Proactive Scan Fast Handoff with Smart Triggers for 802.11 Wireless LAN

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Outline

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- Problem definitions and related work
- Our approach
- Triggers for proactive scan
- Proactive scan
- System design and implementation
- Experimental results
- Conclusions

Introduction

- The goal of this research is to support seamless roaming (50ms for human)
- Client-only software-only solution
- Link asymmetry phenomenon
- Decouple the time-consuming channel scanning from actual handoff

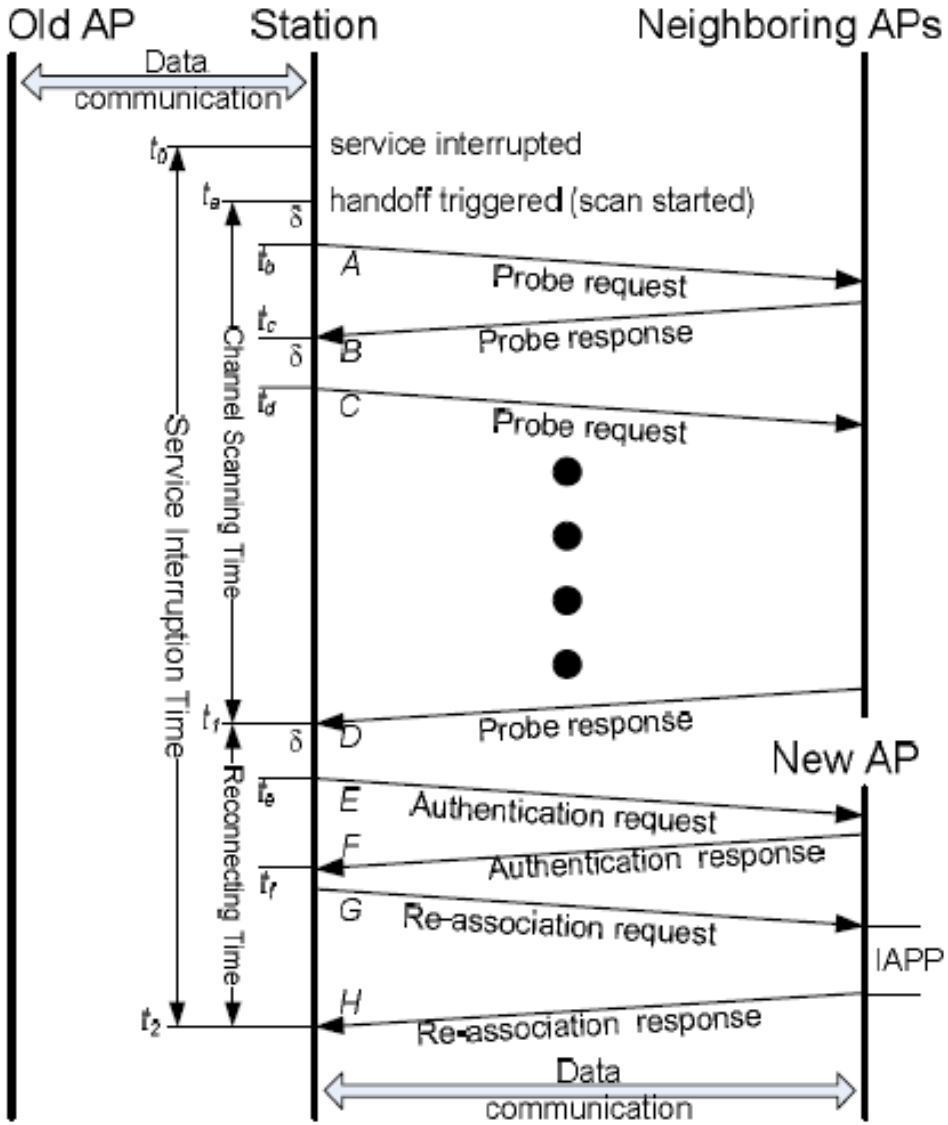


Figure 1. The handoff procedure by the IEEE 802.11

Link asymmetry in 802.11 networks

- AP and station have different transmission and receiving capabilities
- AP and station will have different hardware and software implementations
- We measure uplink and downlink **FLR(frame loss ratio)**

Figure 8. Map and device locations for handoff experiment

Power / Location	Min Tx power		Max Tx power	
	Uplink	Downlink	Uplink	Downlink
B(2.2m)	2.94%	0%	1.9%	0%
C(4.5m)	5.96%	0%	3.92%	0%
D(8.6m)	97%	0.3%	7.7%	0%

Table.1 The FLR of uplink and downlink at different locations

Impact of link asymmetry on 802.11 handoff

- Most implementations use a single trigger that measures quality at one transmission direction
- If a station uses passive scan ,it will only have the downlink quality for handoff decision
- AP's beacon can be heard by station, while the station's transmission in not received by AP. It will lead to timeout and long delay in the reconnection phase

RSSI(Received Signal Strength Indicator)

- RSSI represents the downlink quality, the number of retransmission at the station , or the loss of beacons
- In VoIP application, the traffic is bursty and unbalanced between uplink and downlink
- There are few packets on uplink direction to update FLR and trigger handoff

Our approach

- A station will actively probe other channels early and when the handoff trigger is fired it has all the updated information to jump to reconnection phase
- We divide the actual channel scanning phase into small pieces(10 ms) and interleave them with normal on-going data traffic
- Rate-based trigger covers both uplink and downlink quality and addresses the link asymmetry issue

Triggers for proactive scan

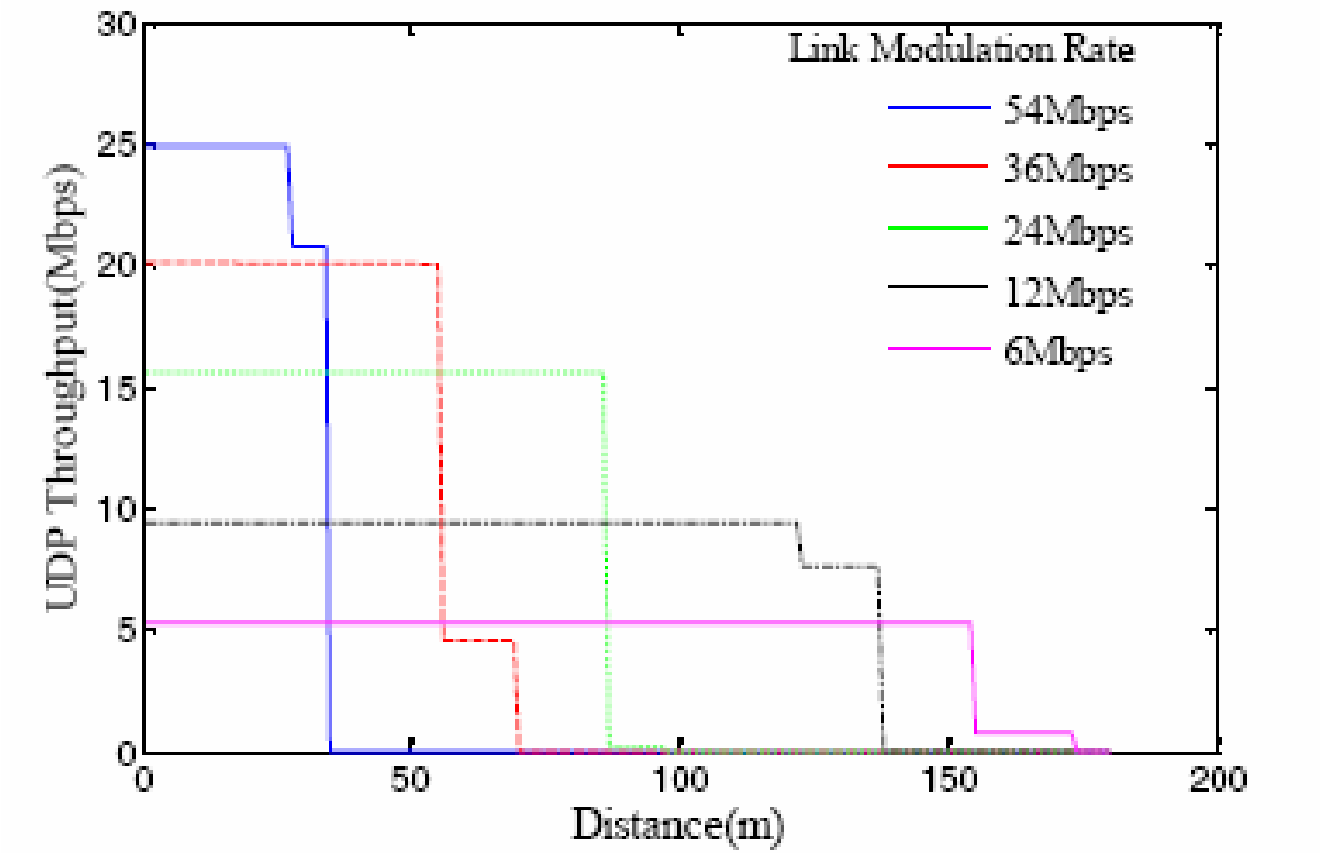
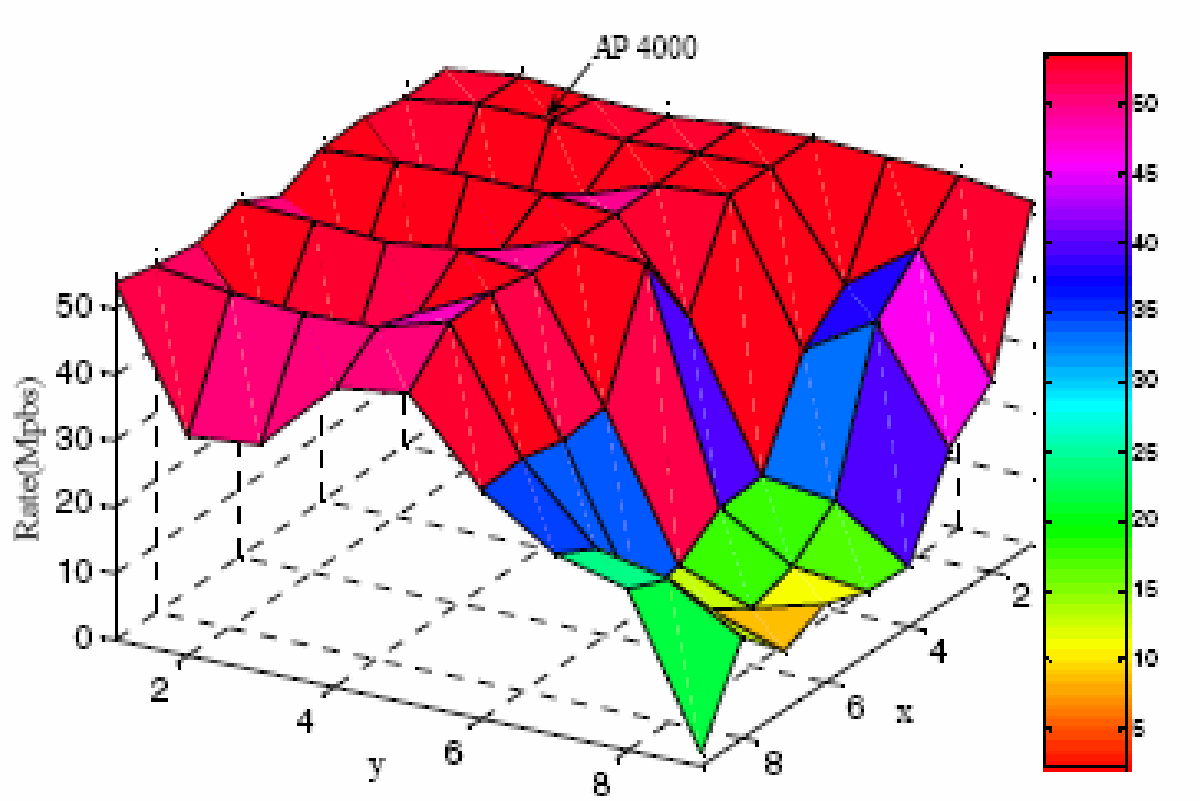


Figure 2. The comparision of throughtput versus distance for 802.11a

Rationale and experiment of rate based trigger

- In current commercial 802.11 interfaces, rate adaptation algorithms are already implemented
- Moreover the adapted transmission rate is actually a metric that represents the quality on both uplink and downlink because the protocol requires an ACK frame for each data packet



(1)Rate drops to certain value is good indicator for handoff

(2)The speed of rate dropping or rising can be used as the indication of how fast the user is moving

Transmission rate vs. RSSI(Received Signal Strength Indicator)

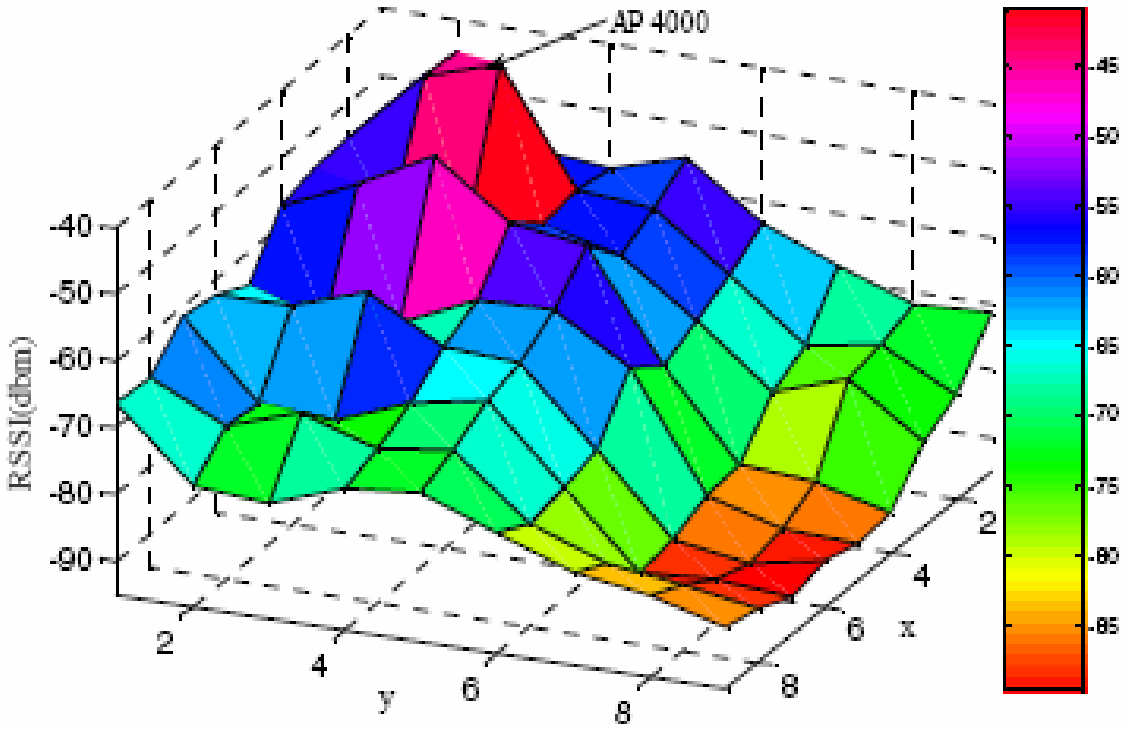


Figure 4. The RSSI from AP to stations at different locations

Filtered by TSWMA(Time Sliding Window Moving Average)

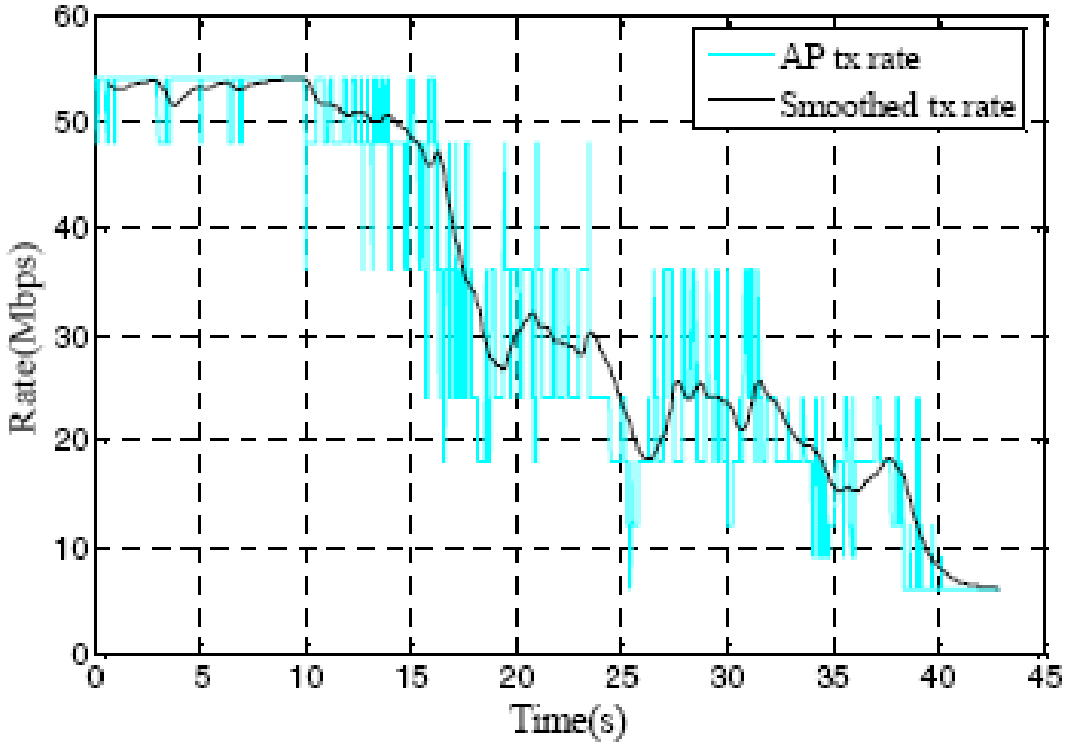


Figure 5. The adapted rate from AP to stations when station is moving

Scan trigger and handoff trigger

- VoIP traffic may be highly unbalanced and bursty
- The rate metrics are valid only when
  - There are certain number of frames transmissions made in the time sliding window
  - The slope of the smoothed rate is negative than a predefined threshold

Proactive scan procedure

0. Proactive scan has been trigged and not finished:
1. Select the candidate channel by the adaptive channel sequence adjustment procedure,
2. (optional) Send Sleep request to current AP.
3. Switch to the candidate target channel (if different with current one), and send out the probe request frame,
4. Switch back to the working channel after timeout or received response frame,
5. (optional) Send awake notification to current AP.
6. Schedule the next channel scanning event by the adaptive scanning interval procedure.

Adaptive channel scanning interval

- Take two thresholds trigger as example: Th_h and Th_l

1. If $x < Th_l$, then $ni = I_l$
2. Else if $x < Th_h$, then $ni = I_m$
3. Else $ni = I_h$

Adaptive channel scanning sequence

- We use a priority channel scan list in addition to the full channel list
- The priority channel list contains all the channels where there exist APs ,and those APs use the same SSID(Service Set Identifier) as that of the current AP

System design and implementation

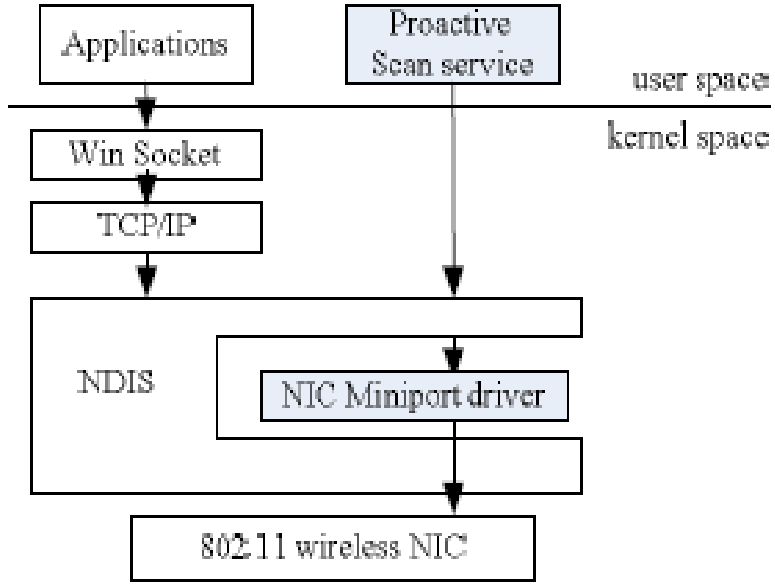


Figure 6. Architecture of a prototype implemention for Proactive Scan

Traffic on target channel	Averaged Waiting Time – Probe & Response(ms)	Total(ms)
No Traffic	0.71	6.49
TCP(AP→STA)	1.63	7.44
TCP(STA→AP)	2.08	7.89
20Mbps UDP(AP→STA)	0.93	6.72
20Mbps UDP(STA→AP)	1.04	6.85

Table2. The averaged active probing time versus traffic on target channel

Experimental results

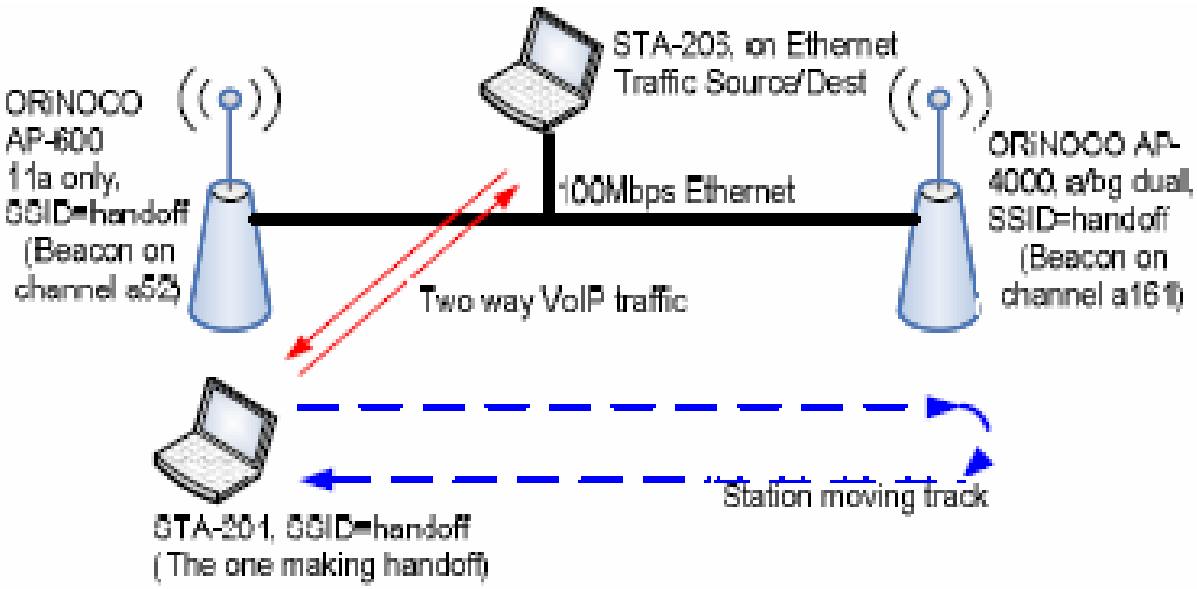


Figure 7. Experimenal setup for handoff

Service interruption during handoff

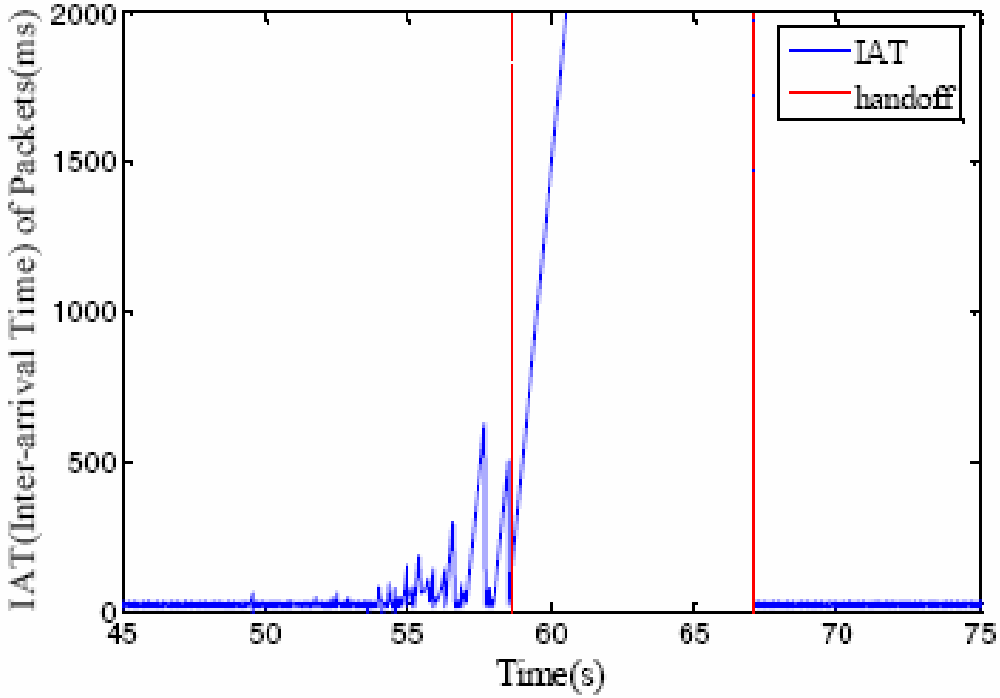


Figure 9. Handoff on standard Windows XP Atheros 5212 driver

Fast handoff with proactive scan

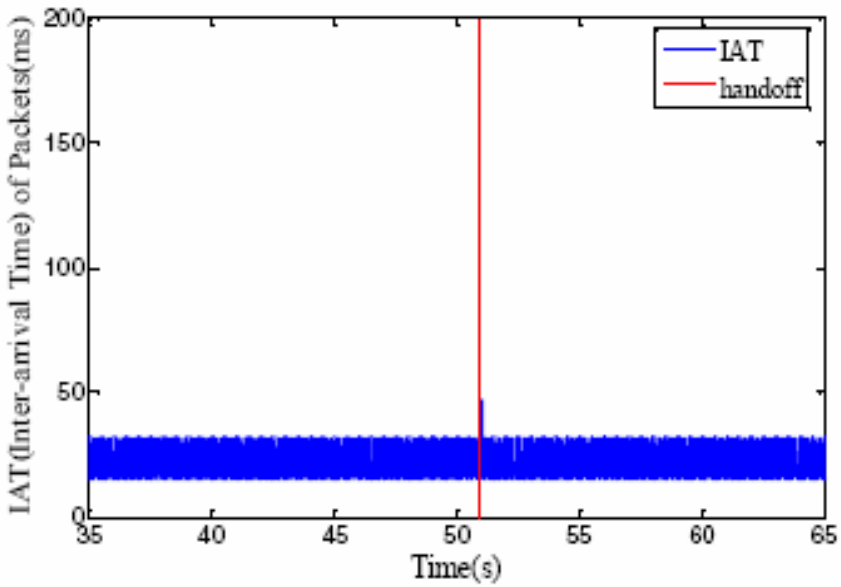


Figure 10. Fast Handoff with proactive scan

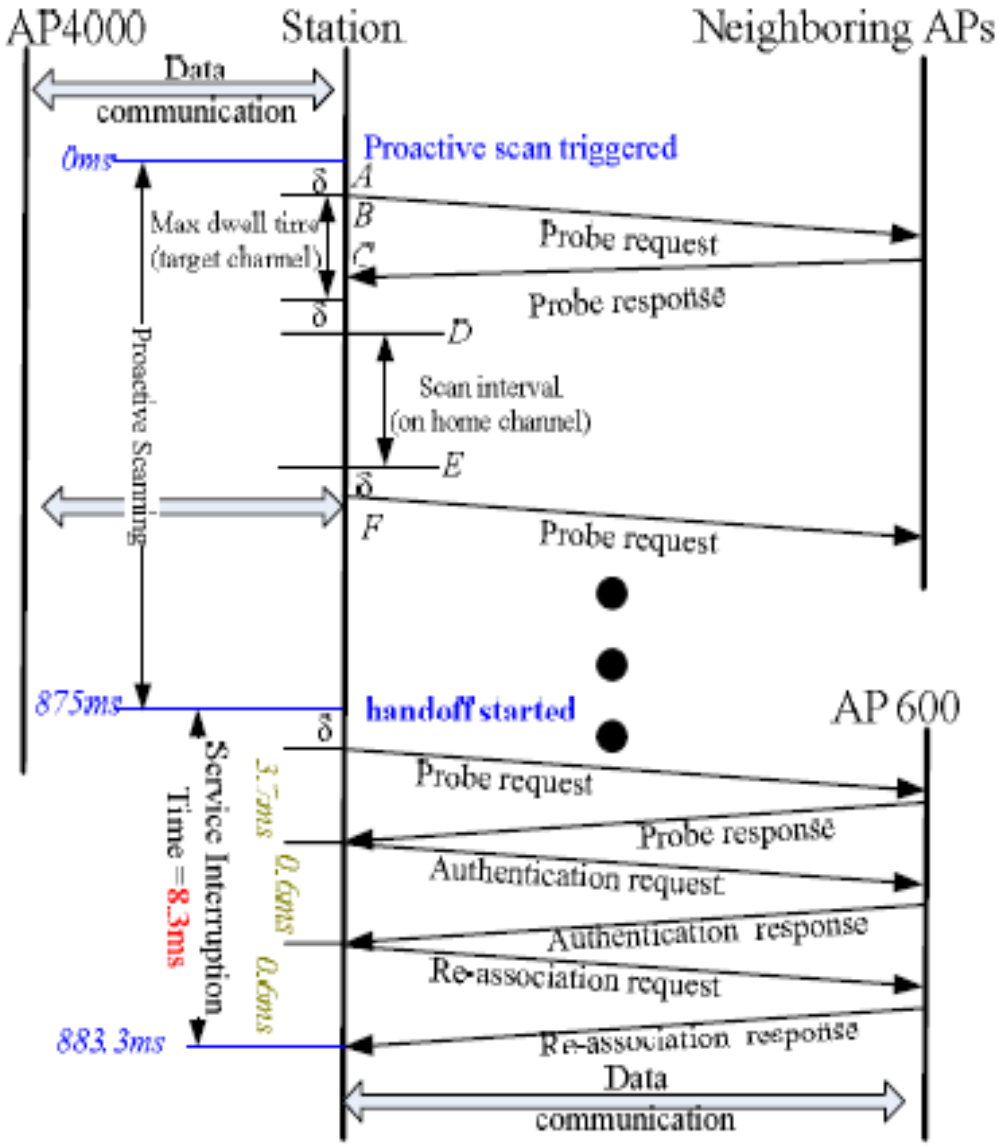


Figure 11. Fast Handoff procedure

Overhead introduced by proactive scan

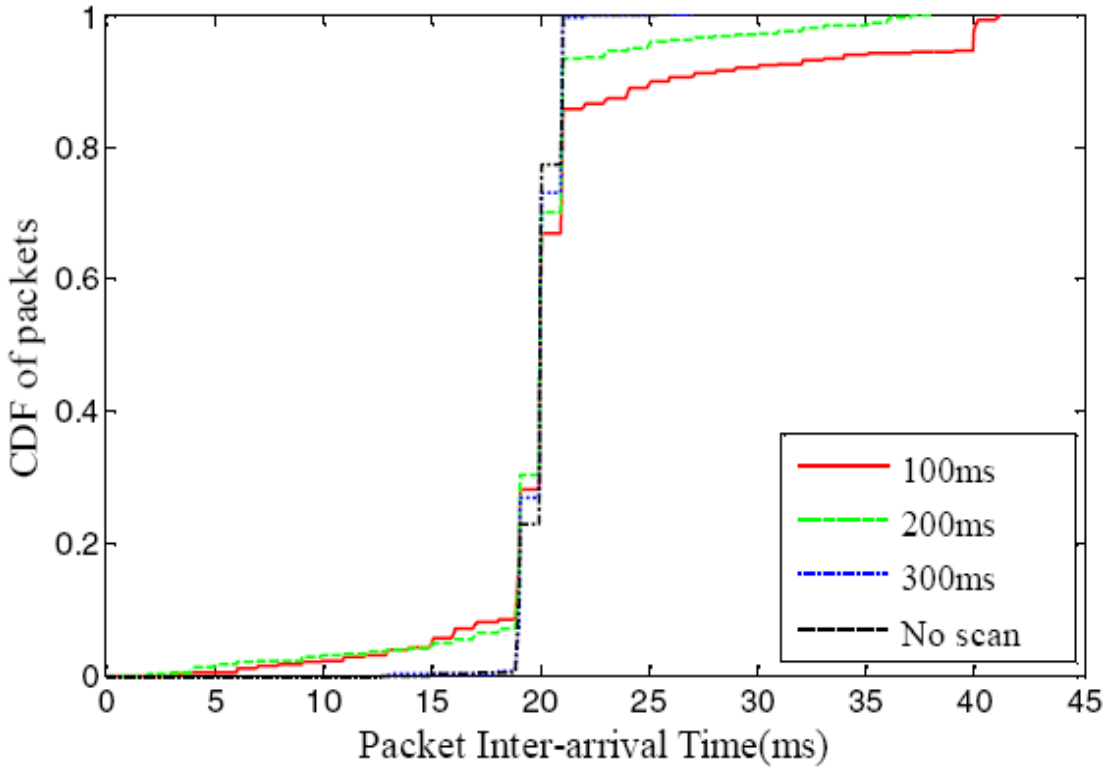


Figure 12. CDF of packet interarrival time versus proactive scan interval

Conclusions

- Proactive scan is a software module residing at an 802.11 NIC driver to make intelligent handoff decisions
- Out triggers address the link asymmetry which widely exists in WLAN and have much better accuracy for scanning and handoff decisions