



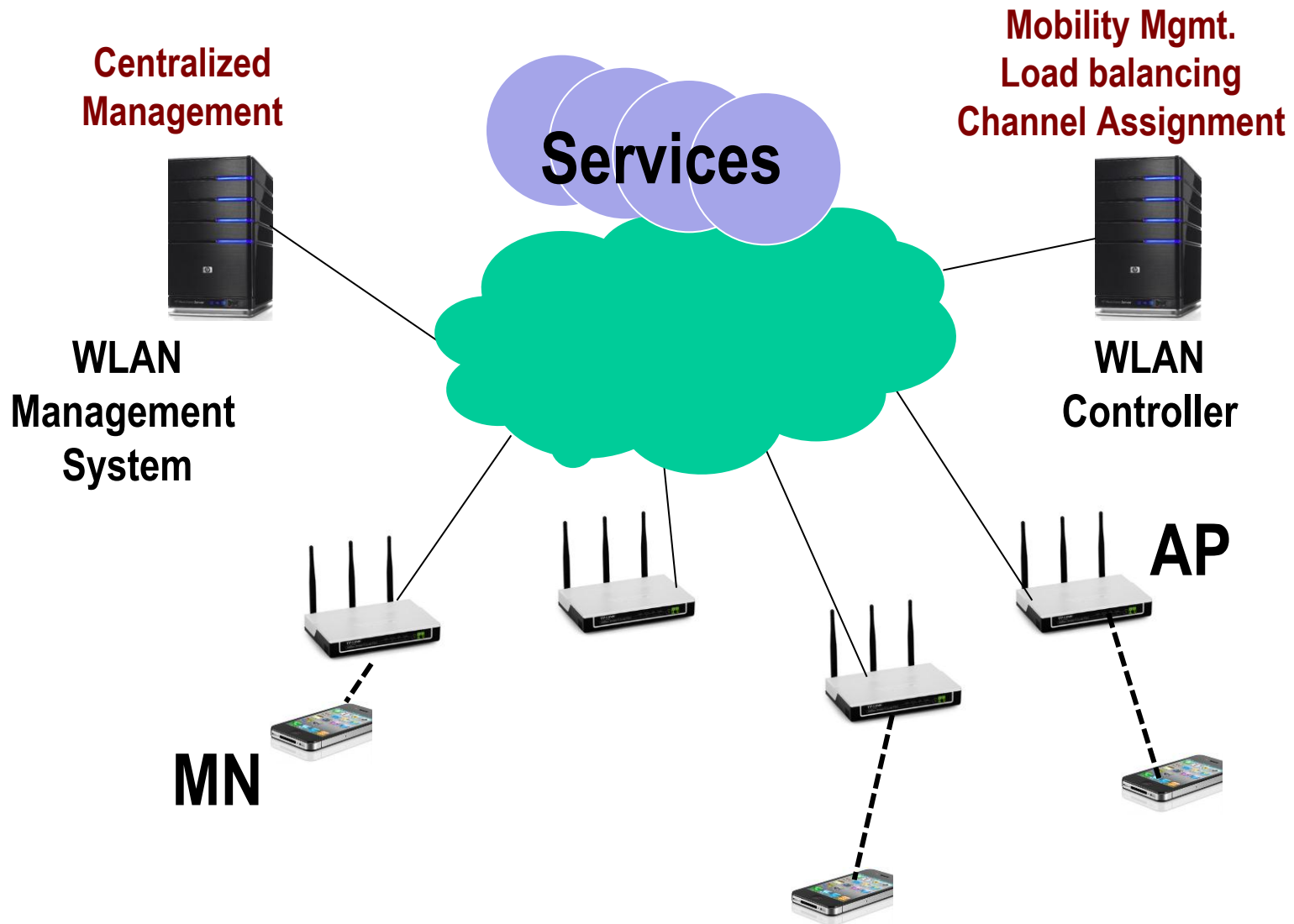
# CLOUDMAC - TOWARDS SOFTWARE DEFINED WLANS

Roman Szczepanski, Nico Bayer, Hans J. Einsiedler, Peter Dely, Jonathan Vestin, Andreas J. Kassler; ITG 5.2.4 Workshop, Munich, November 2013



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# LARGE DEPLOYMENTS (E.G. ENTERPRISE WLANS)



# MOTIVATION

- AP hardware and software are getting fatter and fatter

How can we offload some processing to data centers?

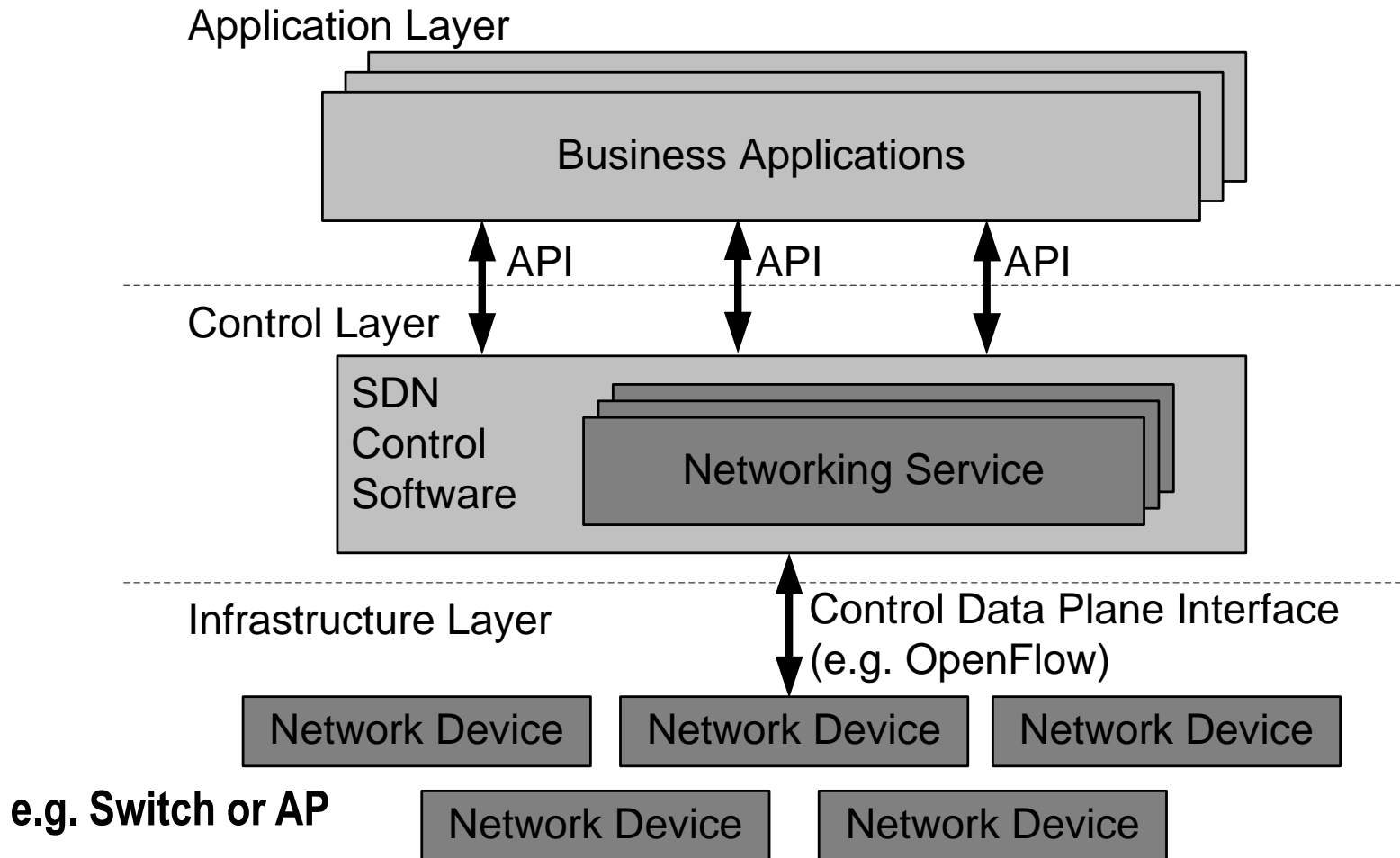
- No standard, vendor-independent way to deploy network applications

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

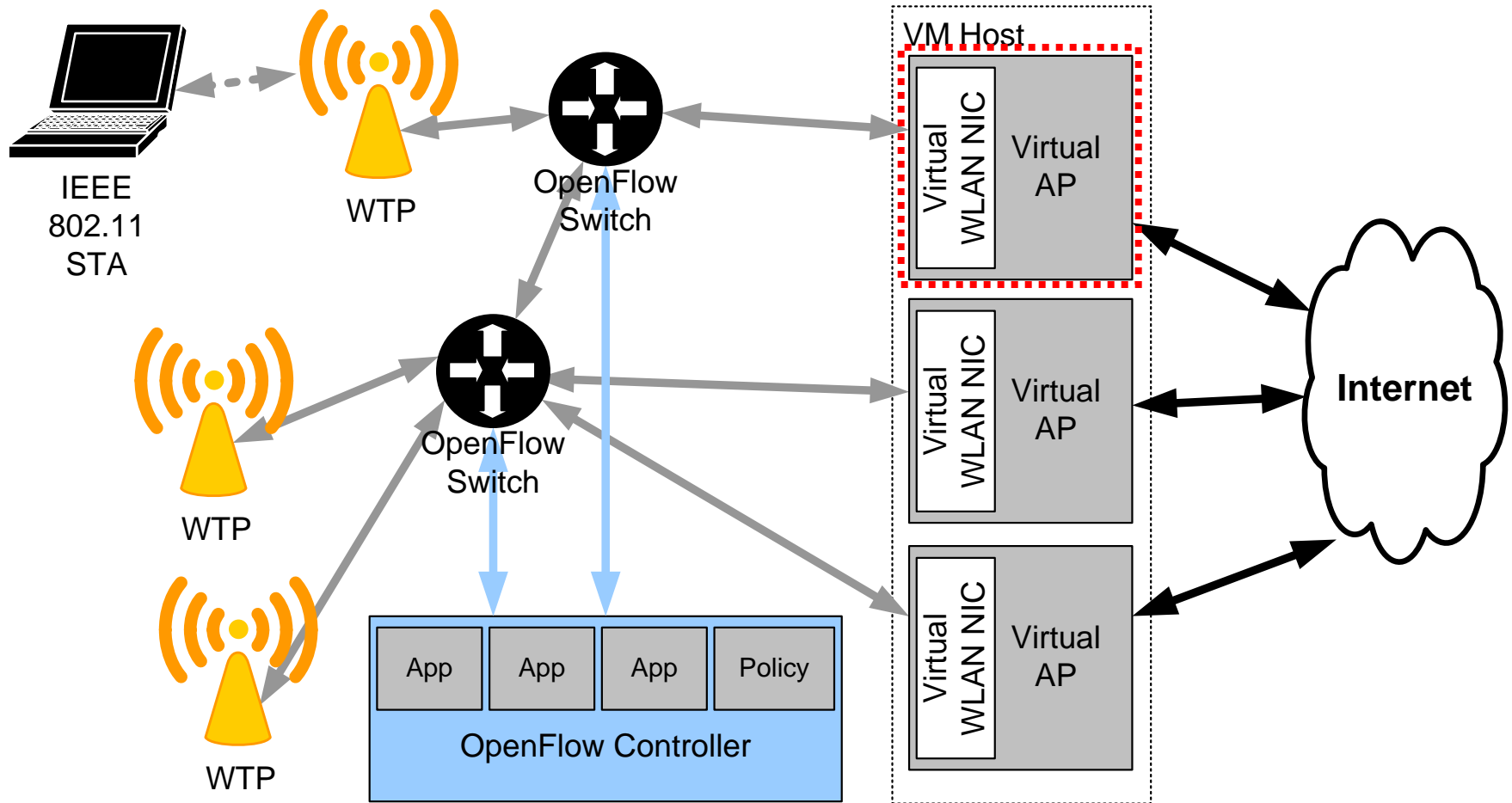
- Fast IEEE 802.11 PHY layers make centralized control planes difficult to implement

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

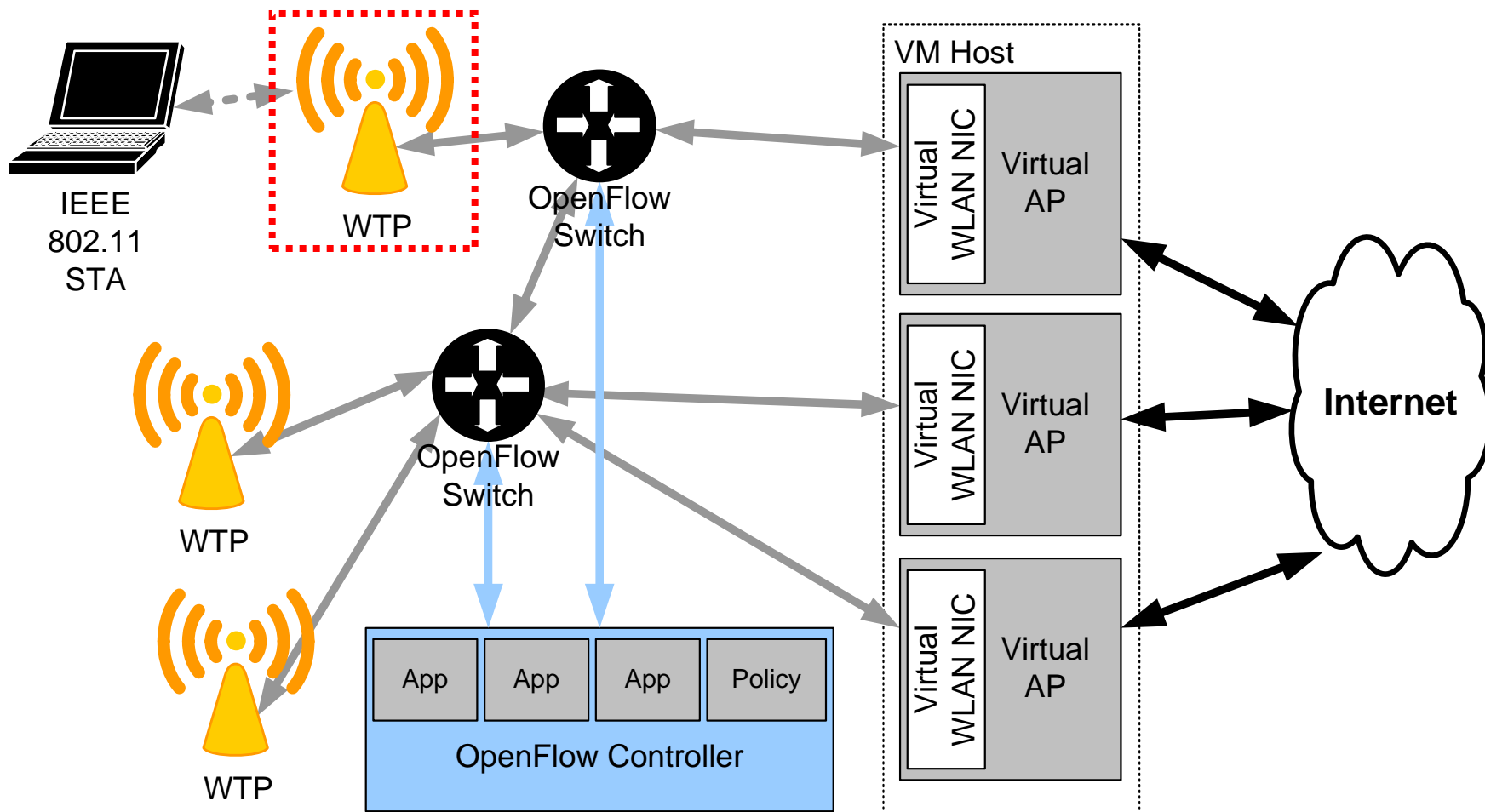
# SDN AND OPENFLOW



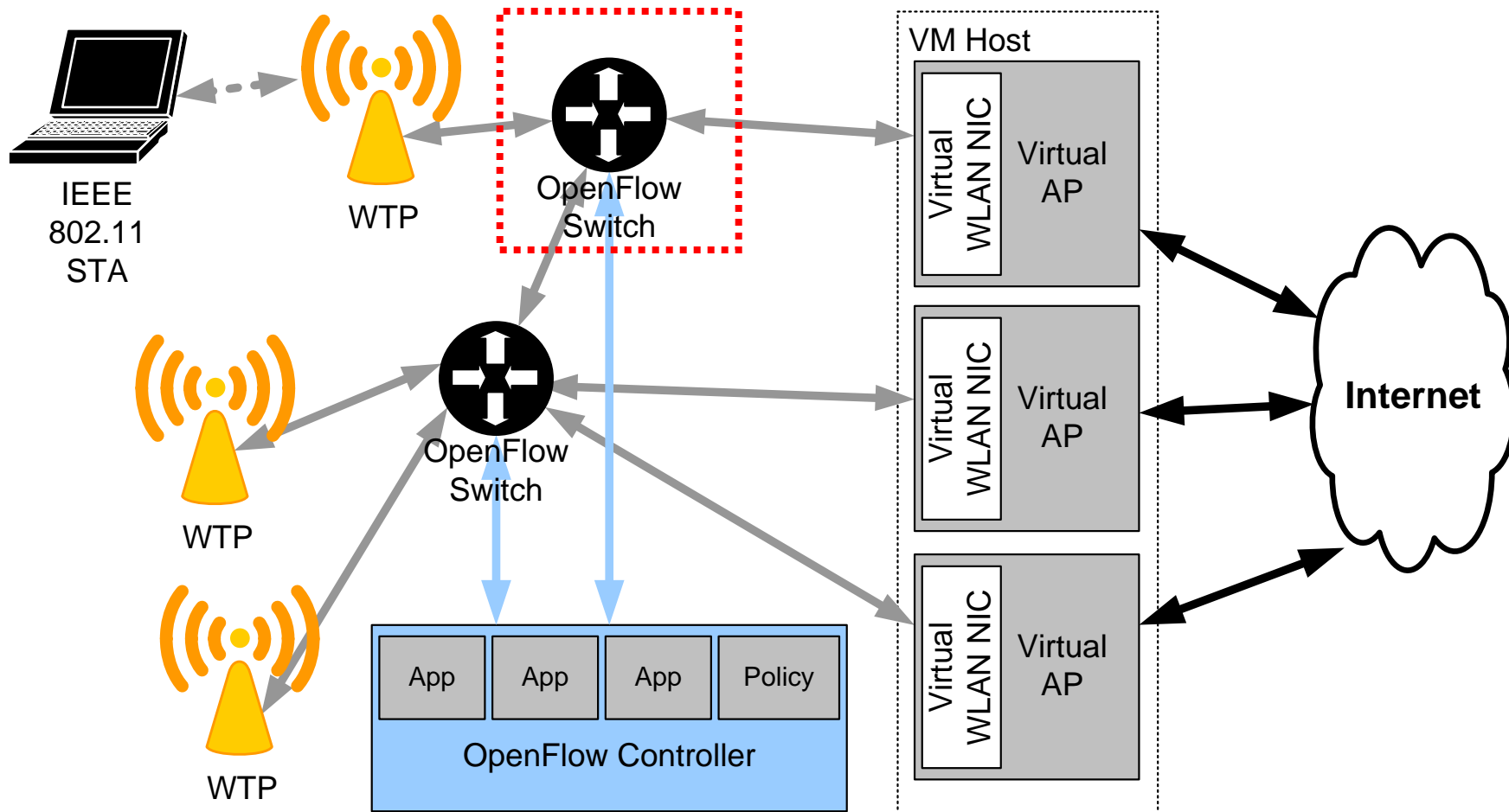
# CLOUDMAC ARCHITECTURE



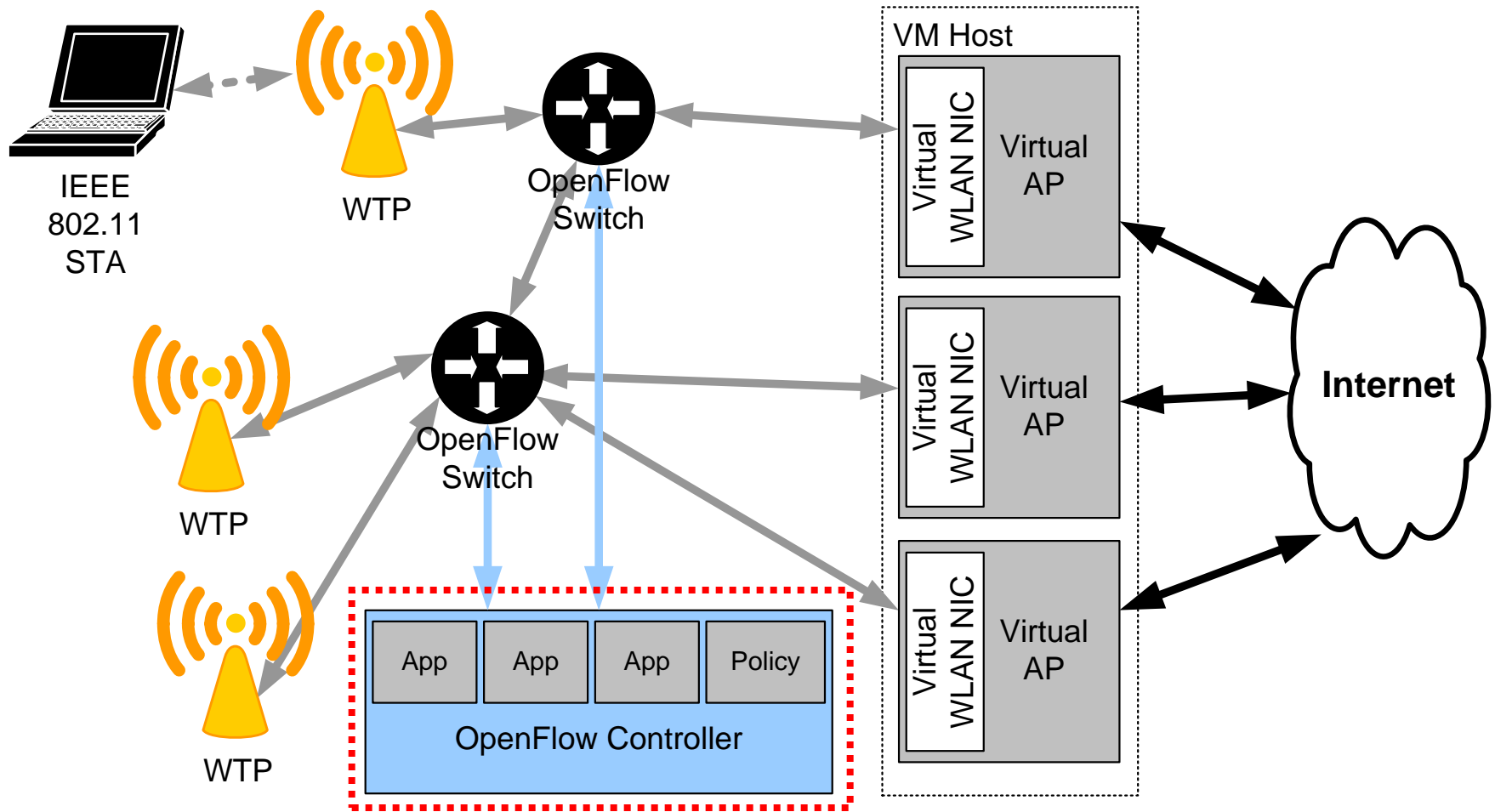
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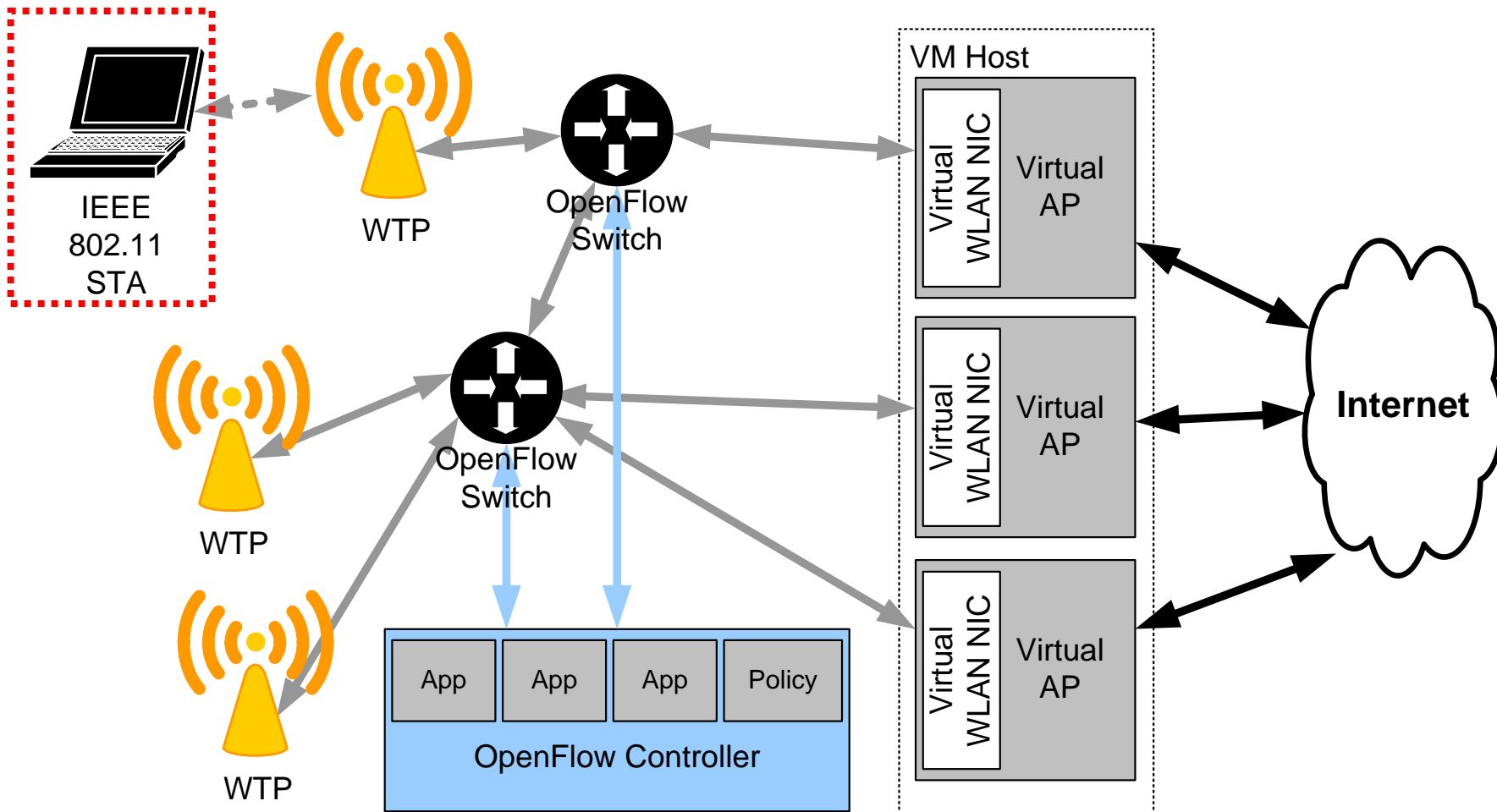


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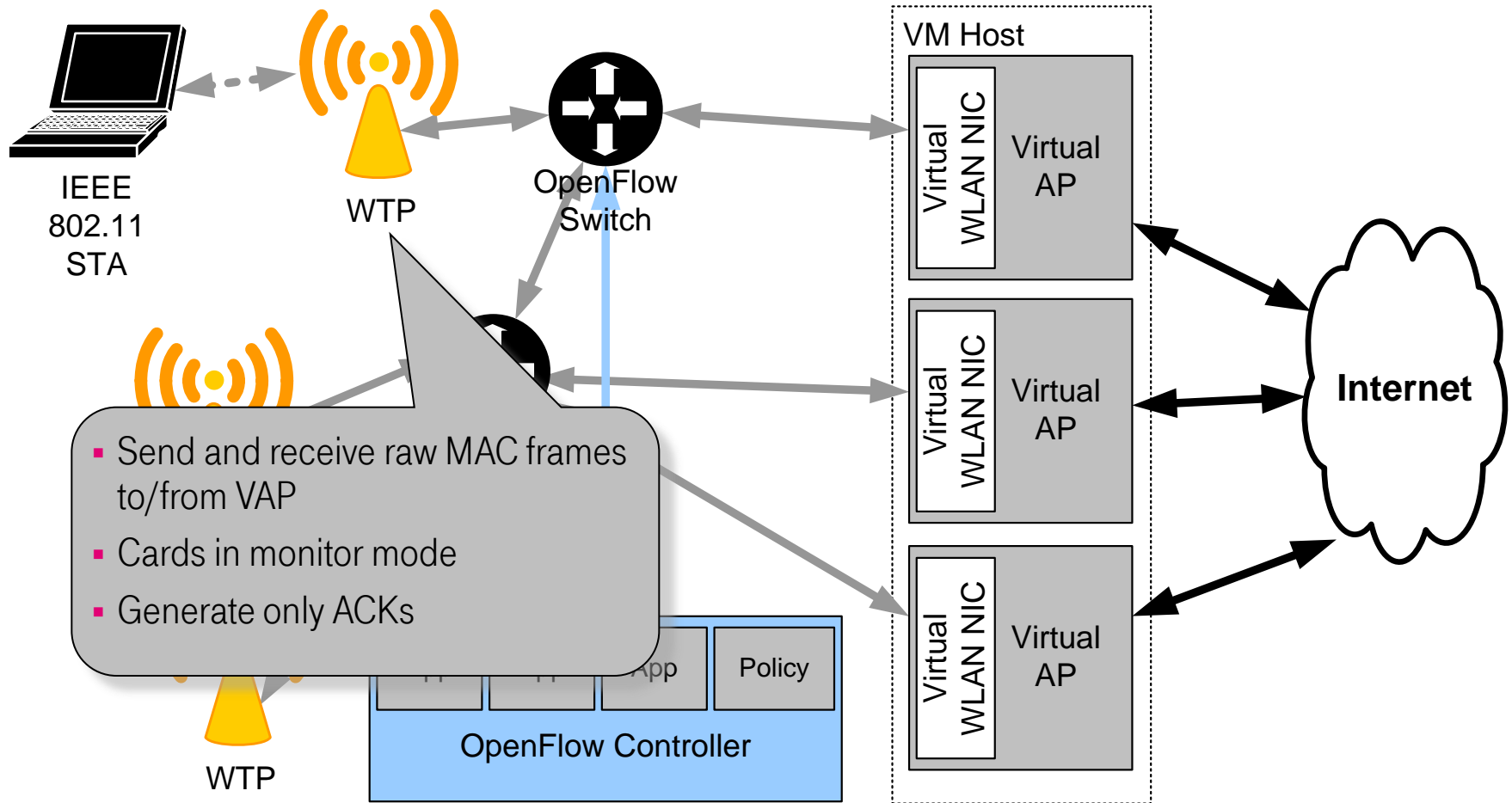




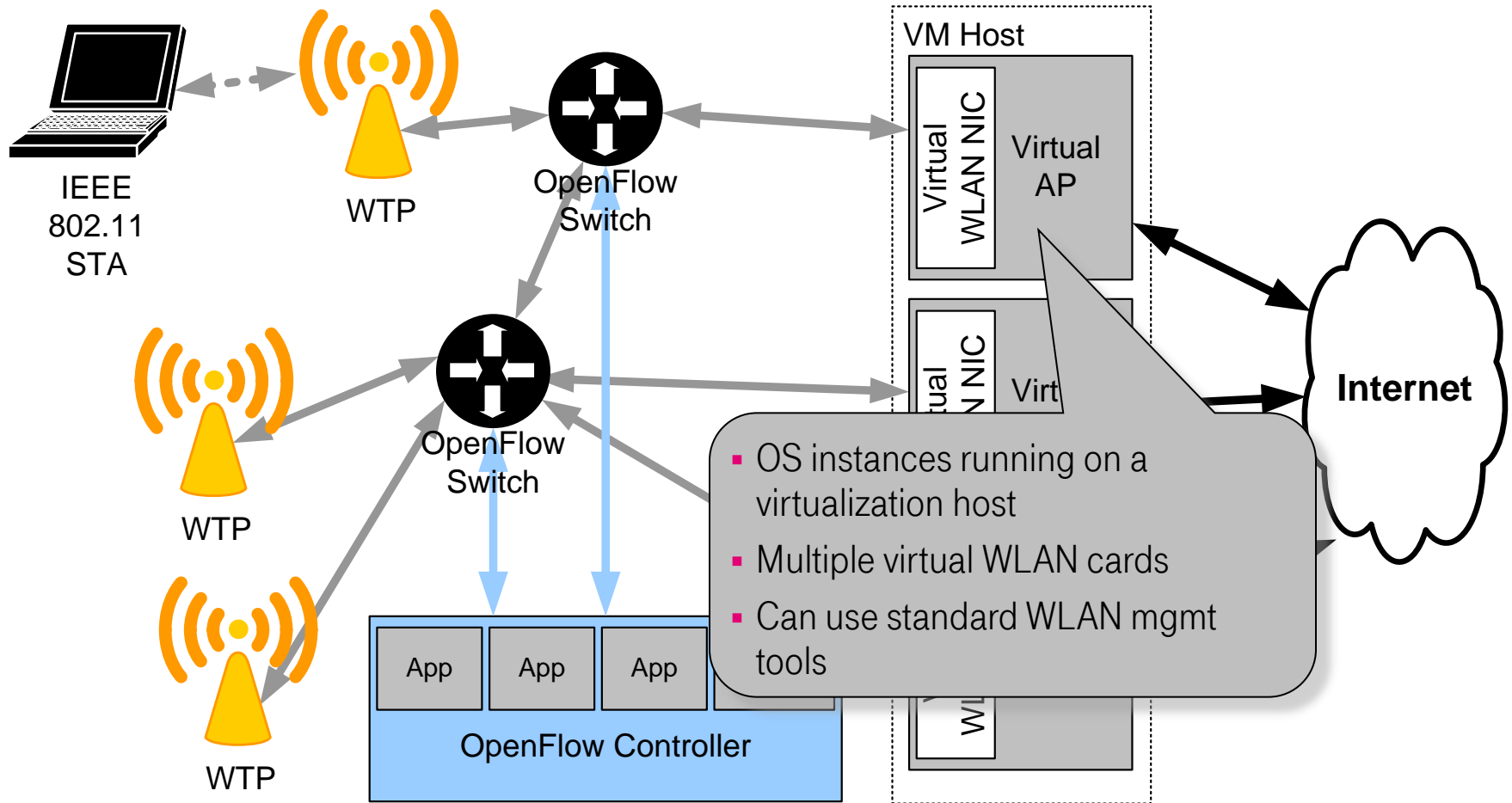
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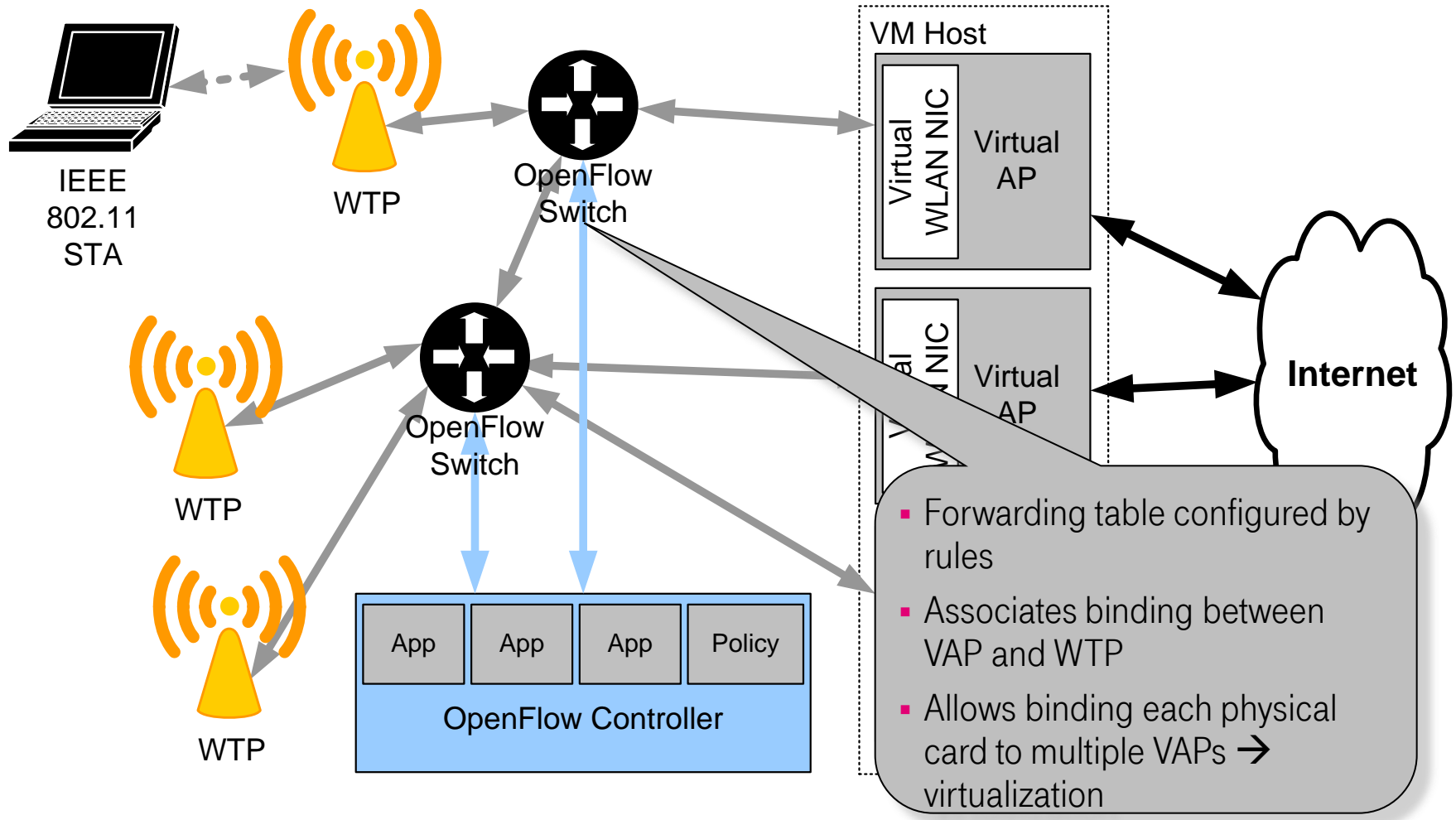
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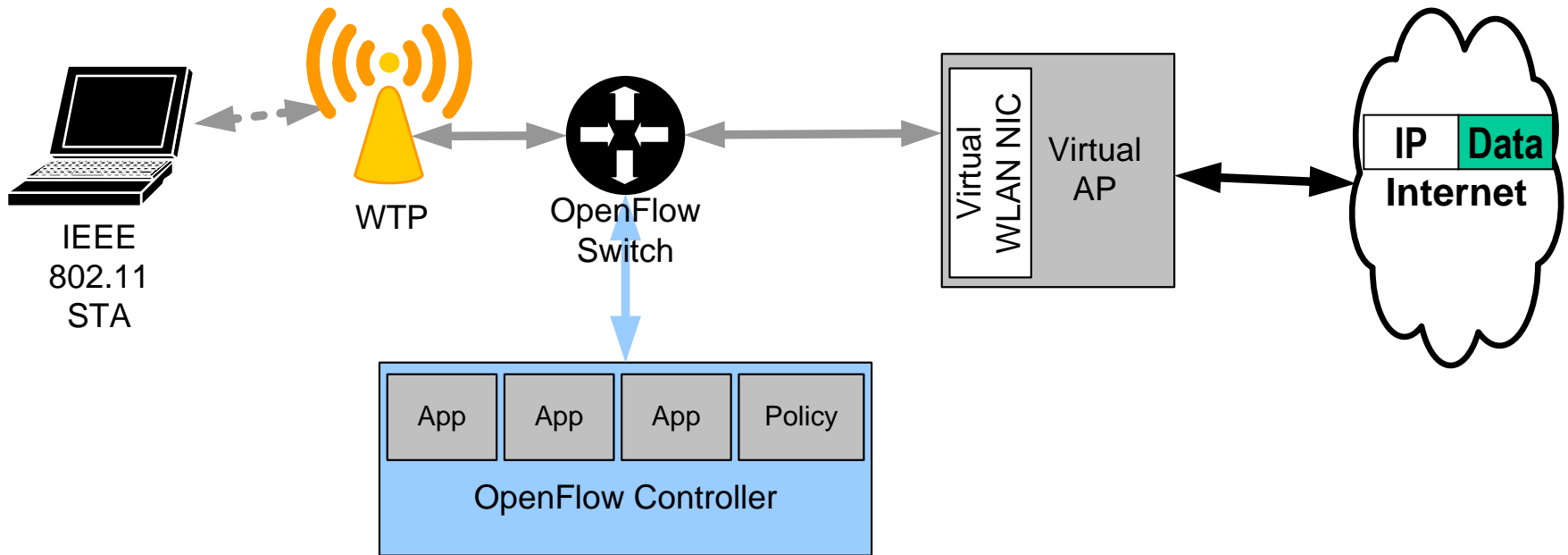
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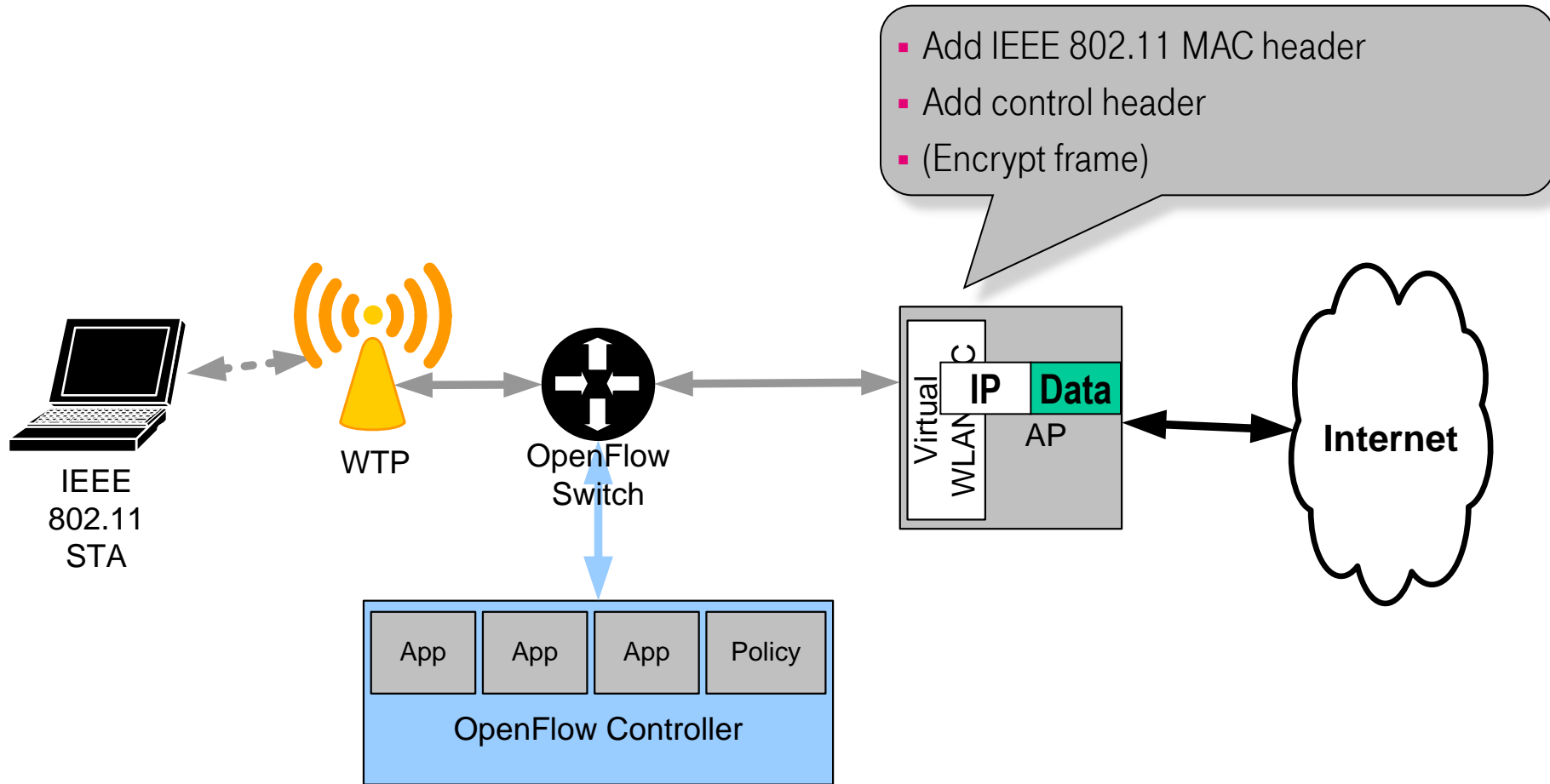
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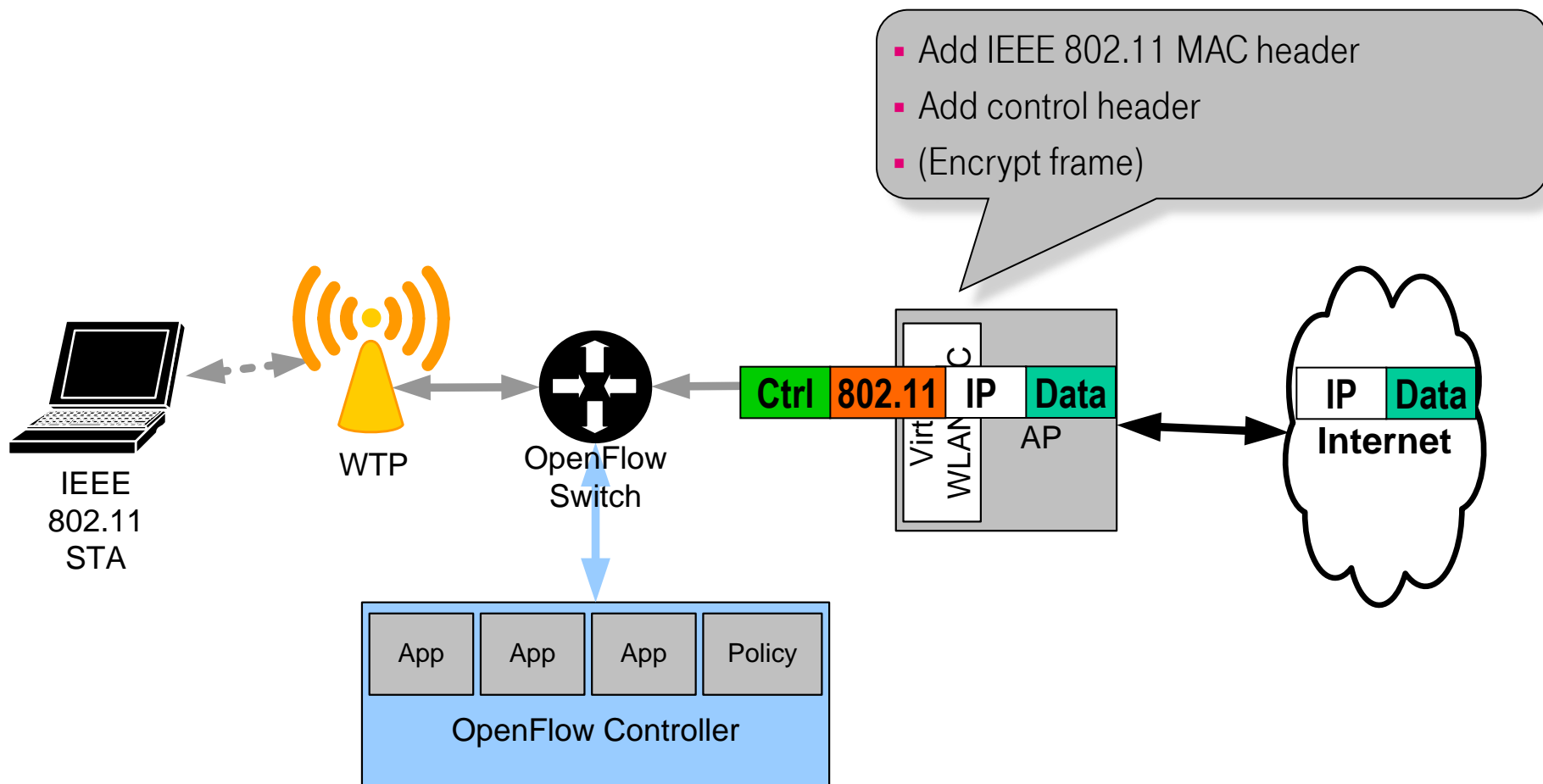
# CLOUDMAC: TX-PATH



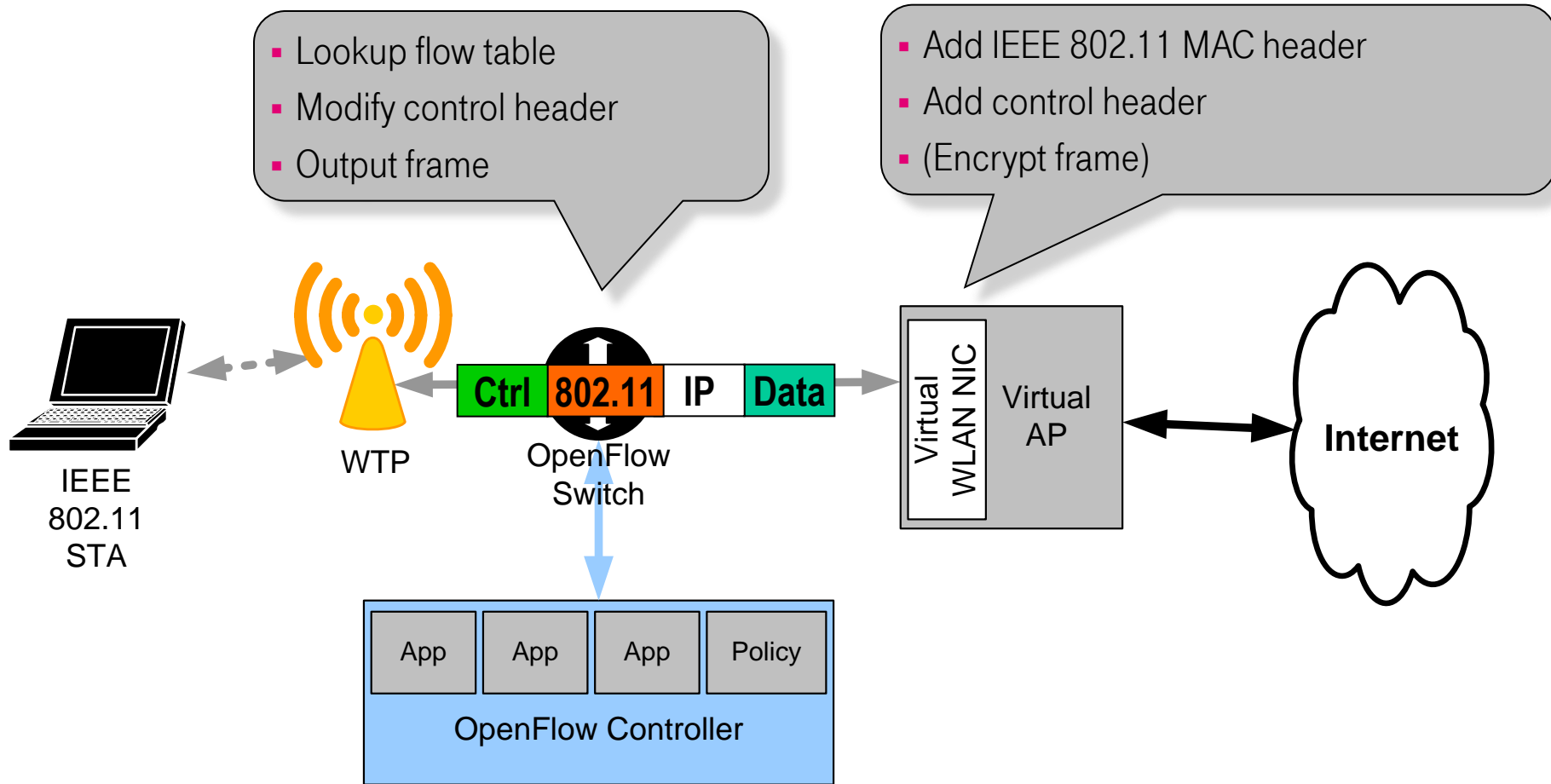
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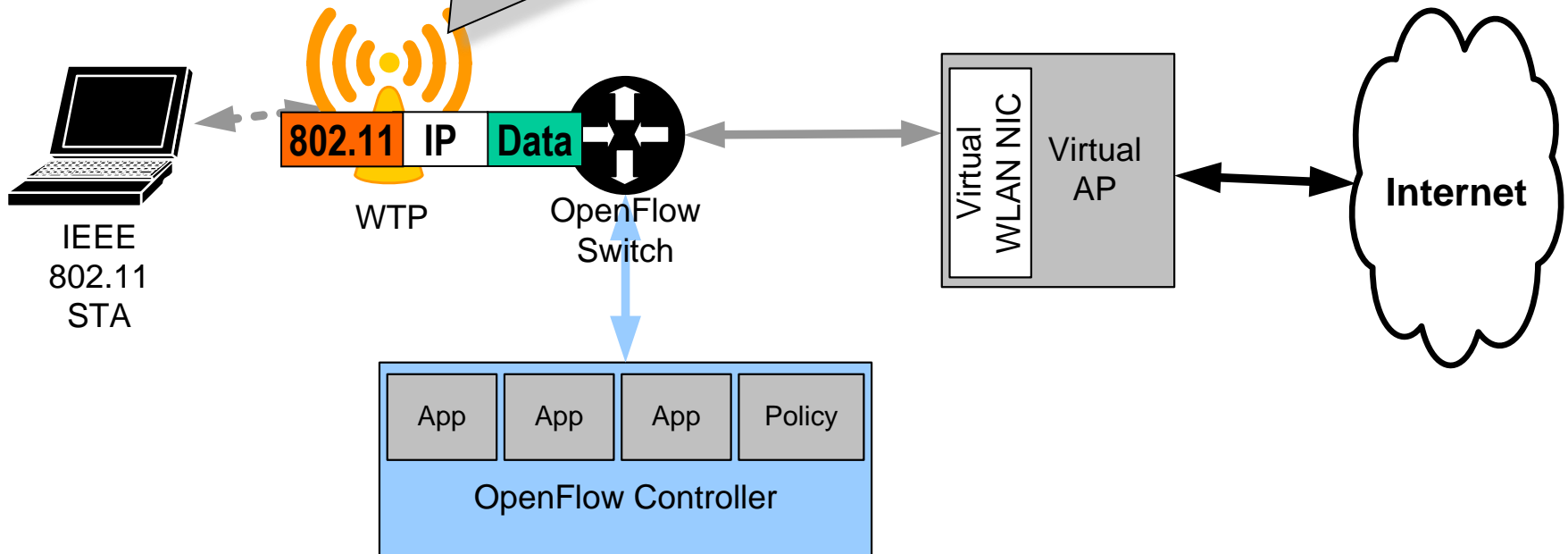
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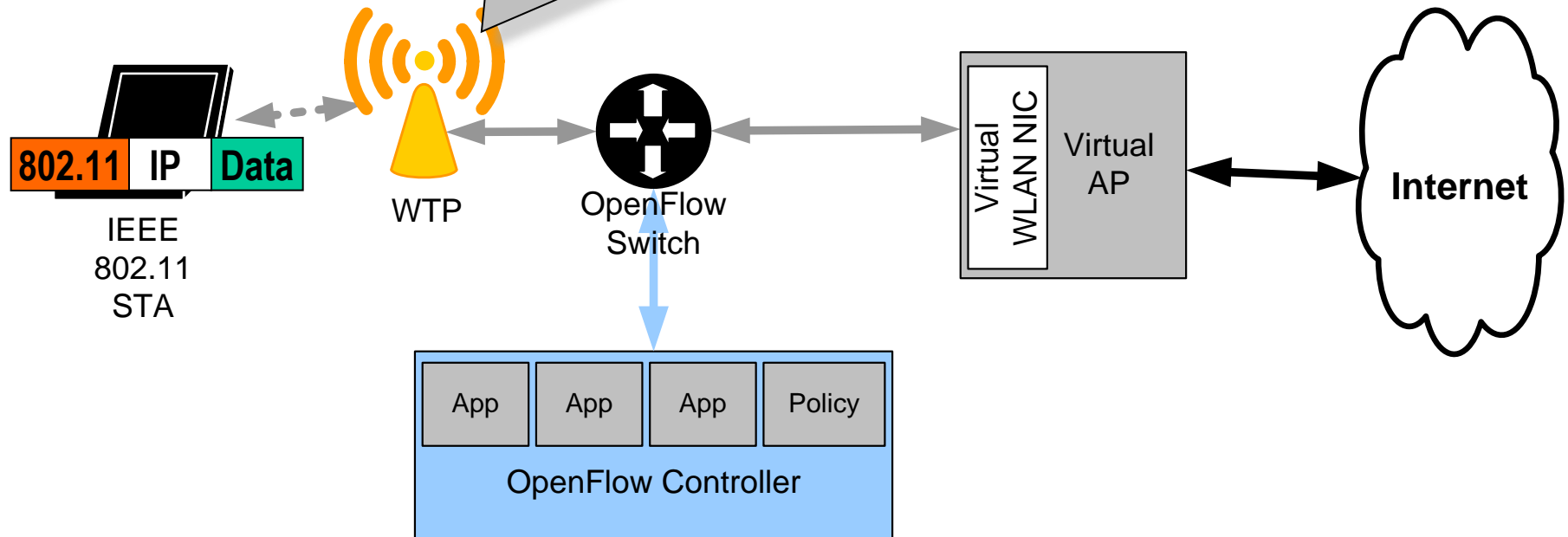
# CLOUDMAC: TX-PATH

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



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# BENEFITS AND POTENTIAL

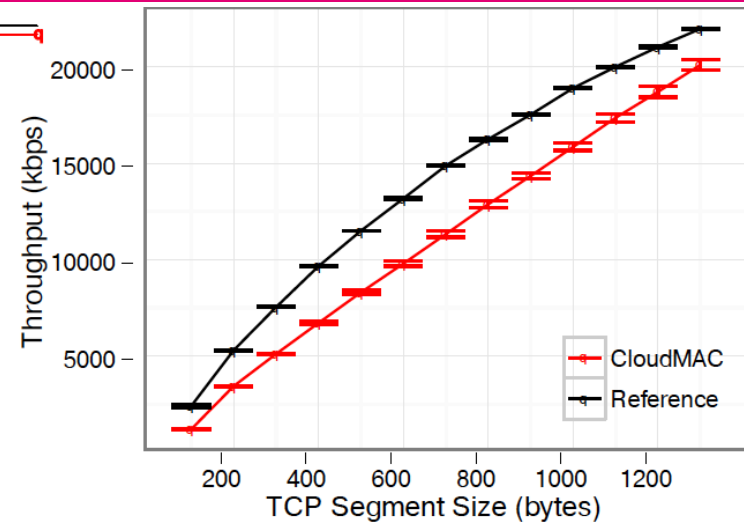
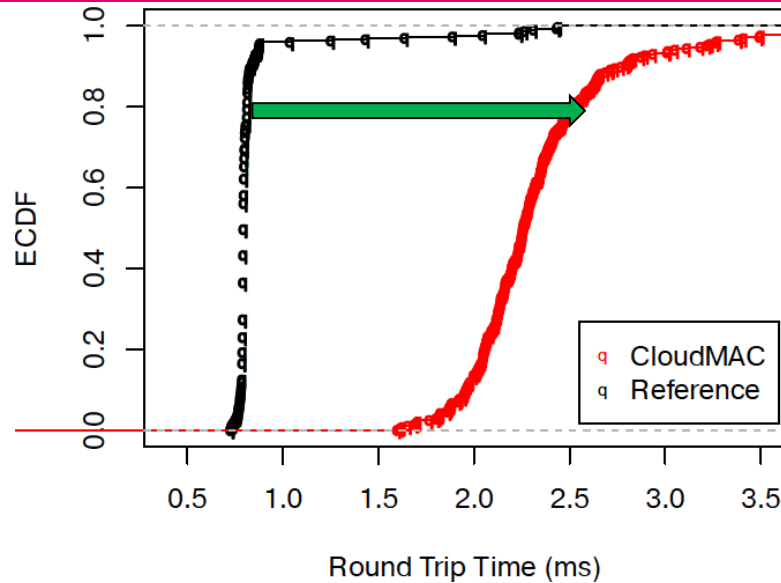
- Thin APs
  - Association state kept in the cloud
- Simplified Administration
  - E.g. can add new encryption by changing cloud implementation
- Integration with OpenFlow
  - Reuse infrastructure and Apps implemented for OpenFlow
- Simple Deployment of new Apps
  - On-Demand AP
    - Dynamically Enabling 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

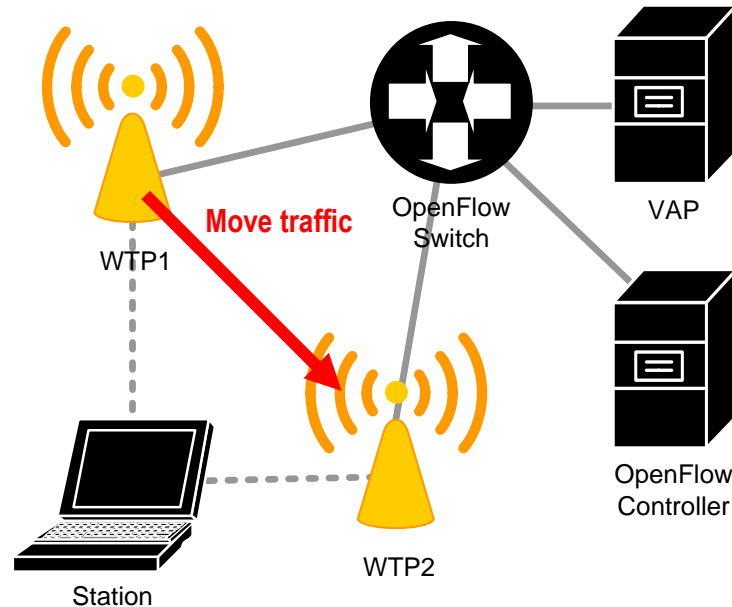


**CLOUDMACs additional delay due to the additional processing in software is limited!**

**Performance loss due to the header overhead and rule processing is tolerable! Can be reduced by kernel implementation.**

# CLOUDMAC DEMO: SEAMLESS AP SWITCHING

## SZENARIO

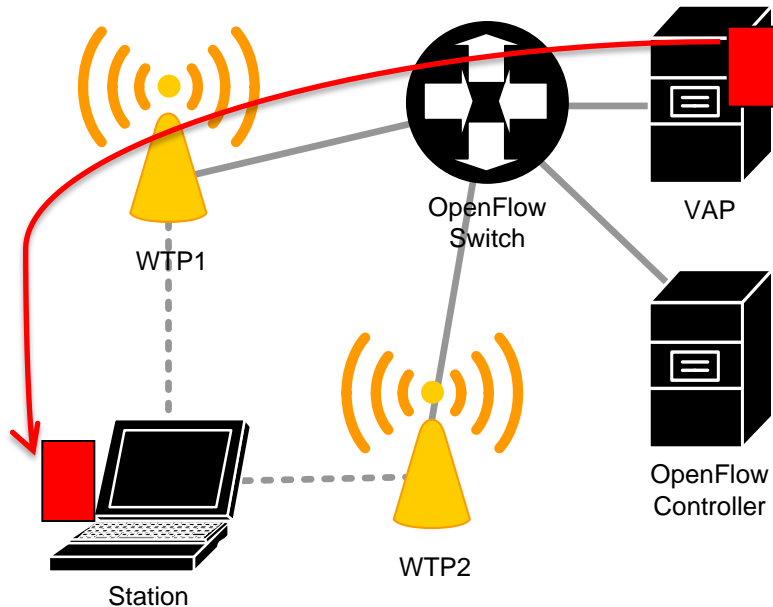


- Move traffic from WTP1 to WTP2
- Mobility management or energy saving
- Standard IEEE 802.11: scan and re-association
- CloudMAC: Association state in VAP → no re-association

## MEASUREMENT RESULTS

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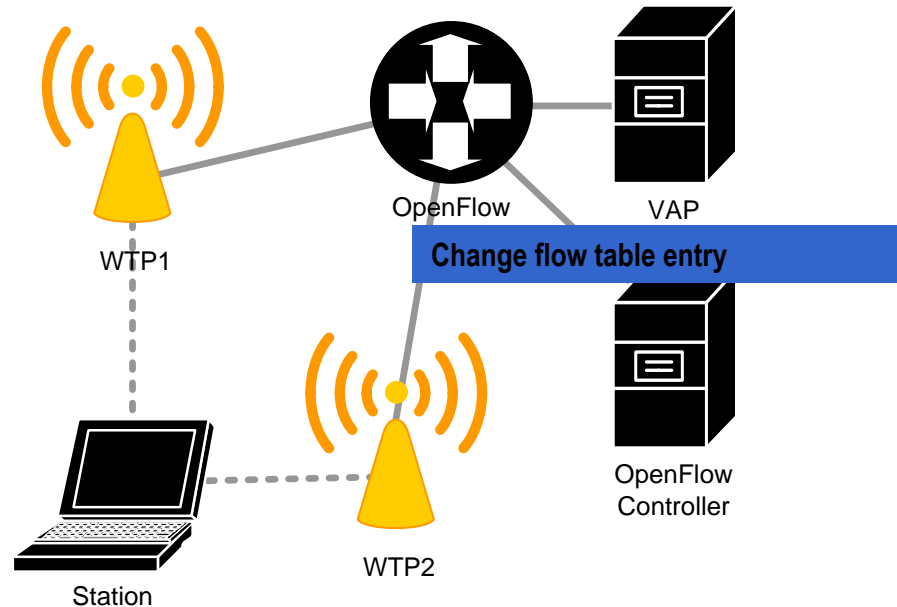


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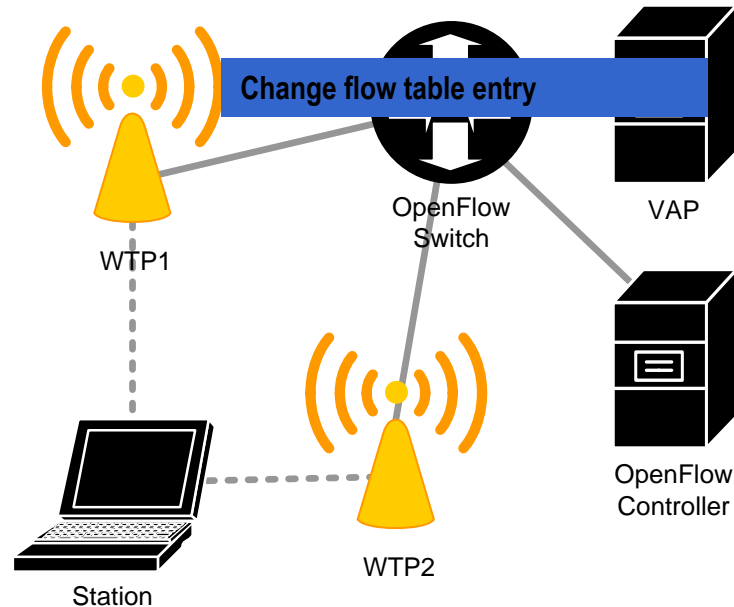
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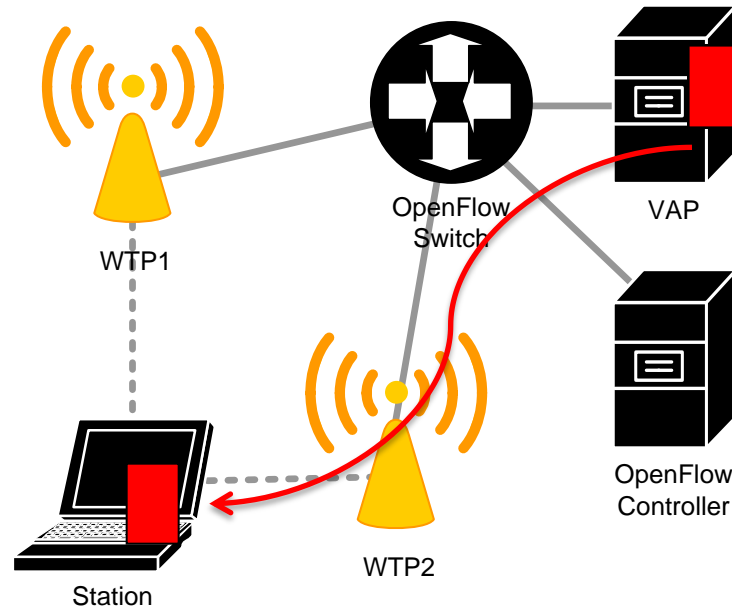


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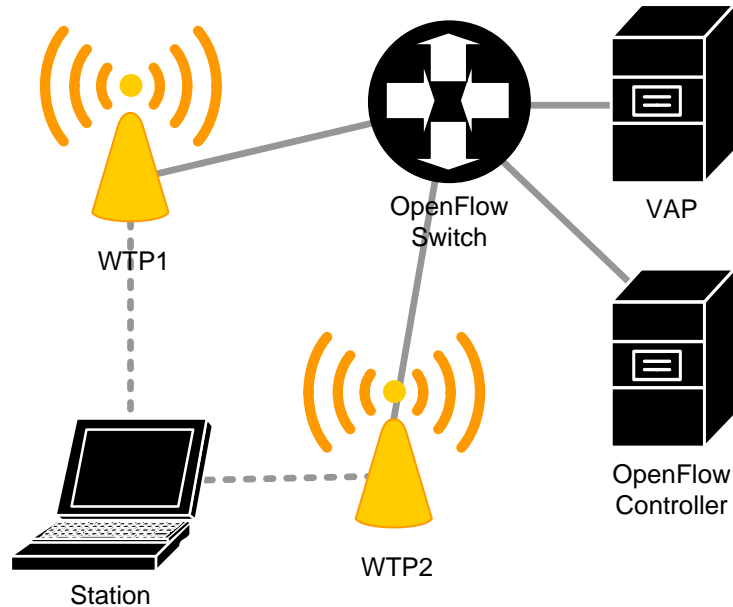


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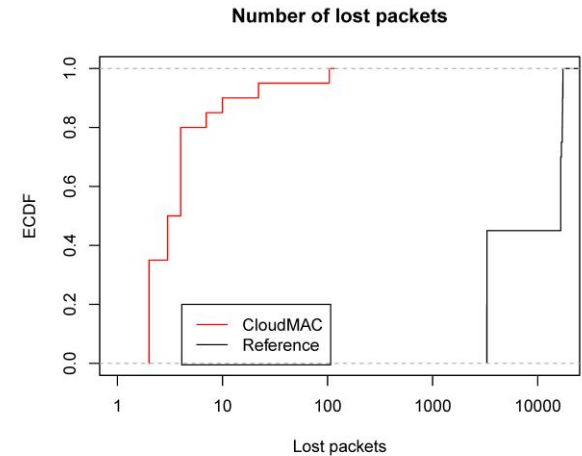
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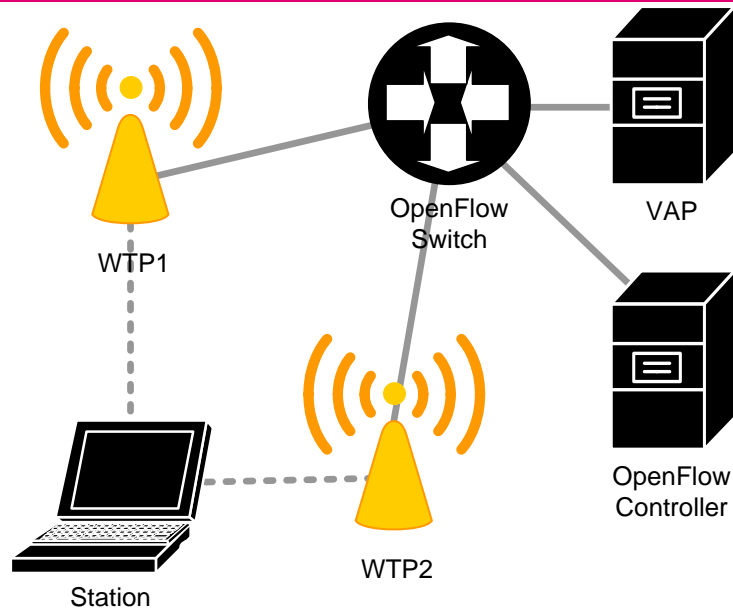
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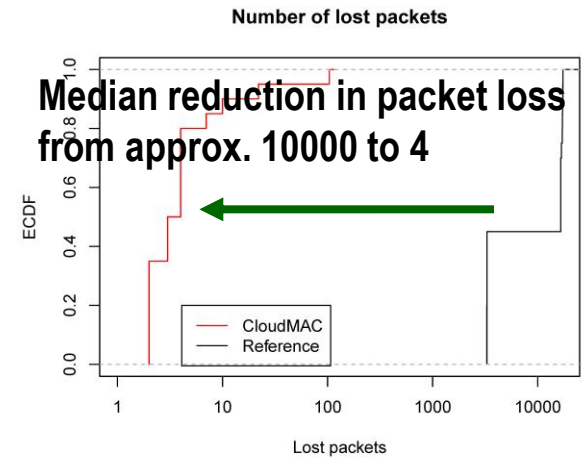
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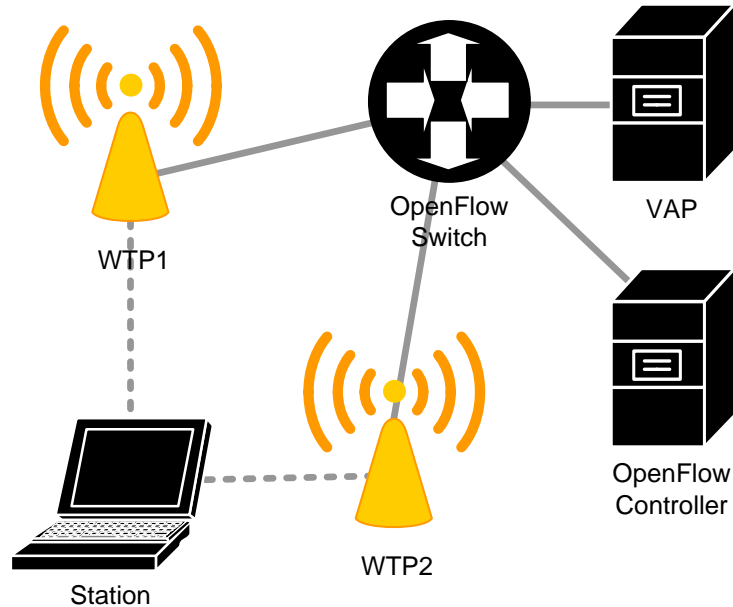
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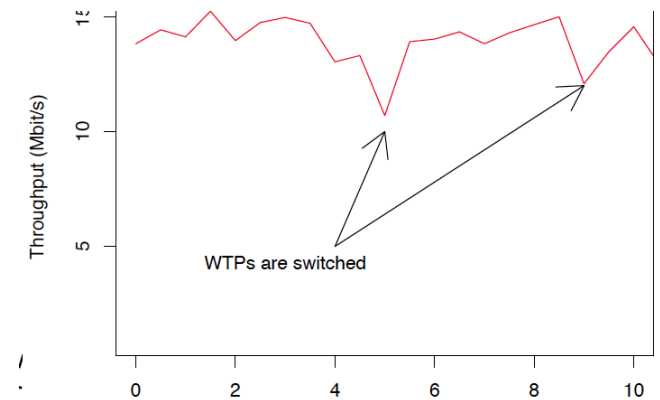
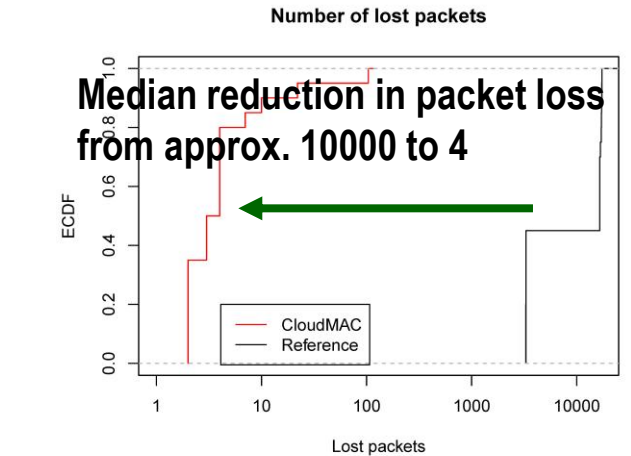
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## MEASUREMENT RESULTS



# CLOUDMAC@CODEBASIN

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## CLOUDMAC

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### cloudmac @ master

Statistics | Branch: master | Revision:

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

### Latest revisions

#	Date	Author	Comment
951daab2	05/10/2013 11:28 pm	peter	changed defconf
2eed9927	05/10/2013 04:32 pm	root	Merge branch 'master' of gitolite@codebasin.net:cloudmac
5ba4d7ac	05/10/2013 04:31 pm	root	changed to hw switch
726c781f	05/10/2013 04:26 pm	Peter Dely	pox ng
741faa62	05/10/2013 04:24 pm	Peter Dely	hw switch
20ea8263	05/10/2013 04:24 pm	Peter Dely	hw switch
c902beb4	05/10/2013 04:23 pm	Peter Dely	hw switch
3840ca0d	05/10/2013 04:21 pm	root	cloudmac ng controller
7d472770	05/10/2013 04:13 pm	Peter Dely	PS off
40cd3e04	05/10/2013 04:09 pm	Peter Dely	DHCP

[View differences](#)

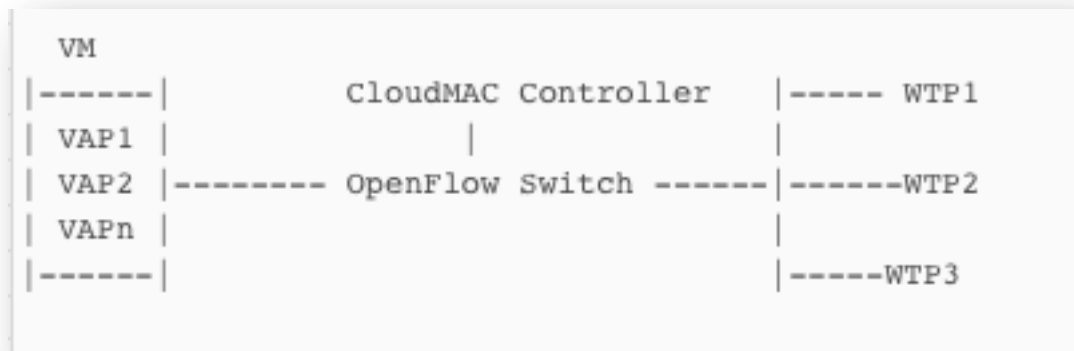
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# CLouDMAC@CODEBASIN

- 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
  - Cloud MAC - Using OpenFlow to Process 802.11 MAC Frames in the Cloud, Peter Dely, Andreas Kassler, Nico Bayer, Hans Einsiedler, Christoph Peylo, in: Proceedings of NetSys, Stuttgart, March 2013.
  - Software Defined Networking for the Management and Operation of WLANs, Peter Dely, Andreas Kassler, Nico Bayer, Hans Einsiedler, Christoph Peylo. Standardisation Insider 2013
  - CloudMAC - An OpenFlow based Architecture for 802.11 MAC Layer Processing in the Cloud, Jonathan Vestin, Peter Dely, Andreas Kassler, Nico Bayer, Hans Einsiedler, Christoph Peylo, in: Proceedings of GC'12 Workshop: The 8th Broadband Wireless Access Workshop (GC'12 Workshop - BWA), Anaheim, 3-7 December 2012, USA.
  - CloudMAC – Towards Software Defined WLANs, Jonathan Vestin, Peter Dely, Andreas Kassler, Nico Bayer, Hans Einsiedler, Christoph Peylo, in: Proceedings of MobiCom'12: The 18th Annual International Conference on Mobile Computing and Networking, Istanbul, August 2012.
- Patent Application - submitted
  - Method and system for the distribution of the control and data plane in wireless local area networks
- Prizes
  - 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://http://www.kau.se/en/cloudmac>



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