Software-Defined Crowdshared Networks

2nd GAIA Meeting

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Introduction

- Affordability is the main barrier to Internet access in residential areas
  - Internet access costs 10x – 40x the average income in some developing countries
  - Internet is not entirely affordable in the developed world
    - 22.7 % of Nottingham population without Internet access, can’t afford it (Nottingham Citizens Survey, 2011)

- Home network sharing
  - Bandwidth availability during off-peak periods
  - Density of wireless access points
    - Opportunities for WiFi resource pooling
Crowd-shared Networks

Home network user

I can share 2 Mbps from 22:00 to 6:00

Guest user

Home Network

Access link

ISP

Internet

LCD-Net: Lowest Cost Denominator Networking, ACM CCR 2013
Virtual Public Networks, IEEE EWSDN 2013
Requirements

• Bandwidth isolation
  – Guest users should not be allowed to hog the bandwidth

• Confidentiality
  – Traffic eavesdropping by collocated devices should be prevented

• Authentication
  – Guest users should be able to authenticate themselves with the network

• Accountability
  – Sharers should not be accountable for the actions of guest users

• Minimal configuration overhead for users and ISPs
  – Network configuration and management should be outsourced to third parties
Virtual Network Operators

- Extending the stakeholder value chain with Virtual Network Operators
  - Incentives for home users and ISPs
  - Opportunities for cheaper Internet Access

- Enablers:
  - SDN (Openflow, ...)
  - Access Point APIs
User sharing patterns

- Internet access may not be shared for certain periods
  - Users need all their bandwidth
  - No free port in the home router

- PAWS deployment:
  - Limited number of active home routers

- Need for extended coverage
Crowd-shared Wireless Mesh Network

- Extend coverage with wireless mesh network (WMN)
  - Multiple points of access
  - Opportunities for resource pooling
Crowd-shared Wireless Mesh Network

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User stops sharing
Crowd-shared Wireless Mesh Network

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WMN Management Challenges

• Guest users with diverse traffic rate/patterns
  – Guest user-to-AP assignment
  – WiFi resource pooling
WMN Management Challenges

- Guest users with diverse traffic rate/patterns
  - Guest user-to-AP assignment
  - WiFi resource pooling

- Diverse sharing patterns
  - Guest user traffic redirection
Software-Defined Crowed-Shared WMN

- WMN management and control
  - SDN control plane implementation
  - Deployment in CONFINE community networks
  - Evaluation against PAWS

COSMOS (CONFINE OC2) Project
CONFINE Community-Lab

Diagram showing the interaction between users, administrators, technicians, researchers, and various devices and networks within the CONFINE Community-Lab environment.
SDN Control Plane Implementation

- Control plane modules implemented in POX
- Tunnel management and monitoring via XML-RPC
Crowd-shared WMN vs. PAWS

• Experimental setup in Athens Wireless Metropolitan Network (AWMN):
  – 5 home routers and a controller
  – Using TAP devices, emulated DSL links with 4 Mbps (traffic shaping with Click)
  – Router availability modeled as on-off Markov chain, based on PAWS datasets

• Evaluation metrics:
  – Shared bandwidth utilization
  – Guest user serving rate
Application-Centric Wireless Access
Motivation

• Public WiFi networks are highly underutilized\(^1\):
  
  1.2 billion of connections per year  
  100M customers  

  1.0 connection per customer per month  
  10% active customers

• User-centric public WiFi infrastructure impacts user experience\(^2\):
  
  – 12 clicks are required by users to access Internet with a splash page on iPhone
  – 25% of users abandon the web page after 4 seconds
  – 50% of users abandon the web page after 10 seconds

\(^1\)Profile of AT&T WiFi in 2012 per its public announcement  
\(^2\)Ericsson
FreeSurf: Application-centric Wireless Access

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Solutions</th>
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<tbody>
<tr>
<td>Discovery</td>
<td>Networks are dynamic in terms of configuration and scale</td>
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<td>Application servers are fed with updated information from the FreeSurf Controller</td>
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<tr>
<td>Authentication</td>
<td>User authentication requests must reach the application server to authenticate</td>
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<td>FreeSurf Controller installs the flow table on the AP so that the authentication requested are routed securely</td>
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<td>Access control</td>
<td>Only access to the applications should be allowed</td>
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<td>FreeSurf APs forward the data based on policy</td>
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<td>BloomFilter used to improve efficiency</td>
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FreeSurf Architecture

FreeSurf App Srv

FreeSurf Module
Auth Flow Data Flow
Lower Layer
Access Point

FreeSurf Controller

End-User

FreeSurf Module
Auth Flow Data Flow
Lower Layer
Access Point
Wireless Access with FreeSurf

User Device → FreeSurf AP

- Offset=6 octets
- Match Criteria = *.amazon
- Policy = encapsulate & forward to amazon

Auth Request

Forward Authentication Flow to the FreeSurf APP (1)

DataFlow Policy

Forward Data Flow to the FreeSurf APP (2)

Steering the traffic for authenticated users

Application Registration

Notification upon change (3)

Application’s Auth Server → Application’s Web Server

Traffic from Authenticated users

Traffic to other sites

(1) Content-aware secure forwarding
(2) Policy based traffic filtering
(3) Observatory based discovery
* The authentication username starts from the 6\textsuperscript{th} octet in the EAP message
Conclusions

• SDN as enabler for home broadband connection sharing:
  – More efficient shared bandwidth utilization
  – Ability to accommodate greater volumes of guest user traffic
  – Creates opportunities for new stakeholders (mostly driven by social goals)

• Application-centric wireless access with FreeSurf:
  – Driver for free Internet access
  – Opportunities for mobile application vendors to opt-in
Thank you!

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