SMARTA: A Self-Managing Architecture for Thin Access Points

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Outline

- Motivation
- Requirements
- Architecture
- Evaluation
- Status and conclusions

Five reasons why IT managers hate 802.11

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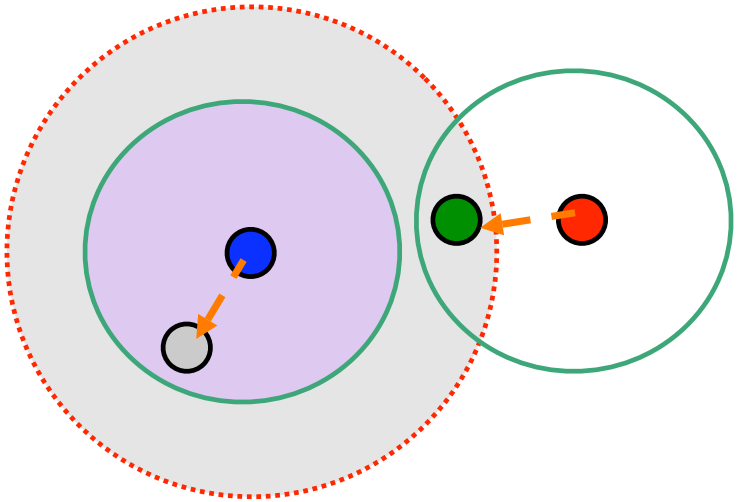
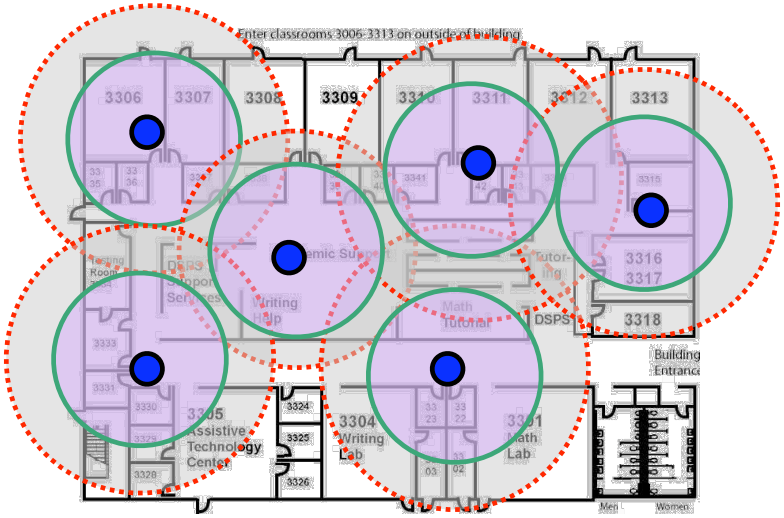
1. Interference

- Due to simultaneous reception of two transmissions at a receiver
  - whether or not decoded




Enter classrooms 3006-3313 on outside of building
3306
3307
3308
3309
3311
3313
3316
3317
3318
DSPS
Writing Lab
Math Tutorial
3305
Assistive Technology Center
3304
Writing Lab
3301
Math Lab
3324
3325
3326
Men
Women

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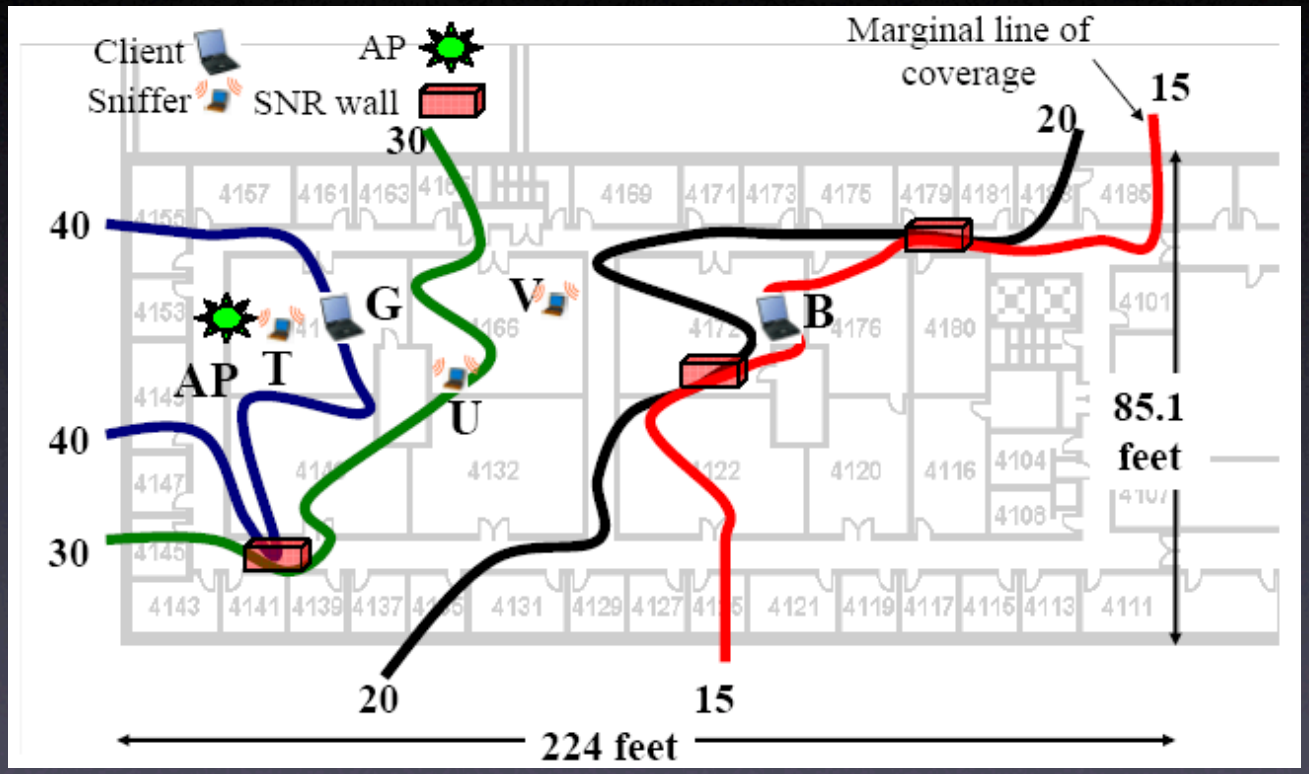
2. Irregular coverage



From: J. Yeo, M. Youssef, A. Agrawala, Characterizing the 802.11 Traffic: The Wireless Side, UMD Tec. Report (CS-TR-4570)

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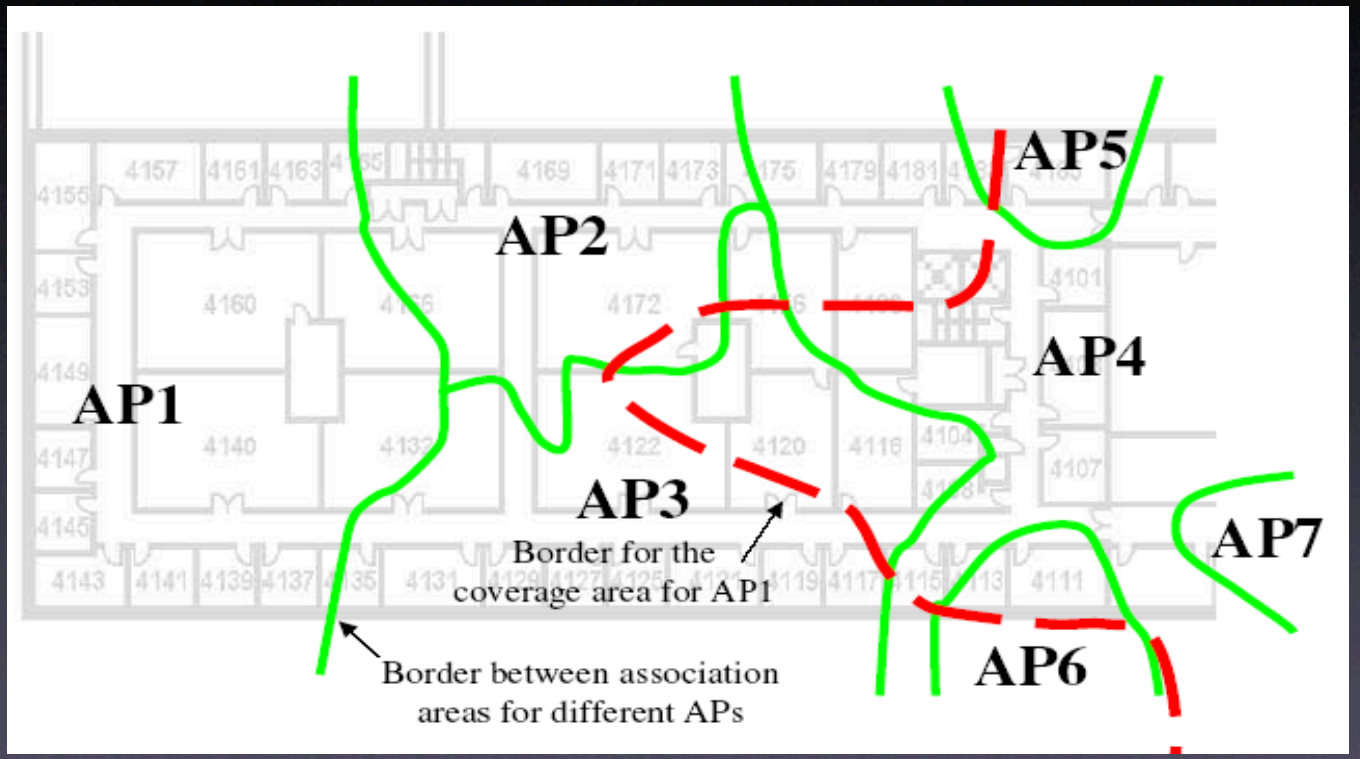
3. Dynamic coverage



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4. Parameter hell

- For each AP, need to select
  - Technology: a, b, g (or n?)
  - Channel: 1 of 3 or 12
  - Power level: 1 of about 50
  - Sensitivity: a number from 1 to 90
  - Security type: WEP, WPA, 802.1x, …
  - Vendor-specific extensions
  - …

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5. Legacy clients

- Can't assume that you can change all client software
  - even in corporate environments!

How can we help?

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Ideally...

- Install APs near power points and wired access
- And walk away...
- System should self-adapt to changes in channel conditions, user load, user mobility, and user population

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Solution requirements

- Cheap deployment/maintenance costs
  - Must use off-the-shelf hardware
- Need to support legacy clients
- Realistic wireless channel modeling
- Flexible controls for network administrator
  - Choose to maximize throughput or minimize delay

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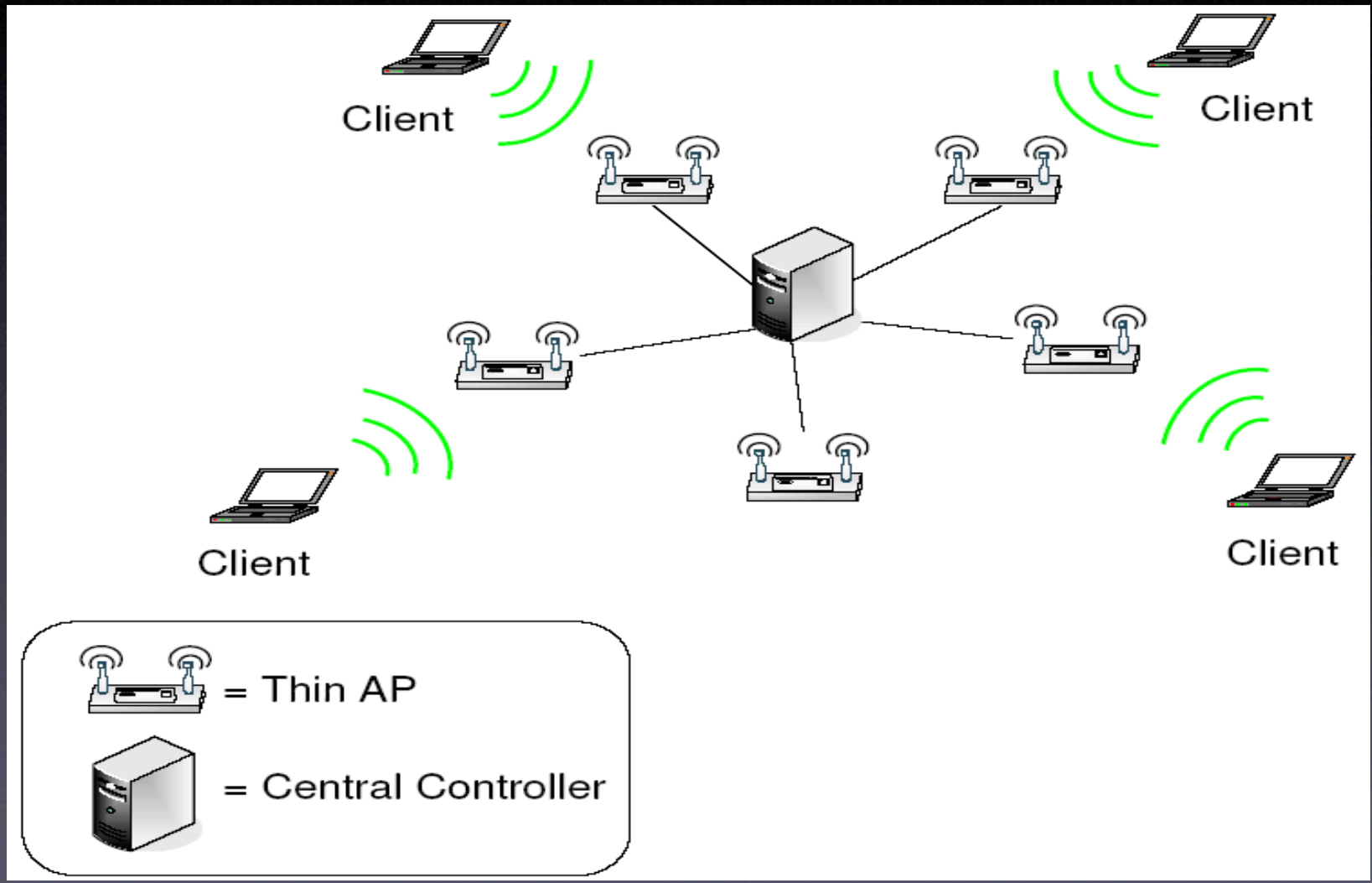
Our approach

- Central controller and thin access points
- Measure the system using simple experiments
- Tune parameters
  - Channel Assignment
  - Transmit Power control
- Dynamically re-tune to adapt to changing conditions

SMARTA Architecture



Representing the system

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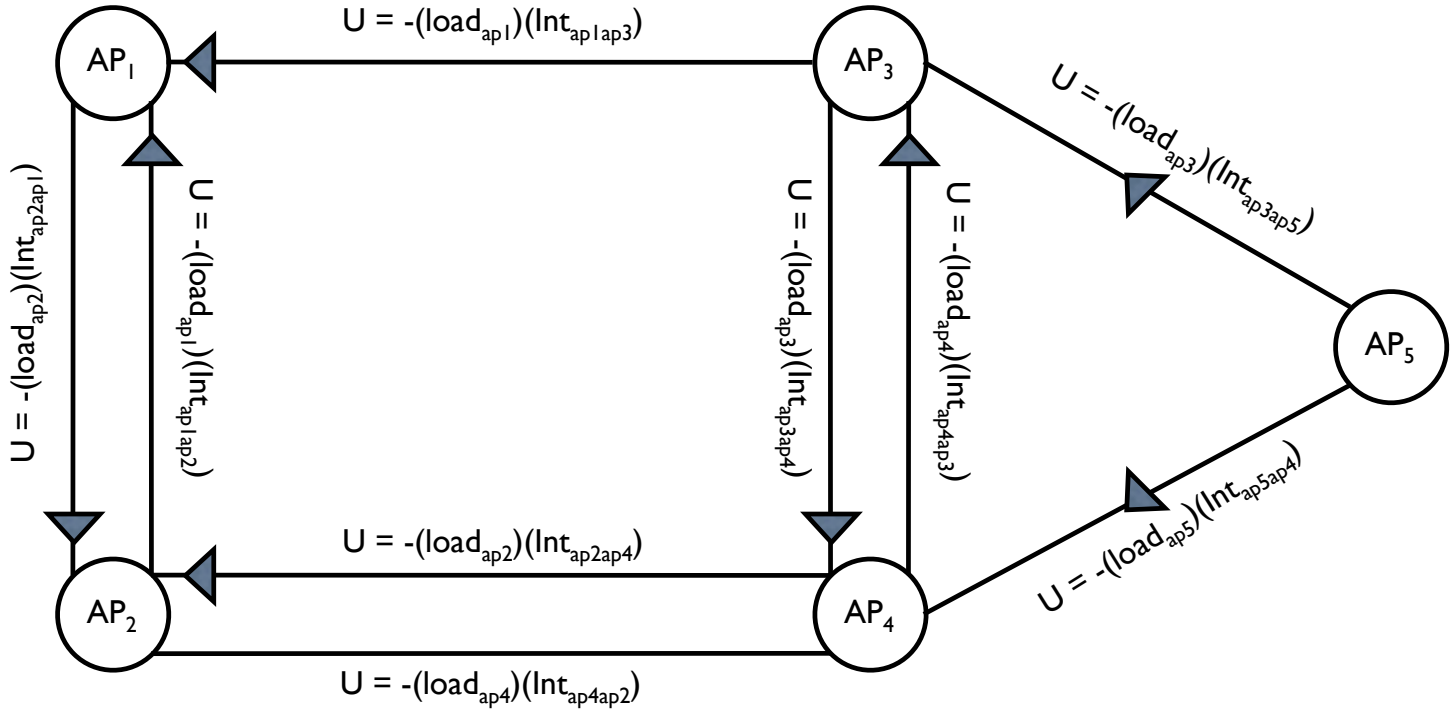
System model

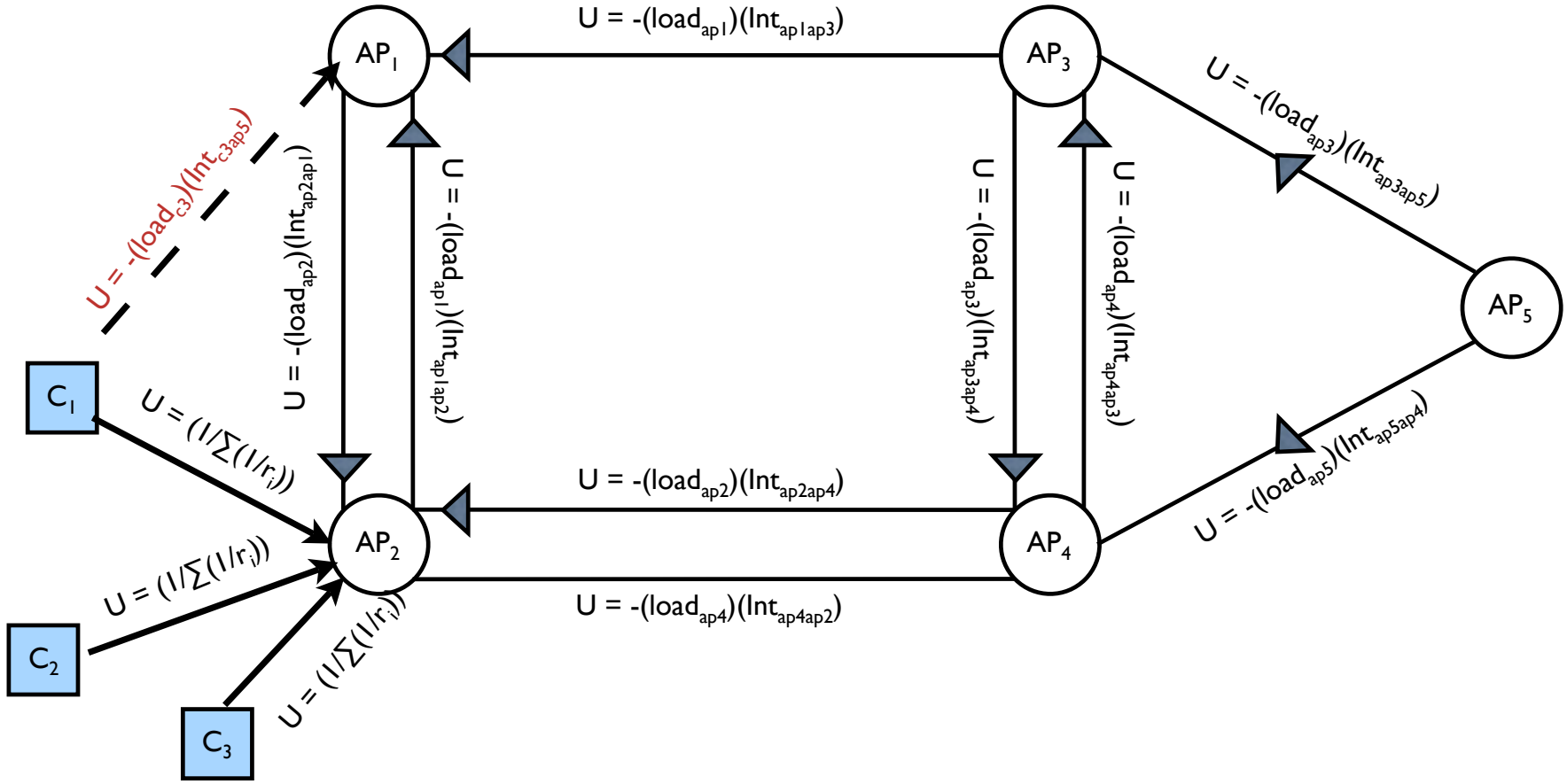
- Conflict graph
  - + clients
  - + utility annotations

Conflict Graph

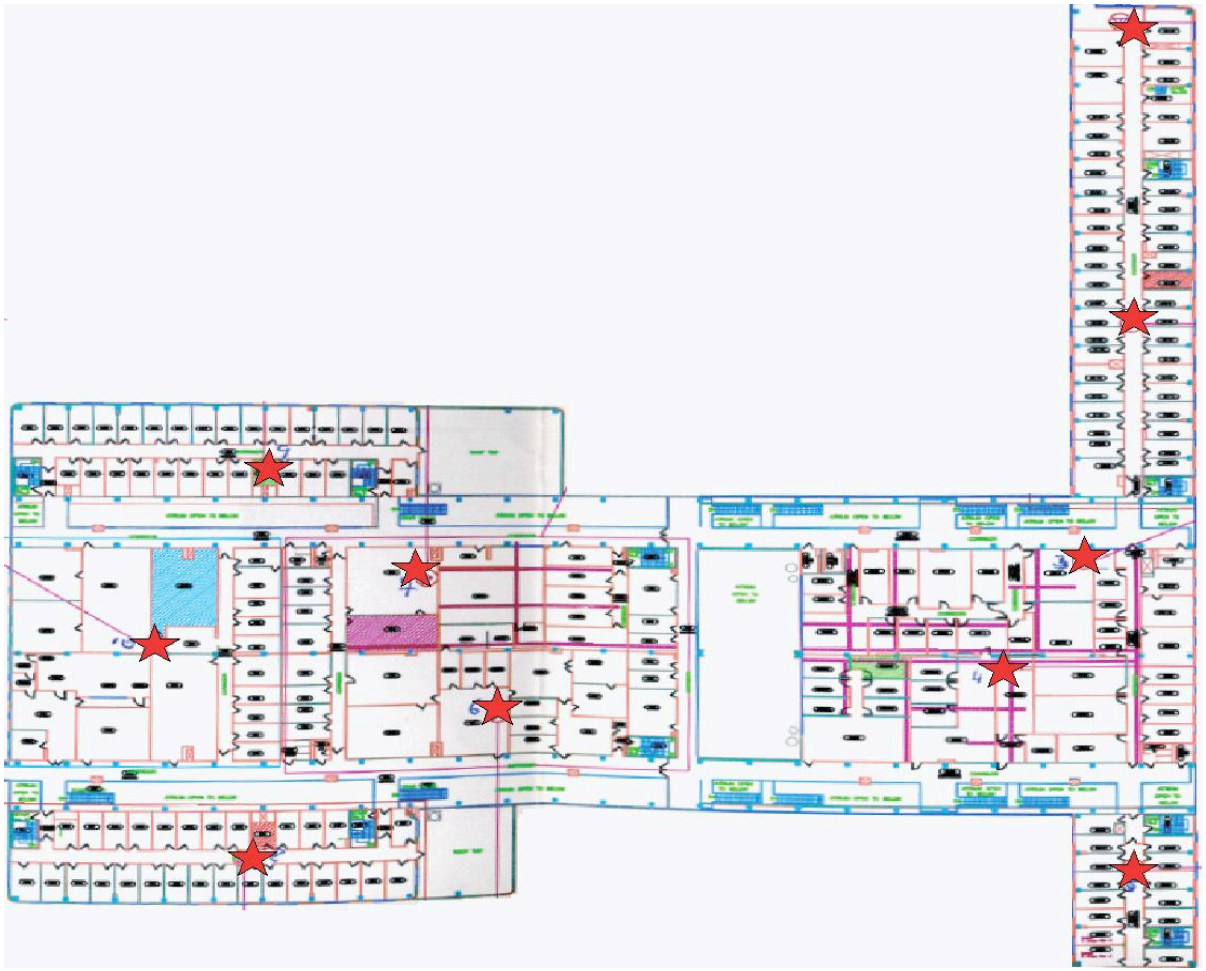


Max. Power Single Channel (MPSC) graph

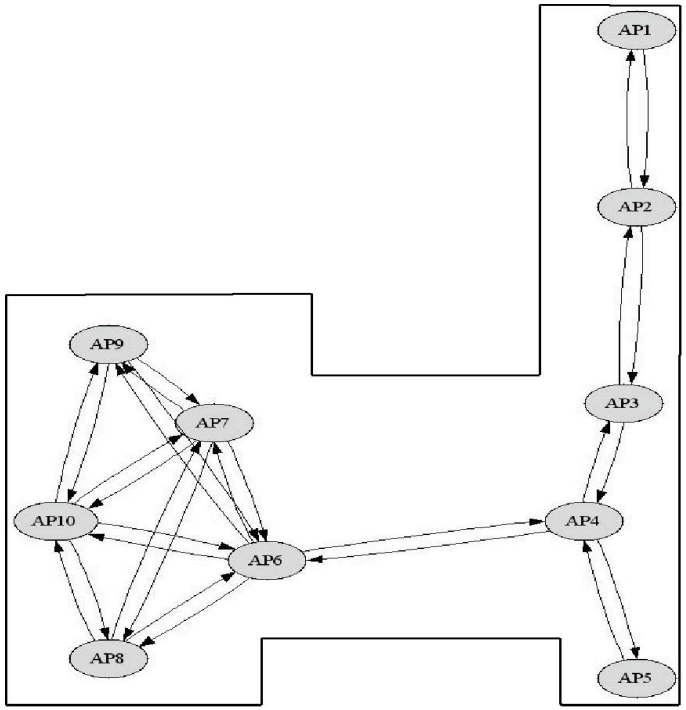
Annotated Conflict Graph



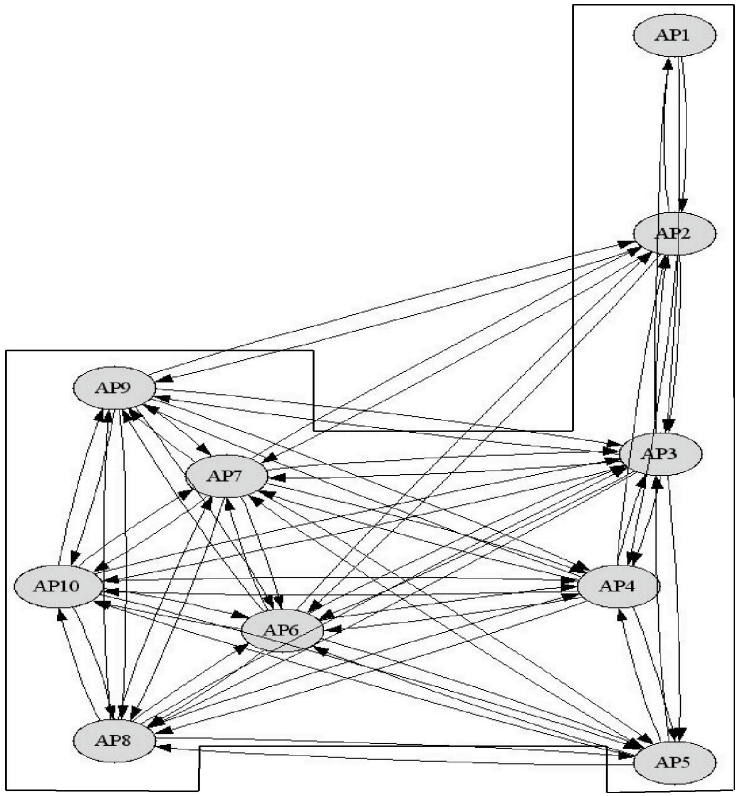
Davis Centre Access Point Layout



Davis Centre Conflict Graph



Conflict Graph at 20dbm



Conflict Graph at 30dbm

Measuring the ACG

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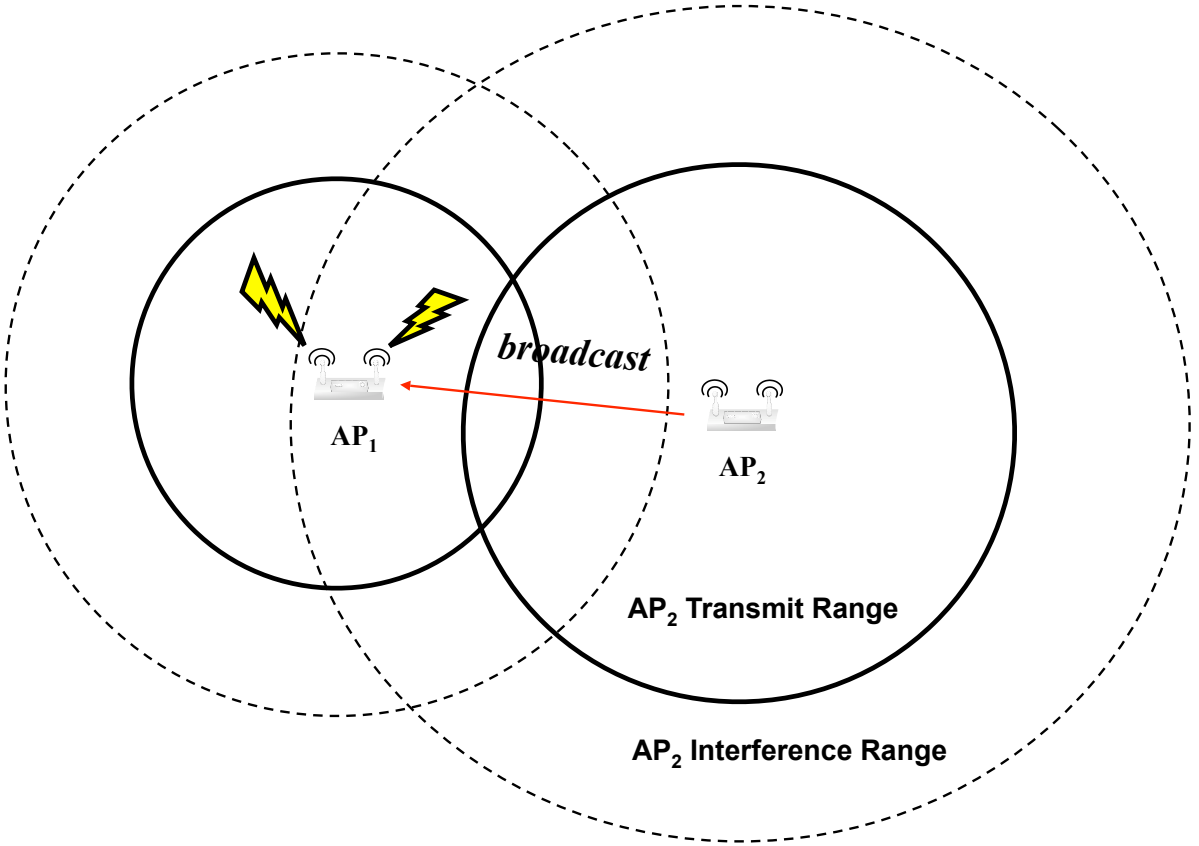
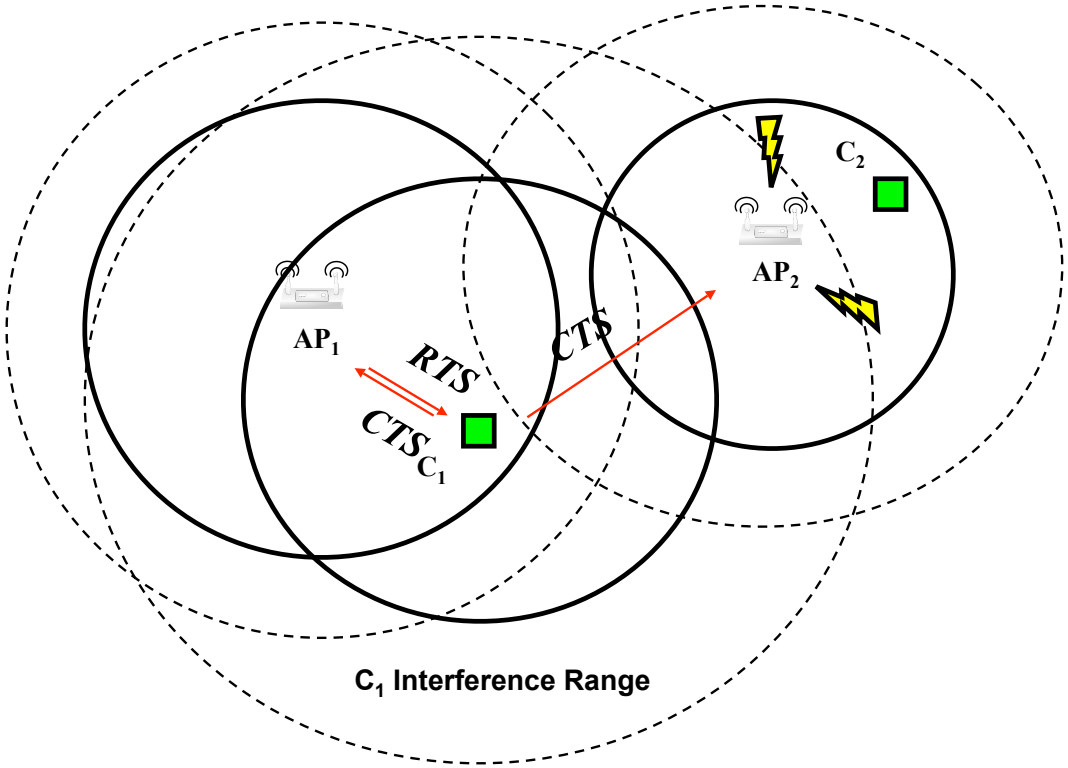
Interference Experiments

- Perform pairwise tests to determine RF interference
- What is required?
  - 'Clean' RF environment
  - Synchronization between testing nodes
  - No client modifications
  - Speed

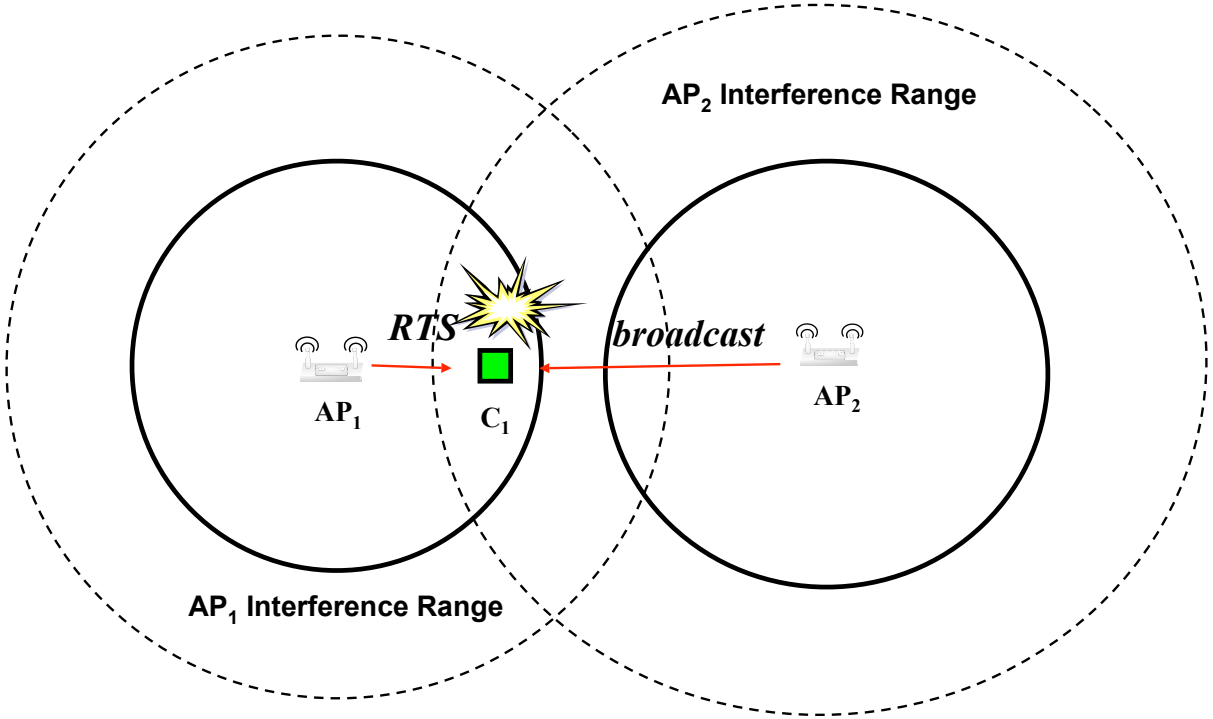
Inter-AP Interference



Client-AP Interference



AP-Client Interference



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Disutility of interference

- Currently approximated as a log-linear relationship between sending rate of interferer and throughput of interfered node
- Open problem

Tuning

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Utility Optimization

- Channel Assignment (using CG)
  - Well-known NP-hard problem
  - Use hill-climbing approach to optimization
- Power Control (using ACG)
  - Ensure clients don't lose connectivity
  - Re-compute ACG if power level changes

Re-tuning

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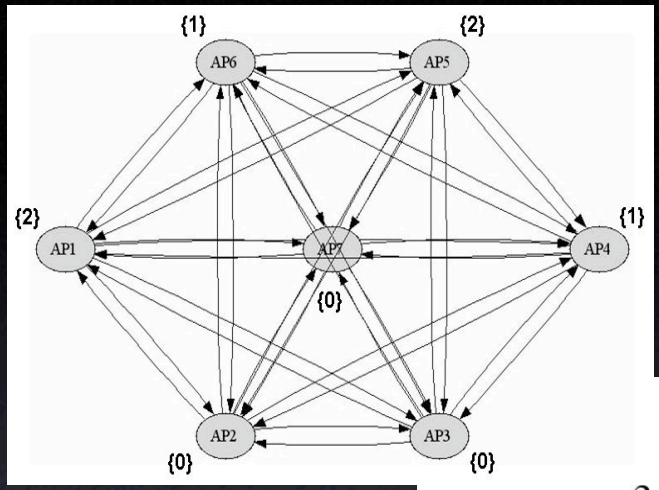
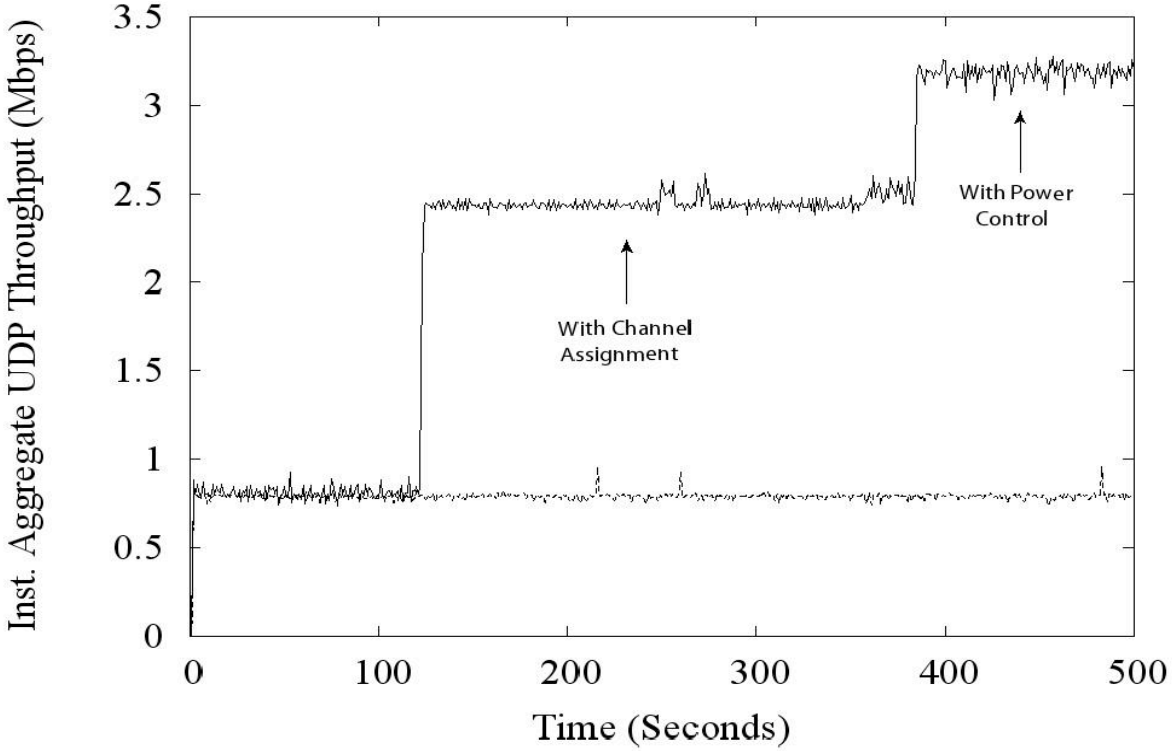
Dynamic Reconfiguration

- Utility-based triggers for re-computation
- Utility change greater than threshold (α)
  - Re-compute channels/power levels from scratch
- Utility change less than threshold (α)
  - Refine power levels

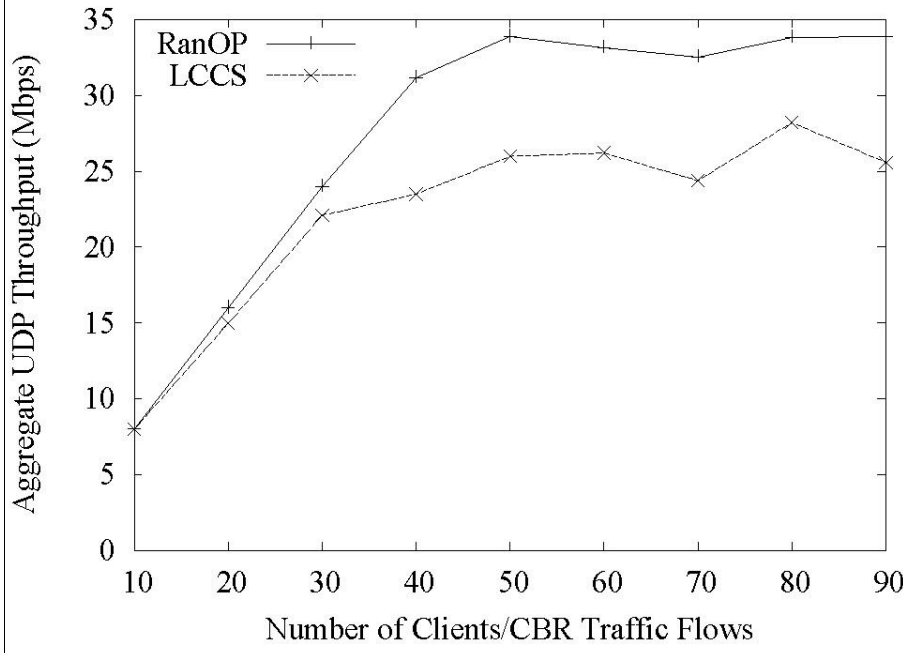
Evaluation

Star Topology

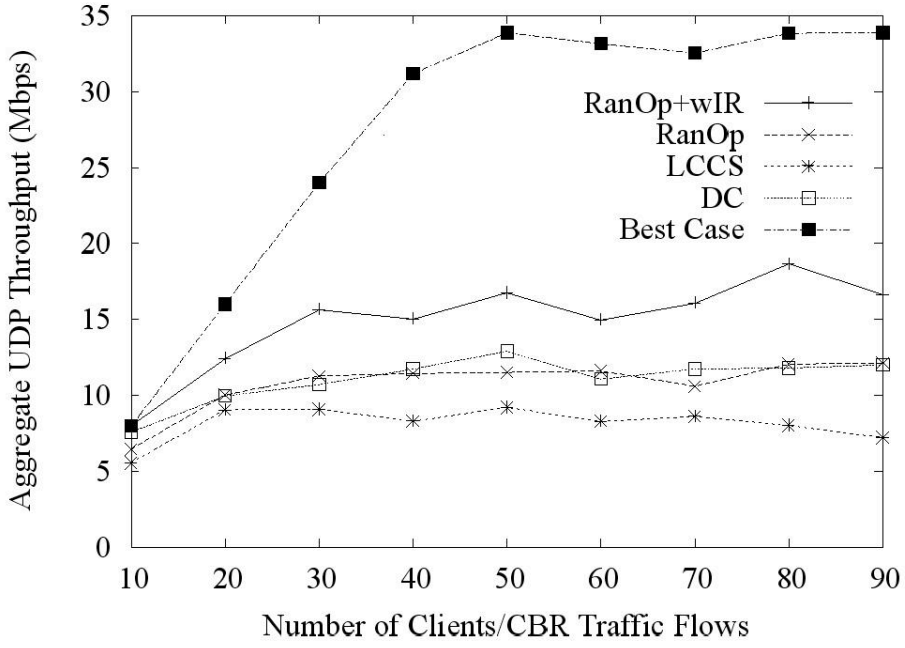




Davis Centre (throughput)

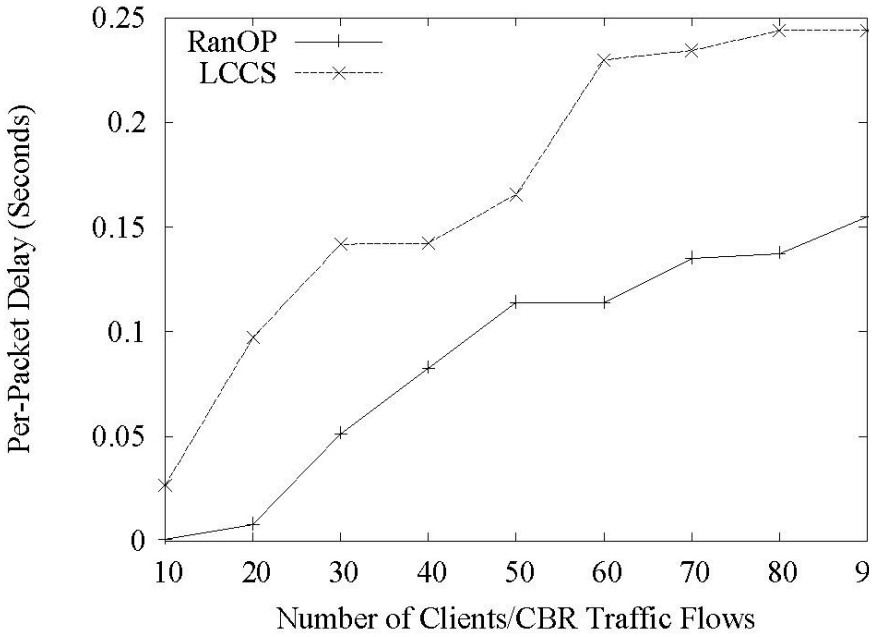


12 Channels

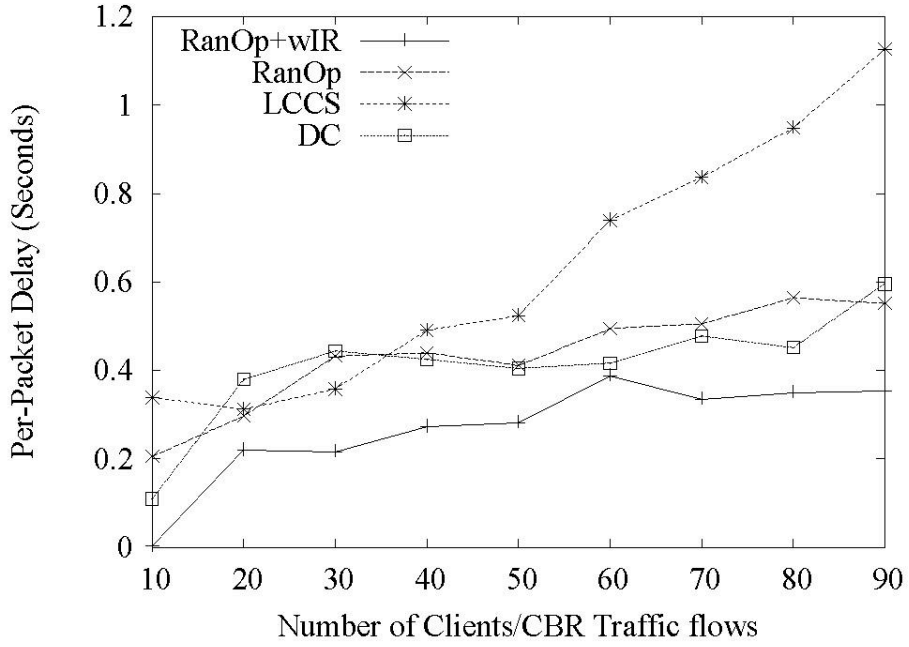


3 Channels

Davis Centre (delay)

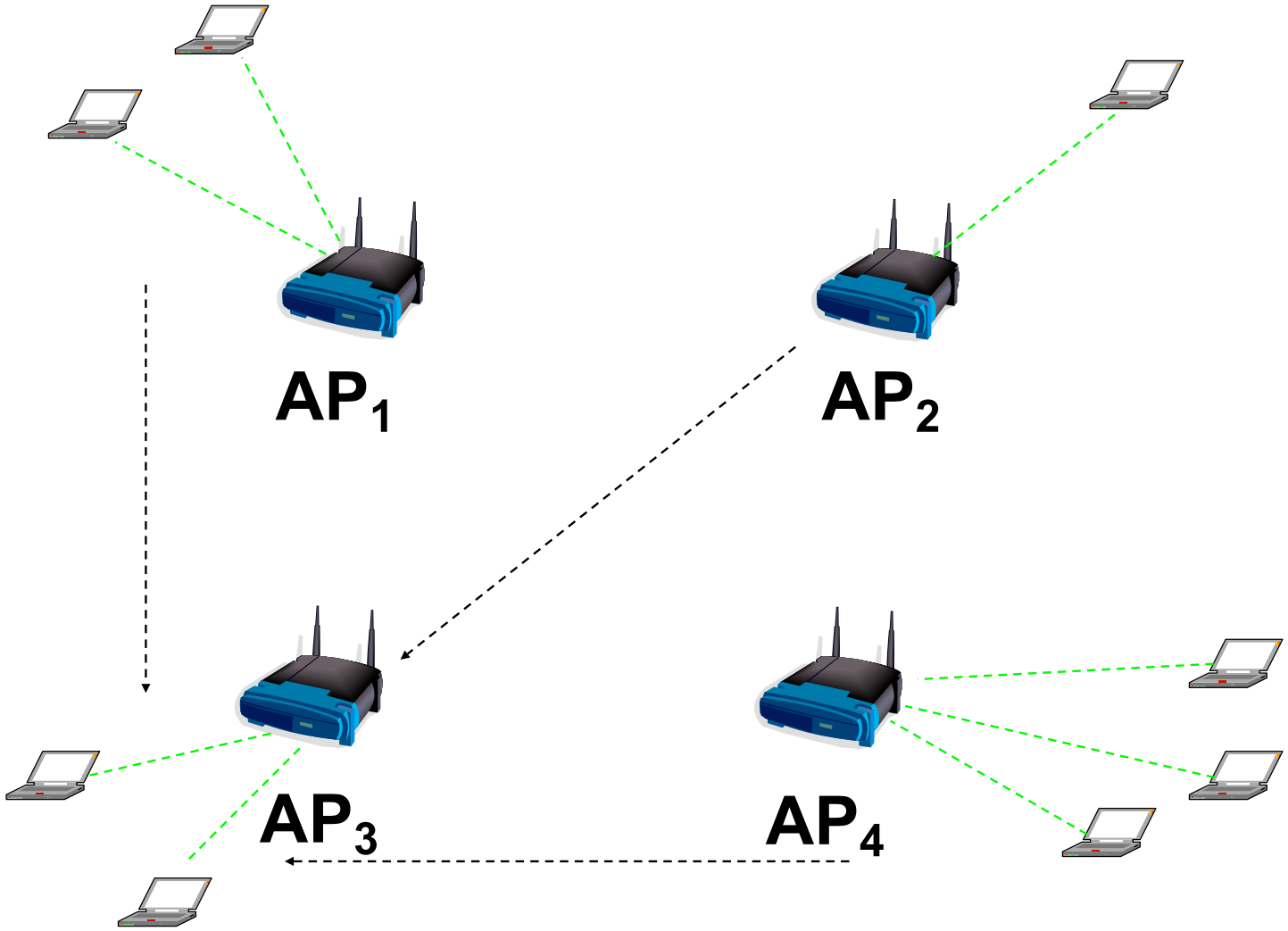


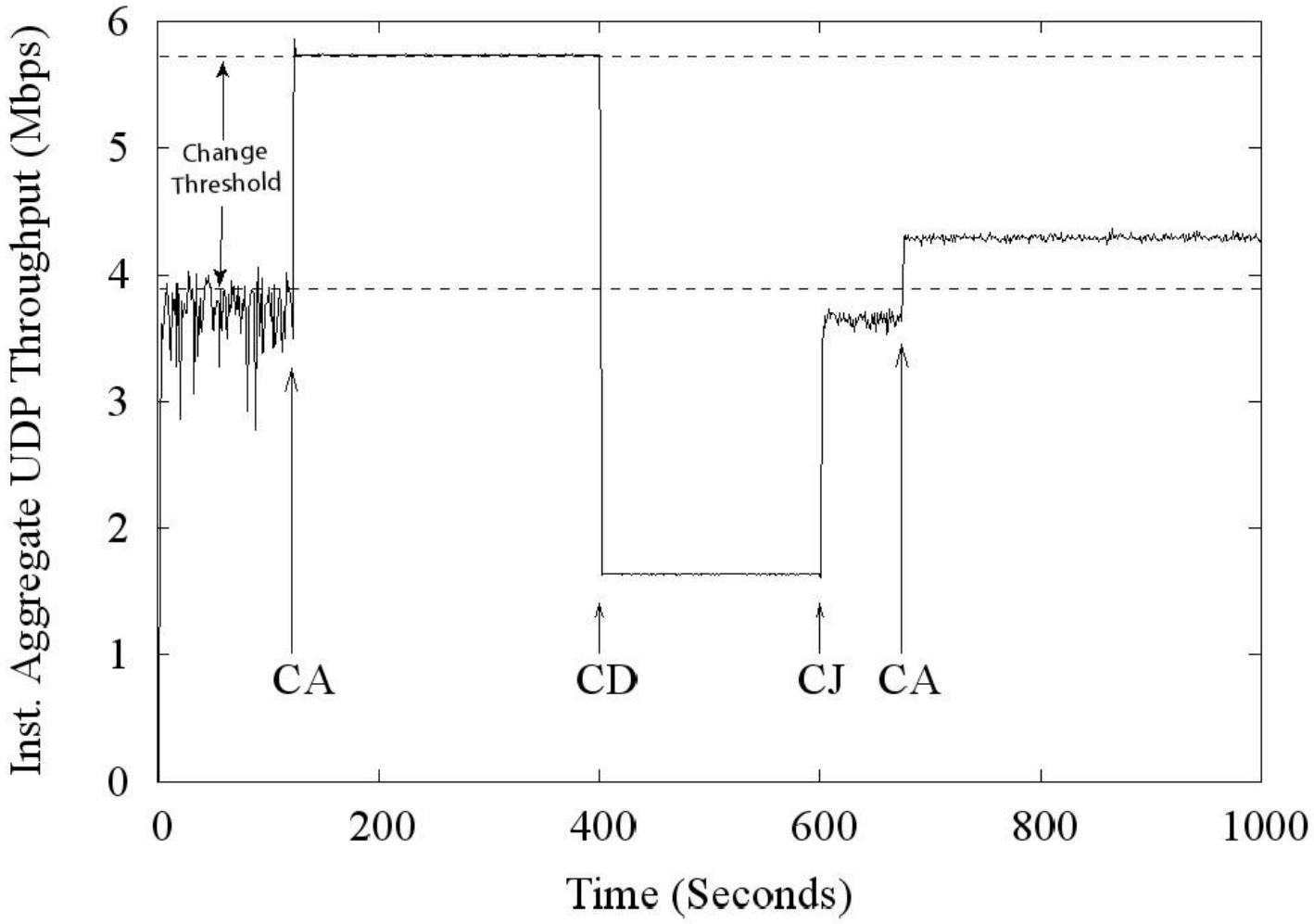
12 Channels



3 Channels

Effect of Mobility




Inst. Aggregate UDP Throughput (Mbps)
Time (Seconds)
Change Threshold
CA
CD
CJ
CA
0
1
2
3
4
5
6
0
200
400
600
800
1000

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Discussion

- Limitations
  - Don't accurately capture client statistics
  - Don't properly model effect of interference
- Future enhancements
  - Choice of CCT
  - Optimal scheduling of interference tests
  - Infrastructure-directed association and load balancing

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Current Work

- Department-wide deployment test bed at Cambridge
  - 40 APs (carrying synthetic workloads)
  - Intel 2915 ABG wireless cards
- Access Points
  - FW & µCode implementation for 2915ABG chipsets
    - Signal detection (w/out packet decode)
    - Received SNR (for all detected signals)

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Conclusions

- Setting up and managing an enterprise WLAN is (surprisingly) hard
- SMARTA provides a centralized solution with realistic assumptions
- Measurements are used to create an annotated conflict graph
  - which is also the basis for cominatorial optimization

Thank you!

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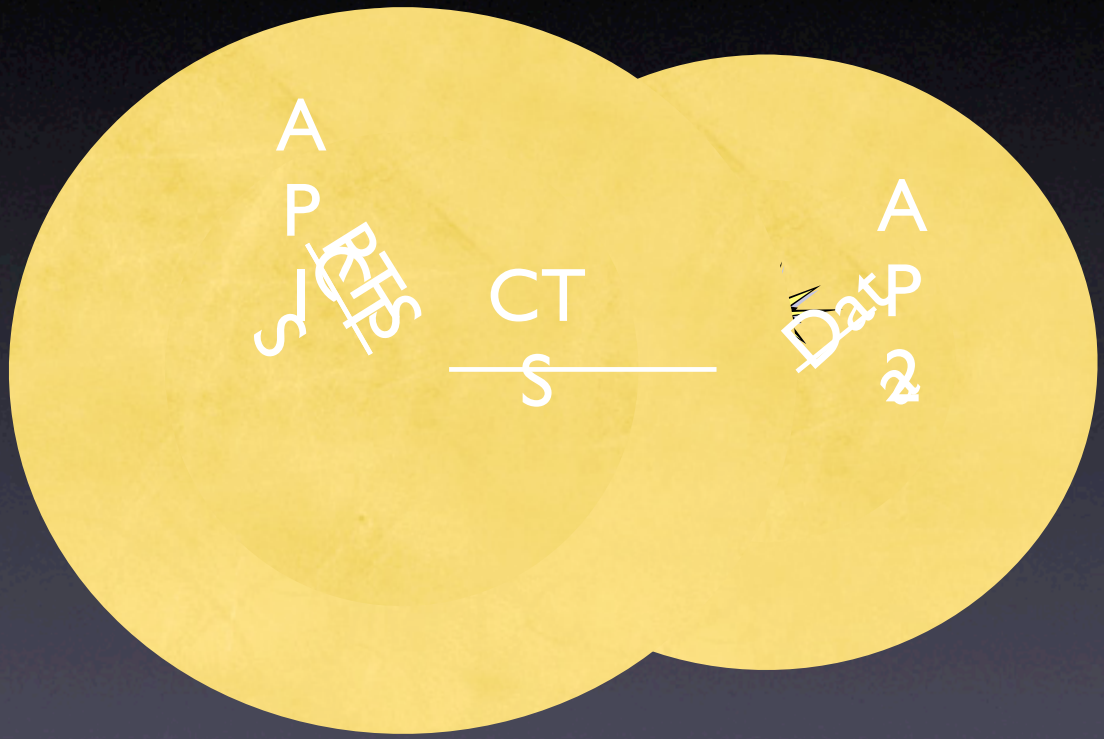
Setting Up Test Environment

- Test Procedure:
  - All APs send unsolicited CTS to temporarily halt all transmissions from clients.
  - Designated AP performs test to detect RF interference scenario
  - All APs/clients resume normal operation
- Above procedure repeated for each test

One-Hop Interference (OC)

Two-Hop Interference



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A Simple Analysis

- Effect of interfere
  'almost' log linear
  approximation)
- Thus, increase in i
  factor of decrease
- UA= - (loadB)(Int
- B=interferer, A=