Low-Latency Mobile IP Handoff for Infrastructure-Mode Wireless LANs

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Motivation

- Explosive Growth of 802.11b Wireless LANs
- Common mode of deployment is Infrastructure mode
- Network level roaming can be achieved using Mobile IP
- There are latency issues with Mobile IP handoffs which affect Real-Time apps

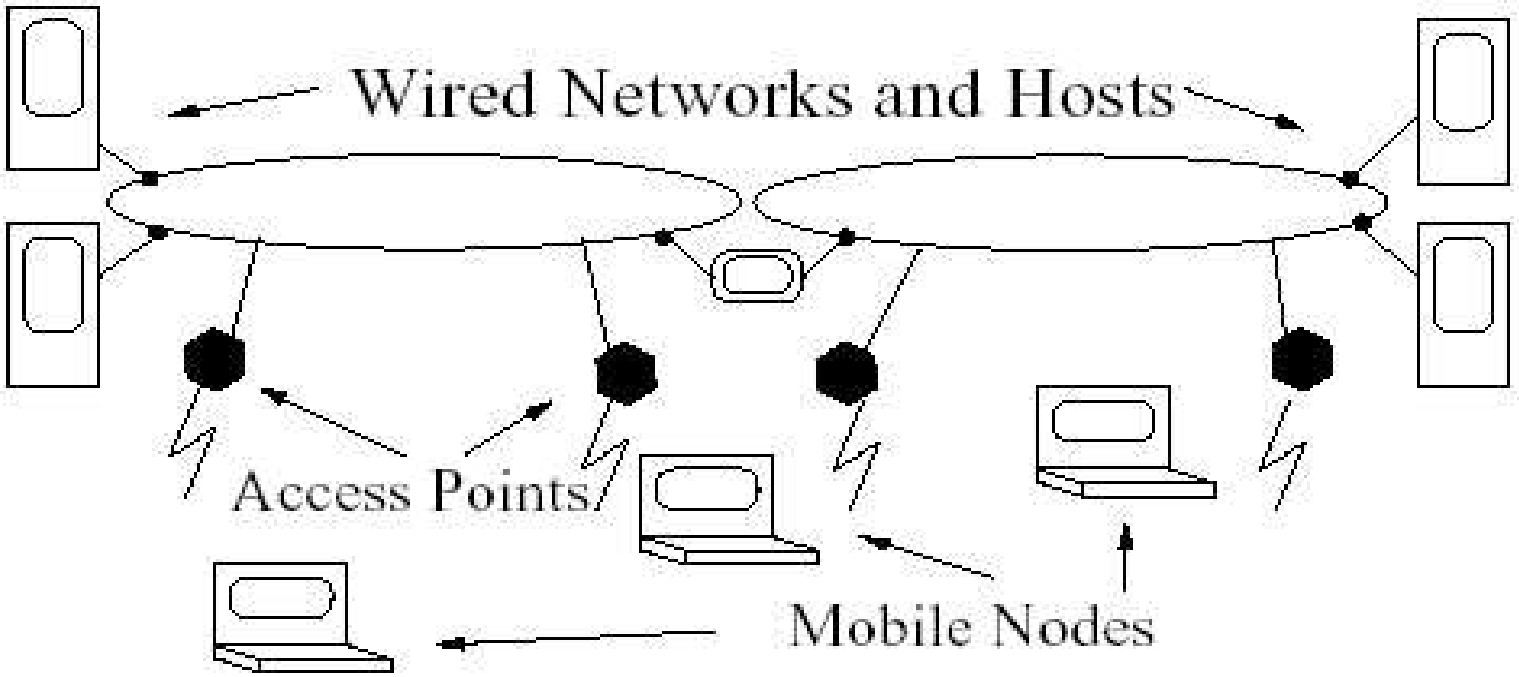
Organization of Talk

- Motivation
- Mobile IP overview
- Problem Statement
- Proposed Solution
- Performance Measurements
- Related work

Mobile IP

- Mobility at the network (IP) layer
- Allows Change in subnet attachment without affecting transport layer semantics
- Essentially a *routing management* solution
- Not heavily used, but common enough and picking momentum

Infrastructure mode setup



Mobile IP operation

- Requires Mobility Agents
  - Home Agents and Foreign Agents
  - Broadcast beacons to announce their presence
- Mobile nodes are mobility aware
- When a mobile node is in foreign subnet the connectivity is retained through triangle routing
- **Mobile IP handoff** is switching from one agent to another

Types of Handoff

- **Soft:** Connectivity with both, old and new, points of attachment are active
- **Hard:**Connectivity with exactly one point of attachment is active
- **Forward:** After handoff cannot talk with old agents directly
- **Backward:** Handoff is initiated with the participation of old agent in handoff

Issues with Mobile IP Handoff

- Mobile IP does not interact with Link layer
  - Relies solely on agent advertisements and agent discovery
- Link-layer handoff is unilateral by the NIC
- Mobile IP sees link handoff as hard and forward

Problems with Agent Discovery

- Max Advertisement frequency is 1 every second
- Agent expiry time is (3*freq) sec
  - Min 3 sec
- Mobile IP on mobile node does not have a direct knowledge of break in connectivity (hard and forward handoff)
- The handoff duration is on the order of **seconds** not good for real-time apps

Handoff Period Breakdown

- Duration of *link change detection* by Mobile IP
- Duration between link handoff detection and Mobile Agent *advertisement*
- Duration for initiating *registration* with new agent
- Duration for response from new agent

Link Handoff detection

- NICs allow software to probe for current AP association
- The probe is inexpensive
- Can be done periodically in kernel
- Probe is not reliable
- Keep a history and only when a threshold number of probes are positive indirectly trigger Mobile IP handoff.

Agent Discovery

- Conventionally through advertisements and solicitations
- Broadcast packets are asynchronous data packets on wireless LANs
- Solicitations are not allowed if the previous agent advertisement has not expired(3*freq)

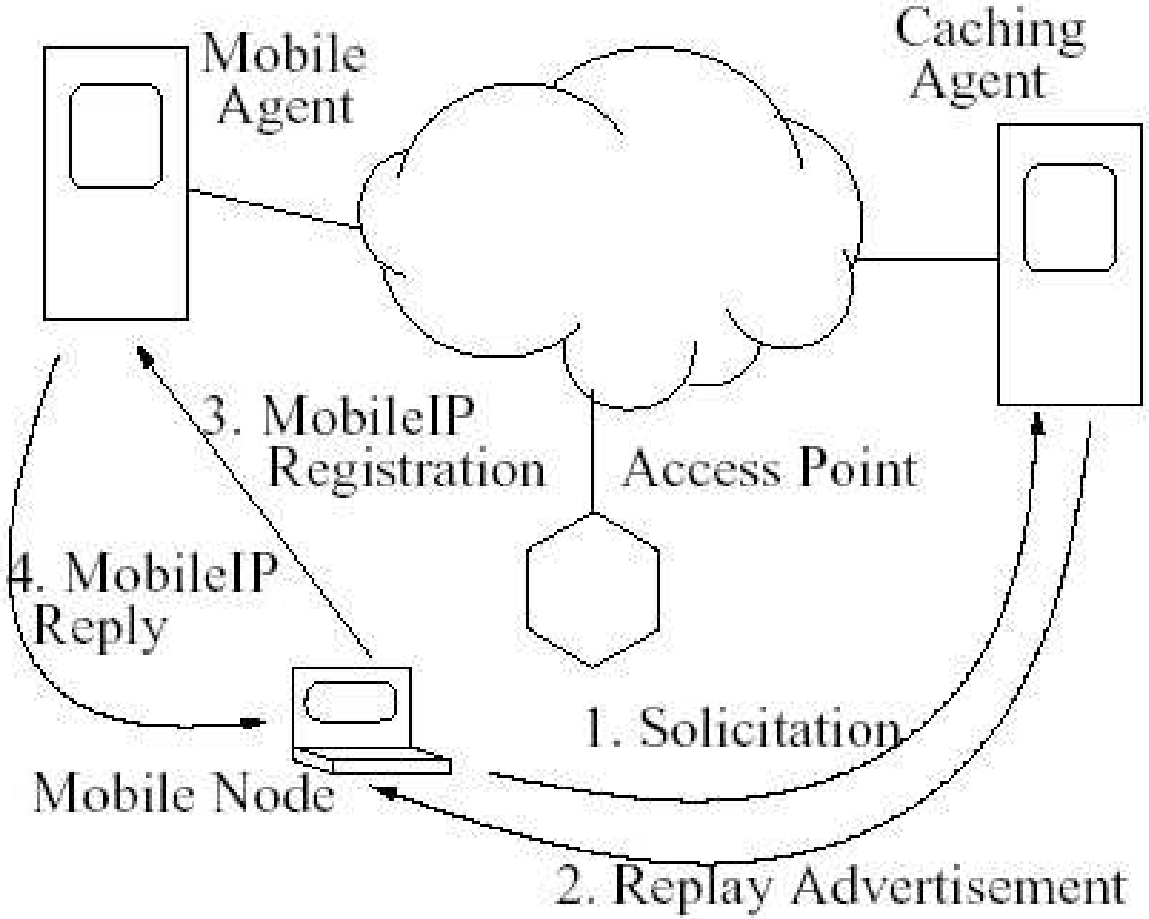
Caching Agent

- Co-located with Mobile Agents
- Modifies wired network switch forwarding database with *well known MAC address* (say a:b:c:d:e:f)
- Mobile nodes are aware of this address
- Mobile nodes send unicast solicitations to caching agents using *wkMa*
- Caching Agents replay the advertisements
- Mobile IP is unaware of this interaction

Mobile Node Registration

- Needs Policy based handoff support from Mobile IP
- Contacting Newest-FA, Early-Expire of old agents etc.
- Common features in prominent Mobile IP implementations

Optimized Mobile IP Handoff

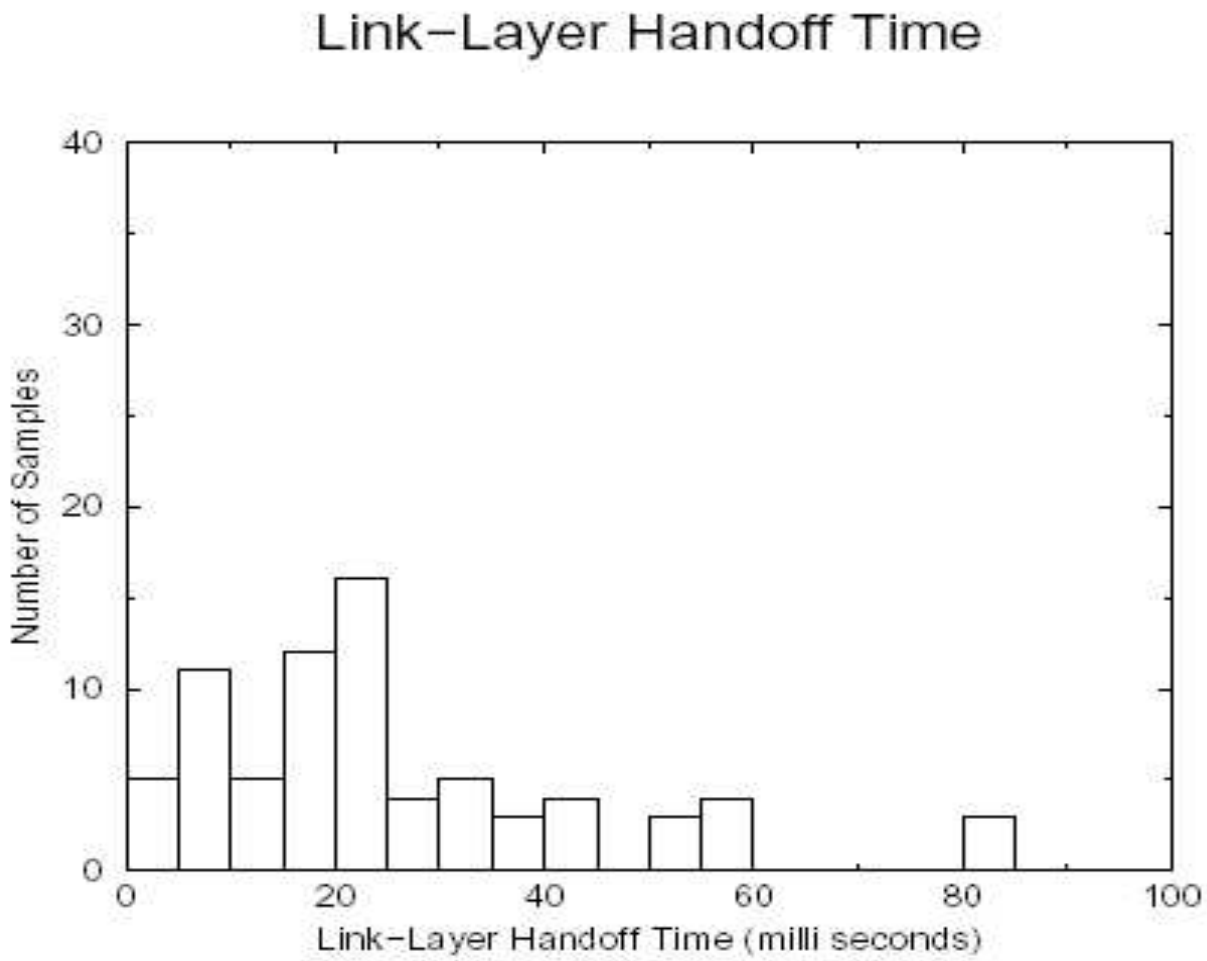


Performance Evaluation

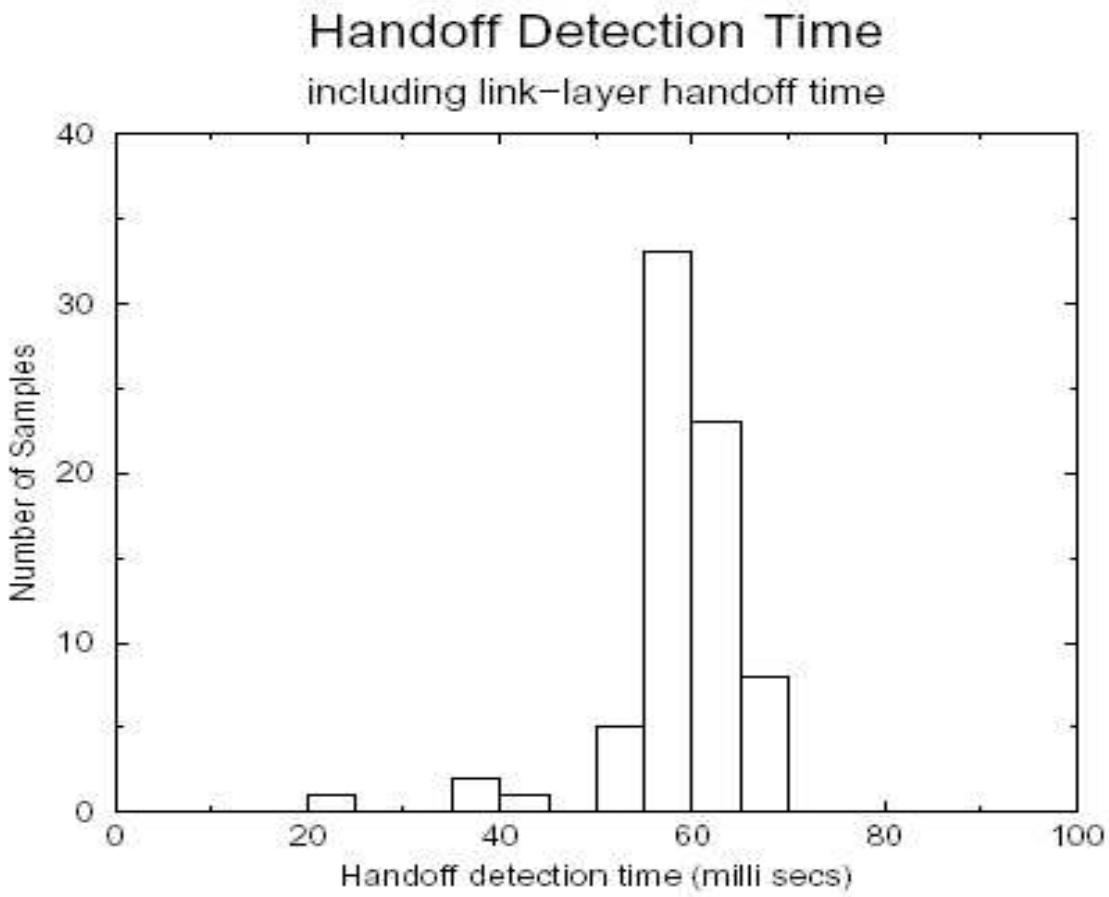
Test-bed Setup

- Linux Kernel 2.2.16/ Redhat 6.2/7.0
- Caching Agent: Pentium-II 400MHz 128MB RAM
- Mobile nodes: Pentium-III 650MHz 64MB RAM, notebooks, Mobile Agents: Pentium-III 650 MHz 128MB RAM, desktops
- Mobile IP: HUTS Dynamics ver 0.7.5
- NIC: Orinoco pcmcia cards

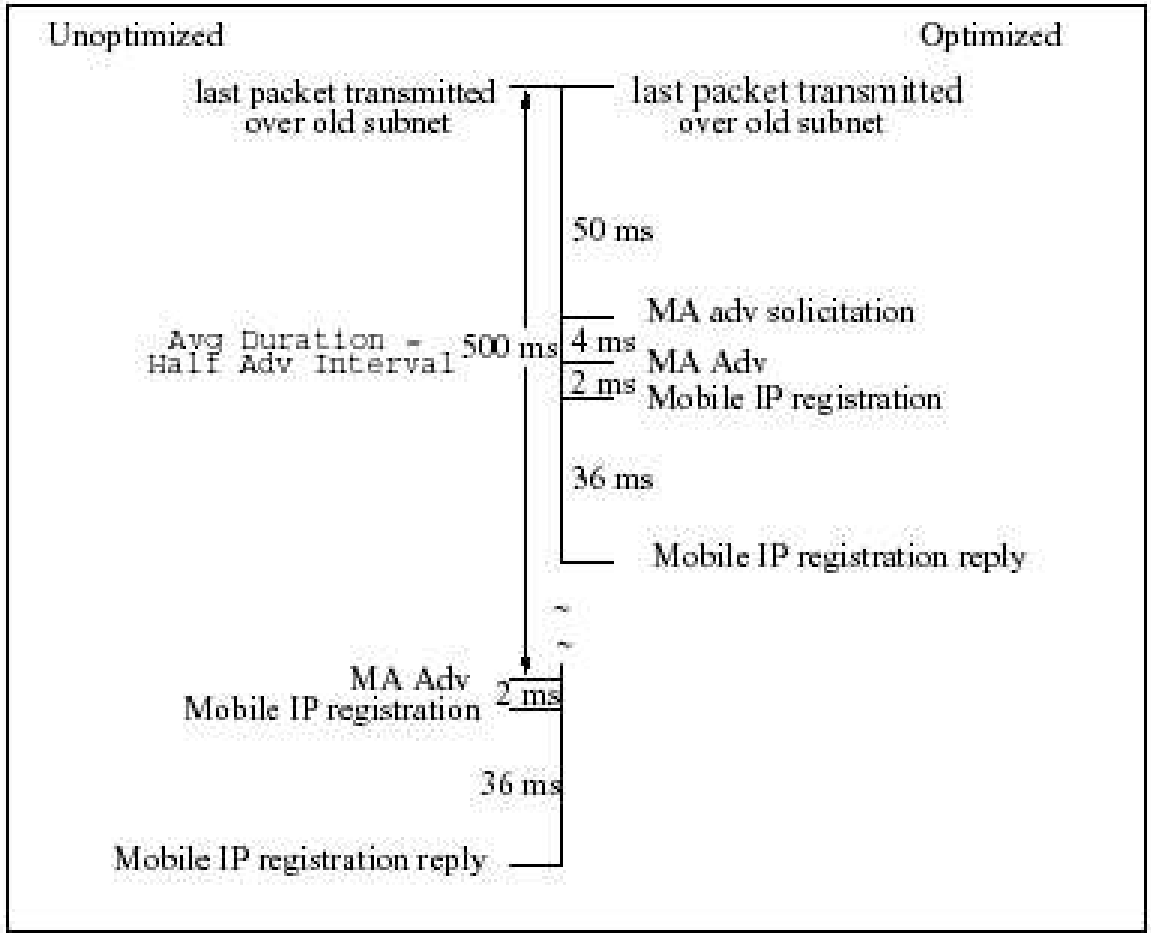
Link Layer handoff time



Link Handoff detection time



Comparison with/without Optimization



Data Loss

Stream Rate	Packet Size	Data Loss	Packet Loss	Examples
1.5 Mbps	1400 bytes	14 to 17 Kbytes	10 to 12 packets	MPEG1 stream
64 Kbps	64 bytes	300 to 450 bytes	5 to 7 packets	4 voice channels
16Kbps	64 bytes	64 to 128 bytes	1 or 2 packets	Voice Channel

Related Work

- Mostly theoretical or simulation based
- Tries to optimize triangle routing setup
- Does not concentrate on hard and forward nature of handoffs: Not tailored for 802.11b infrastructure LANs
- Anticipation based

Related Work…

- Daedalus: Handoff anticipation, multicast based solution, does not fit with Mobile IP
- NeighborCasting: Relies on neighboring cell information. Utilizing/wasting wired bw to save on handoff data loss and duration
- Hierarchical Agents
- IETF: specifies L2 trigger mechanism. Anticipation based

Summary

- Only handoff mechanism so far to achieve <100ms latency for 802.11b WLANs in infrastructure mode
- Does not need to modify Mobile IP
- Can fit with other existing/future solutions