Mobile IP and Ad Hoc Networking in the Internet

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NSF WMPG Workshop

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Some History

Internet ad hoc networking is not new:
• Dates back at least to 1972 to DARPA Packet Radio program
• A large part of the motivation for the creation of TCP/IP to replace NCP, and the evolution from ARPANET to Internet
• The IETF has been working on standardizing ad hoc network routing since 1997

Internet Mobile IP is not new:
• Dates back at least to 1980 with Sunshine and Postel proposal “Addressing Mobile Hosts In The ARPA Internet Environment”
• To support hosts in other types of networks that are mobile and move between IP subnets
• The IETF has been doing standardization for Mobile IP in 1992

Why is neither technology in widespread use yet?
Mobile IP

What’s right?

• A simple overlay to the existing Internet functionality
• Only correspondent node, home agent, and mobile node (and foreign agent) need to be aware
• Very scalable, since all state is only at the communication end points (and mid-point)
• No overhead when mobile-capable node is at home

What’s not so right?

• Roaming/reregistering in new location is too slow
• Route optimization is still not defined for IPv4, and Route optimization is not as secure as it should be for IPv6
• Both are hurt by the difficulty of security problems
• Also still dependent on the home agent: a bottleneck in terms of performance and reliability
Ad Hoc Networking

What’s right?
• Lots of good work on unicast routing protocols
• Lots of simulation work, some experience with real implementations in testbeds

What’s not so right?
• There is more to life than unicast routing
• Need more work on multicast and other kinds of routing (e.g., anycast, geocast)
• Need to provide “standard” services like DNS, web caching, etc.
• Need much more work on security: prevent route spoofing, denial of service attacks, etc.
• Particularly need work on security where ad hoc network integrates with the Internet and with Mobile IP
Some Emerging New Ad Hoc Networking Areas

- **Sensor networking:**
  - Nodes are generally stationary
  - Long lifetime (power conservation) is most important

- **Mesh networking:**
  - Shared Internet access, neighborhood gaming, medical and emergency response, neighborhood watch, shared community resource, distributed backup, etc.
  - Route to nearest base station or direct to destination node

- **Vehicular ad hoc networking (VANET):**
  - Limited/predicable mobility, good power availability
  - QoS is important (emergency notification), traffic management, general network access
Some Thoughts on Missing Pieces

*Interconnection of ad hoc network, Internet, and Mobile IP:*

- How does mobile node discover local router (foreign agent)?
- What if there are multiple Internet connection points reachable from the mobile node through the ad hoc network?
- If you have different types of connections, can you use different connection for different types of data?
- Can ad hoc network dynamically serve as a transit network?

*Support for mobile routers:*

- Mobile IP handles mobile nodes visiting a mobile router vehicle
- But nodes whose home is on the mobile vehicle are not well supported
- Problem for Mobile IP is mobile router’s authorization to speak on behalf of entire subnet’s care-of address
- But it would also be useful for members of mobile subnet to know when subnet has moved
Some Thoughts on Missing Pieces

Session or connection persistence:
• Wireless/mobile will always have periods of disconnection
• Current TCP connections are very fragile and will abort
• Many applications are not very tolerant either
• A problem for Mobile IP mobility or wireless in general
• A big problem for ad hoc networking

Addressing, mobility, and autoconfiguration:
• Mobile IP depends on your “home address”, and ad hoc networking requires at least a unique address per node
• If you have a permanent home address, both are easy
• But particularly IPv6 is supposed to be able to do address autoconfiguration
• And what if your home network renumbers while you’re away?
• Need some higher level “permanent” identifier
Experiments and Testbed Experience

December 1998 through March 1999:

- 5 cars, 2 stationary nodes (E1 and E2) about 3 radio hops apart
- DSR ad hoc network integrated into Internet and Mobile IP
- “Wireless propagation is not what you would expect”
- “Bystanders will think you are crazy”

Also July 2000 live audio and video driving around NJ hotel
Physical Implementation using Simulation Code

2004 Rice PRAN (Physical Realization of Ad Hoc Networking):

- Uses **unmodified** code from **existing simulation model** of ad hoc network routing protocol
- When running, **everything is real**, not simulated
- Implemented with ns-2 on FreeBSD Unix and on Linux
- Portable to other OSs and simulation systems
- Tested with DSR and AODV
- Implement protocol once, share with simulation
- Can test real system in simulation
- Can validate simulation in real experiments
The “Killer Application” for Ad Hoc Networks?

Many basic applications proposed, but dominated by:

• Military applications, emergency/disaster relief
• “Closed” (e.g., industrial) applications
• “Casual” networking
• Sensor networking?

But what is the “killer application” for ad hoc networking?

• I think this is like the Internet before the web was invented
• A compelling application that everyone has to have and that will change the way we all work and live (and play)

And how do you enable commercial applications?

• What is the business model?
• What will people pay for?
• What service level can you provide or guarantee?
Conclusion

From The Economist Magazine, June 20, 2002:

• Four disruptive technologies are emerging that promise to render not only the next wave of so-called 3G wireless networks irrelevant, but possibly even their 4G successors.

• Ad hoc networking will create more scope for “mom and pop” network operators and free community networks, all stitched together in a casual, ever-shifting web.

• Network operators will still be needed to carry long-haul traffic, but their role could become less (rather than more) important in future. In the process, the entire structure of the industry could shift from a top-down approach to one that is organised from the bottom up. There are already signs of this happening in the emerging area of commercial WI-FI networks, which allow individuals to club together to form a larger network.