COAP: A Software-Defined Approach for Home WLAN Management through an Open API

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Dense residential WLANs today...
Real Scenario in an Apartment Building

Long periods with channel congestion
Other Problems in Dense Home WLANs...

- Non-WiFi interference (MobiCom’13)
- Upto 80% WiFi link degradation due to non-WiFi interference
- Static and inefficient AP configuration (MobiCom’13)
- Spectrum Wastage: More than 50% of home APs used static channels
Goal: Managing Home Access Points (APs)

- Mitigate WiFi and non-WiFi interference
- Enable AP cooperation to improve performance
- Software-only solution for commodity WiFi APs
- Vendor neutral APIs for wider adoption
Enter COAP...

- COAP: Coordination framework for Open APs
  - A cloud based management service using OpenFlow SDN

- Apartment Building
- COAP Enabled APs
- Internet
- COAP Cloud Controller (Hosted by ISP or Building manager)
Outline

• Introduction

• COAP Framework Overview

• COAP Applications
  – Efficient spectrum utilization
  – Interference mitigation using airtime management

• Summary
COAP Framework

- COAP enabled home Access Points
- COAP Cloud Controller (Hosted by ISP or Building manager)

Uses open-source OpenFlow SDN + Floodlight controller

Implemented OpenFlow wireless extensions to collect statistics from APs

Cloud-based COAP controller collects and coalesces statistics to configure APs
COAP API Examples

- **APConfigManager**
  - SetParameters(channel, power)
  - SetAirtimeAccess(slotDur, xmitBitmap)

- **BasicStatsReporter**
  - GetAirtimeUtilization()
  - GetLinkStatistics()
  - GetNeighborInfo()

- **DiagnosticStatsReporter**
  - GetNonWiFiDevices() (AirShark, IMC’11)
  - GetPacketSummaries() (WiSe, MobiCom’13)
COAP Framework Components

Access Point (APs 1…n)

- AP specific interfaces (e.g., luci)
- airshark
- click

- APConfigManager
- DiagnosticStatsReporter
- BasicStatsReporter

- OpenFlow modules

- Floodlight modules

- ConfigManager
- COAPManager
- StatsManager

- Learning algorithms

- History Logs
  - Link Statistics
  - Traffic Statistics
  - Non-WiFi activity

COAP enabled home APs

COAP Cloud Controller
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Example 1: WiFi Channel Configuration

- **AP 1 (Channel 1)**
- **Client 1**
- **Microwave Oven (Channel 11)**
- **AP 2 (Channel 6)**
- **Cordless Phone (Channel 1)**
- **Client 2**

Channel 6 or 11?
Example 1: WiFi Channel Configuration

Apartment Building

APs

Channel?

Channel?

Channel?

Airtime Util Statistics

Channel Configuration

COAP Cloud Controller
Using airtime-aware channel configuration

12 COAP APs in an apartment building

Random vs “airtime-aware” channel config over 6 days (one day per scheme)
Using airtime-aware channel configuration

12 COAP APs: Random vs “airtime-aware” channel config over 6 days (one day per scheme)

Upto 42% reduction in airtime utilization
Example 2: Interference mitigation

(a) Congestion due to background traffic

(b) Packet losses due to interference

Interference Problems

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Airtime-access API - Throttle

Manage congestion experienced by critical flows (e.g., videos)

(a) Throttle API

AP 1 (Bulk transfer)

AP 2 (Video)

10 ms

t₁  t₂  t₃  t₄

Throttle(AP1): AP1: SetAirtimeAccess(10ms) “1010”
“Throttle” mechanism example

Throughput (Mbps) vs. Time (in sec)

- Throttle Link 2
- Link 2 improves

Throttle background flows/bulk downloads to free airtime for important traffic flows (e.g., video)
Airtime-access API - Slotting

Avoid hidden terminal style interference by avoiding overlapping packet transmissions

Slot(AP1, AP2):
AP1: SetAirtimeAccess(10ms, “1010”)
AP2: SetAirtimeAccess(10ms, “0101”)
Mitigate interference using “Slotting”

Slotting hidden terminals can provide protection to affected traffic flows.
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• Presented an SDN framework for managing home Access Points

• Enabling better spectrum utilization (upto 42%) though centralized management

• Motivated “Airtime access API” to mitigate interference and protect critical flows
Thanks!

http://research.cs.wisc.edu/wings/projects/coap/