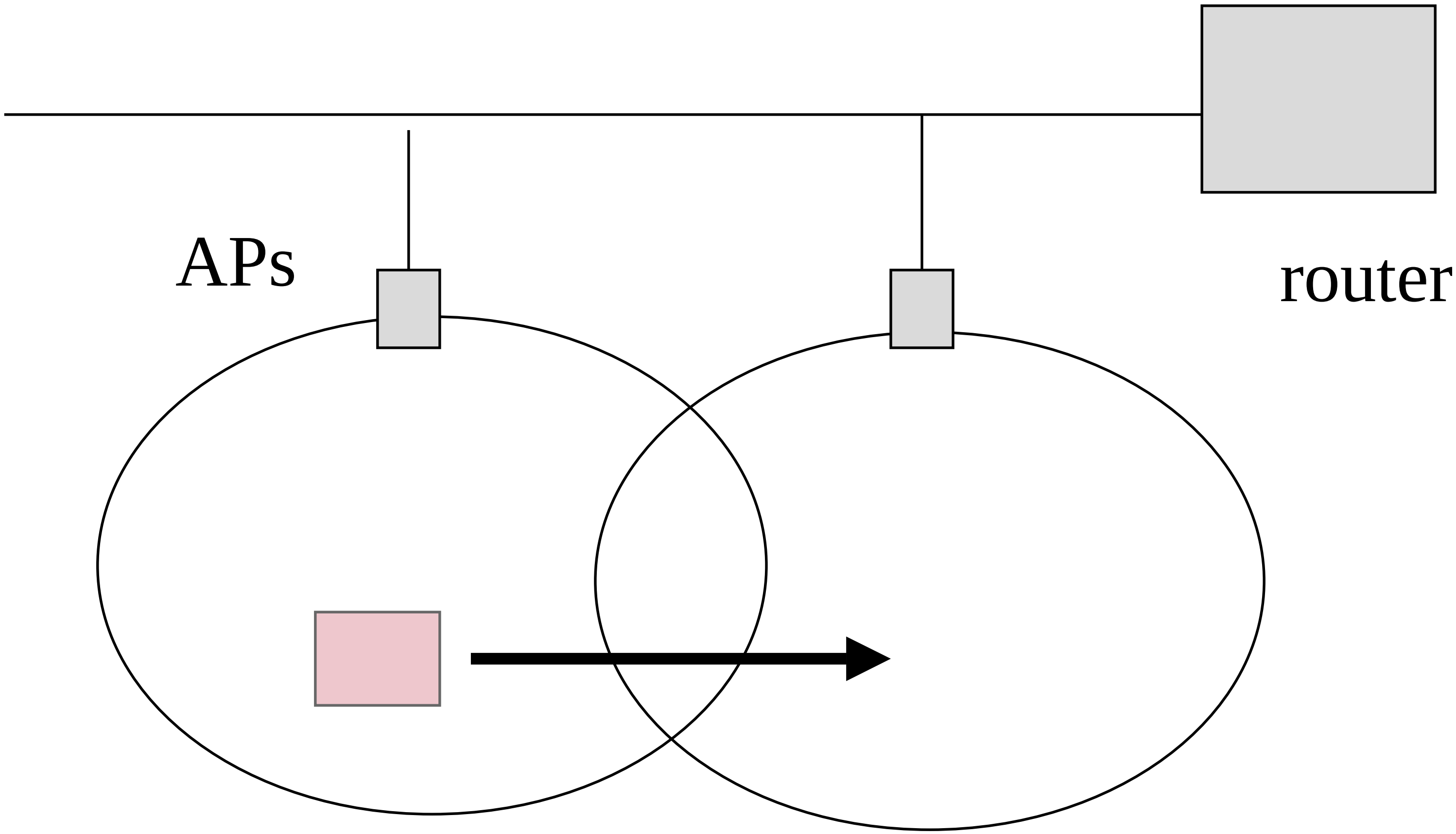
certain high-level problems

- multiple interfaces and networking, where again you have an assumption that you don’t change i/fs (or IP addresses)
  – o.s. objects bound to immutable lower objects
  – Novell server knows your mac -- change cards?
- security - dumb end station no longer sheltered by firewall (still a problem)
- finding information on the road that applies only to travelers

3 mobile net design prototypes

- roaming; e.g., IEEE 802.11 wireless,
  - beacons from Access Points
  - STAtions login to A.Ps
  - IP subnet/connection problems ignored
- DHCP per subnet
  - can give you DNS (pro)
- Mobile-IP
- your idea here ...

IEEE 802.11 - roaming



station/moving thru cells

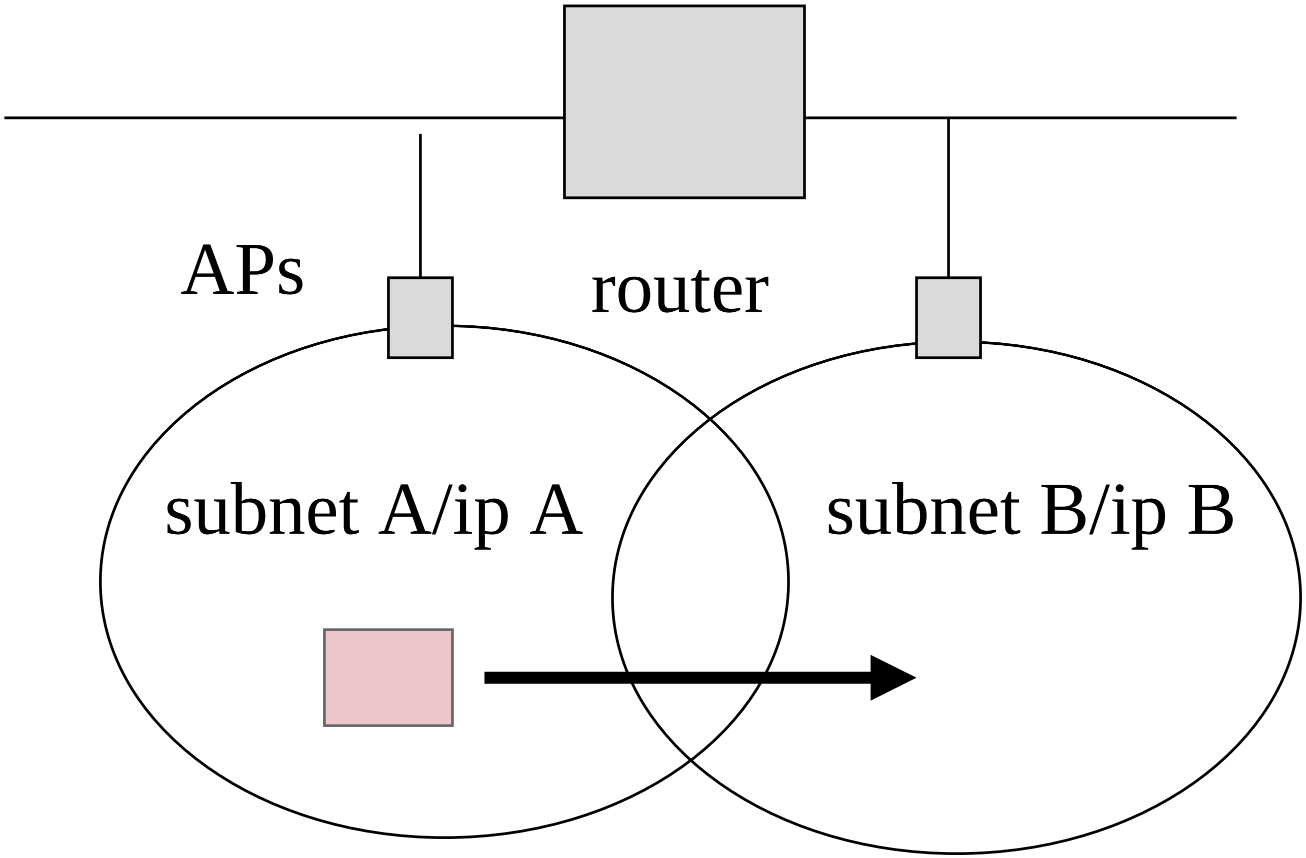
pros/cons

- pros
  - claimed interoperability
- cons
  - can’t span IP subnets
  - one security model: mac addresses known a-priori
    - » mac addresses are spoofable
  - bridge-centric (bridges leak)
  - loading factor of wireless devices low

virtual lans

- vlans might save it
  - campus-wide external (outside) vlan model
  - must be top-down switch infrastructure
- more cons of wireless devices
  - too expensive
  - APs really too expensive

DHCP-model (sitzkreig mobility)



station/moving thru cells

DHCP model

- everytime you go to new subnet - you must replug (per subnet IP address)
- can co-exist with roaming model
- (may exist but) no well-known way to dynamically do this other than user-initiated
- can work with ethernet as well as wireless
- con: loss of connections on move
- security model: overall same as mobile-ip
  - however DHCP exchanges are unauthenticated

understand

- DHCP is an auto-discovery protocol
- not a routing protocol
  - can give you local default router
- gives you router/DNS/subnet mask/IP address
  - IP address is leased
  - perhaps time here should be shorter than 1 day
    - » 1 hour?

Mobile-IP

- rfc2002 - way too long to produce, standards trk
- basic goal: defeat the IP address fixed at a link problem; i.e.,
- invariant: **the Mobile Node may retain a “home” IP address that does not change from link to link**

pros for MIP

- easily change same-domain links - no bureaucracy
- IP address hides link-layer details; e.g., beaconing (or link discovery) is now MIP property
  – **FA beaconing makes for faster handoffs (mcast doable)**
- DNS name binding fixed
  – keep same name, change IP hard due to caching
- TCP connection may be retained across links - can’t change peer state easily

pros (but worthy of argument)

- NO A.P. (wireless bridges) need apply
  - **do it with routers** to minimize flat universe + broadcast/security/multicast flooding problems
- extends IP address space
  - (IP away, IP at home) == 64 bits
  - **you need never go home**
  - (or 256 in the case of Ipng) - JOKE!
- meta-pro: IP address as name is useful

cons

- IGP or EGP (cross domain)?
  - if latter then huge security problems
- isn't DHCP way more cool?
  - slightly different problems
  - DHCP doesn't preserve an IP address
  - make case that **both are needed for adaptable MN**
  - FA or DHCP admin easier?
- fundamental attack on IP subnet model (pro?)?
- surprise: didn't solve all possible mobility problems

protocol

- MIP is a routing protocol that consists of:
  - 1. **link discovery** via advertisements or solicitiations (ICMP router advert + MIP part)
  - 2. **forwarding via tunnels** (IPIP) from Home Agent to Foreign Agent/Mobile Node
  - 3. **MIP UDP registration protocol**
    - » UDP request/UDP reply
    - » MN (to FA) to HA and back again
- network layer - but app daemons

jargon/entities

- **MN - Mobile Node** (say, a laptop or peripatetic toaster)
- **HA - Home Agent** (router at “home” IP subnet)
  - when at home, normal IP
  - when away, HA forwards packets to your remote site
- **FA - Foreign Agent** (aka base station, router at “foreign” link/subnet, where you wandered to)
  - ids link, and serves as tunnel endpoint
- **CH - Correspondent Host**, any peer end system
- **COA - care of address**, where you wandered to

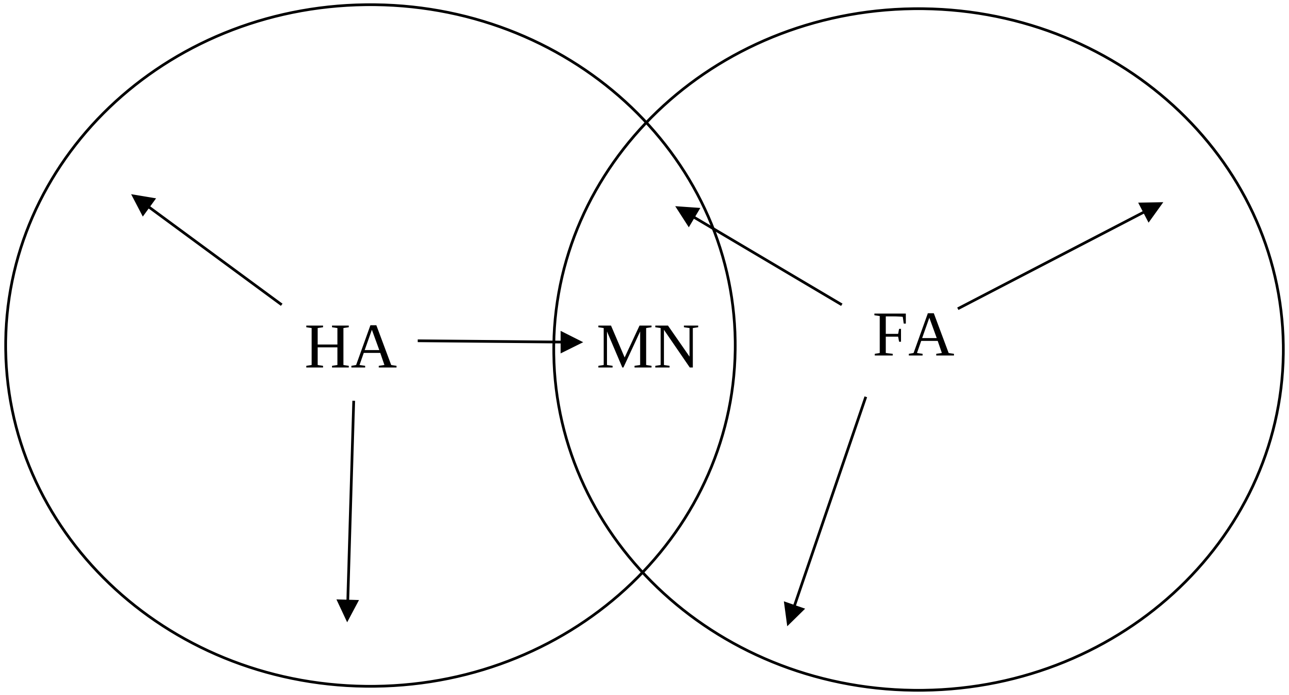
2 basic MIP topologies

- #1: FA-MIP: MN assumes FAs exist at subnets that are “elsewhere”
- #2: COA-MIP: MN acts as own FA, must be able to acquire local IP address on foreign FA-less link,
  - say via DHCP
  - or PPP dynamic IP allocation
  - or manually (ethernet config, SLIP)
- local net admin will determine which is available MN should adapt to link
- **MN could use DHCP for opt. info in all cases**

link discovery

- agents (HA/FA) may send ICMP router advertisements with MIP extension
- MNs can hear and make decisions about who to use
- MN may send solitication, but agent beacons enable faster handoff
- **FA beacon provides FA COA + local link IP address (may/may not be same)**

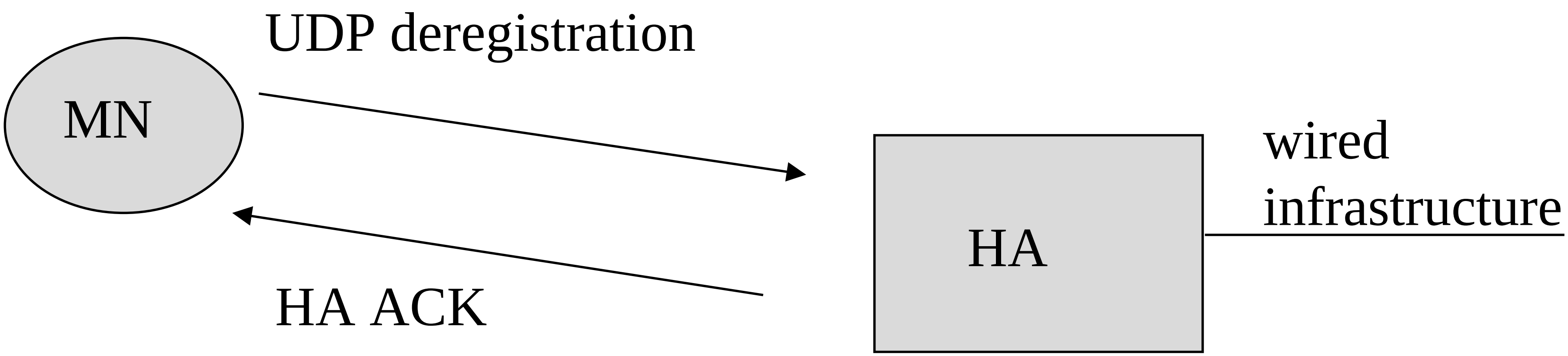
beaconing - radio POV



MIP registration

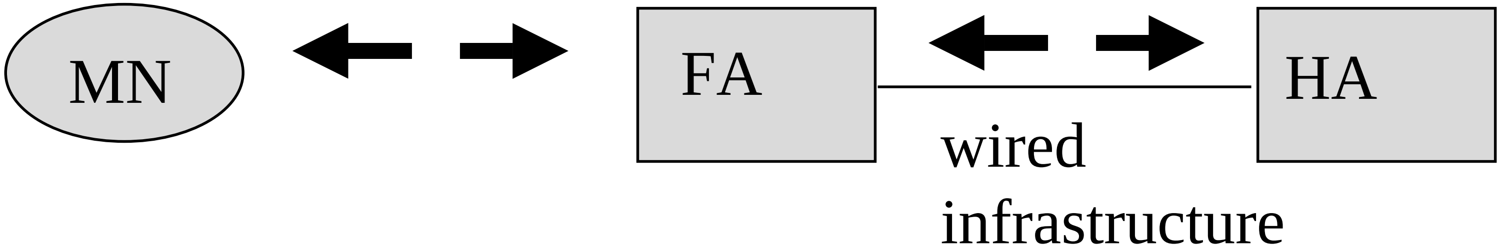
- MIP protocol consists of UDP registration/ack message on port 434
- at home MN tells HA it is home - HA cancels any “AWAY” tunnels/state
- treated as normal IP
- at FA, MN sends FA UDP registration (includes FA COA + HA address)
- FA proxy forwards to HA, and back to MN

MN - HA registration at home



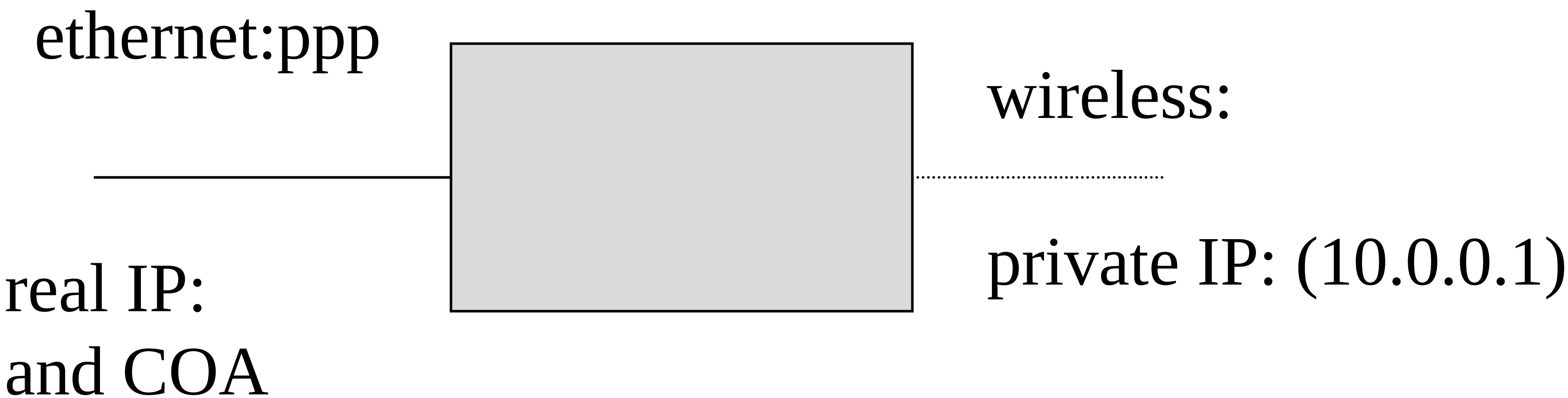
at FA

UDP registration/port 434



FA acts as application gateway to forward UDP registration to HA, MN tells HA that it is at FA

possible FA architecture/wireless

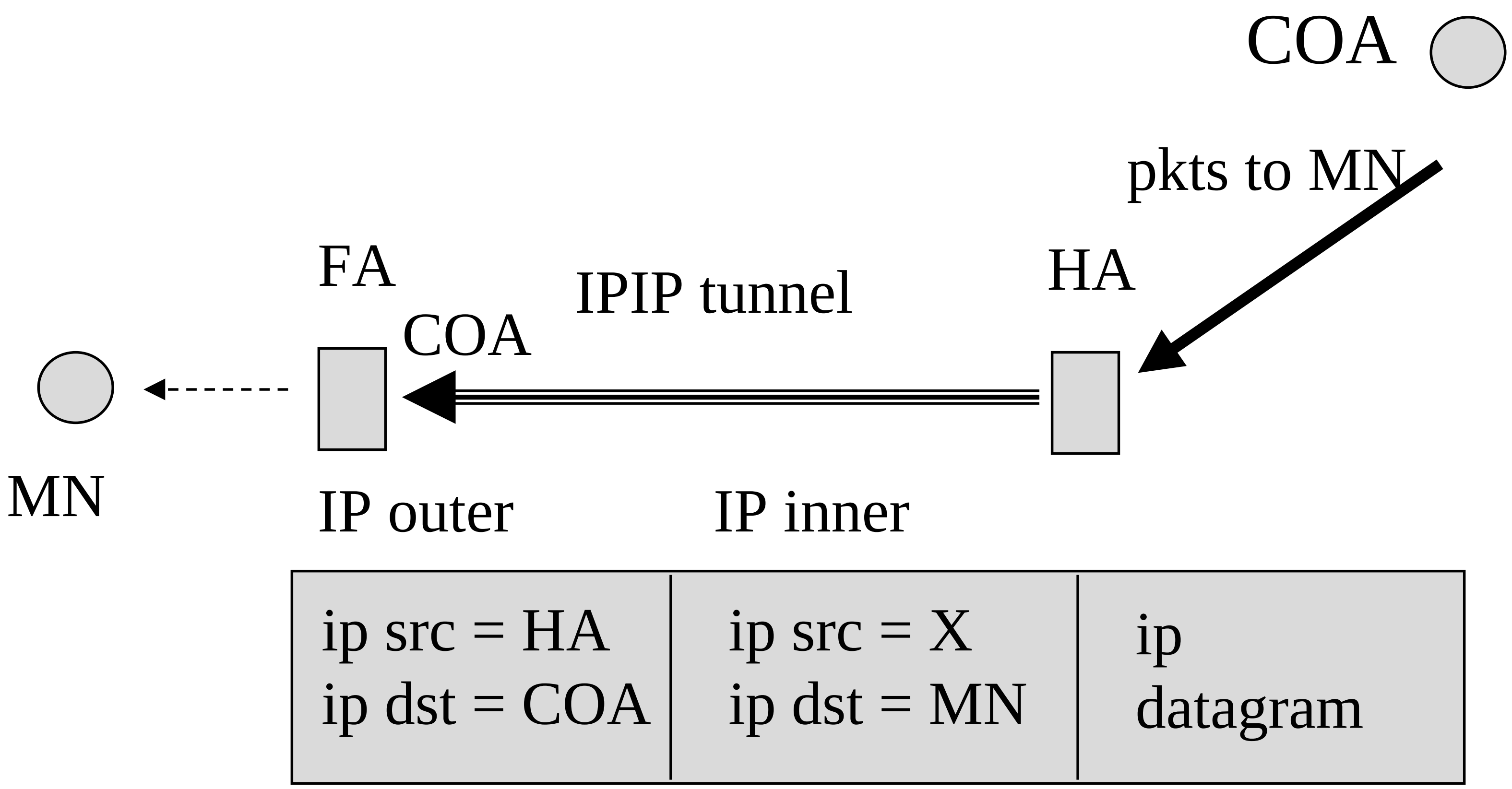


non MIP systems can only attack FA
don’t waste IP address on FA side

registration result: MN/HA

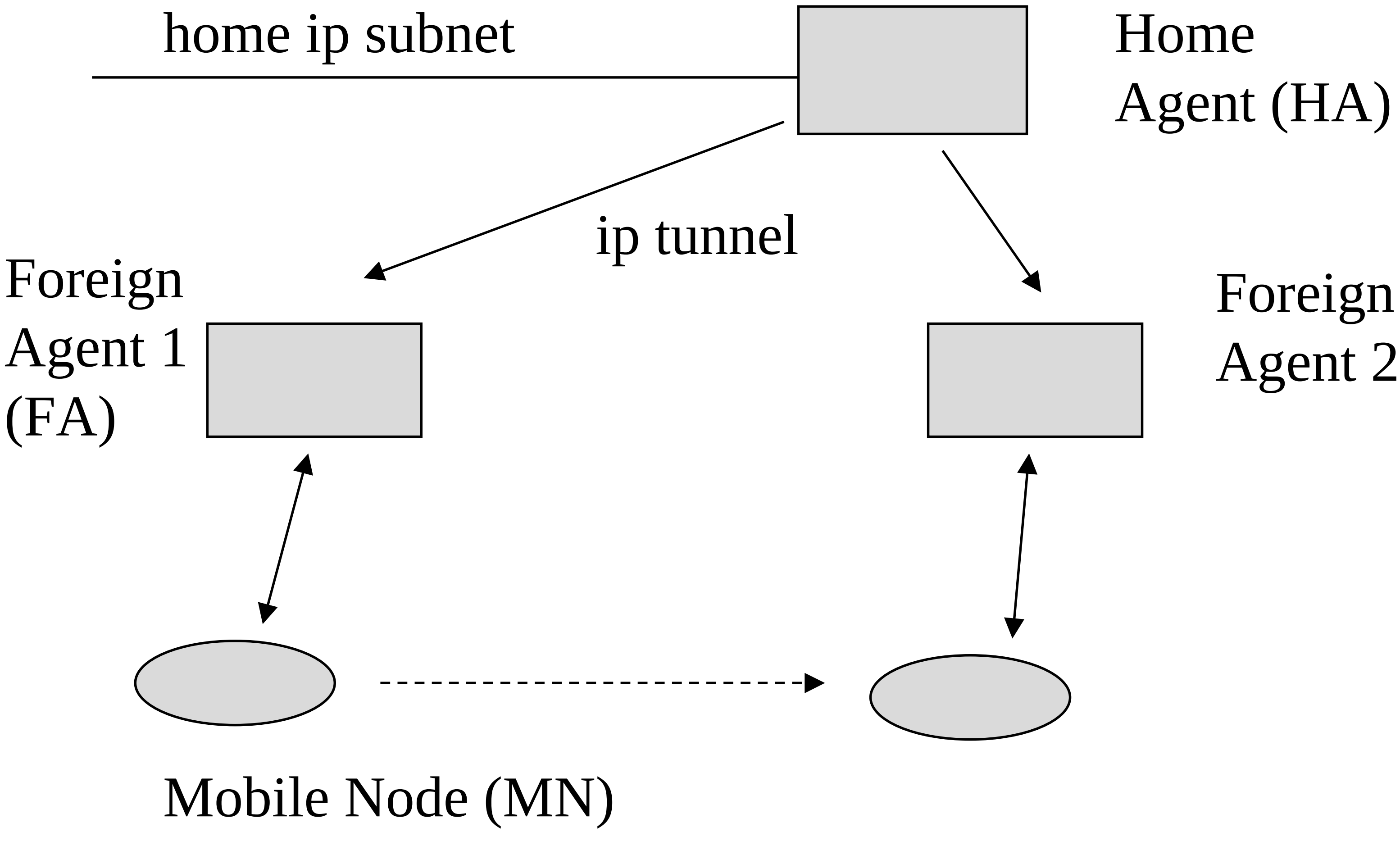
- HA knows that MN is at (COA IP, MN IP)
- uses IPIP(4) tunnel (or GRE etc...) to forward packets send to MN at home to FA
- FA is tunnel endpoint
- FA strips outer IP header and delivers inner IP datagram to local MN
- if no-FA case, MN acts as own tunnel sink

IPIP tunnel, HA to MN



note: IPIP is unicast, not multicast MBONE/DVMRP

MIP TOPO Overview



routing note

- packets to MN when AWAY are forwarded by HA to COA; i.e., local link surrogate
- MN must keep HA appraised of that COA, when it moves, tell HA about change
- fundamental MIP only deals with packets “to” the MN
- packets from the MN are routed normally; i.e., MIP need not apply

MIP UDP packet authentication

- shared symmetric MD5 128 bit key
- MN/HA, MN/FA, FA/HA authentication all may exist
- not dynamic, but manual key
- implemented with TLV at end of registration/reply packet
- IP address, SPI as indices
- 2 kinds of replay protection, TS, nonce

3 MIP security/net topos?

- **interior**: FA based for quick handoff, DHCP optional for local info (DNS server, printer)
- **exterior**: (for guests), DHCP a requirement so that MNs can get local address?
  - net admins must consider local security
- **on the road**: must be FA based for quick handoff and cell discovery.

problems ...

- MIP is IP-layer, a step up but not silver bullet for all known mobility problems
- triangle routing may be considered a problem (or an advantage ...)
- subnet && mobility a problem
  - wireless link and subnet != reachability
  - MN from subnet X/Y can’t talk directly
- security security security

problems

- o.s. flexibility for MIP support may be put to test - implementation issues
  - bind i/f X (IP address) to subnet Y (FA)
  - change default route dynamically (MN)
  - arp issues
  - do tunnel out and tunnel in (HA/FA/MN)
- HA is possible single point of failure (fate-share)

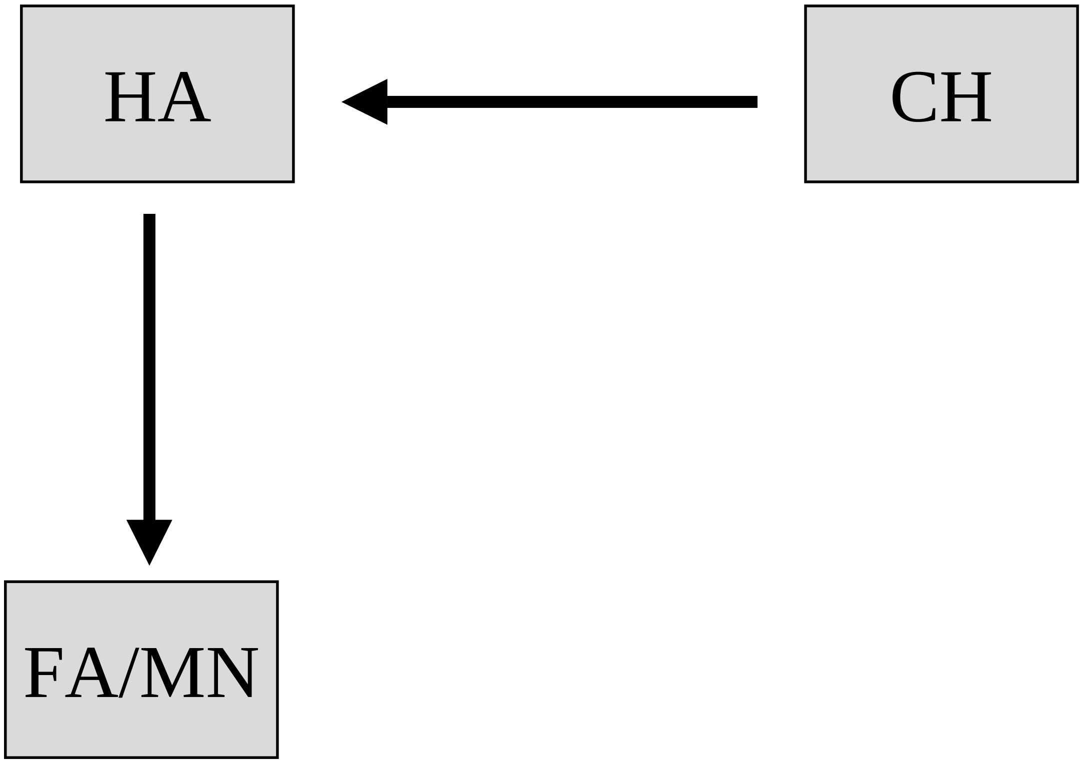
security

- within-enterprise
  – wireless links may be deemed less secure
  – have you heard of TEMPEST?
- without-enterprise
  – laptop && owner abroad have shed home firewall - need own protection
  – enterprise must have insecure subnet for visitors; i.e., visitors can't attack internal nets
  – policy must evolve ... from no visitors allowed

security (more ...)

- MN/HA shared manual keys are scalable but
  - FA/HA (especially > 1 HA at a site)
  - FA/MN are not
- need dynamic lookup say via DNS or Kerberos like system
  - BBN MOIPS/PSU digsig both DNS based
- need security for all MN packets

triangle routing



triangle routing, cont.

- IPv6 to fix - CHs need to told about MN move and tolerate (COA, MN) tuple
- on the other hand, from security POV
- may not want to fix it
- make the MN always appear to be at home
  - don’t tell strangers where you are going ...
  - MN might always tunnel*back* home
  - **2T routing** :->

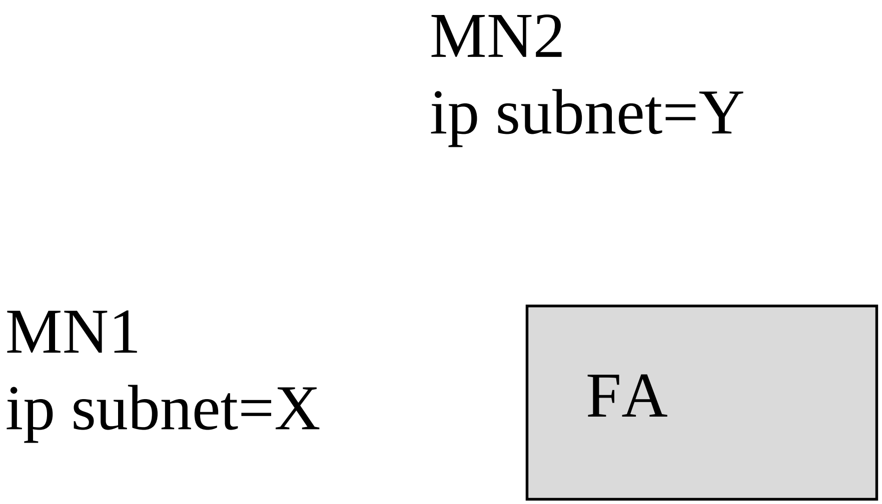
problem: subnet/reachability

- problems that MIP does not address
- call it the “subnet != link problem”
- if B can hear A/C, B can’t assume A can hear C (radio) (it’s not ethernet)
  – ICMP redirects are hazardous ...
- two MNs with different IP and radio sitting on top of each cannot talk with traditional IP/subnet/ARP (need router/FA)

PSU - simple Ad Hoc #1

- everybody beacons - MNs and agents
- overload ICMP router discovery with extra info
- authenticate (MAC src, IP src) with shared MD5 symmetric key (optional but we do it)
- if you hear a beacon, and you can authenticate it, then and only then install link-layer route
- if you don't install route, X can send you packets but you won't send X any
- note: **you don't speak ARP any more (IP/enet)**

2 MNs at a FA - problem #1



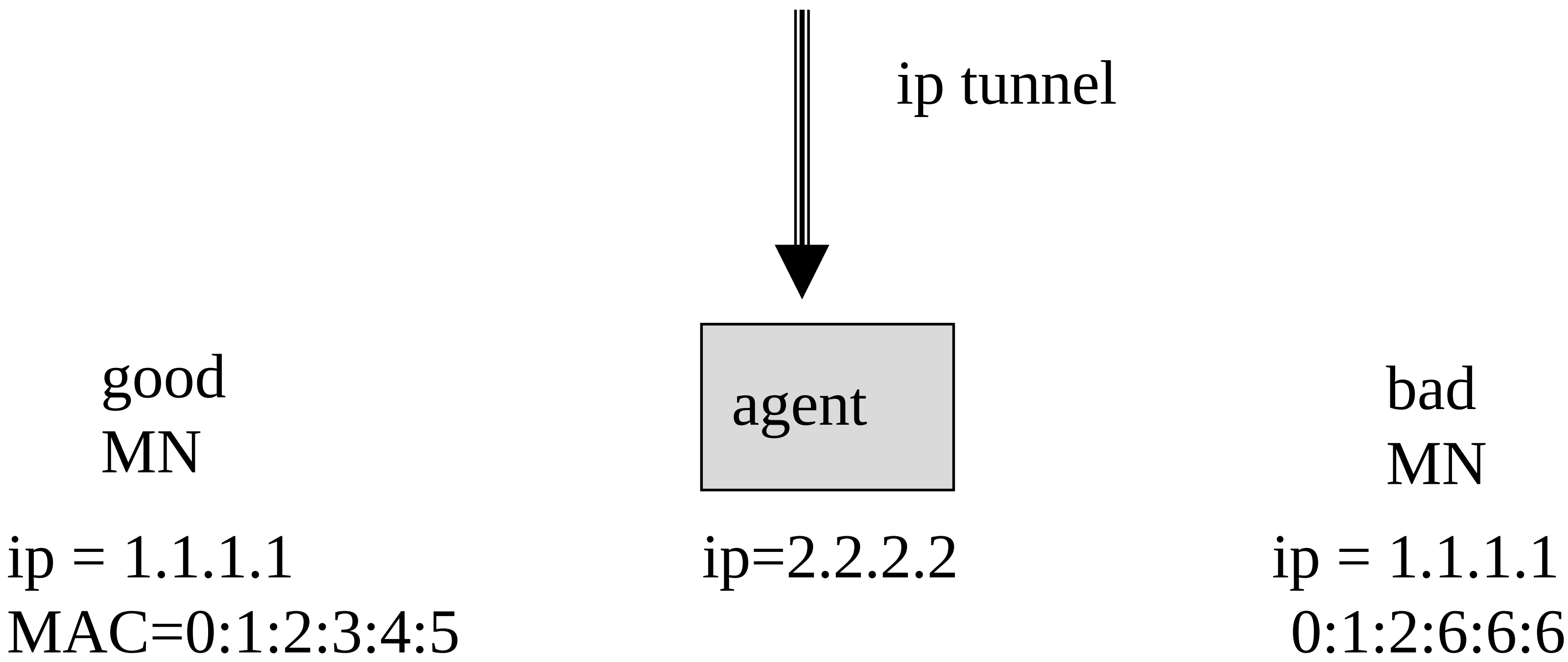
MNs have DIFFERENT IP subnets, but could hear each other and talk direct

note: impossible with conventional IP subnetting, what if no FA? (with our ad hoc can still talk...)

problem #2

- 2 MNs with SAME subnet, one at HOME and one AWAY
- can’t talk to each other with ARP/subnetting because obviousally aren’t on same link && not even close

problem #3: ARP spoof



arp spoof, cont.

- bad MN can send out promiscuous ARP overwrite that only FA can hear
- FA will overwrite ARP cache for good MN, with bad MN's MAC address
- bad MN can steal MIP tunnel and thus evade MIP UDP registration authentication even when MN-FA registration required
- good MN may not be able to hear bad MN promiscuous ARP overwrite ...
- upshot is now need to do MAC spoofing

arp spoof, cont

- spoofing now only possible if MAC the same,
- call it "**MAC spoof**"
- *party attacked will get attackers packets since they share a unicast link address ...*
- **increases odds that attacked party can learn about attack**

problems: beacon scalability

- MN conference == scalability problem?
- **I live for that day ...**
- solution/s:
  - 1. scale back MN/MN beaconing
    - » might answer solicitation (tricky problem)
  - 2. MN pushes beacons (or combines with)MIP FA registration, ignores other MNs when in crowd, so MN/FA only. FA could tell loading

mobile security

- large problem area
- MN when going away must take site security/policies with it
- traditional firewall measures now have TWO new considerations
  - 1. our side abroad (home MN away)
  - 2. friendly visitors here (visitor MN here)

mobisec issues (more than this)

- 1. MN may choose to secure its own data to/from HA or to/from CHs, not just MIP registration security (all data)
- 2. site security must somehow setup visitor quarantine network - net design issues
  - – can include internal wireless of course
- 3. scalability of MIP authentication itself an issue; especially FA/(HA,MN)

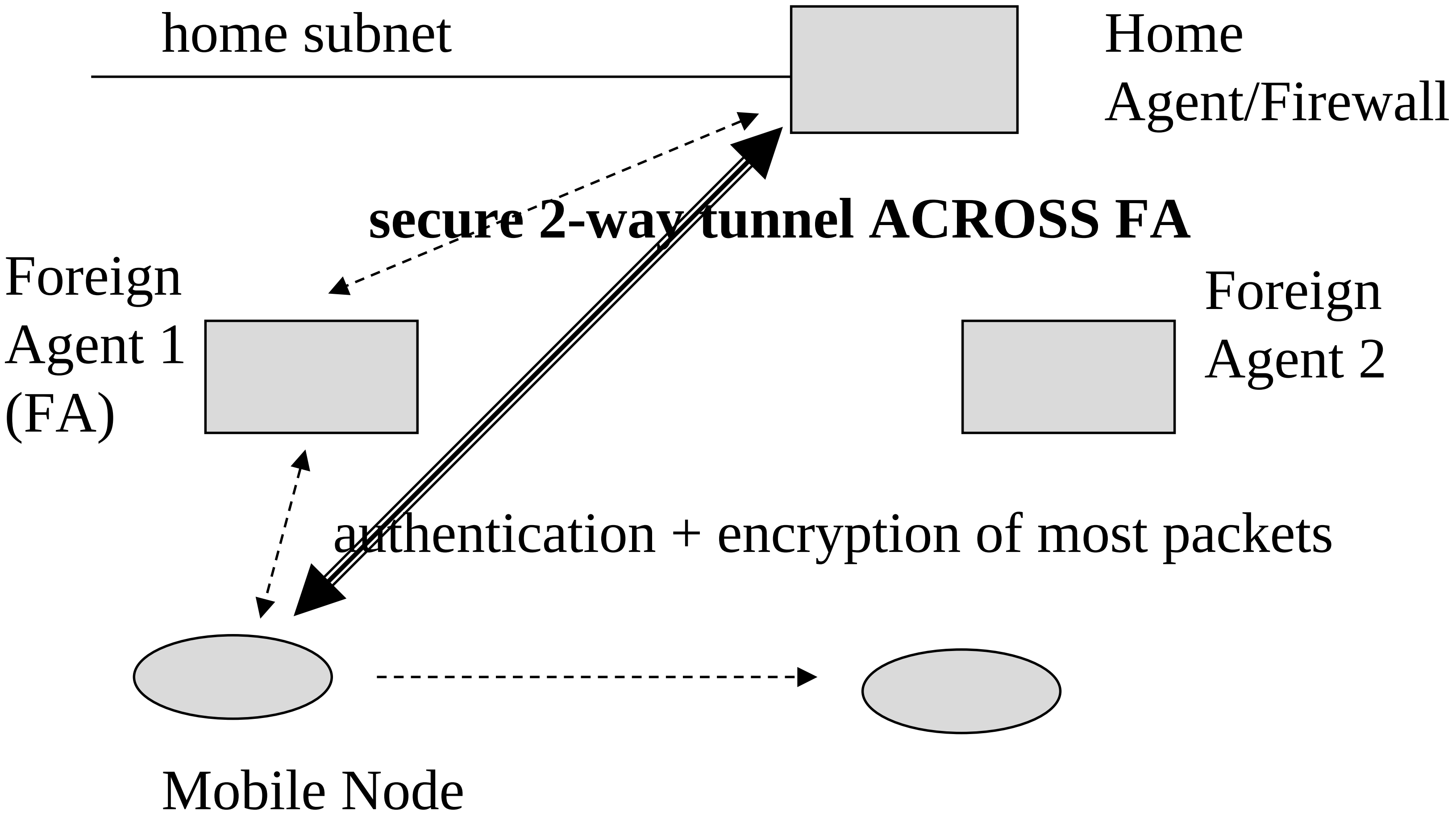
security/routing chicken/egg problem

- assume you want to do a 3-way handshake to setup a dynamic 1-way security association
- you need secure routing to do that; i.e., how to setup security if routing is unsecured?
- arp attack is trivial example of problem
- makes obtaining public keys or 3-way security handshakes hard(er)

data security via IPSEC

- 1st-cut policy && implementation
  - MN/HA 2-way IPSEC tunnels over FA
  - “don’t talk to strangers” FA is man in the middle
  - when at home, MN/HA == link-layer security
- IPSEC (RFCs 1825-), not just IPng
  - AH, authentication header (md5/sha)
  - ESP, confidentiality (DES, ...)

over FA (a long long way to run)



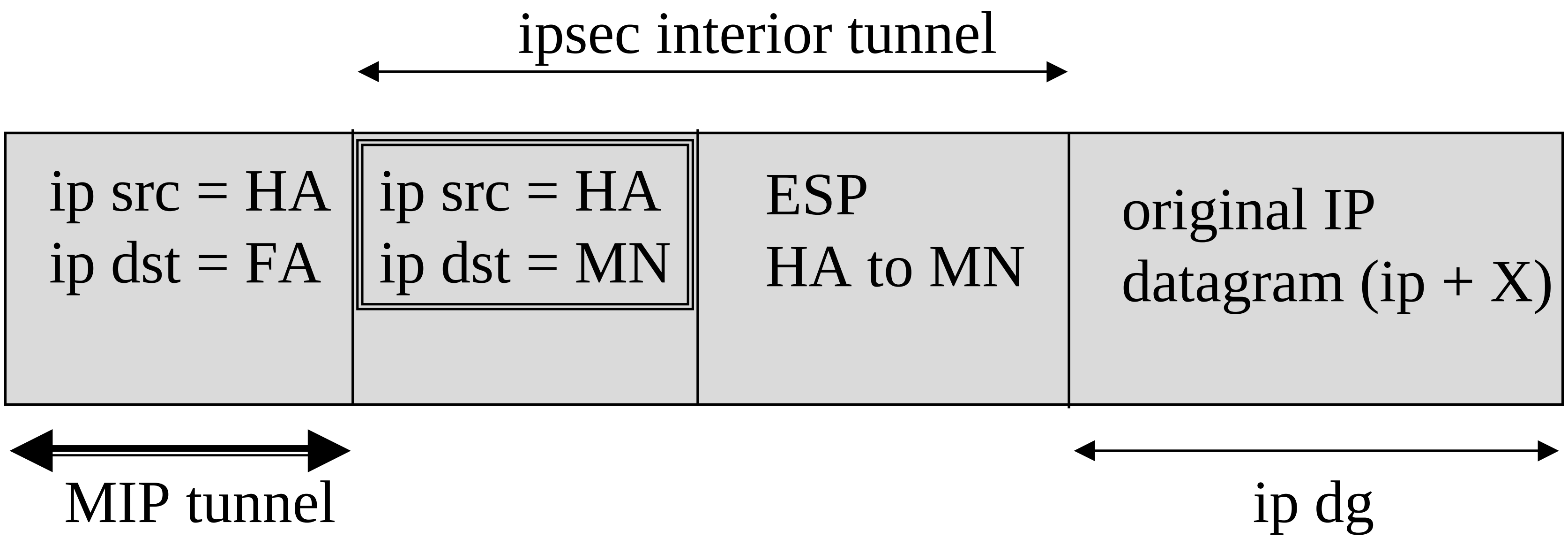
over FA: MN to HA with ESP

outer IP	ESP	IP datagram	
ip src=MN ip dst=HA	ESP spi for MN to HA	ip src=MN ip dst=X	TCP/UDP, etc.

default route to FA (next hop router), has itdst to HA

ip_output adds **IPSEC tunnel**/ESP

HA to MN



1. need IP | ESP insertion for IPSEC tunnel from HA to MN
2. need outer MIP IP header for HA to FA

note: could have AH or ESP between two headers for HA/FA relationship

IPSEC manual key

- **scalability** is of course an issue and key lifetime
- ISAKMP/Oakley are IPSEC answers for using public key technology to
  - dynamically generate security bindings
  - create session keys
- have demonstrated use of ISAKMP between MN/HA for 2-way tunnel

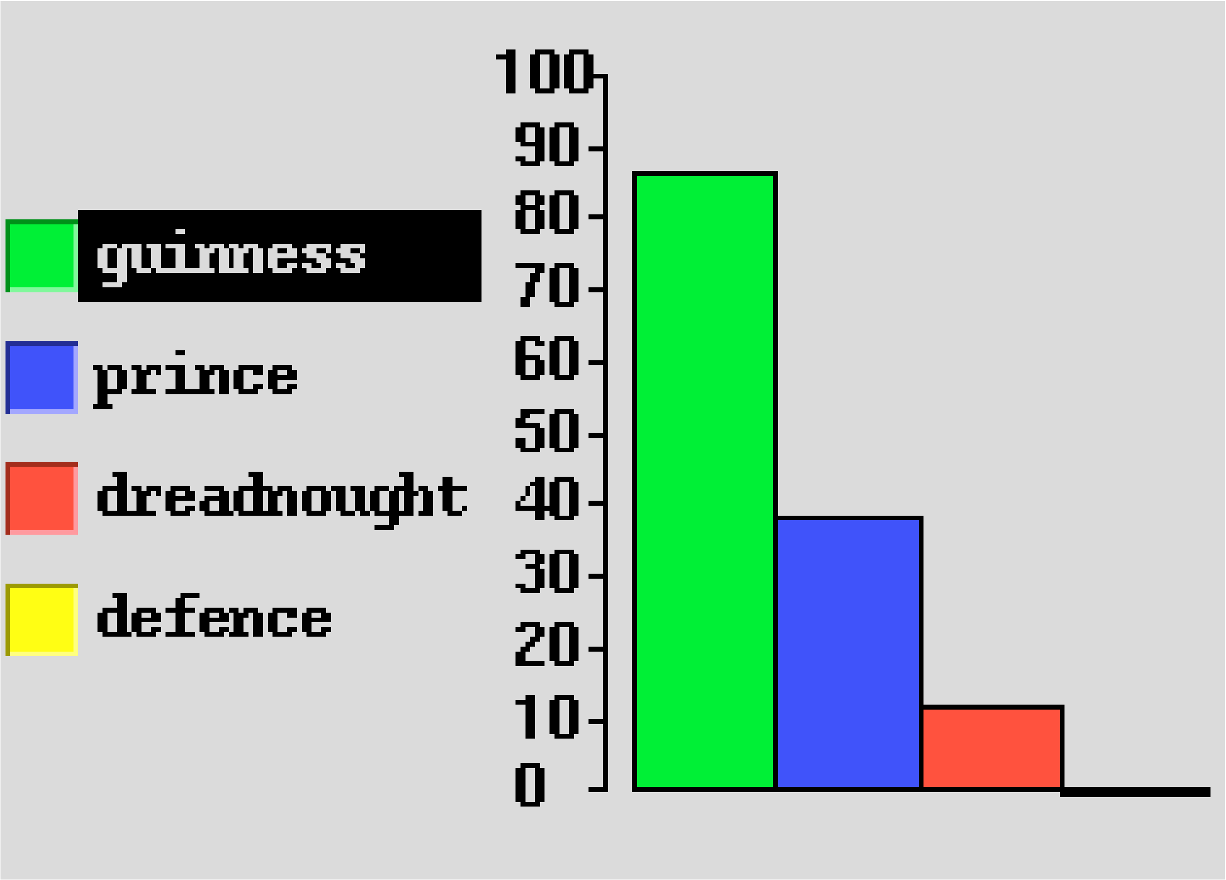
redundancy outline

- ad hoc
  - # 1 (done), link layer (no router needed)
  - # 2 - multi-hop protocol, call it **MADrp**
- HA redundancy (have > 1 at a time) - **HARP (HA Redundancy Protocol)**
- FA redundancy
  - improved wireless handoff (done)
    - » tolerate overlapping Fas ... avoid FA spoof
  - use > 1 router at a time (not released yet)

wireless handoff + redundancy

- use wavelan signal strength + heuristics
- go for best agent over period X (say ten seconds)
- stick with him and don’t bounce around
- agents at MN sorted by SN
- mark Foreign Agent as bad if we don’t get HA ack from it, try another

agent signal strength



ad hoc #2 - MADrp

- multi-hop ad hoc routing protocol
- MNs as routers
- MADrp - *Multicast Ad hoc Demand routing protocol* (MAD for short, or MAD-DRIP)
- works with Mobile-IP so that MN can talk to Internet
- can setup IPSEC tunnels MN/MN if keys installed a priori due to auth. madrp pkts

HA redundancy

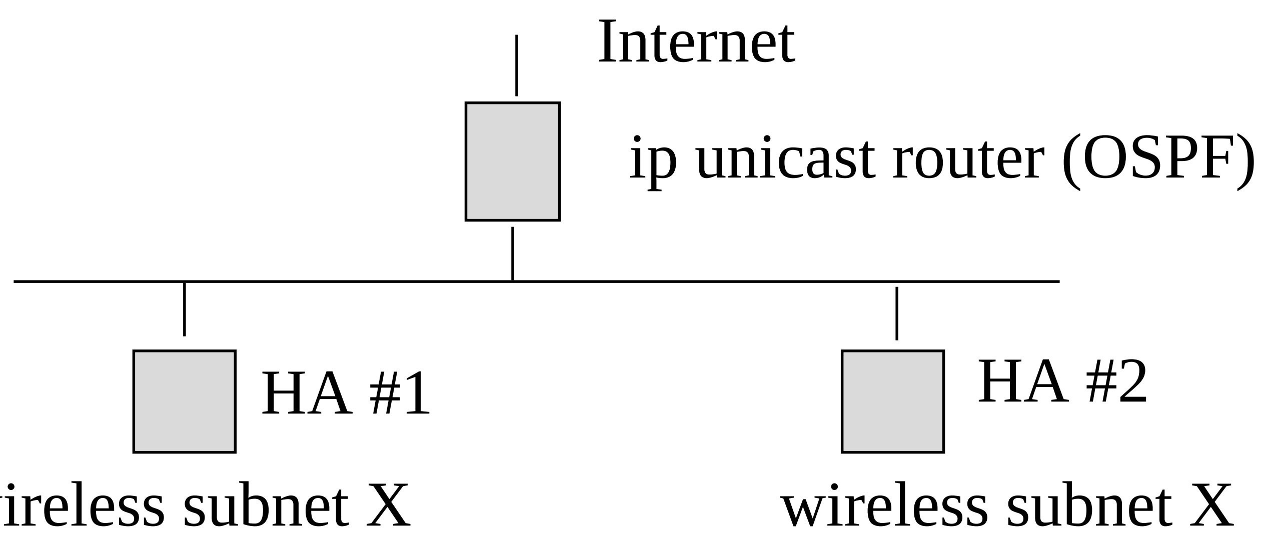
- view as critical for MIP, one HA is **single point of failure**
- if current HA goes down, your MIP net is lost
- FATE SHARING ALL OVER AGAIN

assertions:

- HAs may be on same link but ideally are not
  - probably not too far apart though, but would like to shield against 2 HAs lost due to 1 router (or 1 enet card) failure
  - shared subnet, so can't be on OPPOSITE sides of Inet (barring a bridge technology)
- HAs should keep each other up to date with simple relatively stateless protocol
- ***no MODS to MIP (MNs/FAs won't know)***

plan:

- assume two HAs, each of which is a router and routes to the same (partitioned) mobile-IP subnet
- normal dynamic IP unicast routing can deal with this



whacky idea: HOME MIP

to Internet via ISP

ISP can easily provide MIP services
with HA at ISP location.

PPP
+ FA

router, say ip = 1.1.1.1
for PPP i/f

MIP instead of NAT/proxy?!
useup IP addresses in subnet

radio connection
ip = 10.0.0.1 (private net)

mobile laptop
ip = home ip,
2.2.2.2

DNS works...

at HOME MIP

- MNs need never go home
- can allocate ALL of IP addresses in subnet
- simply use nearby tunnels from ISP term mux to "settop/ppp/FA" and in-house MNs
- MN is 2nd/3rd laptop/telephone/toaster
- this is because MIP addresses are (IP,IP)
- 2nd enhancement: PSU simple ad hoc enables MN/MN communication where subnet doesn't matter

research areas

- security
  - MNs dynamically take policy with them on the road
  - scalability of keys and policy negotiation
- richer data environments for on the road types
- MN flexibility in terms of multihomed, multi-device, multi-address
- wireless flexibility/**loading**/thruput
- multicast (not as done by MIP) routing AND apps
- ad hoc routing, MNs find a way to get there