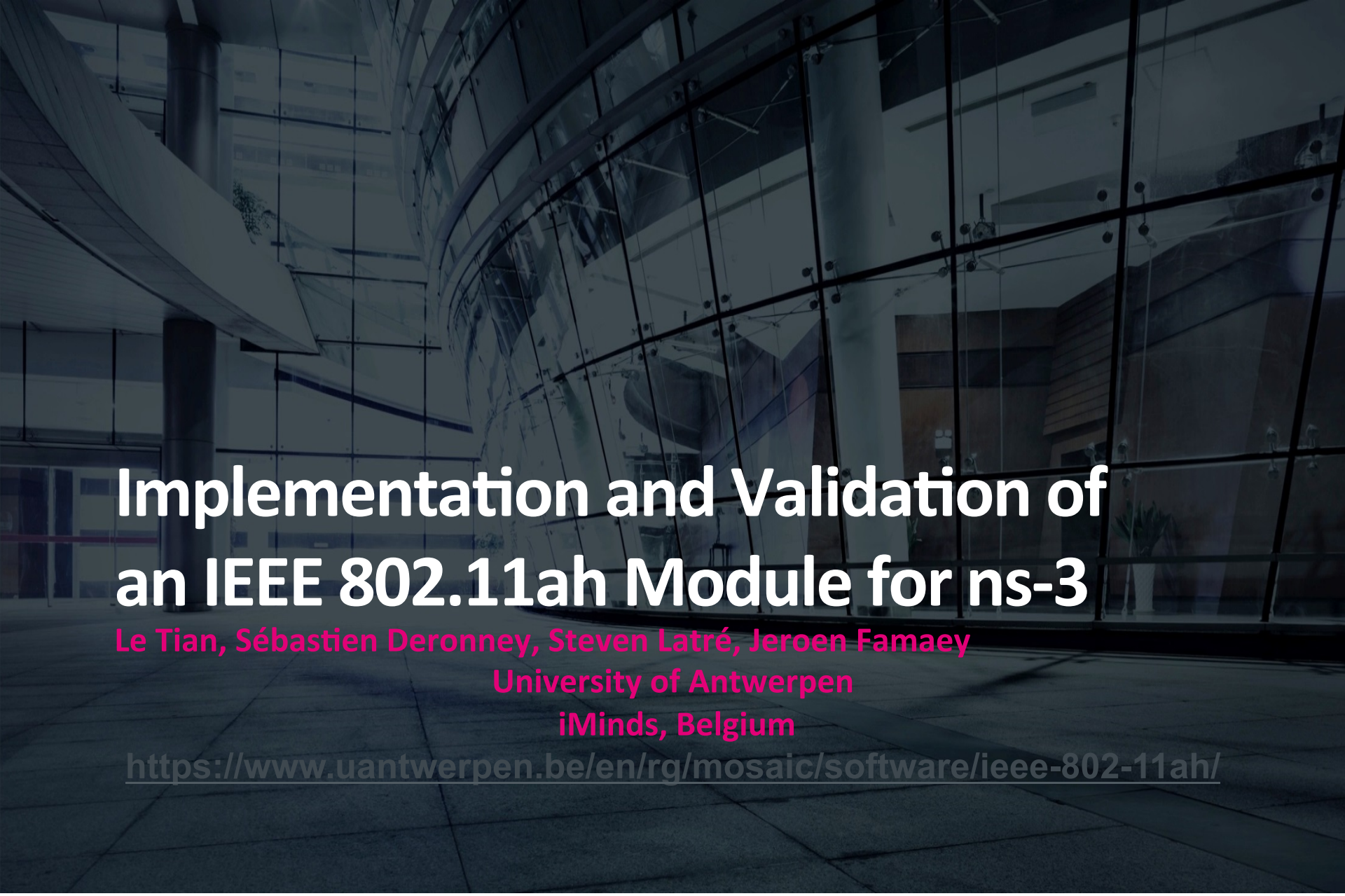

Implementation and Validation of an IEEE 802.11ah Module for ns-3

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University of Antwerpen
iMinds, Belgium

https://www.uantwerpen.be/en/rg/mosaic/software/ieee-802-11ah/

iMinds

MOSAIC
Modeling Of Systems And Internet Communication
University of Antwerp

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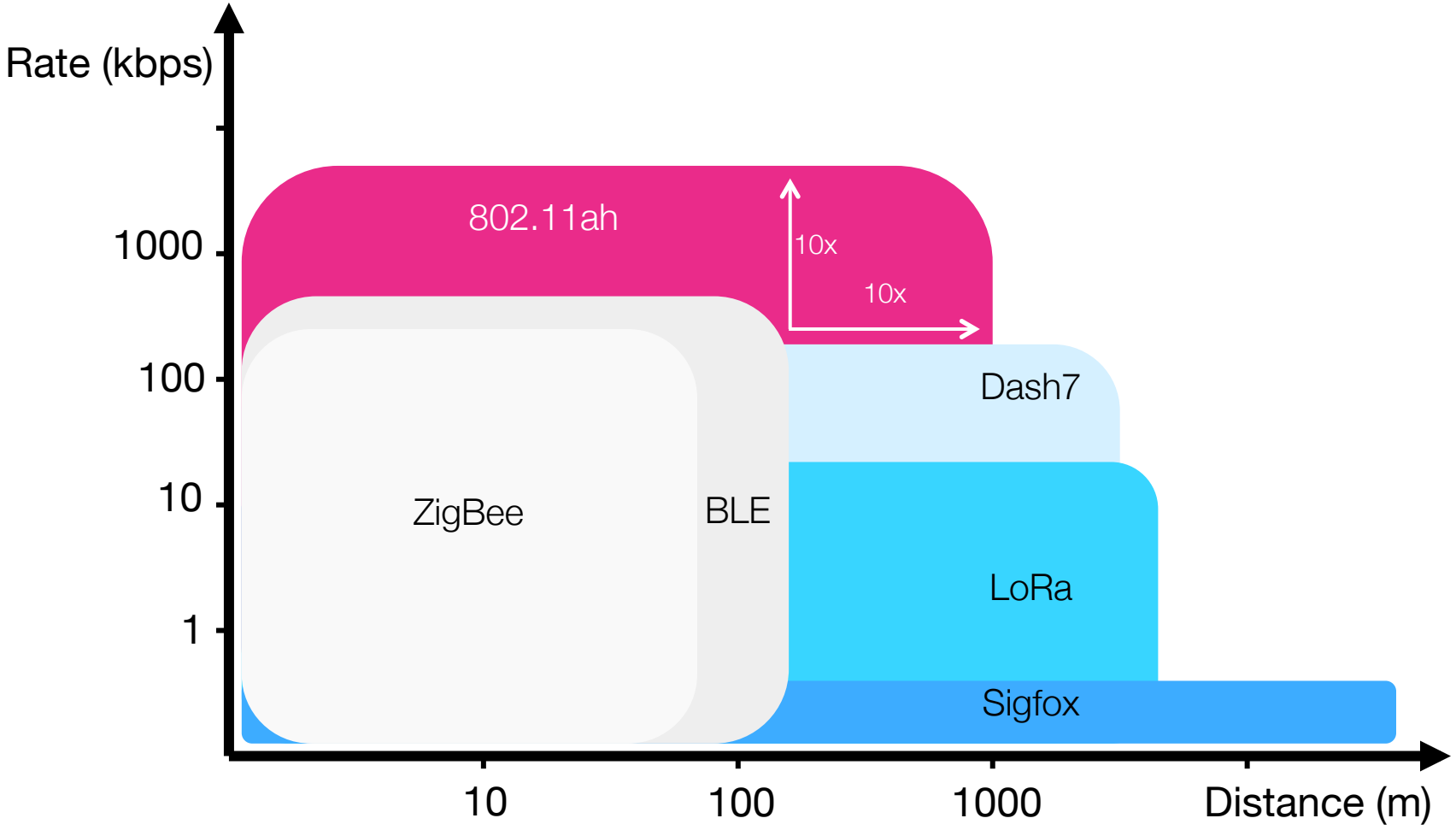
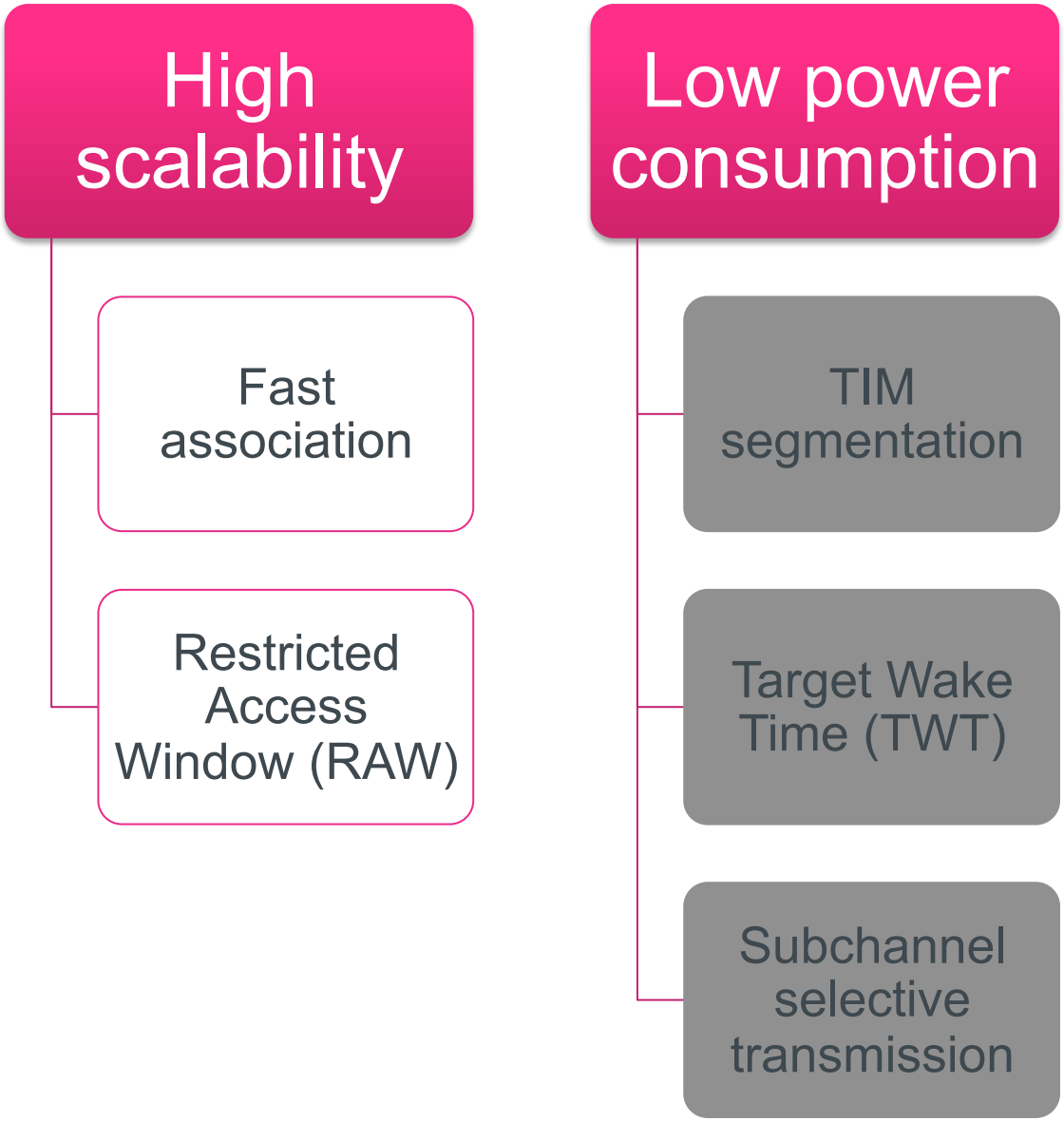
Comparing 802.11ah to WPAN and LPWAN



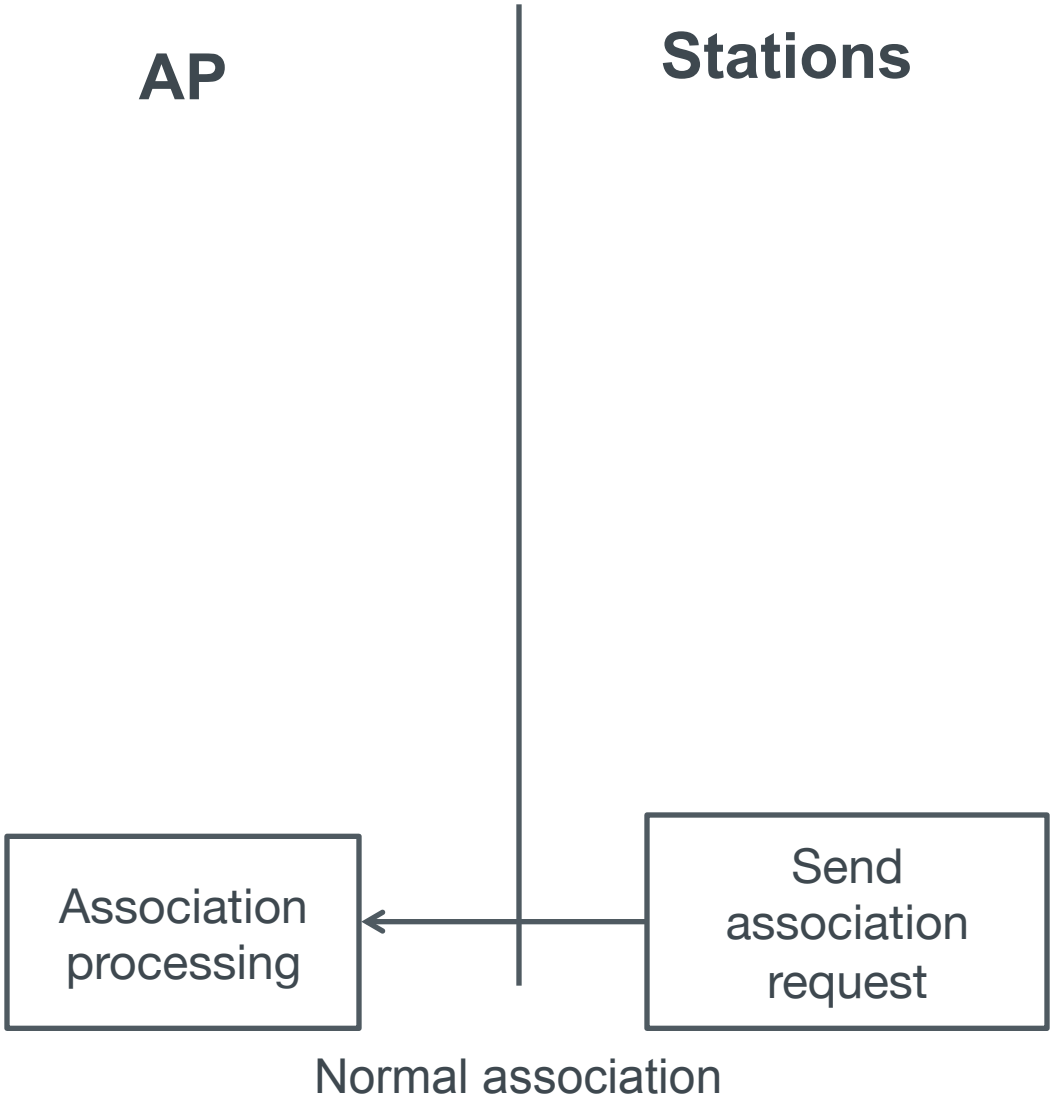
802.11ah in numbers

	ZigBee (802.15.4)	Bluetooth Smart (802.15.1)	HaLow (802.11ah)
Frequency band	Sub-1Ghz, 2.4Ghz	2.4Ghz	Sub-1Ghz
Channel bandwidth	0.3 – 2Mhz	2Mhz	1 – 2 Mhz (4, 8, 16 optional)
Data rate	20 – 250 kbps	up to 1Mbps	0.15 –78 Mbps
Range	10 – 100m	300m	100 – 1000m

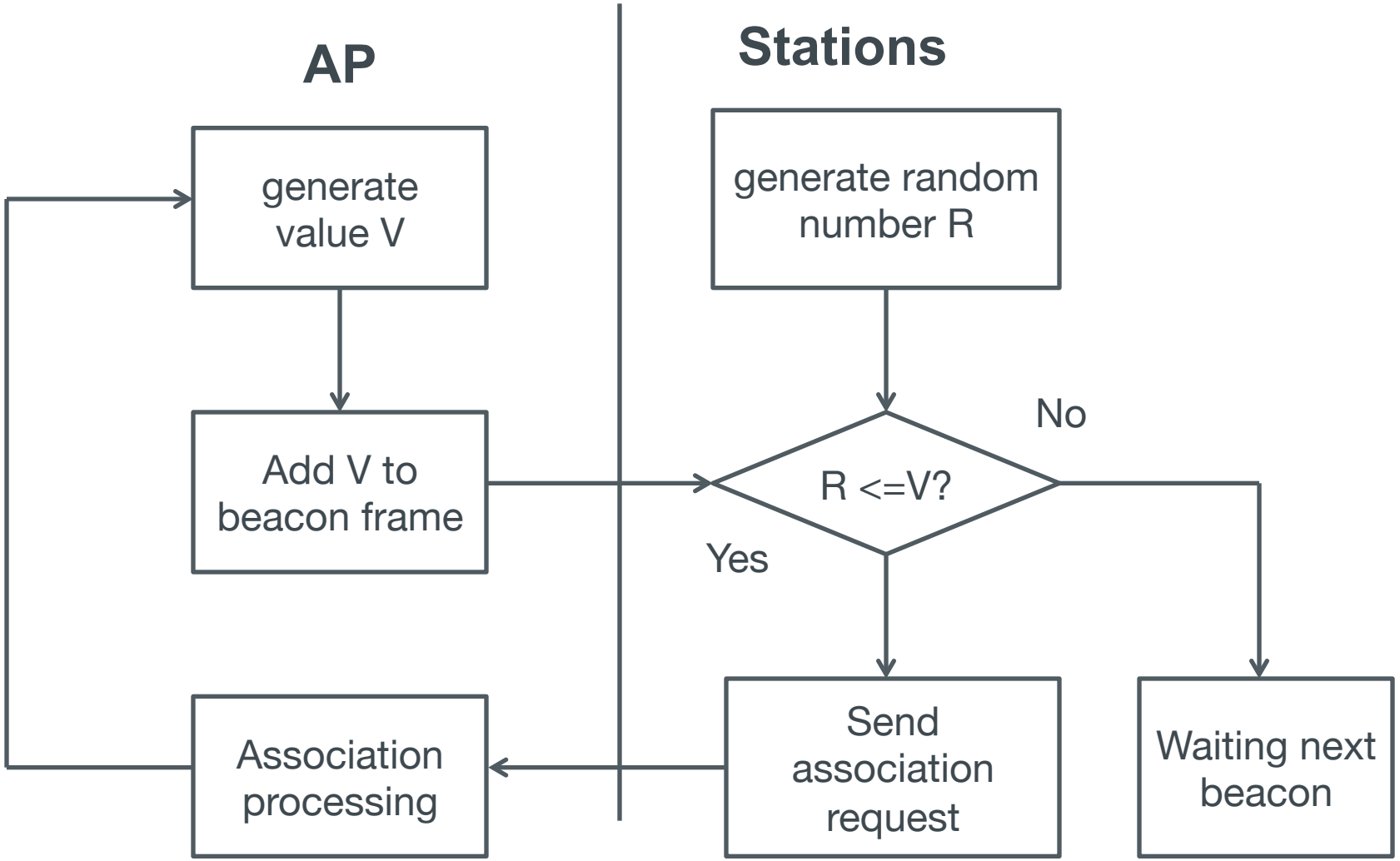
New 802.11ah MAC features



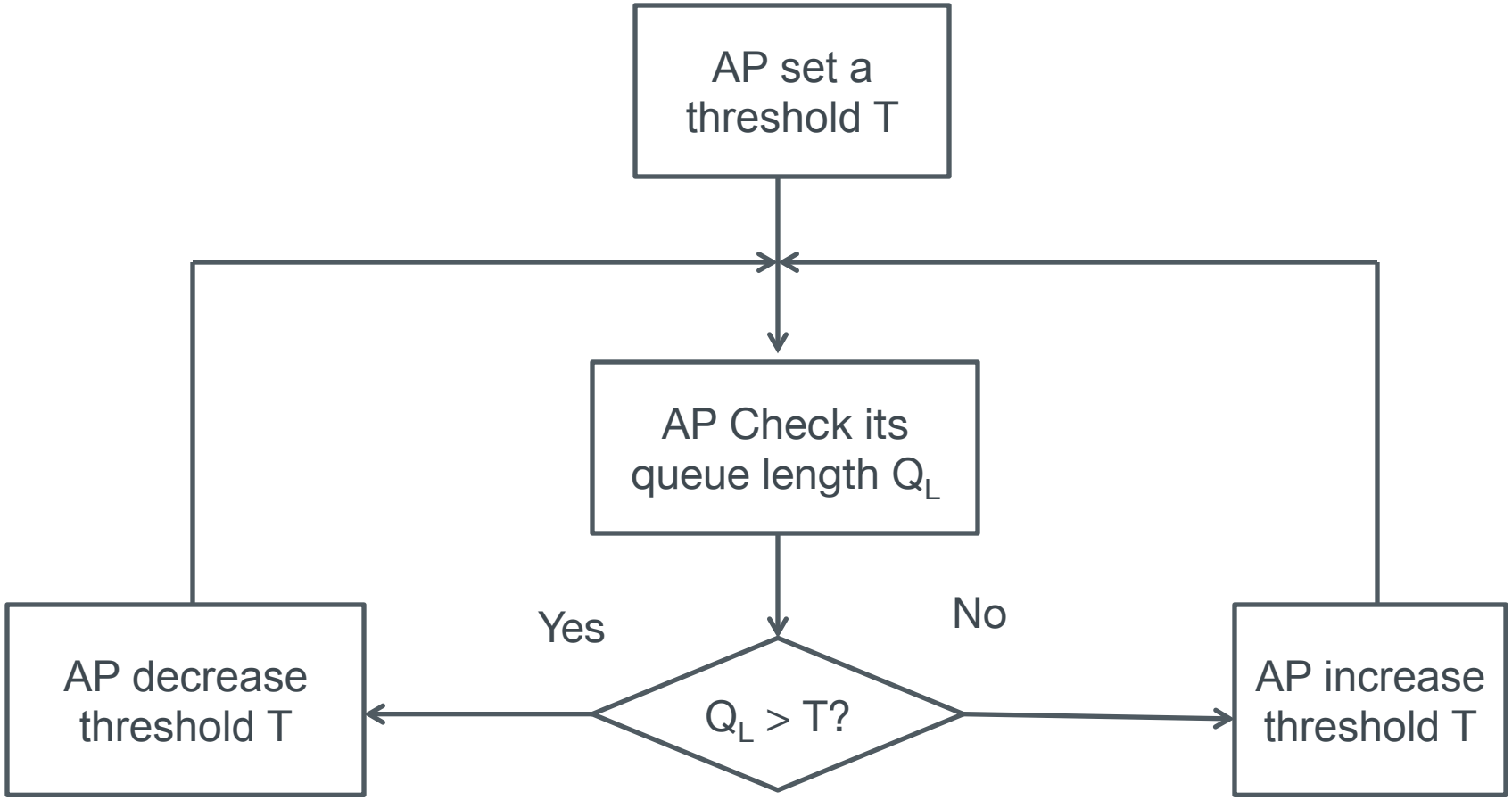
Fast association



Fast association



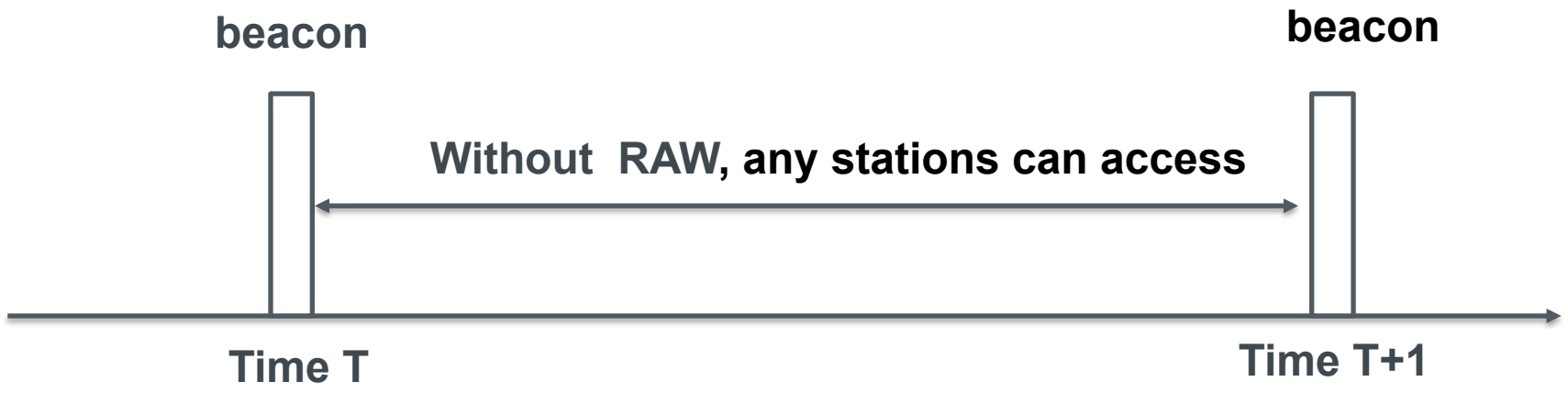
Fast association

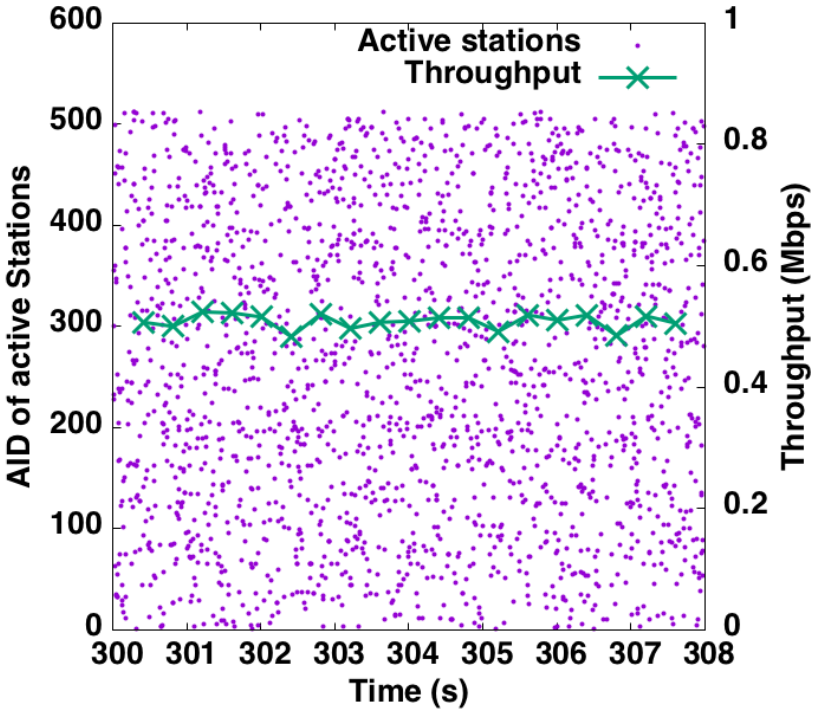


Example of changing value v

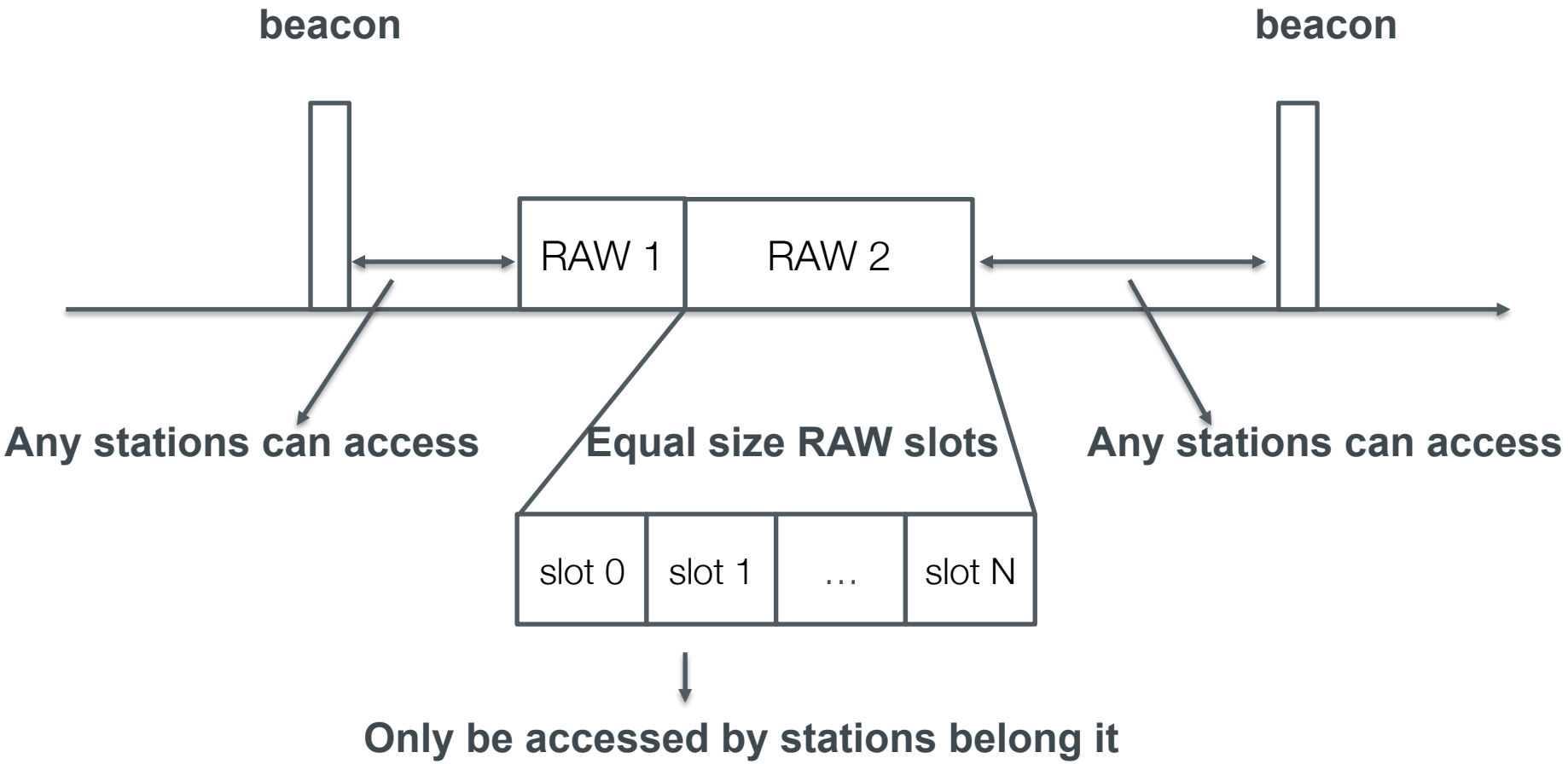
"11-12-0112-04-00ah-supporting-of-the-authentication-association-for-large-number-of-stations.pptx"

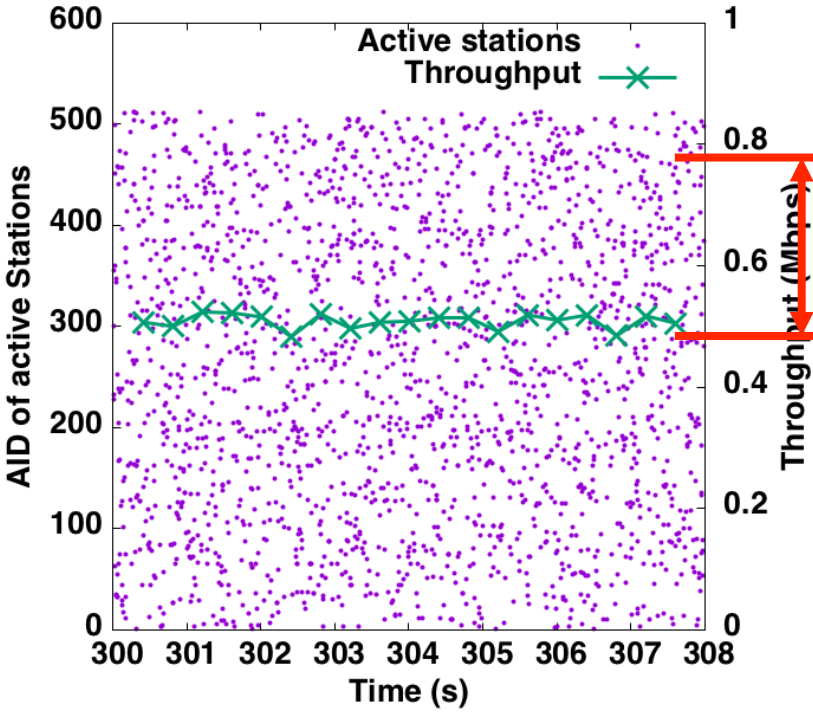
Restricted Access Window (RAW)





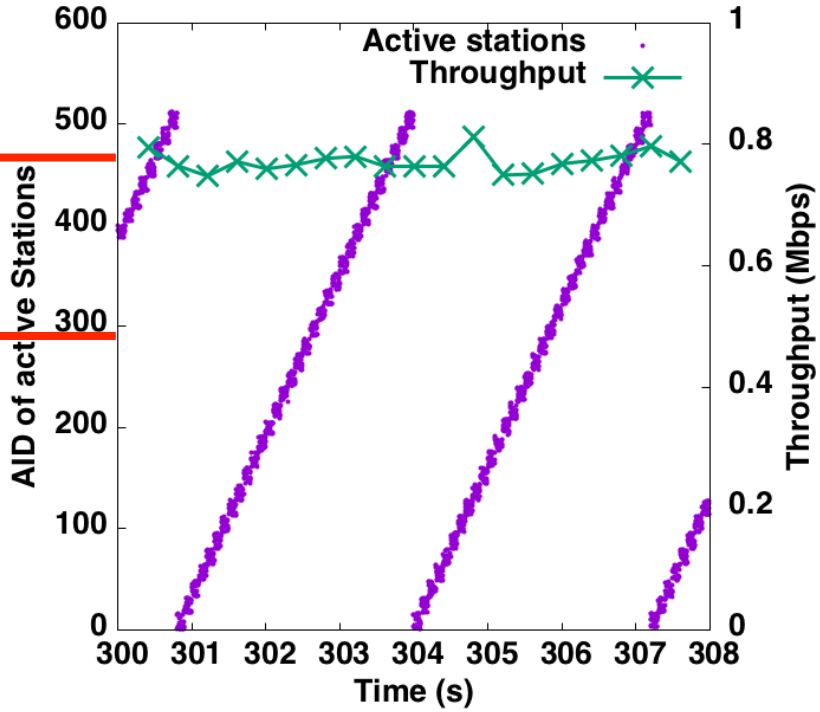
Restricted Access Window (RAW)



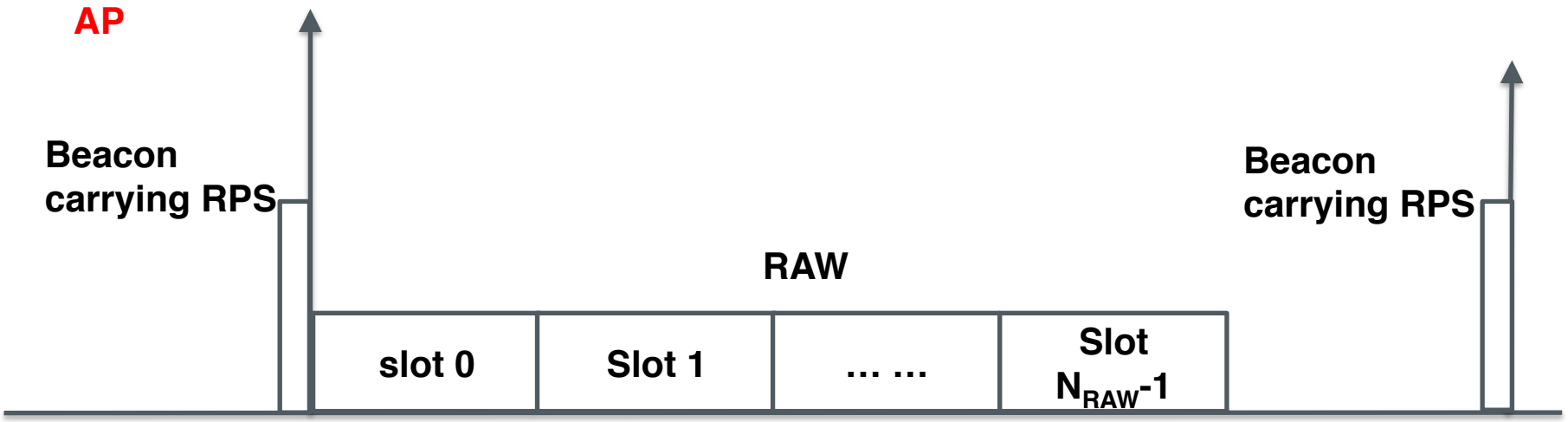


Without RAW

50%



32 RAW slots



Station 1, assigned to RAW slot 1

Station 2, not belongs to current RAW group

Two stage backoff of RAW

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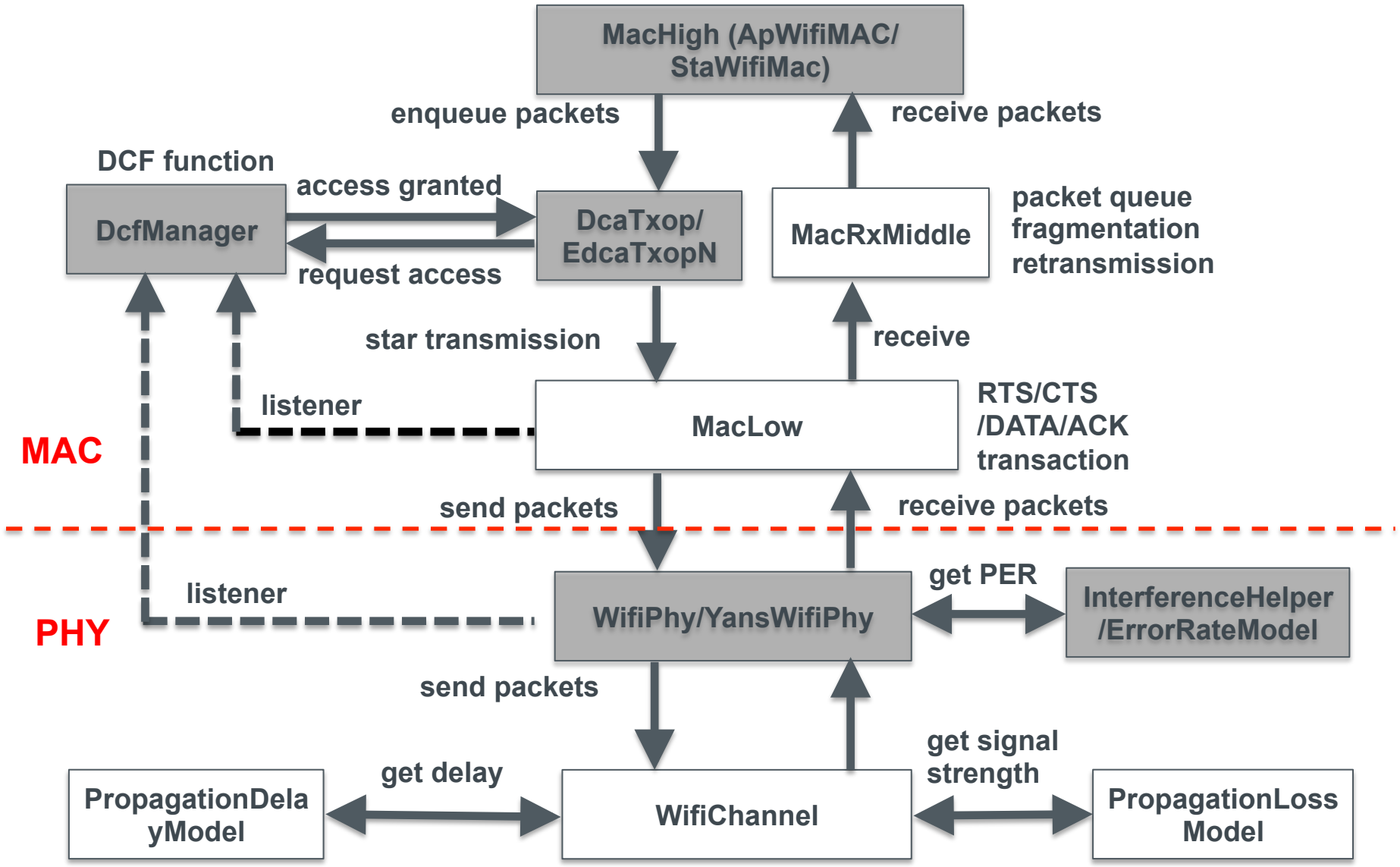
PHY and MAC implementation in ns-3

- Physical layer
  - MCS0~10 modulation/coding schemes for bandwidths 1—16Mhz

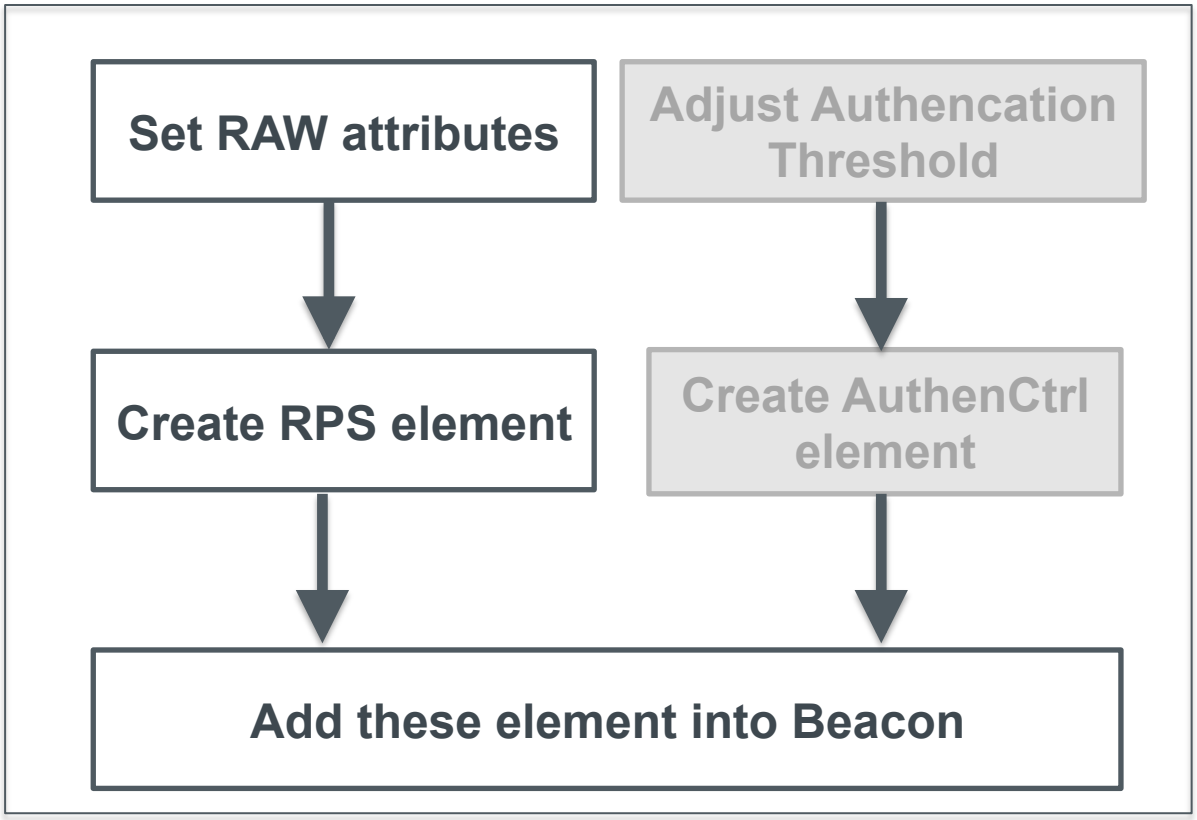
- MAC layer
  - Association ID (AID) assignment
  - Fast association mechanism
  - Restricted access window (RAW)

Source code: https://github.com/MOSAIC-UA/802.11ah-ns3

ns-3 wifi model



RAW related modules in AP side

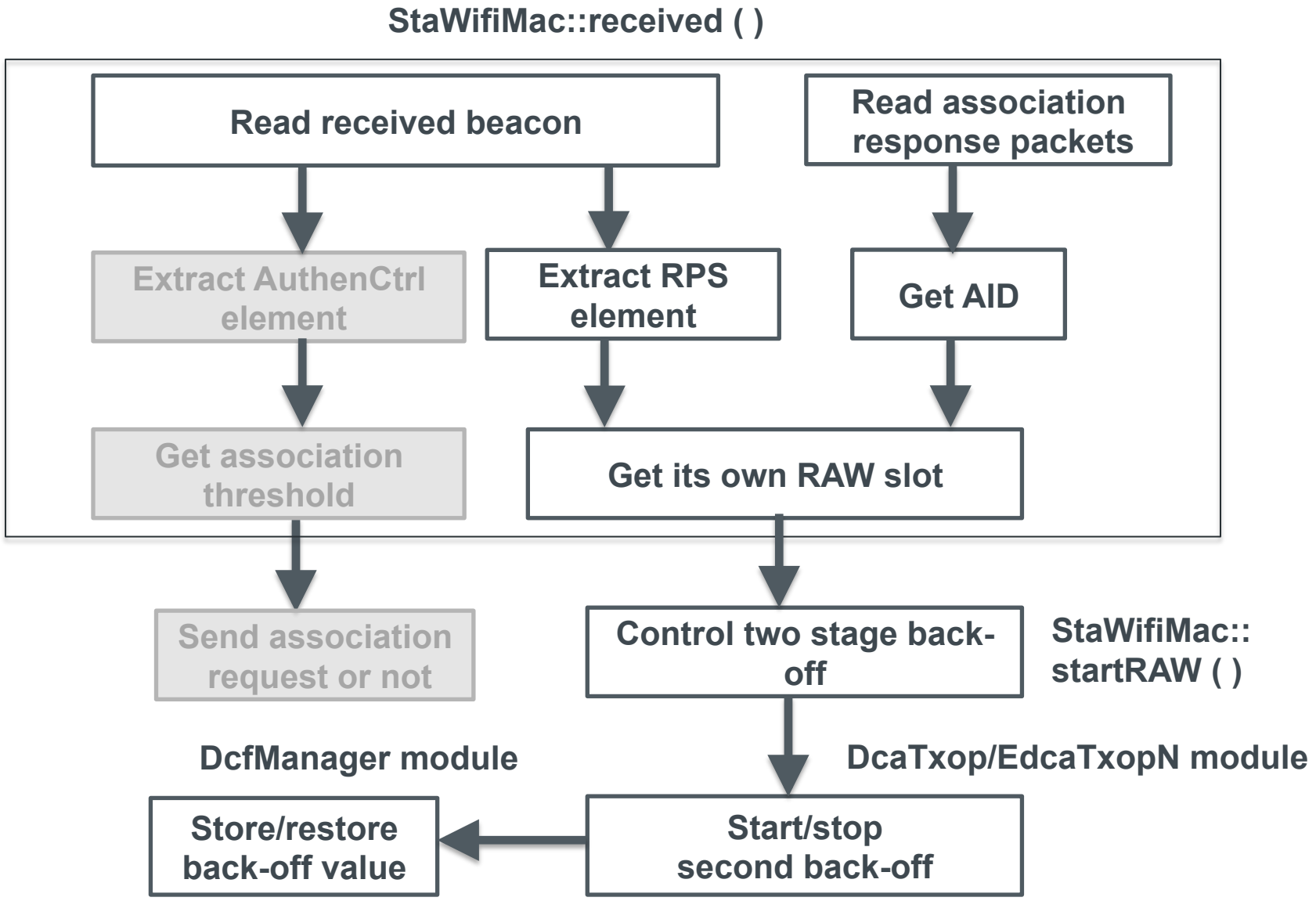


SendOneBeacon ( )

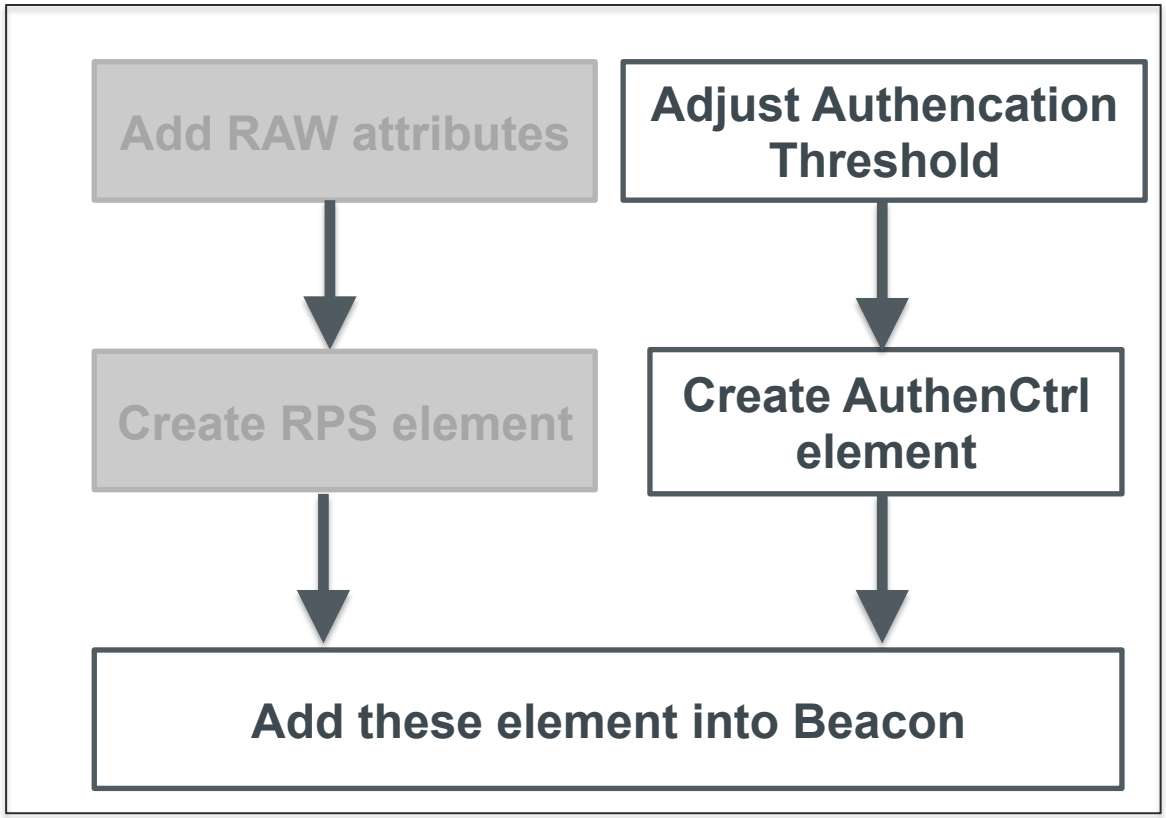
Assign AID to stations

SendAssocResp ( )

RAW related modules in station side



Fast association related modules in AP side

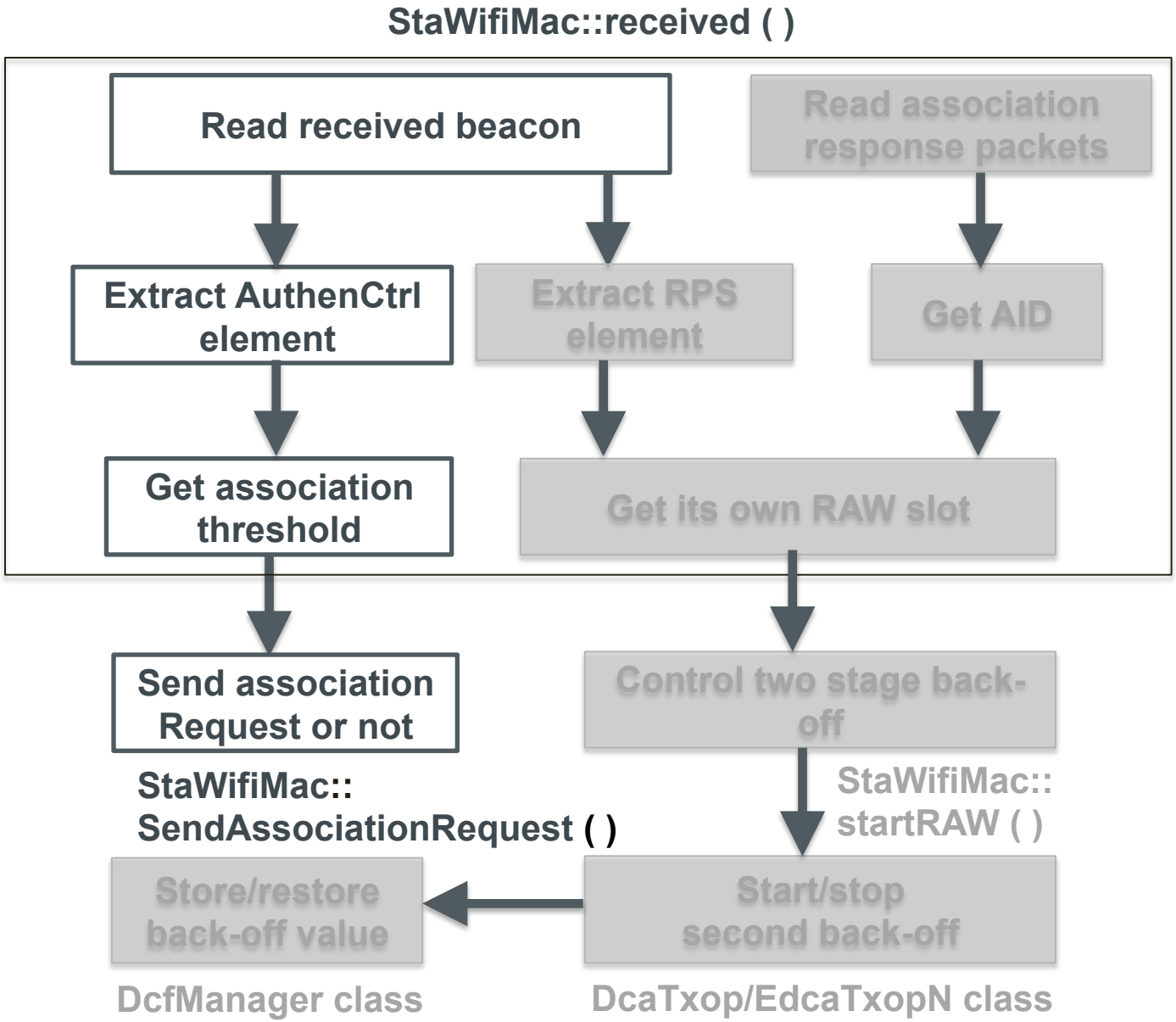


SendOneBeacon ( )

Assign AID to stations

SendAssocResp ( )

Fast association related modules in station side



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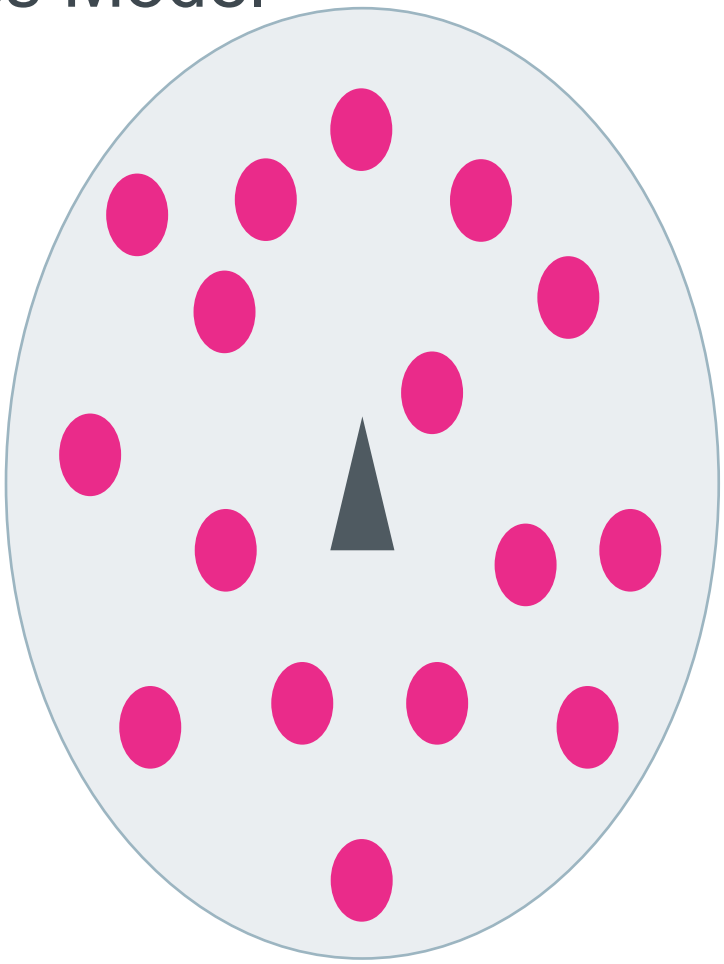
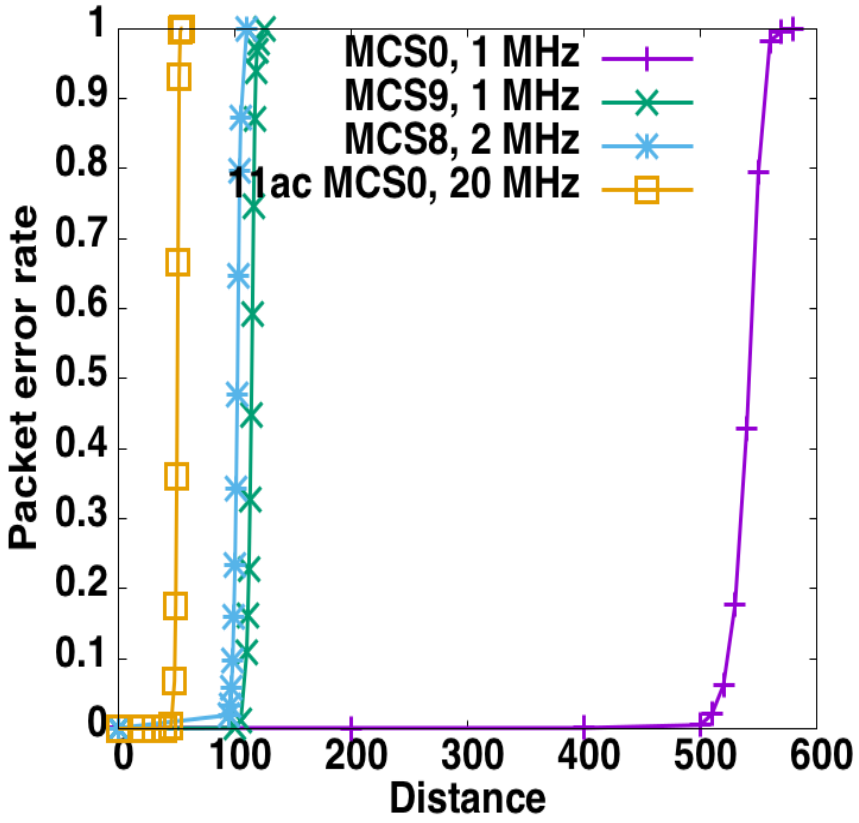
Simulation setup

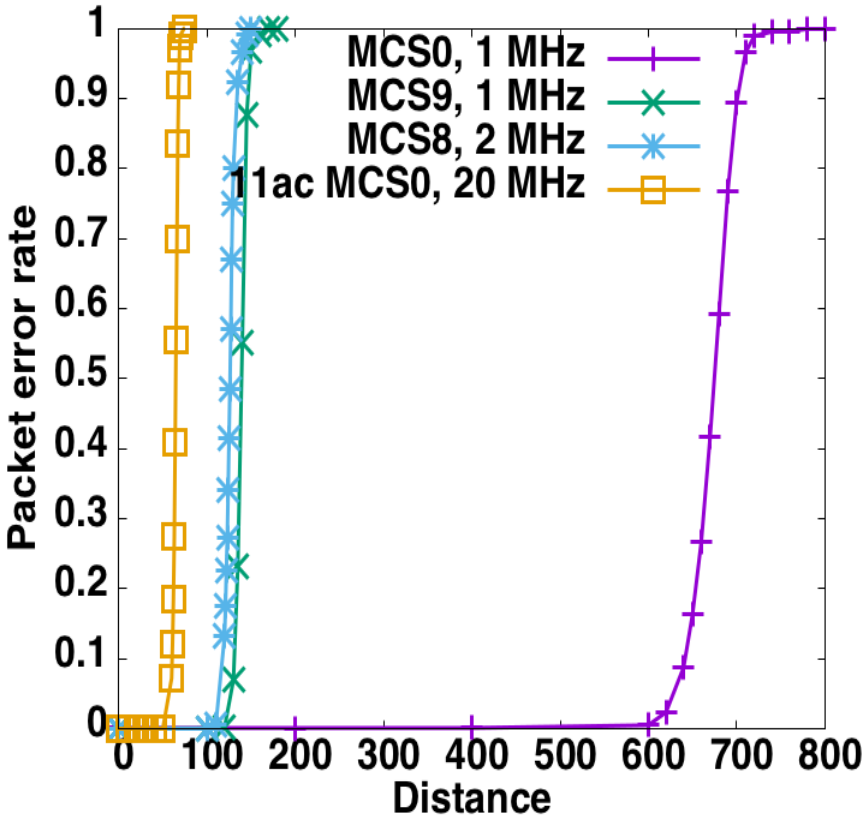
- STAs randomly placed around the AP
- Log Distance Propagation Loss Model
- Constant rate model
- Variables
  - Number of STA
  - Traffic load
  - Number of RAW groups(slots)
- Metrics
  - Throughput
  - Latency



Path loss with different range



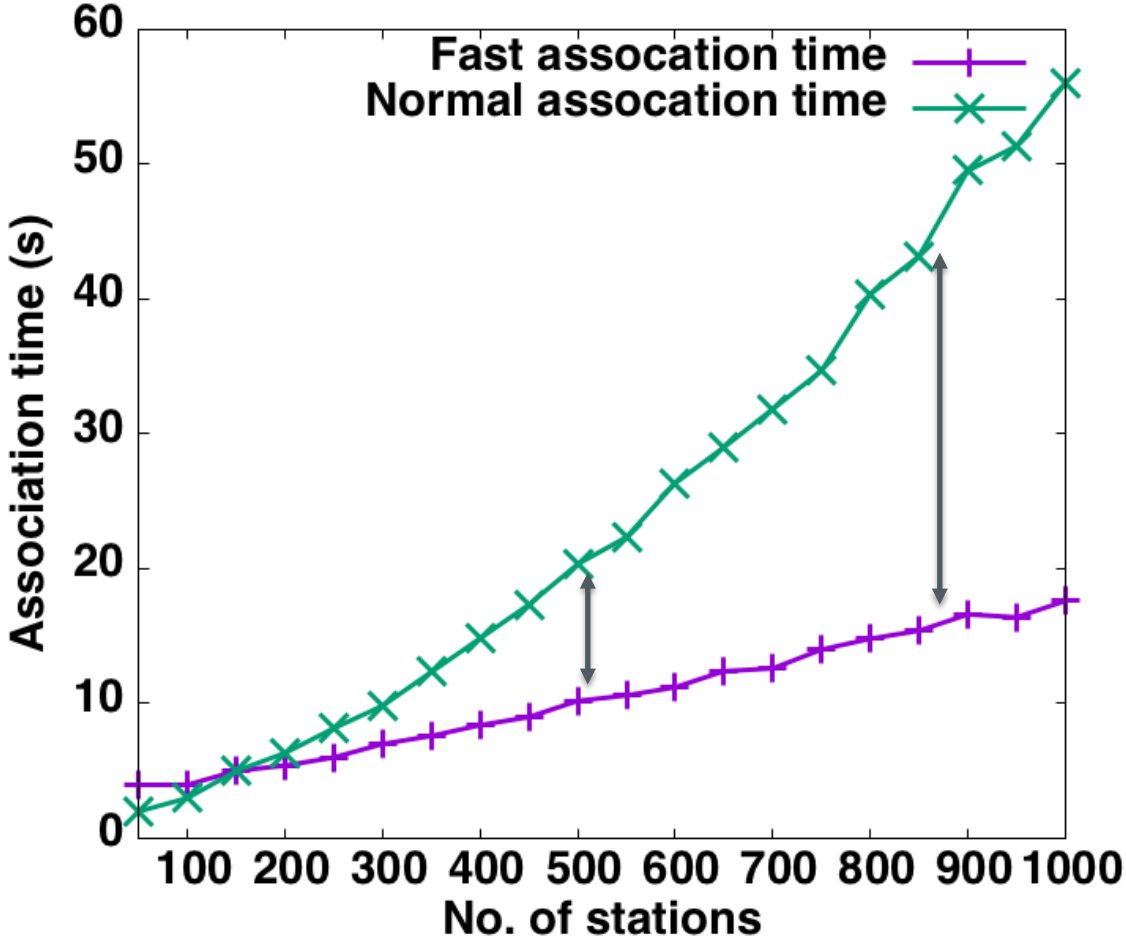
NistErrorRate Model



YansErrorRate Model

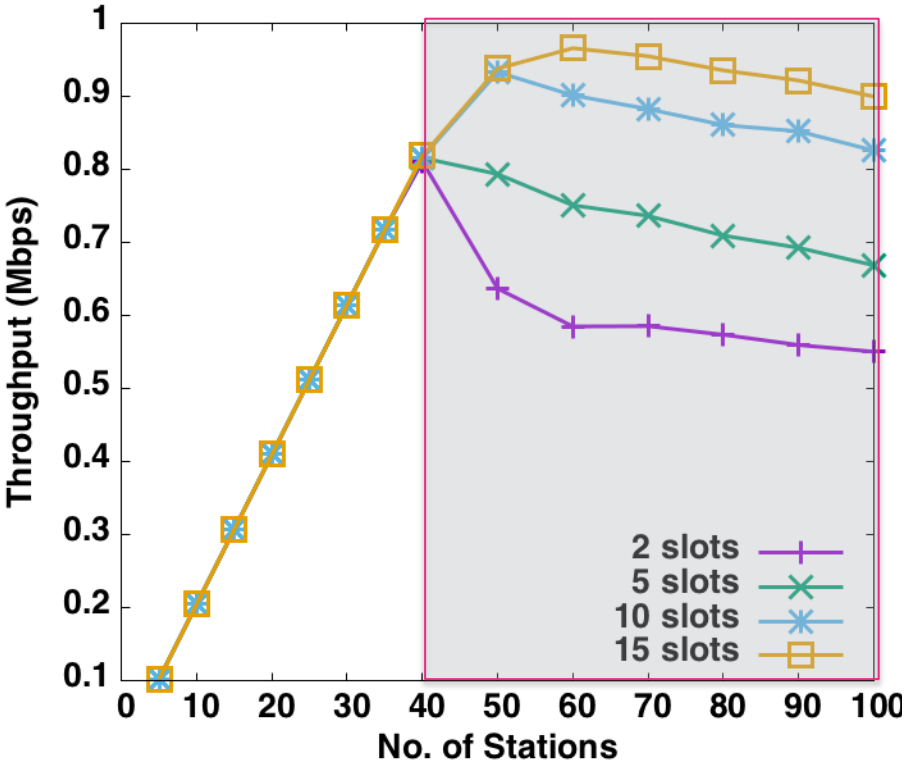
Date rate model MCS10, 1 MHz need to be implemented

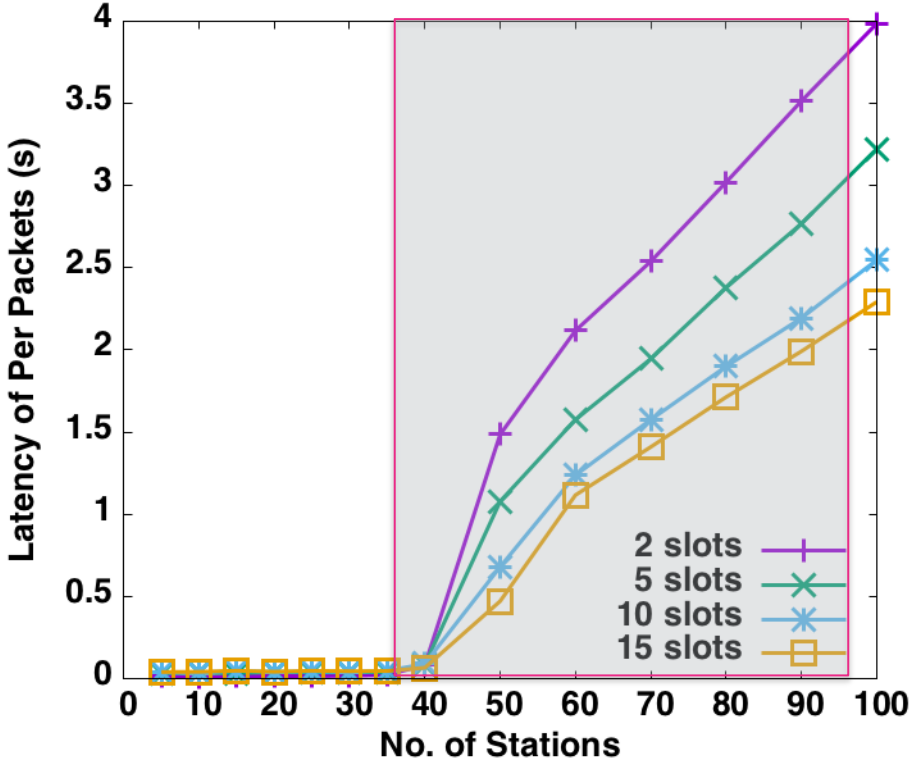
Fast association VS normal association



Fast association scales better as number of stations increase.

Performance of various RAW slots numbers (one RAW group)

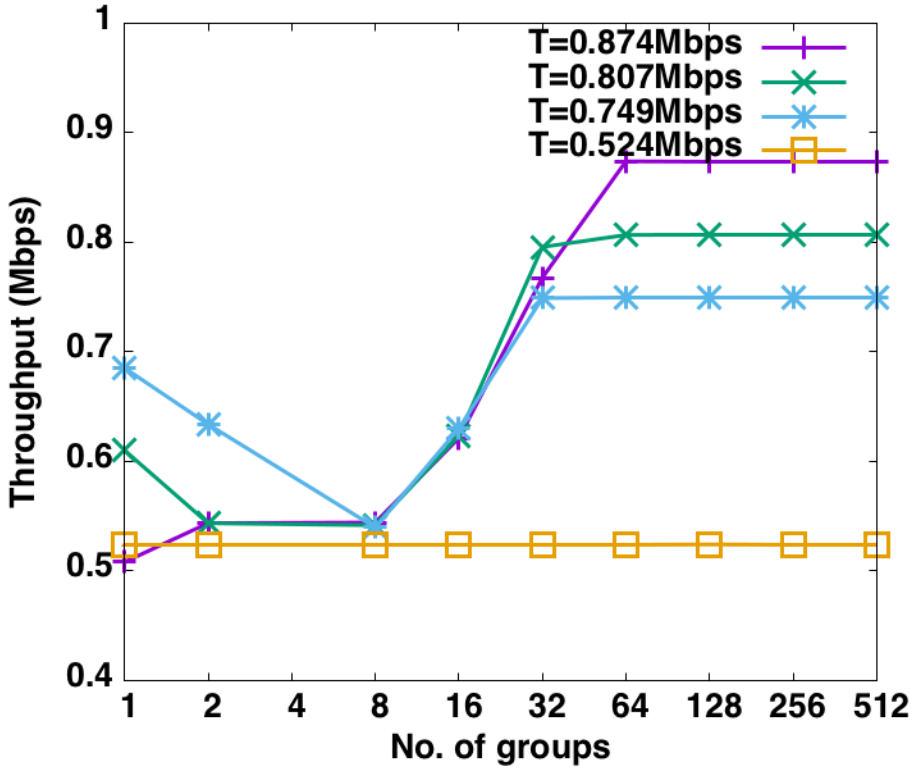




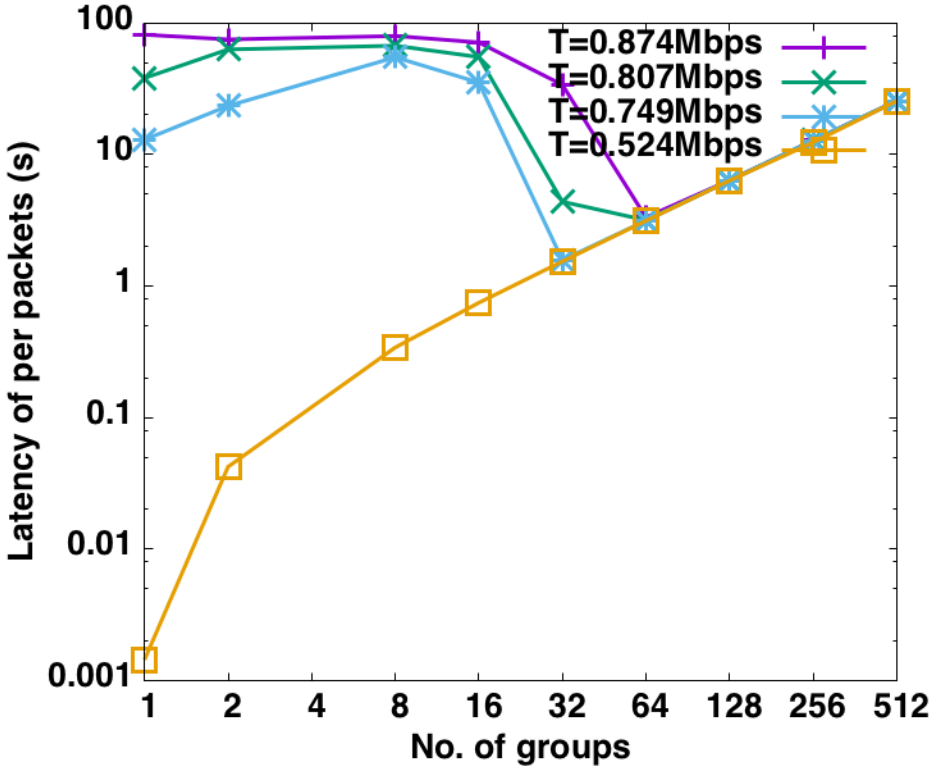
Queue of 10 packets

For **large scale/traffic** network, larger number of RAW slots performs better in terms of throughput and latency.

Performance of various RAW groups



RAW results in bigger gain at higher traffic loads.



Many RAW groups is catastrophic for latency.

L. Tian, J. Famaey, and S. Latre. Evaluation of the ieee 802.11ah restricted access window mechanism for dense iot networks. WoWMoM, June 2016.

Simulation results summary

- Fast association scales better as number of stations increase.
- RAW achieves better performance for large scale/traffic load.
- Optimal RAW groups determined by
  - metric (throughput, latency)
  - traffic load，station number
- RAW optimization algorithm needed !