Wireless Review- Probing

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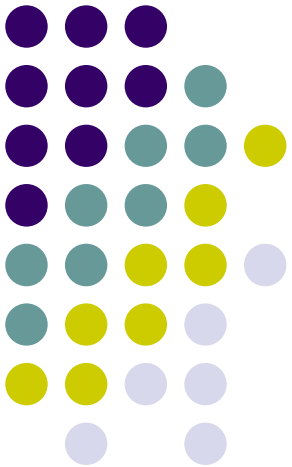
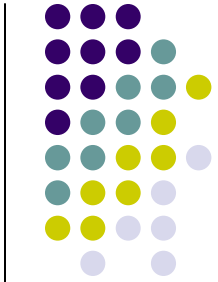
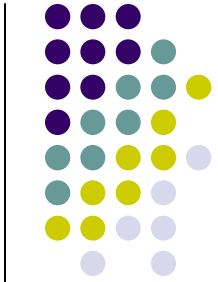


Joint work with students



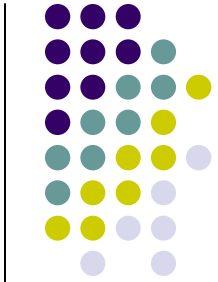
- Min-ho Shin
- Arunesh Mishra

OUTLINE



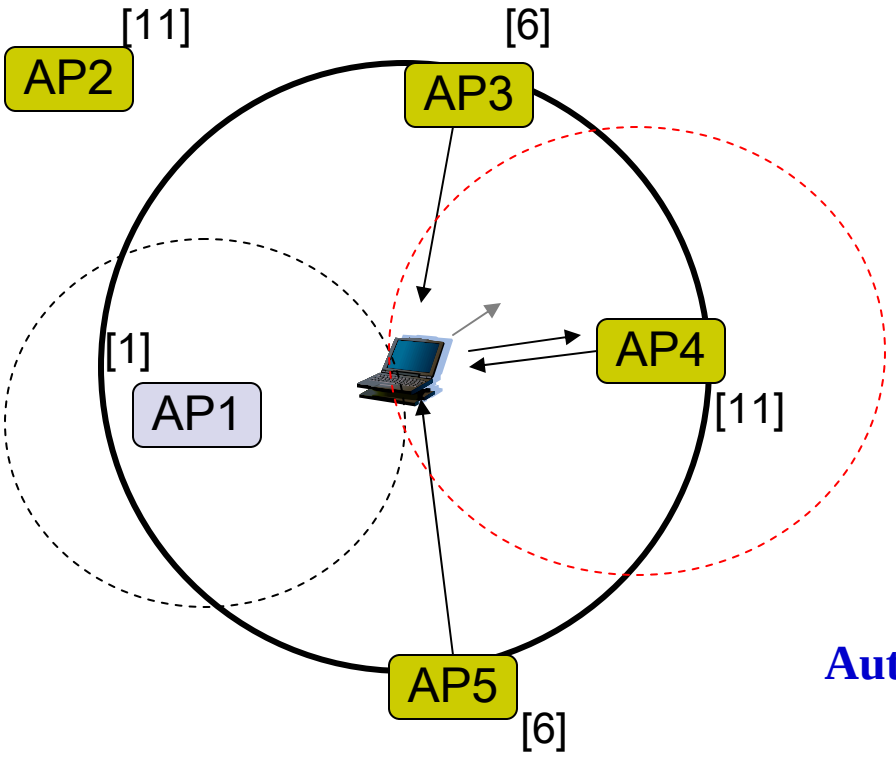
- Motivation & Background
- Neighbor Graph
- NG / NG-prune probing algorithm
- Experiment/simulation results
- Conclusion

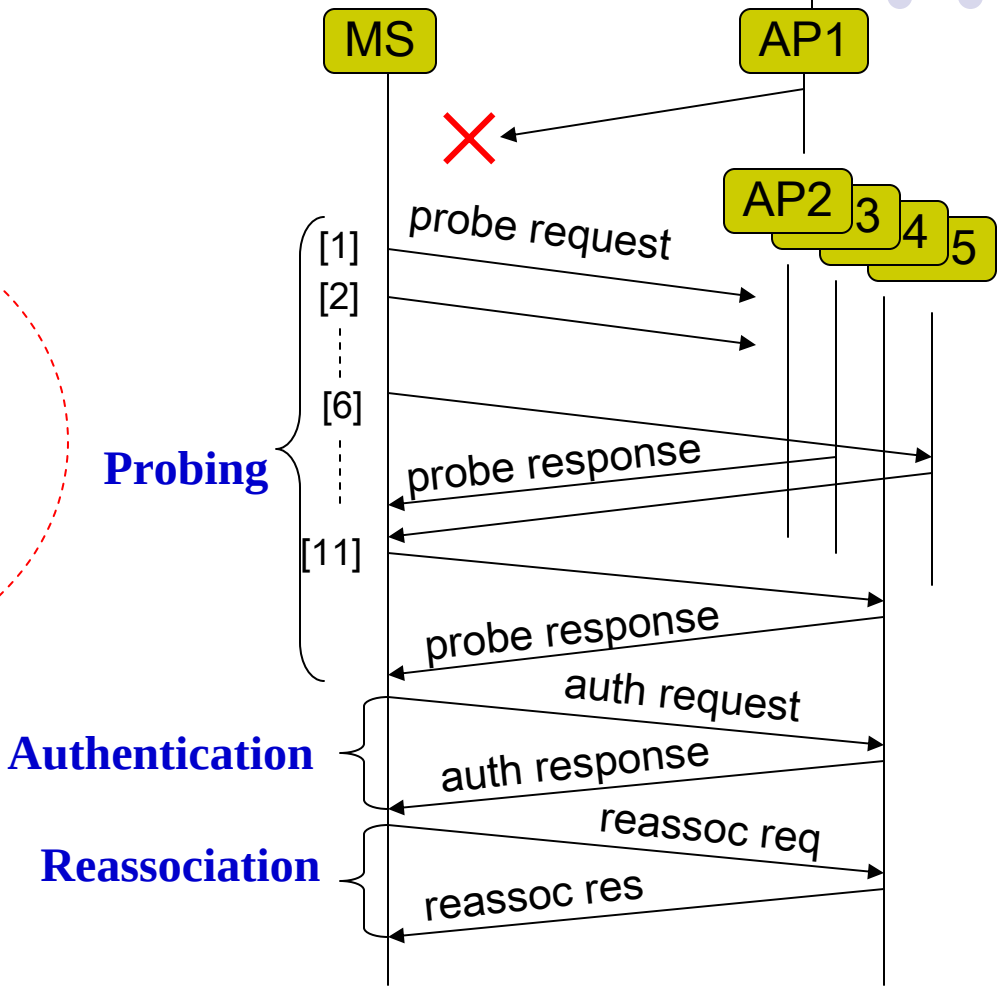
Motivation



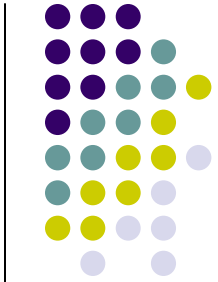
- Hand-off latency is critical in WLAN infra.
  - small coverage
  - demand for multimedia or realtime applications
- High hand-off latency is observed
  - 60 ~ 400 ms, 252 ms on avg, in experiment
  - expected to increase with 11i authentications
- Probing latency > 90% of hand-off latency
- Reducing probing latency is important

Hand-off procedure



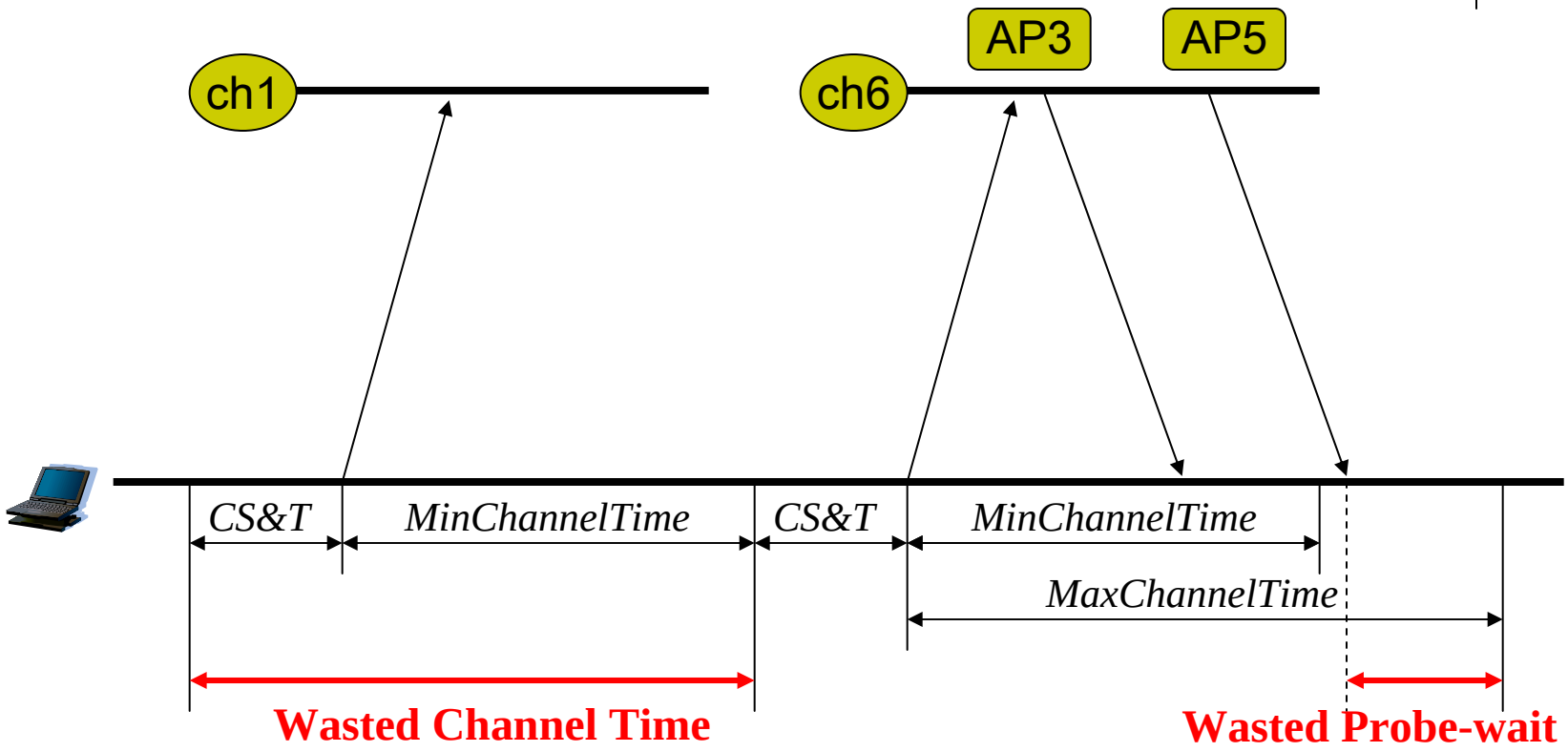


What affects probing latency



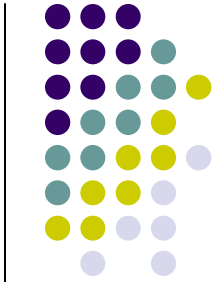
- Number of channels to probe
  - Standard doesn’t define
  - naive : all 11 channels (Full-scanning)
  - only used channels (Observed-scanning)
- Waiting Time for probe response
  - Standard defines
  - MinChannelTime / MaxChannelTime

Probing in detail



- MinChannelTime when no AP respond
- MaxChannelTime when any AP respond

OUTLINE



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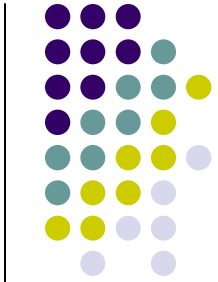
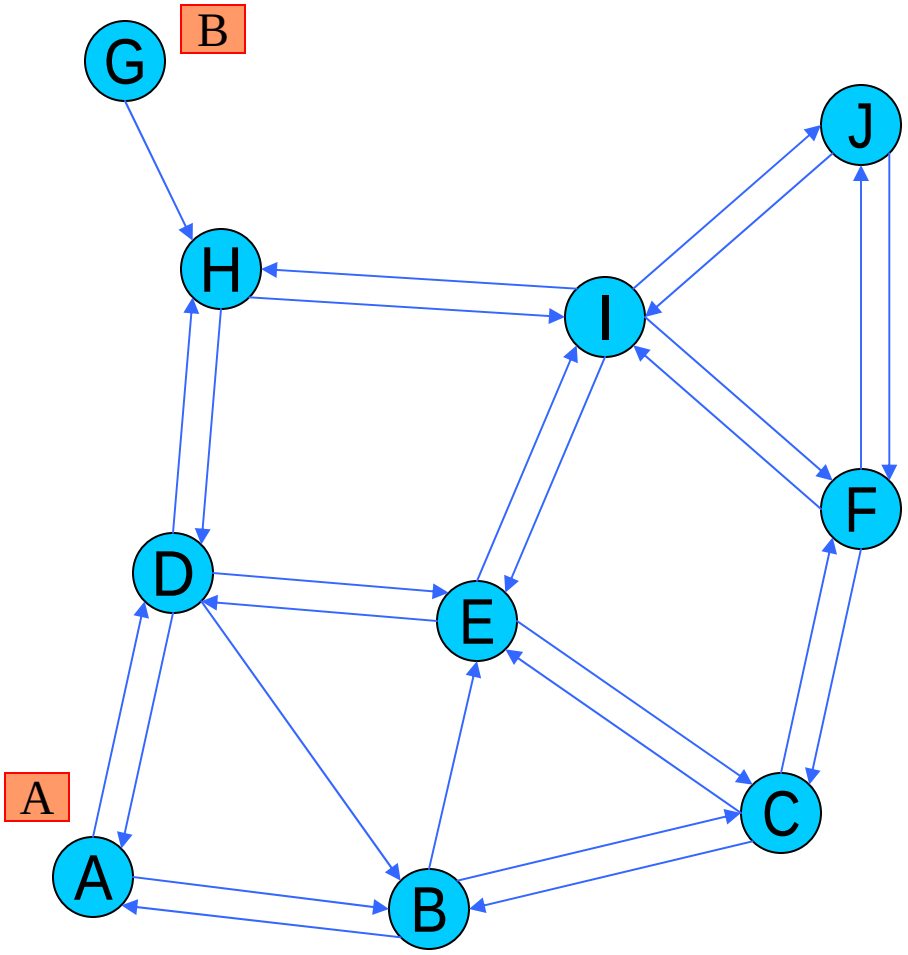
Definition



- [Mishra, Shin, Arbaugh, INFOCOM 2004]
- NG dynamically learns the mobility patterns
- NG = <V,E>, a directed graph
  - *V* : set of all APs
  - *(AP_i, AP_j)* is in E iff a station can hand-off from AP_i to AP_j
- Distributed data structure
  - AP maintains the list of neighbor APs

Neighbor Graph

Generation

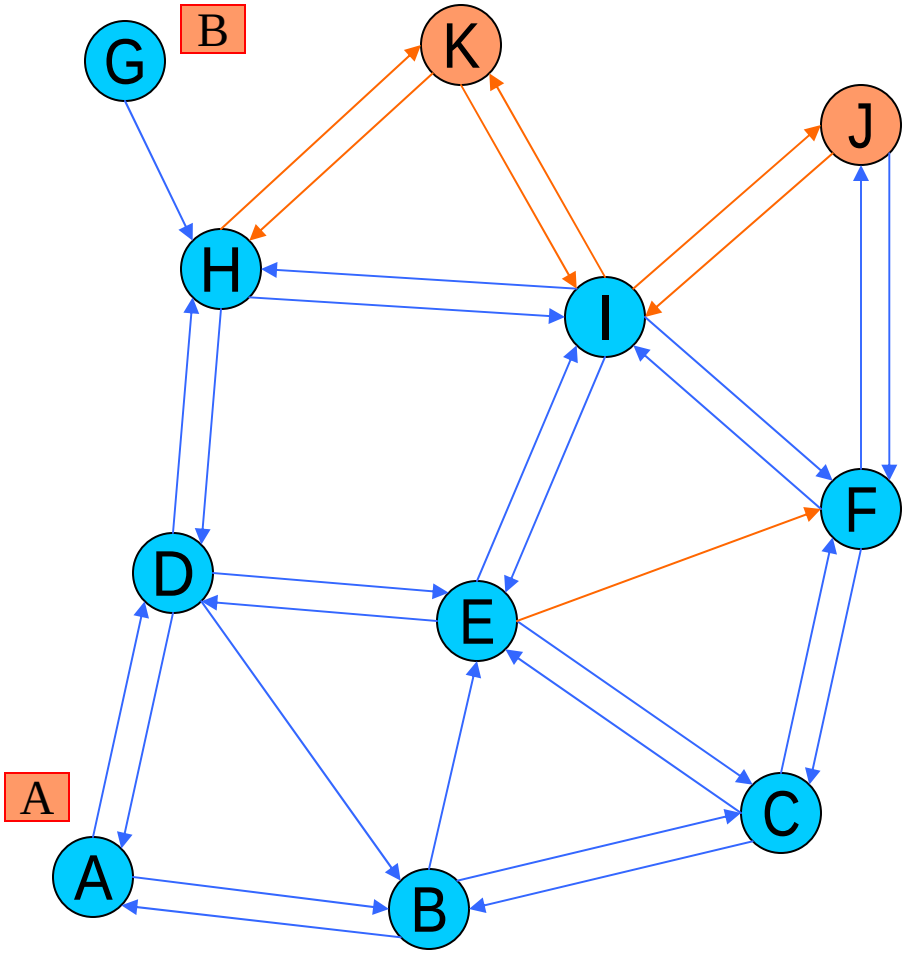


Personal Neighbor Graph (PNG)

Neighbor Graph (NG)

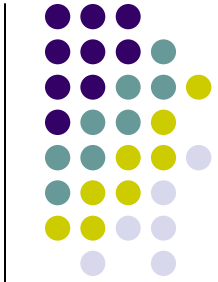
Neighbor Graph

Dynamic Mobility Pattern



- edge-deletion
  - deprecated path
  - AP failure/removal
- edge-addition
  - AP restore/install
  - new path

OUTLINE



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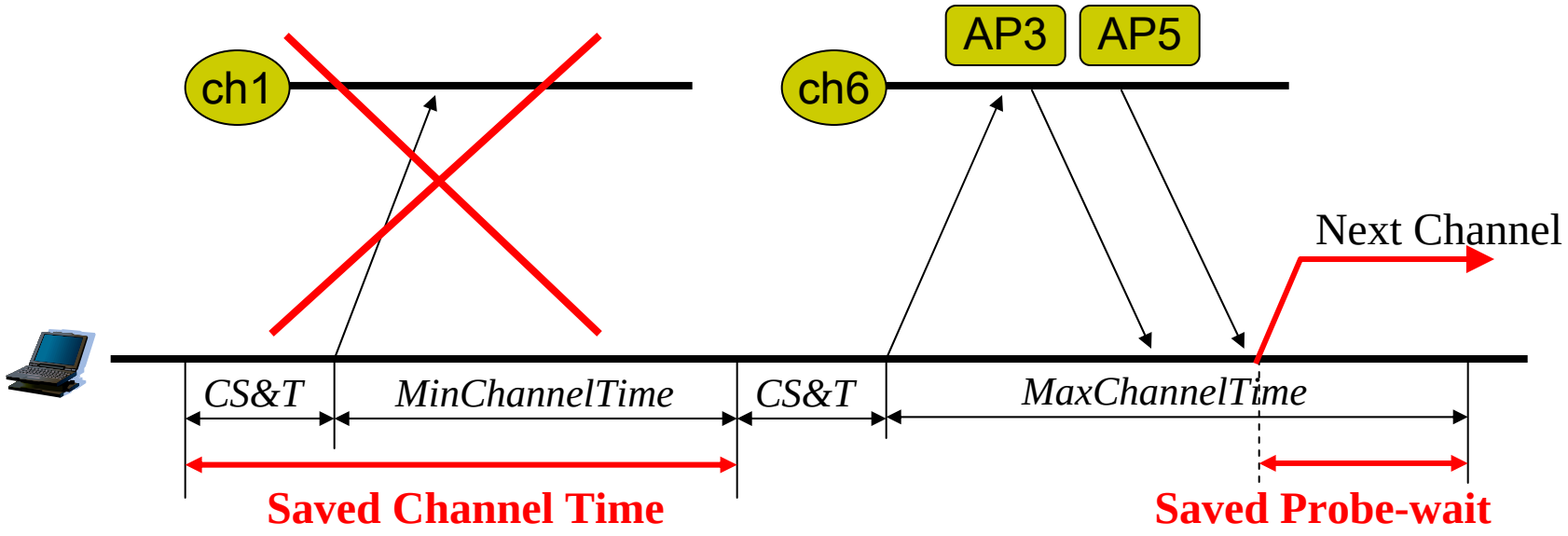
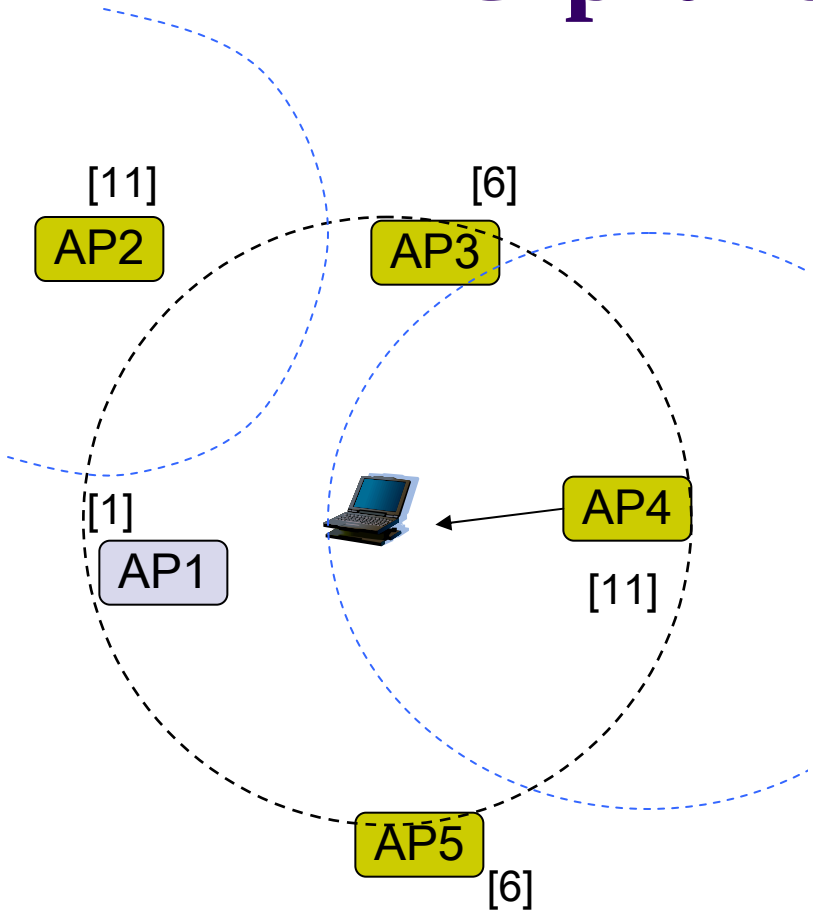
NG probing

- Key ideas
  - Probe only neighbor channels
  - Wait for only neighbor AP's response

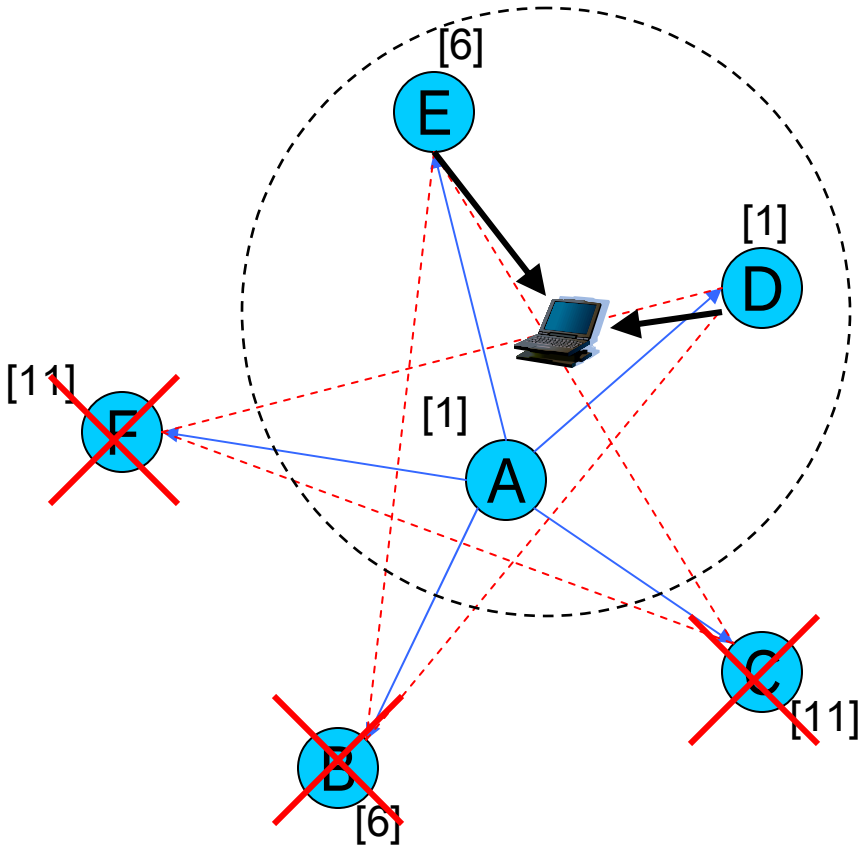


NG-prune technique



- By NG probing, STA waits for MaxChannelTime
- AP2 and AP4 don’t overlap
- If STA knows Ap2 and AP4 doesn’t overlap, STA no longer waits for response from AP2 as soon as AP4 responds
- Use non-overlap graph

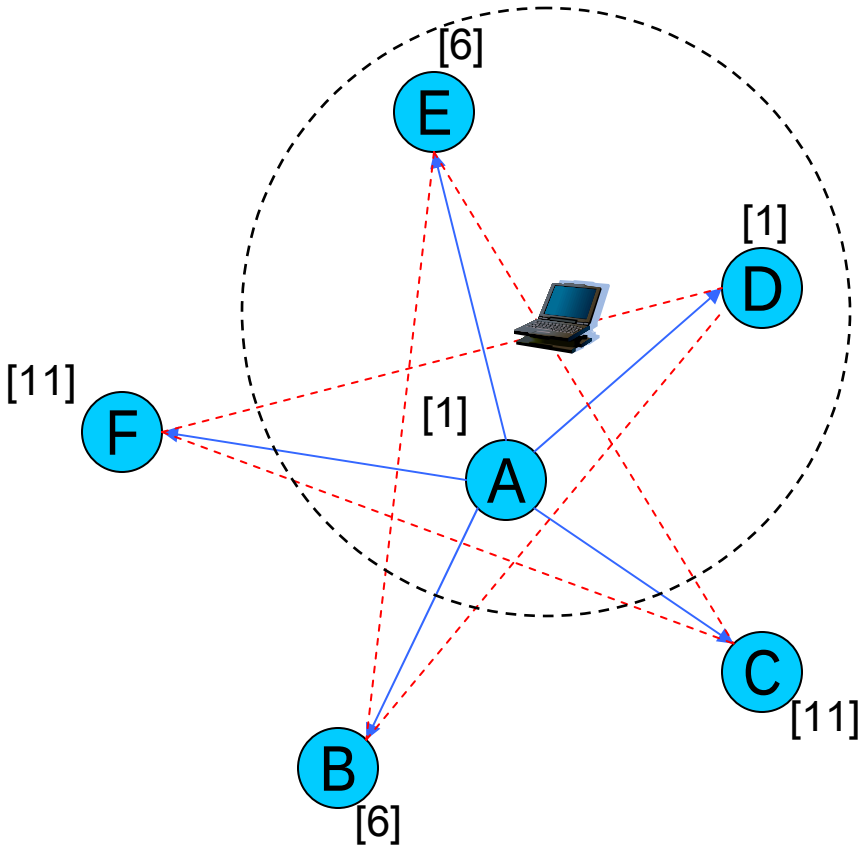
Example



- Channel 1 : 1*RTT
- Channel 6 : 1*RTT
- Channel 11: 0

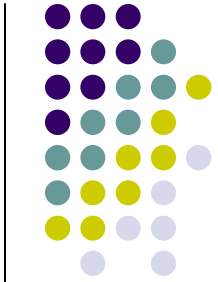
- Reduce both probe-count and probe-wait time

Comparison



- Full Scanning :
  - 2*MaxCT+9*MinCT
- Observed Scanning :
  - 2*MaxCT+1*MinCT
- NG probing
  - 1*Max + 1*Min + 1*RTT
- NG-prune probing
  - 2*RTT

OUTLINE



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Experiment

Methodology

- 20 Cisco 350 APs over two floors using channel 1, 6 ,11
- Avg # of neighbors = 3.15
- STA using laptop with Prism2 based wireless card
- Probing algorithm implemented in driver & user roaming program
- Full / observed scanning, NG / enhanced-NG

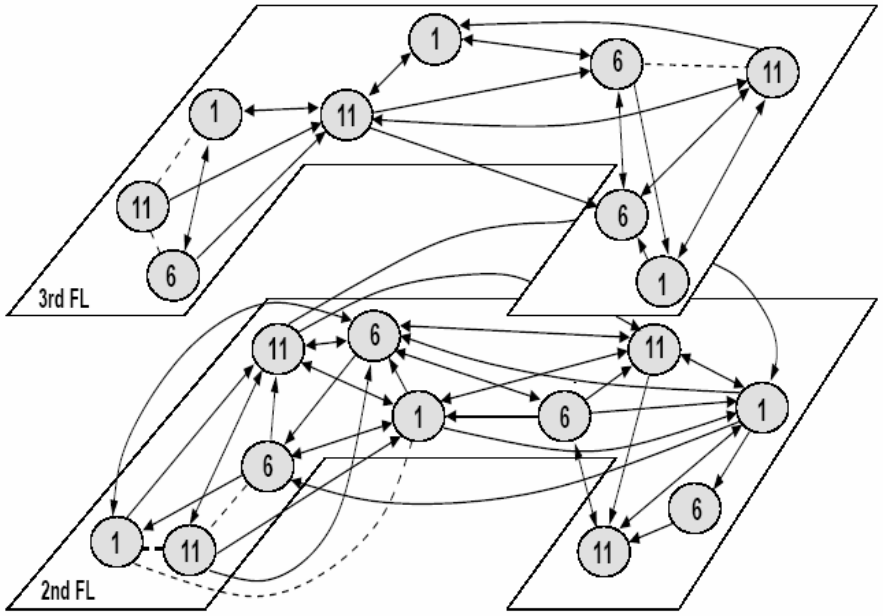
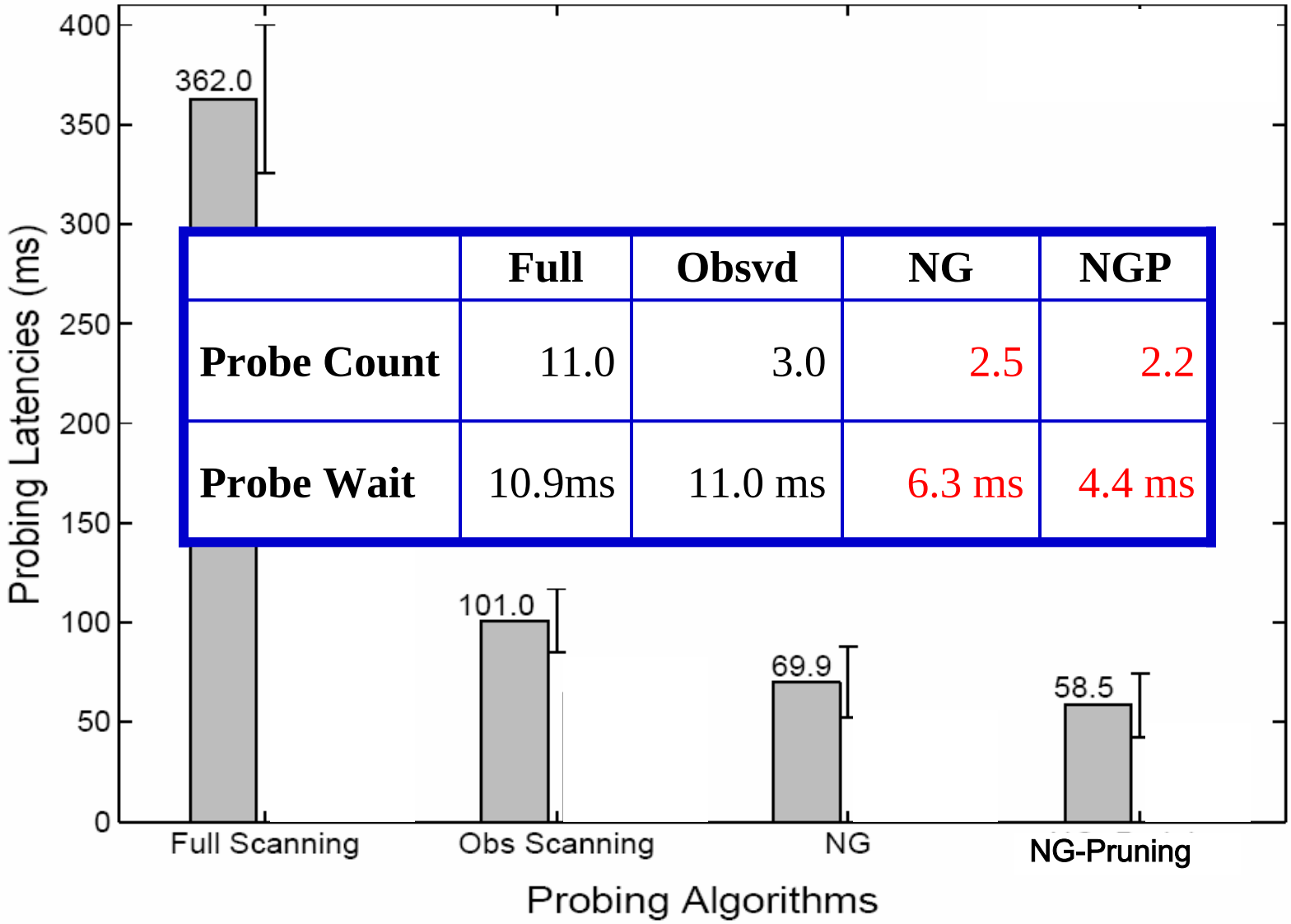


Fig. 4. *Generated Neighbor Graph (solid arrows) and Overlap Graph (solid and dashed lines)*

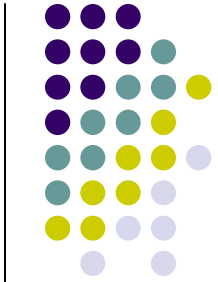
Experiment

Probing Latency



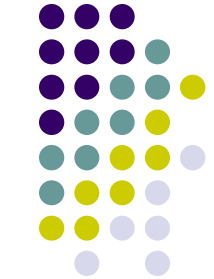
	Full	Obsvd	NG	NGP
Probe Count	11.0	3.0	2.5	2.2
Probe Wait	10.9ms	11.0 ms	6.3 ms	4.4 ms

Conclusion

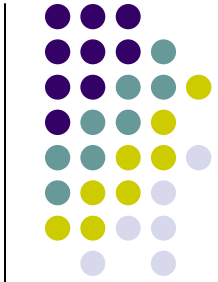


- New efficient probing algorithms (NG/NG-prune probing) and evaluated by experiemt and simulations
- Performance improves
  - as # of indep. channels increase (802.11a)
  - as density of access points increase (# of neighbor increase)

Summary of Publications

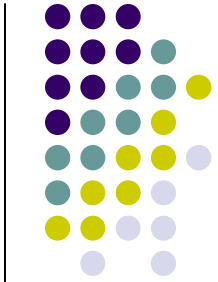


- Mishra, Shin, Petroni, Clancy, Arbaugh, "*Proactive Key Distribution Using Neighbor Graphs*," IEEE Wireless Communications, vol. 11, February 2004.
- Shin, Mishra, Arbaugh, "*An Efficient Handoff Scheme in IEEE 802.11 using Neighbor Graphs*," MobiSys 2004.
- Mishra, Shin, Arbaugh, "*Context Caching using Neighbor Graphs for Fast Handoffs in a Wireless Network*," INFOCOM 2004, March 2004.



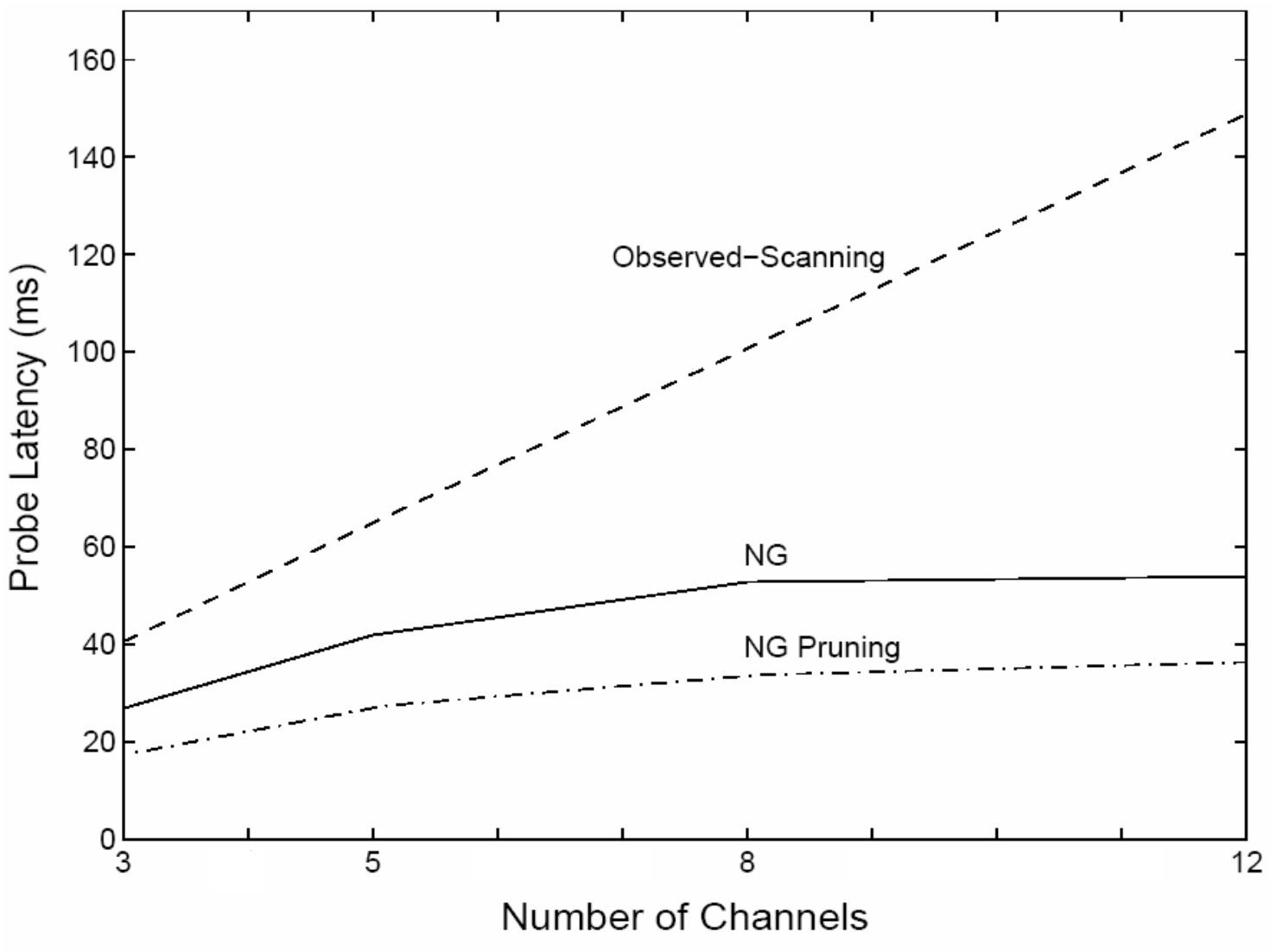
Questions?

Back up slides



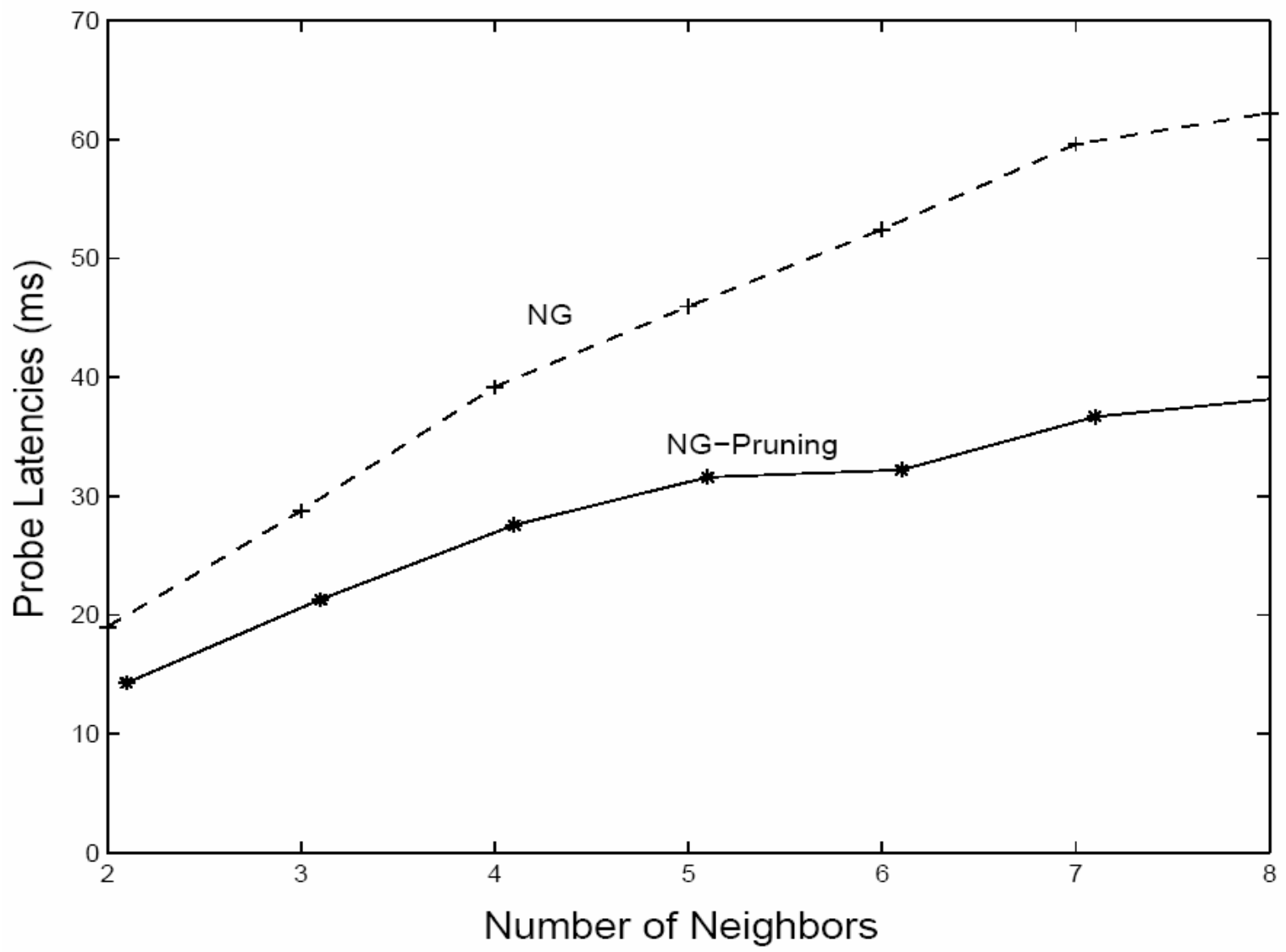
Simulation

Probing Latency vs # of Channels

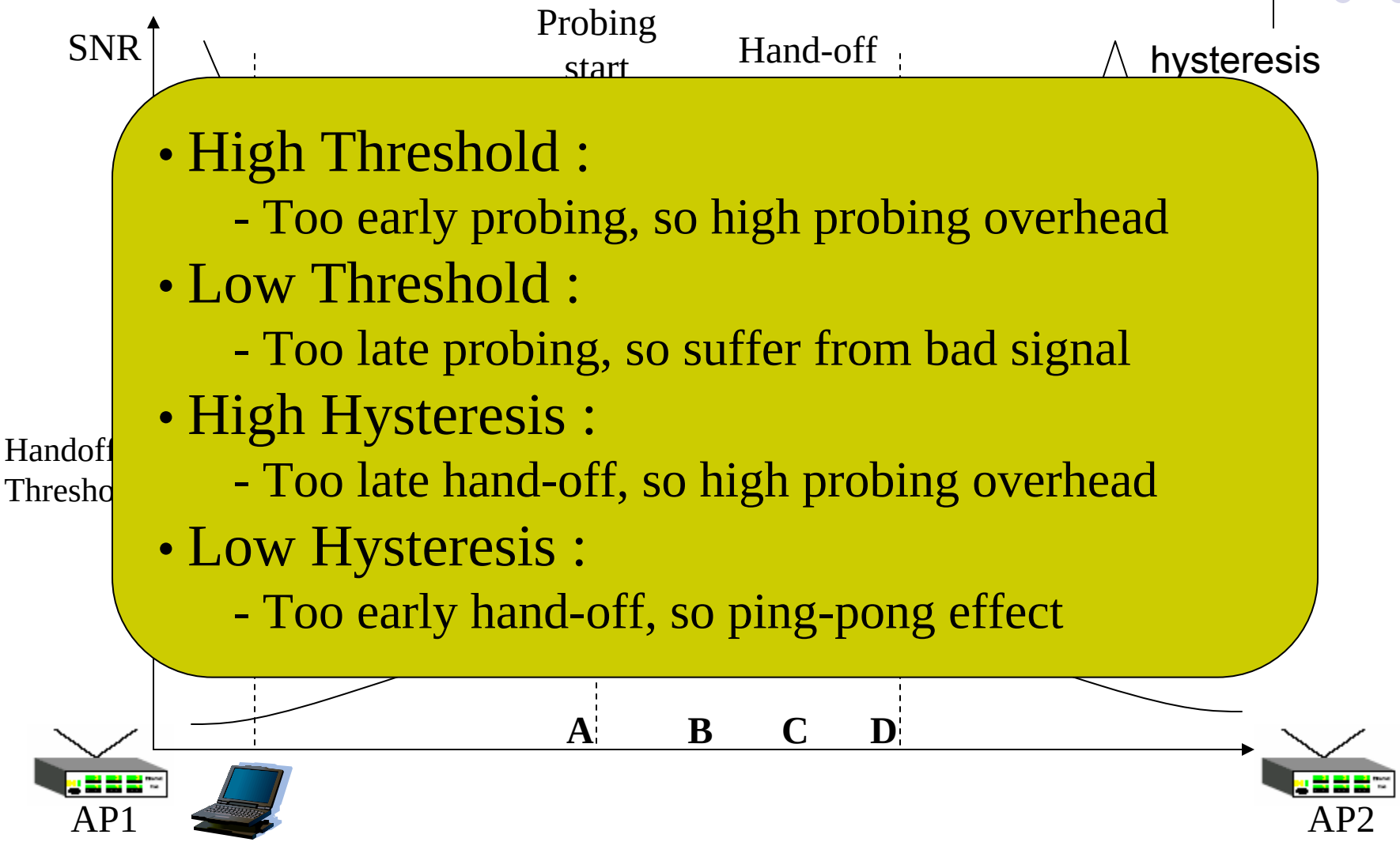


Simulation

Pruning vs # of Neighbor

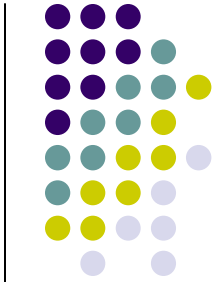


Hand-off Decision



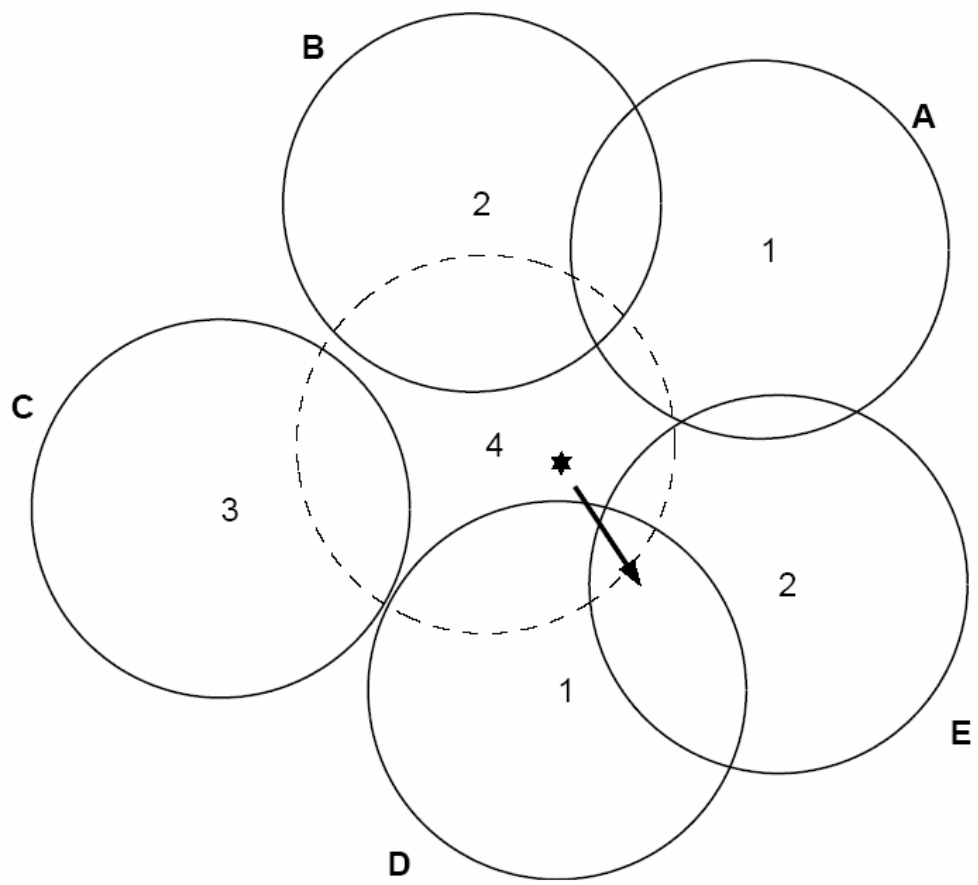
- High Threshold :
  - Too early probing, so high probing overhead
- Low Threshold :
  - Too late probing, so suffer from bad signal
- High Hysteresis :
  - Too late hand-off, so high probing overhead
- Low Hysteresis :
  - Too early hand-off, so ping-pong effect

Non-overlap Graph



- Overlap Graph(OG) is an undirected graph
  - $<V,E>$; V = set of access points
  - $<AP_i, AP_j> \in E$ if their coverages overlap
  - APi, APj overlap $\Leftrightarrow S_i(x) \geq T_h \wedge S_j(x) \geq T_h$
- Non-overlap Graph(NOG) = OG^c
- OG is easier to generate than NOG
- Also distributed structure stored at each AP

Simulation Model



- Identical coverages
- Randomly chosen :
  - # of neighbors
  - positions
  - STA's direction
- Optimaly chosen channel assignments
- Variables
  - # of Nb : 2,3,…,8
  - # of Chnl : 3,5,8,12