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
1. Interference

- Due to simultaneous reception of two transmissions at a receiver
- whether or not decoded
2. Irregular coverage

3. Dynamic coverage

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
  - ...

5. Legacy clients

• Can’t assume that you can change all client software
• even in corporate environments!
How can we help?
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
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
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

- Client
- Thin AP
- Central Controller

Diagram showing network architecture with clients, thin access points, and a central controller.
Representing the system
System model

- Conflict graph
- + clients
- + utility annotations
Conflict Graph

Max. Power Single Channel (MPSC) graph
Annotated Conflict Graph

U = (1/\sum (1/r_i))

U = -(\text{load}_{ap1})(\text{Int}_{ap1ap3})

U = -(\text{load}_{ap2})(\text{Int}_{ap2ap1})

U = -(\text{load}_{ap2})(\text{Int}_{ap2ap4})

U = -(\text{load}_{ap4})(\text{Int}_{ap4ap2})

U = -(\text{load}_{ap3})(\text{Int}_{ap3ap5})

U = -(\text{load}_{ap3})(\text{Int}_{ap3ap4})

U = -(\text{load}_{ap4})(\text{Int}_{ap4ap3})
Davis Centre Access Point Layout
Davis Centre Conflict Graph

Conflict Graph at 20dbm

Conflict Graph at 30dbm
Measuring the ACG
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

broadcast

$\text{AP}_1$

$\text{AP}_2$

$\text{AP}_2$ Transmit Range

$\text{AP}_2$ Interference Range
Client-AP Interference

C₁ Interference Range
AP-Client Interference
Disutility of interference

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

- Utility-based triggers for re-computation
- Utility change greater than threshold ($\alpha$)
  - Re-compute channels/power levels from scratch
- Utility change less than threshold ($\alpha$)
  - Refine power levels
Evaluation
Star Topology
Davis Centre (throughput)

12 Channels

3 Channels
Davis Centre (delay)

12 Channels

3 Channels
Effect of Mobility

- AP$_1$
- AP$_2$
- AP$_3$
- AP$_4$
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
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)
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 combinatorial optimization

Preliminary results are encouraging

larger and realistic testbed being built
Thank you!
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)

CI Interference Range
Two-Hop Interference
Effect of interference on throughput is ‘almost’ log linear (first order approximation).

Thus, increase in interferer load causes same factor of decrease in interferer’s utility.

\[ UA = - (load_B)(Int_{BA}) \]

- \( B \) = interferer, \( A \) = interfered

A Simple Analysis

![Graph showing UDP application throughput vs. mean packet inter-departure time in milliseconds]