BIGAP

Seamless Handover in High Performance Enterprise IEEE 802.11 Networks

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Outline

- Motivation,
- System Model,
- Applications,
- Design Principles,
- Steps involved in Client STA Handover,
- Seamless Mobility,
- Evaluation,
- Conclusion & Future Work.

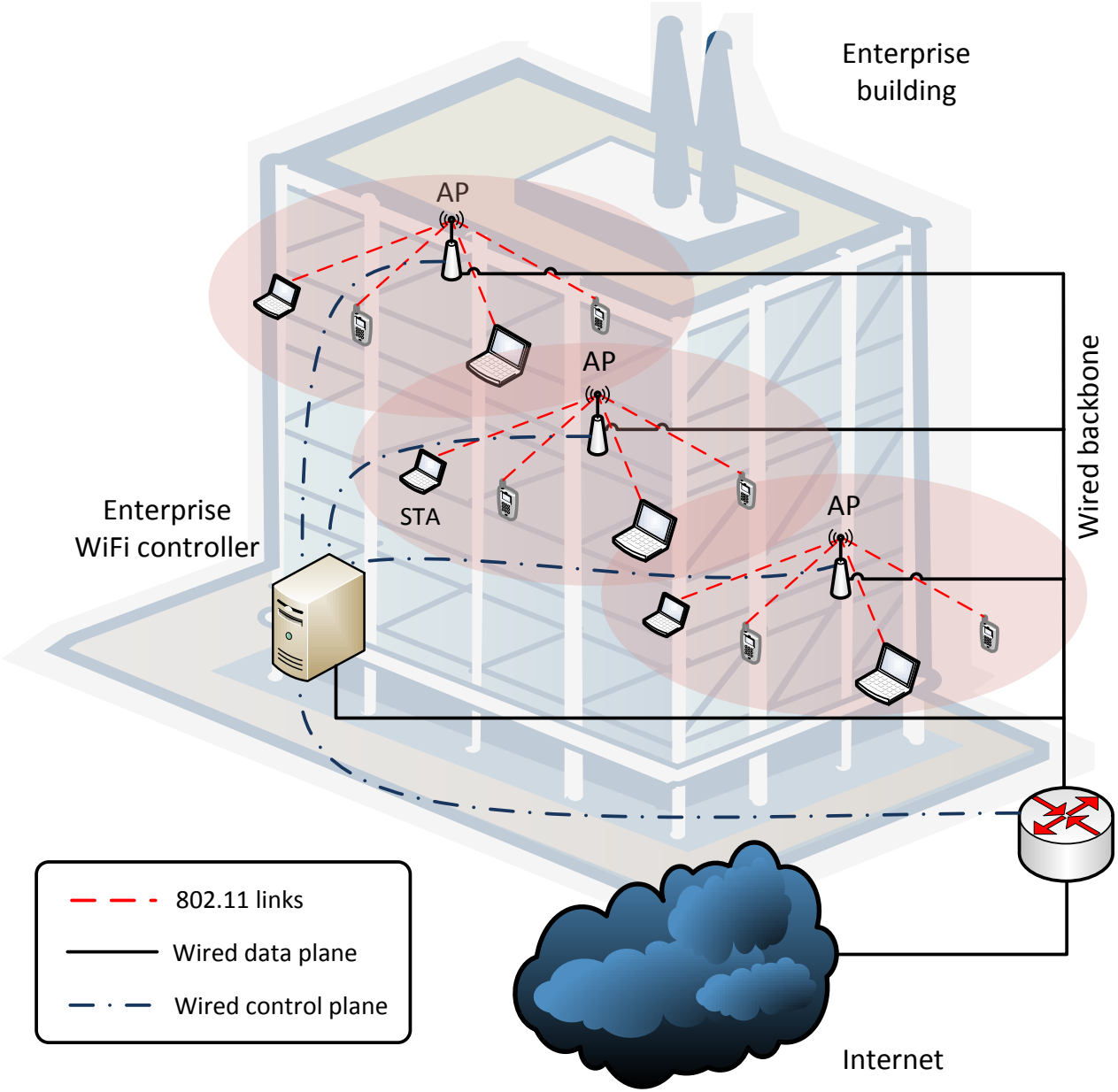
Motivation

- Trend towards deploying dense IEEE 802.11 wireless networks (WiFi) in ***enterprise environments***,
- **BUT** the appearance of WiFi enabled smartphones/tablets require much better mobility support and ***higher QoS/QoE***,
- Although, mobile clients in a dense WiFi network can choose from many possible APs, this ***degree of freedom*** is not fully exploited in 802.11 resulting in restricted mobility.
  - ***Clients decide*** on ***handover*** (HO) operation using just local information,
- There is a need for an ***infrastructure-initiated handover scheme*** which would allow the design of novel ***applications***.

Desired Applications

- Load balancing clients
  - Networks typically suffer from in-balance, i.e. highly and lightly loaded APs (cells)
- Seamless mobility
  - Becomes very important due to appearance of bring your own devices (BYOD),
- Interference management
  - Very important in dense networks (hidden/exposed terminal problem)

System Model – Enterprise WiFi Networks



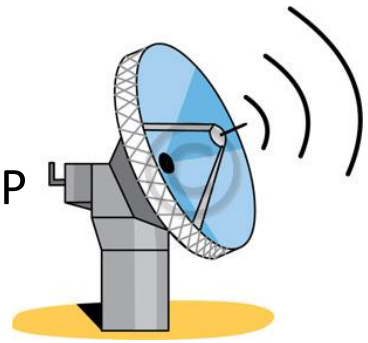
BIGAP's Design Principles

- DenseAP HO [1]:
  - Enables infrastructure-initiated HO without requiring any modifications in existing client devices.
  - But it creates a ***severe network outage*** during HO caused by the amount of time the STA needs for the connection build-up with the new AP.
- Proposed ***BIGAP*** approach:
  - Decreases the network outage duration and removes all delays by ***transferring the current state of the STA*** from the serving AP to the ***target AP***
  - BIGAP topology uses a ***single global BSSID*** for the whole ESS and thereby for all APs.
    - From STAs point of view, the whole ESS including all APs seems like one BSS or ***one big AP***.
  - BIGAP uses ***different RF channels*** for all co-located APs to avoid packet collisions.

[1] R. Murty, et al. , "Designing high performance enterprise wifi networks." in NSDI, vol. 8, 2008.

BIGAP's Design Principles (II)

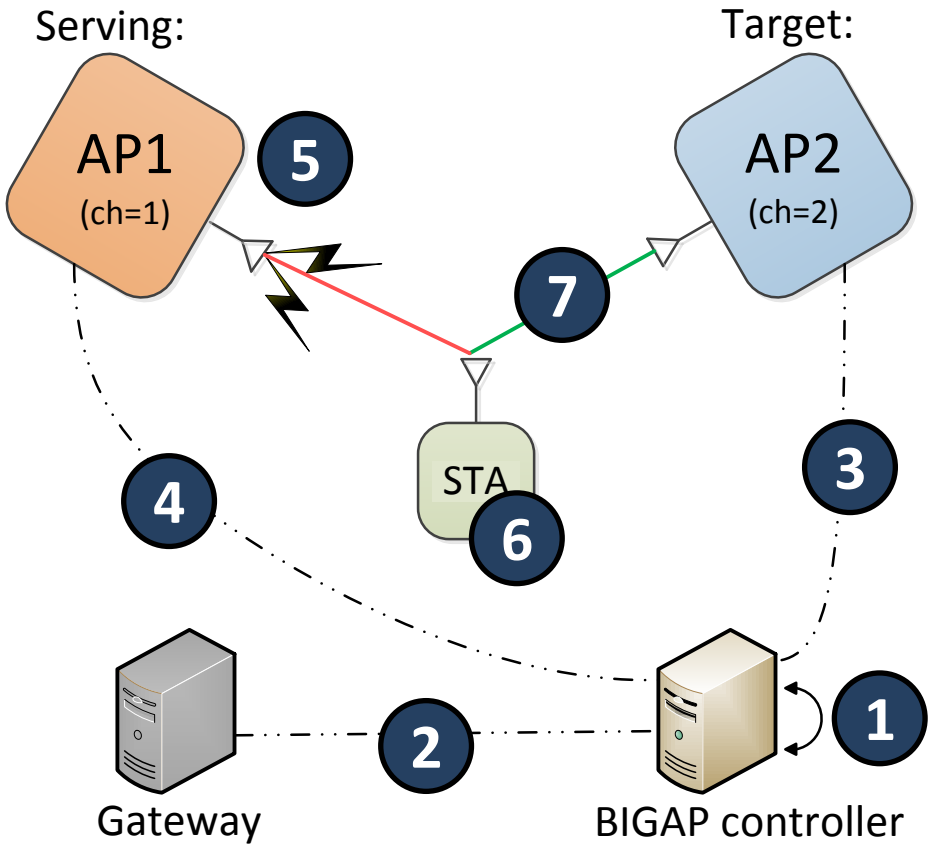
- BIGAP exploits the ***802.11 DFS functionality*** and leads the STA to believe that the serving AP will perform a RF channel switch due to a detected ***radar signal***:
  - But serving AP remains on its channel whereas the target AP is operating on the new channel.
  - The STA believes the new AP is the old AP which has also switched the RF channel:
    - All APs use the same BSSID & current state of the STA on the old AP was transferred to the new AP.
  - Communication can be continued without any further outage except the time needed for channel switching in client device.



- BIGAP works with ***unmodified*** STAs, i.e. support of 802.11n/ac is sufficient.
- BIGAP requires the existence of a sufficient ***large number of available RF channels*** so that different channels can be assigned to co-located APs.

Steps involved during Station HO

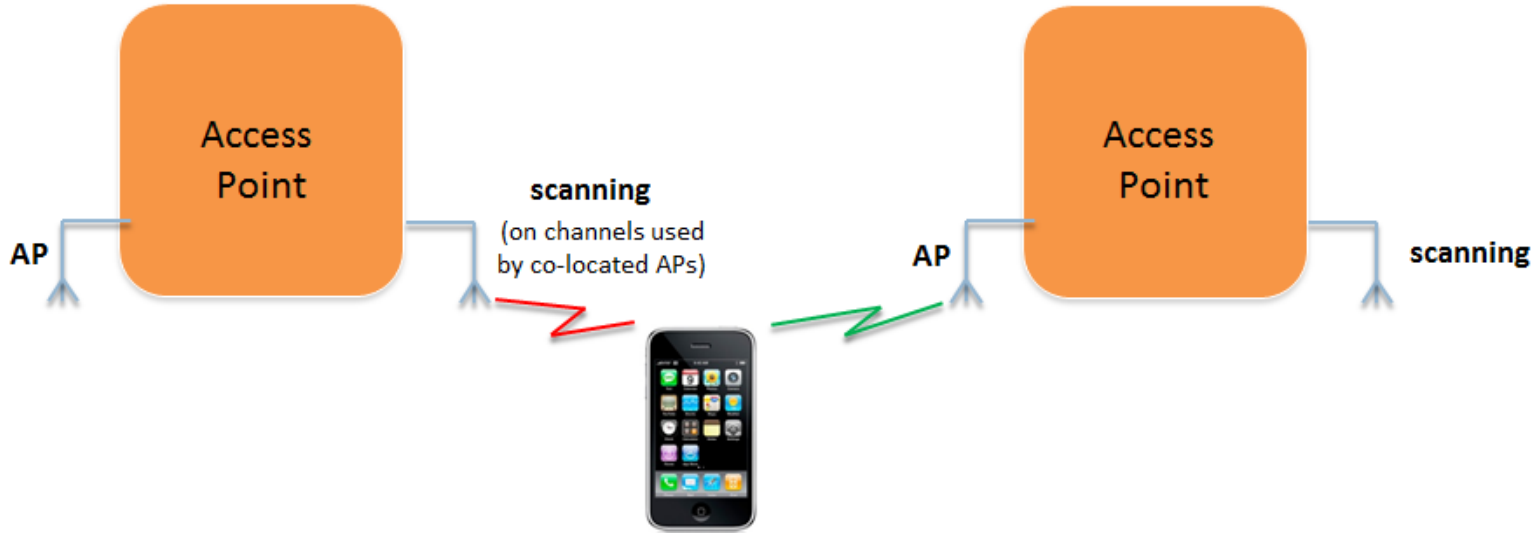
- **1.** ***Decision*** made by controller to handover STA from AP1 to AP2.
- **2.** ***Traffic flows*** towards STA need to be routed over AP2.
- **3.** Controller ***associates and authenticates*** STA on the target AP -> makes sure that after HO the STA is properly registered within AP2.
- **4/5.** BIGAP controller instructs AP1 to send out a ***unicast beacon*** containing a ***CSA-IE*** with the channel set to the target AP, here 2, destined to STA.



- **6.** On successfully receiving the unicast beacon containing the CSA-IE the corresponding STA performs channel switching.
- **7.** Since both AP1 and AP2 have the ***same BSSID***, aka MAC address, the ***STA does not notice*** that it is being served after the channel switch by another AP, AP2. STA continues with its communication.

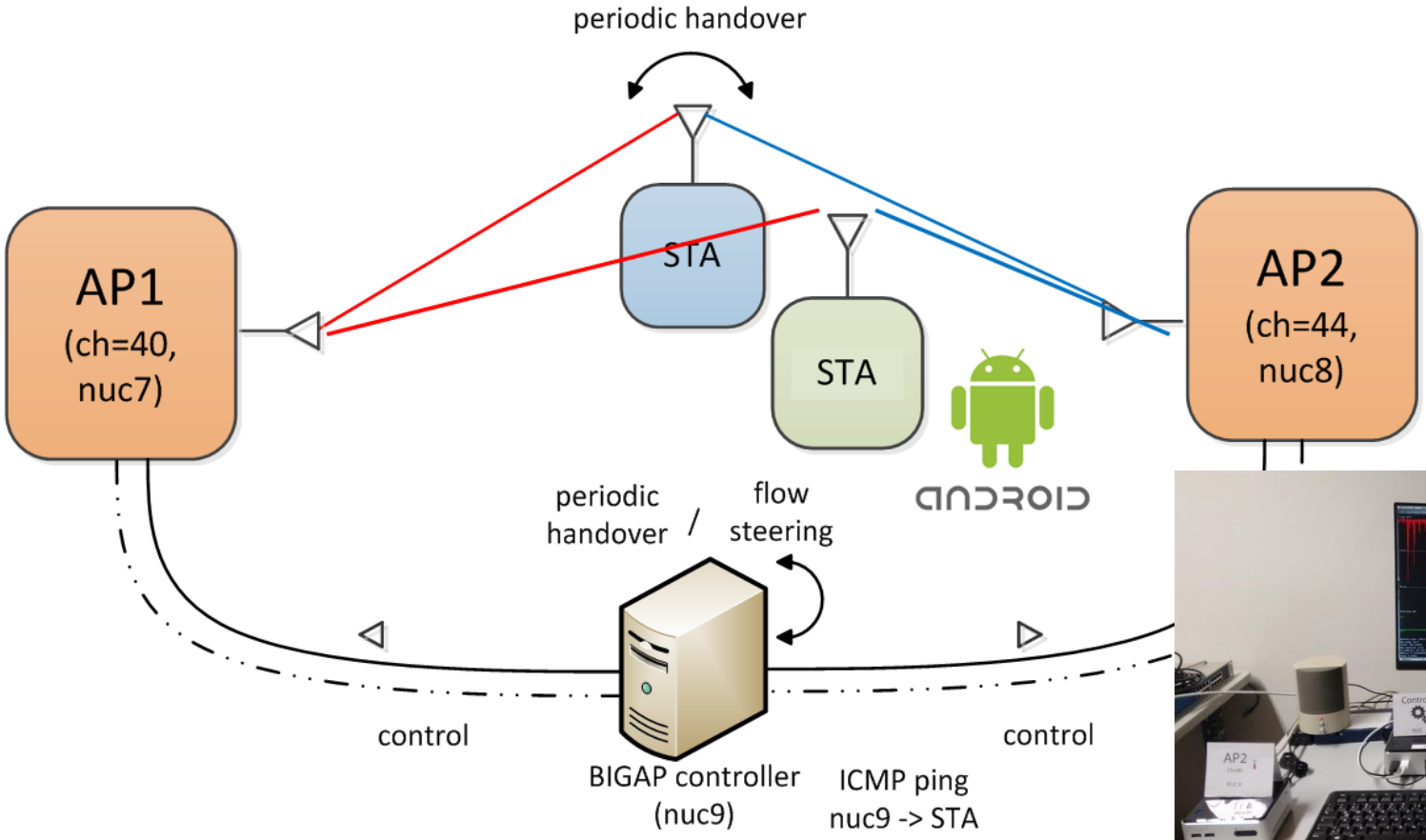
Seamless Mobility with BIGAP

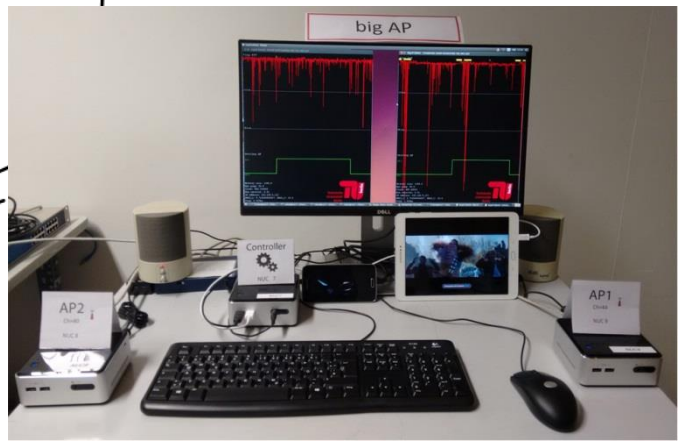
- ***Dedicated scanning interface*** for discovering handover opportunities:
  - Hopping over all channels used by neighboring APs,
  - Overhearing client STA data packets to estimate channel quality (RSSI),
  - Report of client RSSI values to controller
- Solves client stickiness,
- Assumption made: frequency dependency on RSSI is negligible, i.e. RSSI@freq1 ~ RSSI@freq2



BIGAP Live Demo

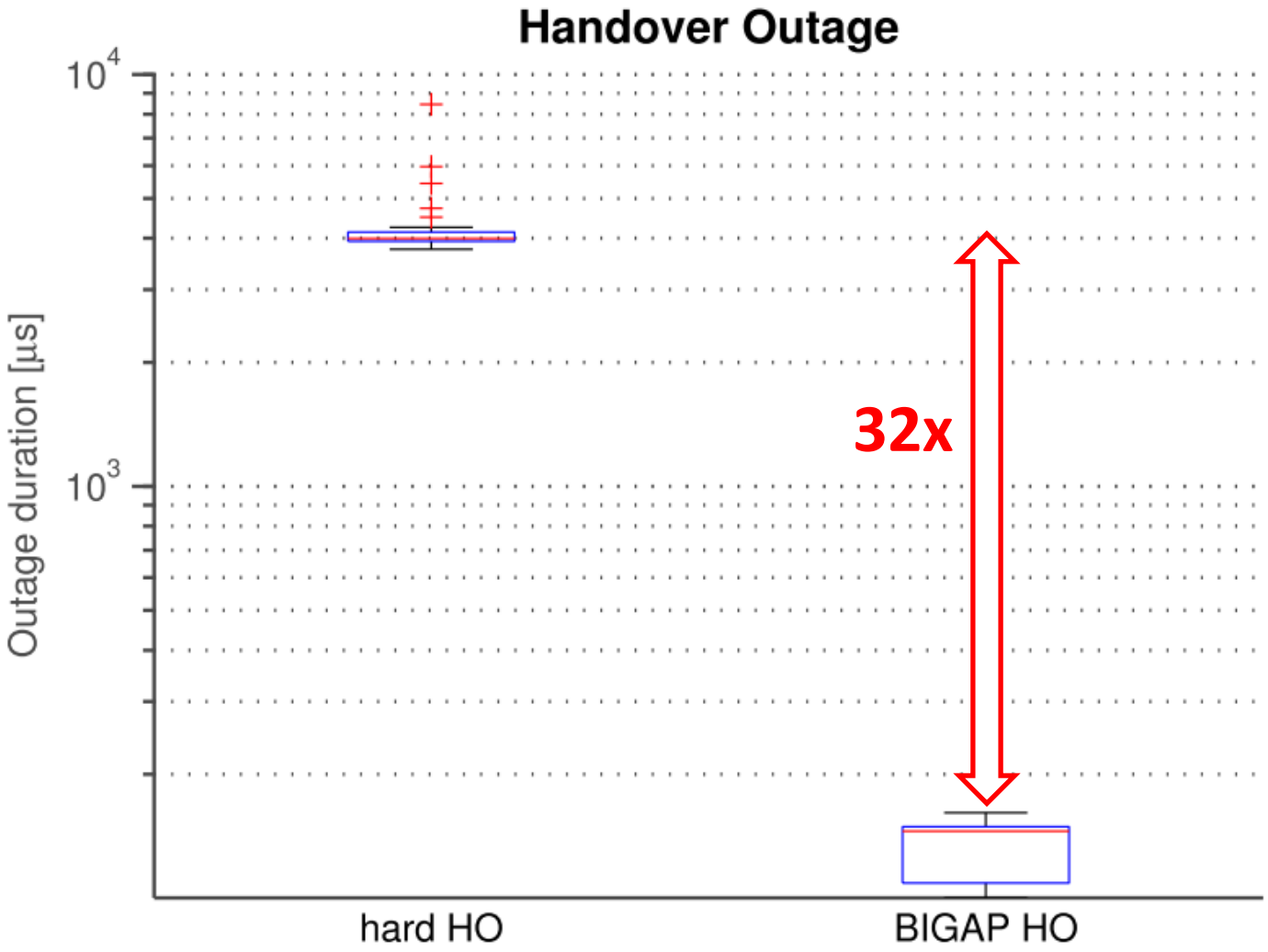
- BIGAP was configured to perform periodic HO operations,
- ***Direct comparison***: STA1/2 with BIGAP/hard HO respectively,
- Unbuffered UDP ***video stream*** towards the STAs.





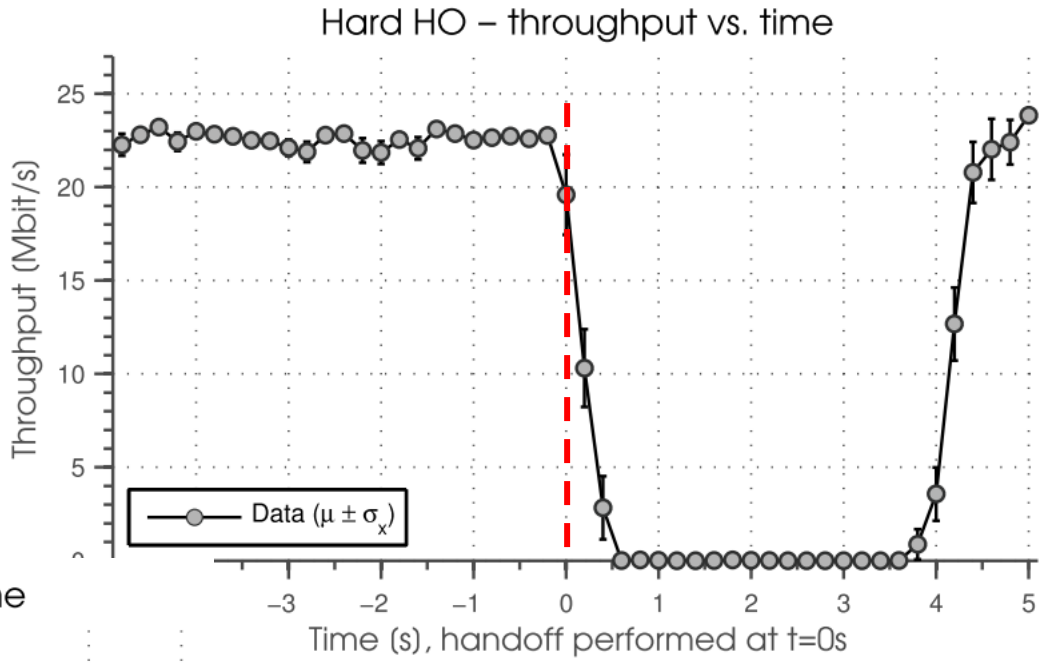
Evaluation

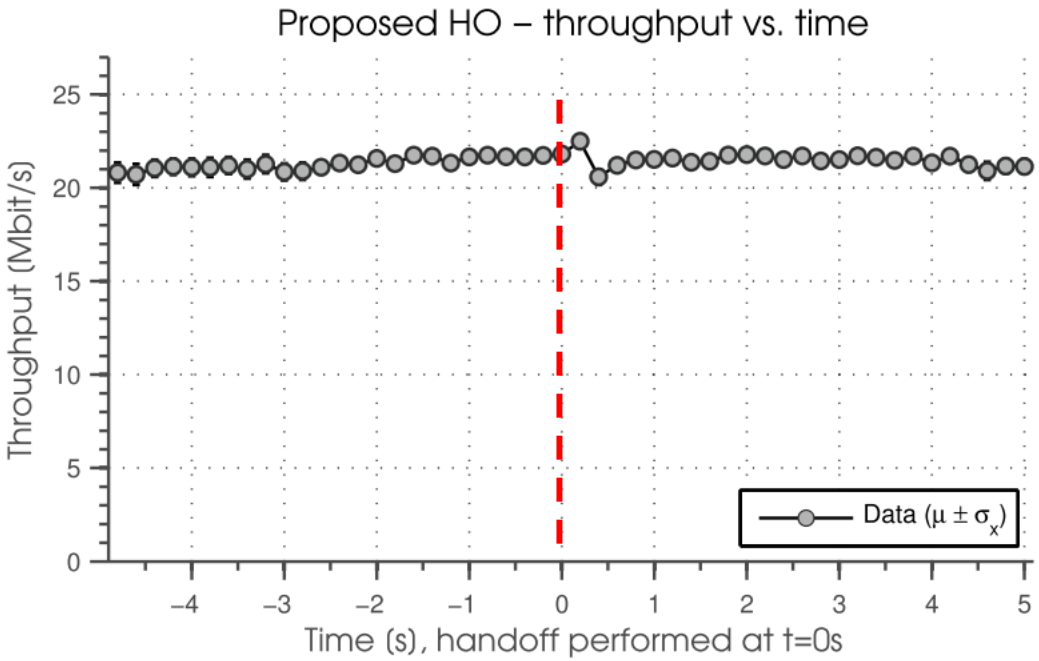
- Network outage duration during HO:



Evaluation (II)

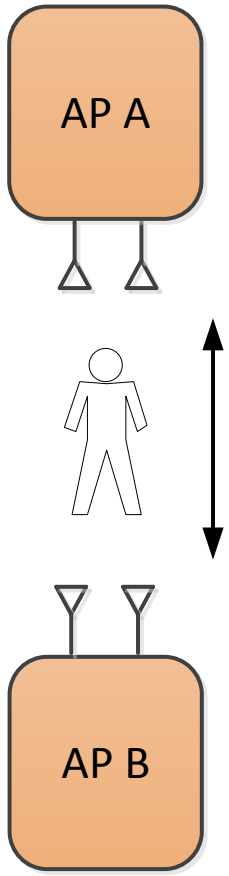
- DL TCP throughput degradation during HO operation is negligible.

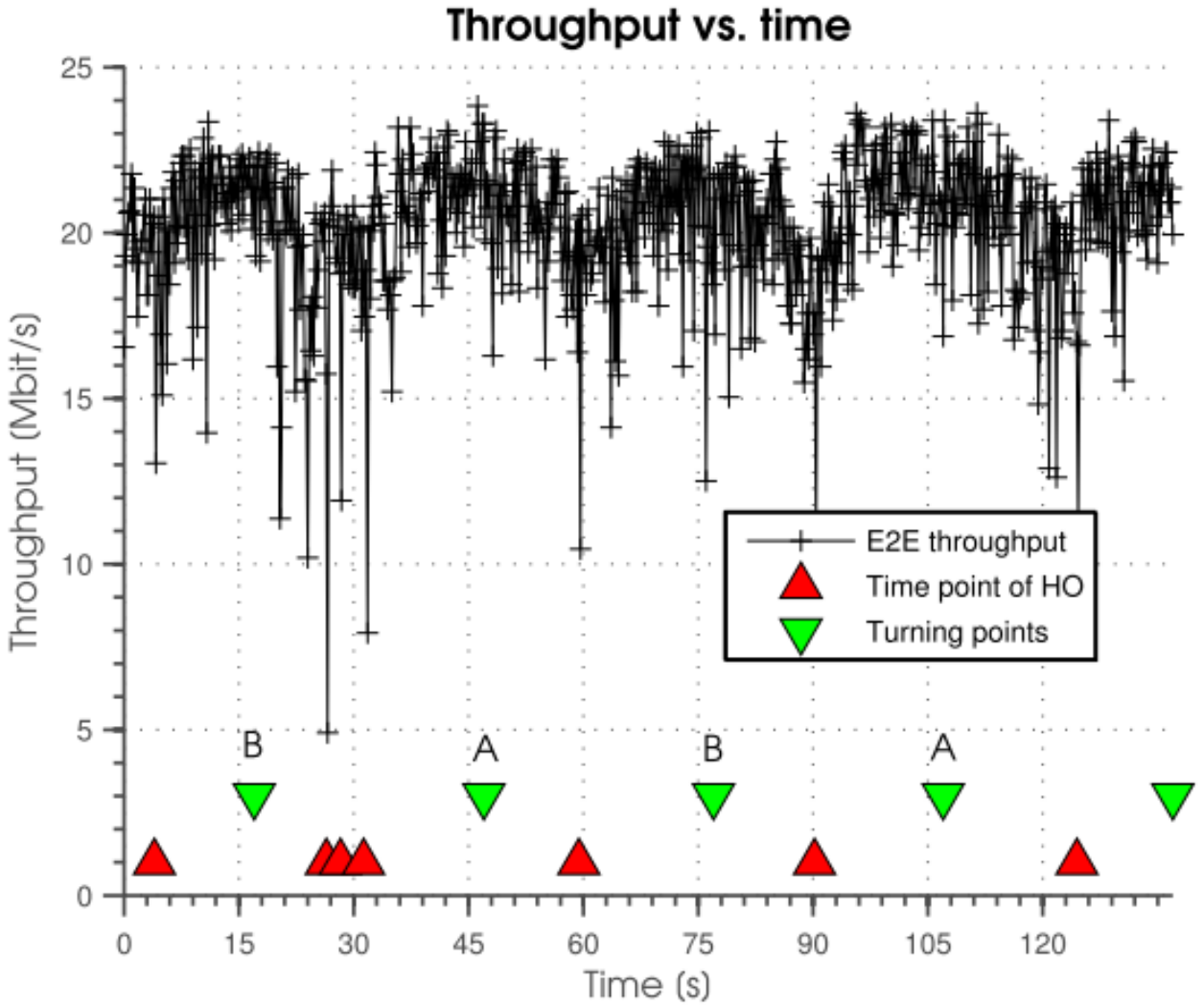




Evaluation (III)

- Support of seamless mobility:





Conclusions & Future Work

- We presented BIGAP which provides both ***high network performance*** as well as ***seamless handover*** in Enterprise WiFi networks:
  - Fully utilizing the available radio spectrum + providing a mechanism for below MAC-layer HO operation.
- ***Future work***:
  - Optimizing backhaul operation using SDN,
  - Addressing limitations, e.g. insufficient no. of channels,
  - Support of security, i.e. centralized encryption in VAP,
  - Support of 802.11 block acknowledgments,
  - Ged rid of the hardware buffers in APs.