CLOUDMAC - TOWARDS SOFTWARE DEFINED WLANs

Roman Szczepanski, Nico Bayer, Hans J. Einsiedler, Peter Dely, Jonathan Vestin, Andreas J. Kassler; ITG 5.2.4 Workshop, Munich, November 2013
LARGE DEPLOYMENTS (E.G. ENTERPRISE WLANS)

Centralized Management

WLAN Management System

Services

Mobility Mgmt.
Load balancing
Channel Assignment

WLAN Controller

AP

MN

Services

Channel Assignment

Load balancing

Mobility Mgmt.
MOTIVATION

- AP hardware and software are getting fatter and fatter

- No standard, vendor-independent way to deploy network applications

- Fast IEEE 802.11 PHY layers make centralized control planes difficult to implement

How can we offload some processing to data centers?

How can we deploy network applications in a vendor independent way?

How can we exploit the fast packet processing in hardware switches to control WLAN transmissions?
SDN AND OPENFLOW

Application Layer

Business Applications

Control Layer

SDN Control Software

Networking Service

Infrastructure Layer

Control Data Plane Interface (e.g. OpenFlow)

Network Device

Network Device

Network Device

Network Device

e.g. Switch or AP

API

API

API

Network Device

Network Device

Network Device
CLOUDMAC ARCHITECTURE

IEEE 802.11 STA

WTP

OpenFlow Switch

OpenFlow Controller

Virtual WLAN NIC

Virtual AP

Virtual WLAN NIC

Virtual AP

Virtual WLAN NIC

Virtual AP

VM Host

Internet

App

App

App

Policy
CLOUDMAC ARCHITECTURE
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Virtual WLAN NIC

Virtual AP

Internet

VM Host
Send and receive raw MAC frames to/from VAP
Cards in monitor mode
Generate only ACKs
CLOUDMAC ARCHITECTURE

- OS instances running on a virtualization host
- Multiple virtual WLAN cards
- Can use standard WLAN mgmt tools
Forwarding table configured by rules
- Associates binding between VAP and WTP
- Allows binding each physical card to multiple VAPs → virtualization
CLOUDMAC: TX-PATH

IEEE 802.11 STA

WTP

OpenFlow Switch

Virtual WLAN NIC

Virtual AP

OpenFlow Controller

Internet

IP Data

App
App
App
Policy
CLOUDMAC: TX-PATH

- Add IEEE 802.11 MAC header
- Add control header
- (Encrypt frame)
CLOUDBAC: TX-PATH

- Add IEEE 802.11 MAC header
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CLOUDMAC: TX-PATH

- Add IEEE 802.11 MAC header
- Add control header
- (Encrypt frame)

- Lookup flow table
- Modify control header
- Output frame

IEEE 802.11 STA

OpenFlow Switch

Virtual WLAN NIC

Virtual AP

Internet

OpenFlow Controller
CLOUDMAC: TX-PATH

- Read and remove control header
- IEEE 802.11 real-time MAC
- PHY processing
- Transmit frame

IEEE 802.11 STA

Internet

IEEE OpenFlow Controller
Policy App App App

Virtual WLAN NIC
Virtual AP

Data IP
802.11 WTP

OpenFlow Switch
CLOUDMAC: TX-PATH

- Read and remove control header
- IEEE 802.11 real-time MAC
- PHY processing
- Transmit frame

Internet

OpenFlow Controller

IEEE 802.11 STA

802.11 IP Data

WTP

OpenFlow Switch

Virtual WLAN NIC Virtual AP

Internet

App App App Policy

App

App

App

Policy
BENEFITS AND POTENTIAL

- Thin APs
  - Association state kept in the cloud
- Simplified Administration
  - E.g. can add new encryption by changing cloud implementation
- Integration with OpenFlow
  - Reuse infrastructure and Apps implemented for OpenFlow
- Simple Deployment of new Apps
  - On-Demand AP
    - Dynamically Enabling beacons for a given SSID, configured via OpenFlow
  - Downlink scheduling
    - OpenFlow switch or Cloud can implement e.g. packet scheduling or TDMA
  - Dynamic Spectrum use
    - WTP can run several WLAN cards on different channels. OpenFlow can create 802.11h action frames to instruct MN to switch channel. No re-association required!
CLOUDMAC: PERFORMANCE

- CloudMAC implementation
  - KAUMesh testbed ([www.kau.se/en/kaumesh](http://www.kau.se/en/kaumesh))
  - WTP: Cambria GW2358-4 with stripped down version of OpenWRT Backfire.
  - VAP: Debian 6.0 VMs on a VSphere Center installation run hostapd 0.6
  - OpenVSwitch 1.3.0 runs in a VM on the same VSphere installation
  - virtual WLAN card driver based on the mac80211_hwsim driver, which was modified to allow MAC frame injection
CLOUDMAC: PERFORMANCE

MEASUREMENT RESULTS

CLOUDMACs additional delay due to the additional processing in software is limited!
Performance loss due to the header overhead and rule processing is tolerable! Can be reduced by kernel implementation.
CLOUDMAC DEMO: SEAMLESS AP SWITCHING

SZENARIO

- Move traffic from WTP1 to WTP2
- Mobility management or energy saving
- Standard IEEE 802.11: scan and re-association
- CloudMAC: Association state in VAP → no re-association

MEASUREMENT RESULTS
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MEASUREMENT RESULTS

<table>
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<tr>
<th>Number of lost packets</th>
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<tbody>
<tr>
<td>Lost packets</td>
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ECDF

11/21/2013 27
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MEASUREMENT RESULTS

Median reduction in packet loss from approx. 10000 to 4
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MEASUREMENT RESULTS

Median reduction in packet loss from approx. 10000 to 4
CLOUDMAC@CODEBASIN

cloudmac @ master

Name                      Size
---------                  -------
cloudmac                  811 Bytes
compat-drivers-3.8-1-u
compat-wireless-2010-10-19
hostapd
pox-master
switch-config
vap-config
wtp-config
README.txt

Latest revisions

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<th>Date</th>
<th>Author</th>
<th>Comment</th>
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<td>05/10/2013</td>
<td>peter</td>
<td>changed defconf</td>
</tr>
<tr>
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<td>05/10/2013</td>
<td>root</td>
<td>Merge branch 'master' of <a href="mailto:gitolite@codebasin.net">gitolite@codebasin.net</a>:cloudmac</td>
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<td>changed to hw switch</td>
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<td>pox ng</td>
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</table>

See all revisions | View revisions
CLOUDMAC@CODEBASIN

- cloudmacd
  - CloudMAC control daemon (on WTP)
- compat-drivers-3.8-1-u
  - Modified WLAN stack for WTPs
- compat-wireless-2010-10-19
  - Modified WLAN stack for VAPs
- hostapd
  - hostapd WLAN authenticator
- pox-master
  - POX OpenFlow controller with CloudMAC application
- switch-config
  - Configuration script for OpenVSwitch
- vap-config
  - Configuration script for VAPs
- wtp-config
  - Configuration script for WTPs
SUMMARY & CONCLUSIONS

- Current APs are complex to manage
- Presented CloudMAC
  - SplitMAC with distributed MAC layer processing in the Cloud
  - Simplifies management as association states are kept in the cloud
  - OpenFlow manages binding between virtual APs and physical one
  - Similar performance to standard system
- New applications can be implemented rapidly
  - Seamless AP switching
  - OnDemand APs
  - Downlink scheduling
  - Centralized Power and Rate Control
- Installed and tested in Indoor testbed WFS, code and docu avail
NEXT STEPS

- Master thesis
  - Central frequency management (based on own access point, but also external APs)
  - Evaluate the performance gaps
  - Improve performance
Tangible Results

- Publications - accepted
  - Software Defined Networking for the Management and Operation of WLANs, Peter Dely, Andreas Kassler, Nico Bayer, Hans Einsiedler, Christoph Peylo. Standardisation Insider 2013

- Patent Application - submitted
  - Method and system for the distribution of the control and data plane in wireless local area networks

- Prices
  - Won the 1st price in the 2012 ACM Mobicom Student Research Competition, among 10 competitors (http://src.acm.org/previouswinners.html)
  - Won the 3rd price for Networked Systems 2013 Communication Software Award, among ca. 30 competitors (http://www.netsys2013.de/csa.html)
THANK YOU!

For more info, see http://www.kau.se/en/cloudmac