Cisco Cooperative Project

Start Recording

Coexistence Evaluation of WiFi and LAA

Student: Li Li
Advisors: Len Cimini, Chien-Chung Shen

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Outline

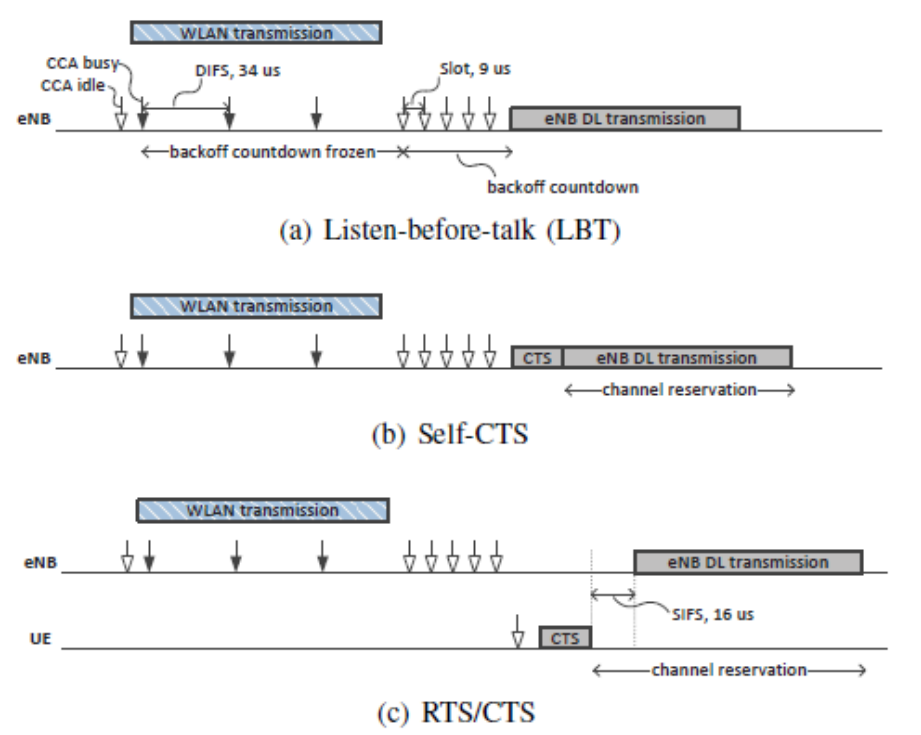
- Discussion on Proposal 2016
- Papers about LAA and 802.11ax
- Adaptive Threshold: Collisions

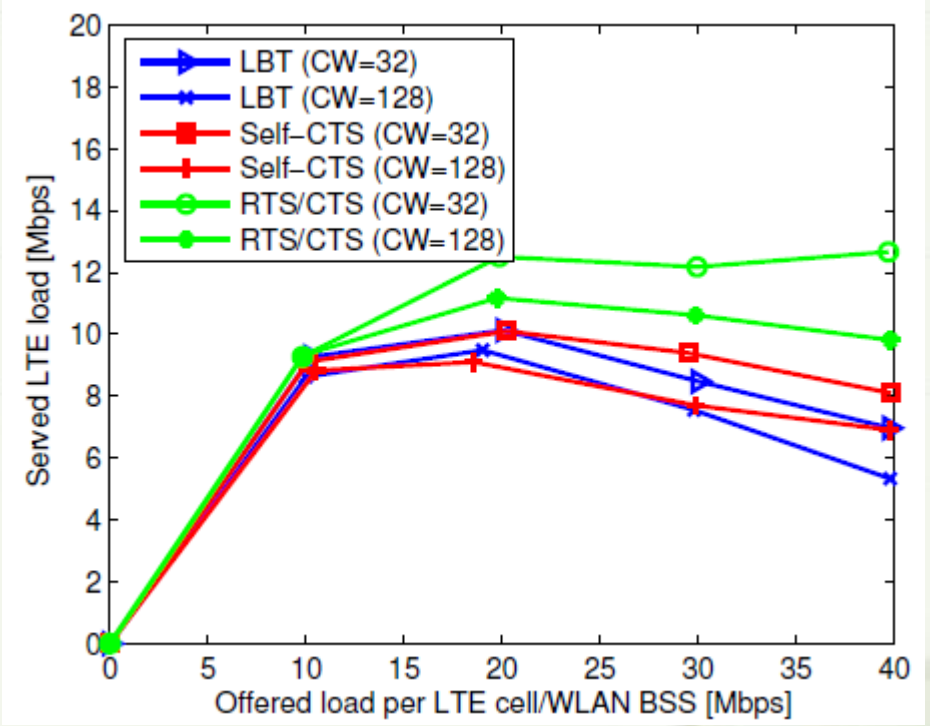
Discussion on Proposal 2016

- Multi-channel: channel selection, coverage *vs* throughput
- Multi-user beamforming: interference avoidance, imperfect CSI?
- Standalone LAA: uplink transmission
- 802.11ax: MAC design, dynamic sensitivity control with LAA

Papers about LAA and 802.11ax

❖ LAA with RTS/CTS



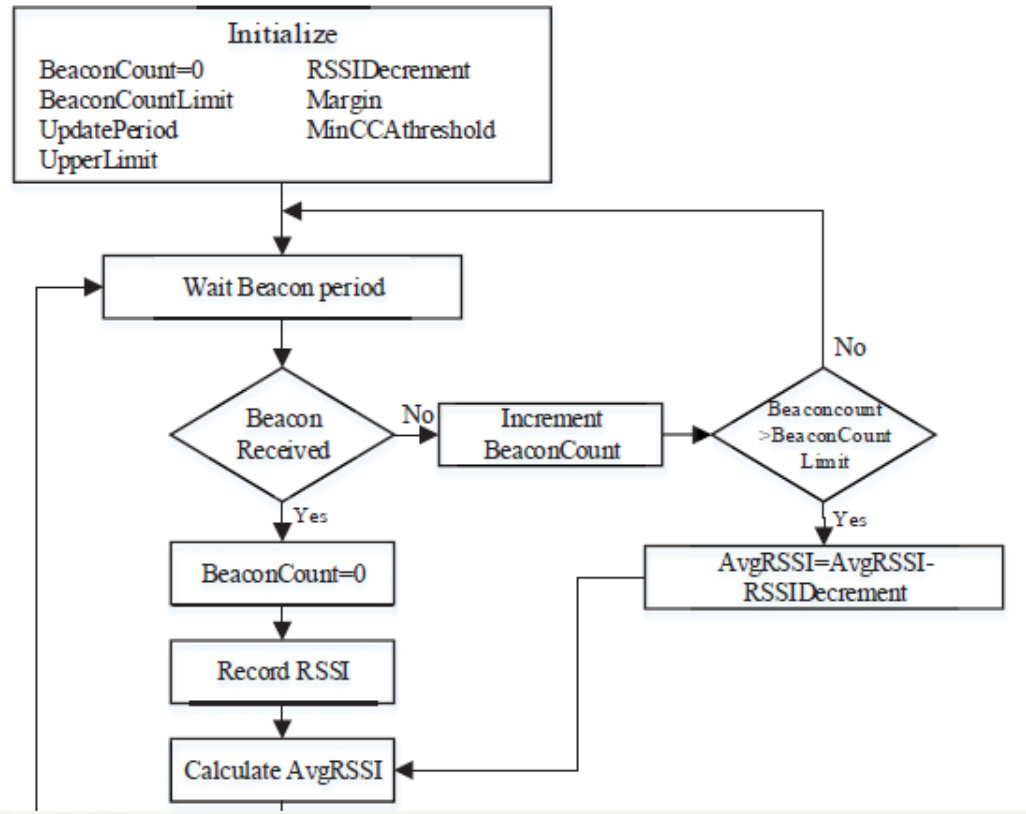


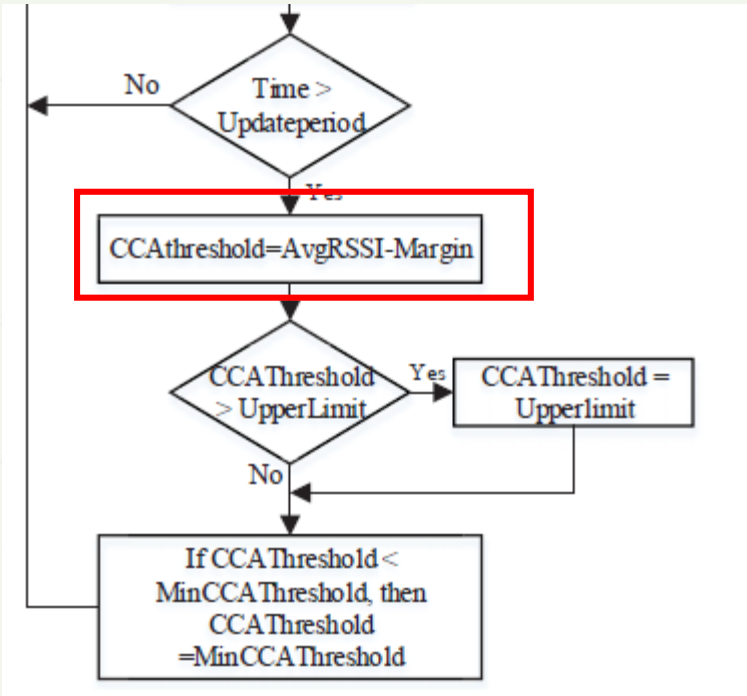
✓ RTS/CTS method can be a reference for comparison.

[1] J. Jeon, H. Niu, Q. C. Li, A. Papathanassiou, and G. Wu, "LTE in the unlicensed spectrum: Evaluating coexistence mechanisms," in IEEE Globecom Workshops, pp. 740-745, Dec. 2014.

Papers about LAA and 802.11ax

- 802.11ax with dynamic sensitivity control (based on SINR, per user)





- ✓ If both 802.11ax and LAA support adaptive ED, maybe the system performance can be further improved.

[1] M. S. Afaqui, E. G. Villegas, E. L. Aguilera, G. Smith, D. Camps, “Evaluation of Dynamic Sensitivity Control Algorithm for IEEE 802.11ax,” in IEEE WCNC 2015.

Papers about LAA and 802.11ax

- 802.11ax. CSMA with deterministic backoff

```
1  while the device is on do
2      r ← 0; s ← 0;
3      b ← U[0, 2^s CW_min − 1];
4      while there is a packet to transmit do
5          repeat
6              while b > 0 do
7                  wait 1 slot;
8                  b ← b − 1;
9              Attempt transmission of 1 packet;
10             if collision then
11                 r ← r + 1;
12                 s ← min(s + 1, S);
13                 b ← U[0, 2^s CW_min − 1];
14         until (r = R) or (success) ;
15         r ← 0;
16         s ← 0;
17         if success then
18             b ← U[0, 2^s CW_min − 1];
19         else
20             Discard packet;
21             b ← U[0, 2^s CW_min − 1];
22     Wait until there is a packet to transmit;
```

Algorithm 1: CSMA/CA

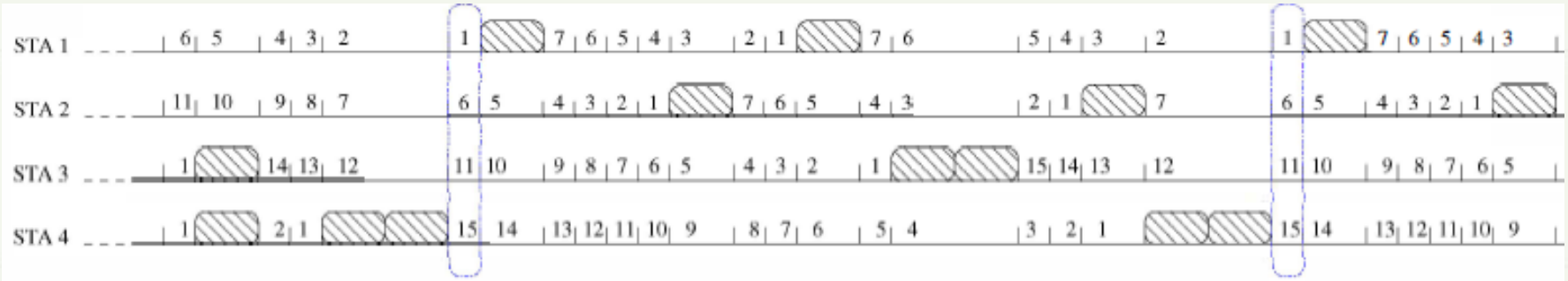
```
1  while the device is on do
2      r ← 0 ; s ← 0;
3      b ← U[0, 2^s CW_min − 1];
4      while there is a packet to transmit do
5          repeat
6              while b > 0 do
7                  wait 1 slot;
8                  b ← b − 1;
9              Attempt transmission of 2^s packets;
10             if collision then
11                 r ← r + 1;
12                 s ← min(s + 1, S);
13                 b ← U[0, 2^s CW_min − 1];
14         until (r = R) or (success) ;
15         r ← 0;
16         if success then
17             b ← (2^s CW_min)/2 − 1;
18         else
19             Discard packet;
20             b ← U[0, 2^s CW_min − 1];
21     Wait until there is a packet to transmit;
```

Algorithm 4: CSMA/ECA with hysteresis and fair-share

[1] L. S. Russo, A. Faridi, B. Bellalta, J. Barcelo, M. Oliver, "Evaluation of Dynamic Sensitivity Control Algorithm for IEEE 802.11ax," in IEEE ICC 2013.

Papers about LAA and 802.11ax

- 802.11ax, CSMA with deterministic backoff



- ✓ No collisions when each node is within the coverage area of the others?
- ✓ What about the case of multiple APs or mixed WiFi/LAA networks?

[1] L. S. Russo, A. Faridi, B. Bellalta, J. Barcelo, M. Oliver, "Future Evolution of CSMA Protocols for the IEEE 802.11 Standard," in IEEE ICC 2013.

Adaptive Threshold: Collisions

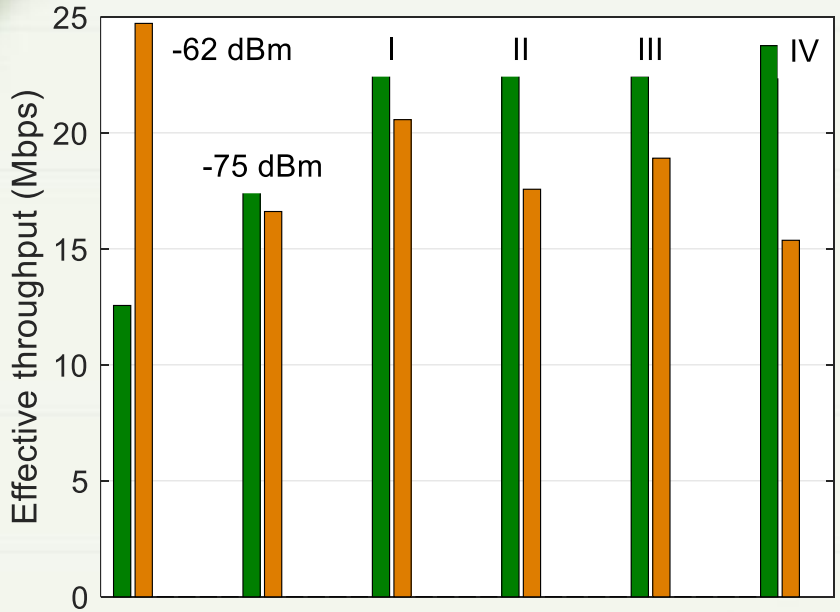
- Simulation Setting
  - ✓ 4 APs, 4 eNBs, and each AP/eNB has five users
  - ✓ FTP file size: 0.5 Mbytes, Poisson process: lambda = 2.5
  - ✓ One LAA eNB serves different UEs one by one.
  - ✓ Modulation-coding-scheme

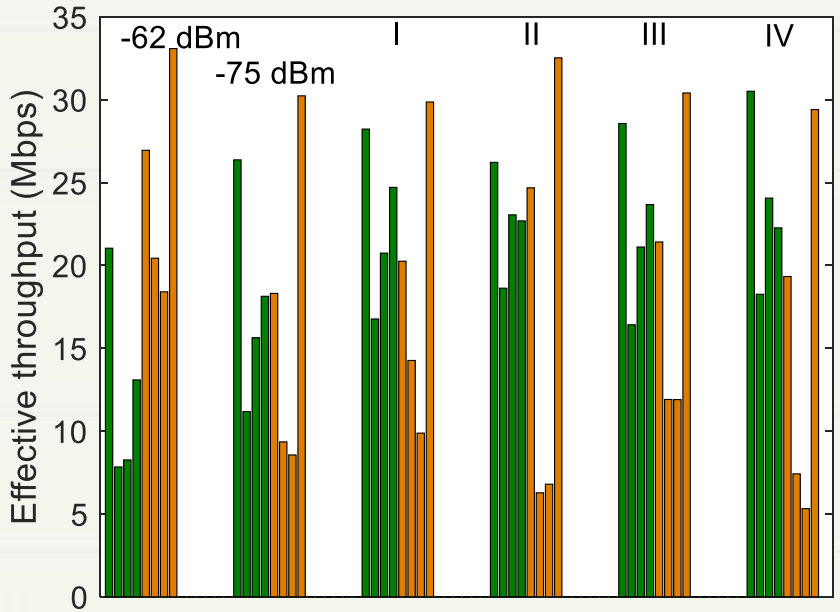
Modulation type	Coding Rate	AC SNR	LTE SNR	AC throughput	LTE throughput
QPSK	1/2	5	2.0	14.4	16.8
QPSK	3/4	9	5.5	21.7	25.2
16-QAM	1/2	11	7.9	28.9	33.6
16-QAM	3/4	15	12.2	43.3	50.4
64-QAM	2/3	18	15.3	57.8	67.2
64-QAM	3/4	20	17.5	65	75.6

Adaptive Threshold: Collisions

- According to collisions (per user)
  - ✓ All LAA eNBs begin with a high ED (-62 dBm) for all users
  - ✓ If collision happens to one user, certain eNBs decrease their ED by 1 for this user.
  - ✓ After a certain period, all EDs go back to -62 dBm.
- "Case I": LAA adopts "RTS/CTS" to avoid collisions. (For comparison)
- "Case II": certain eNBs: those who cause collisions (#2 and #6 in the example).
- "Case III": certain eNBs: the one who suffer from collision (#4 in this example).
- "Case IV": certain eNBs: neighbor eNBs (#2 and #6 in the example).

Adaptive Threshold: Collisions





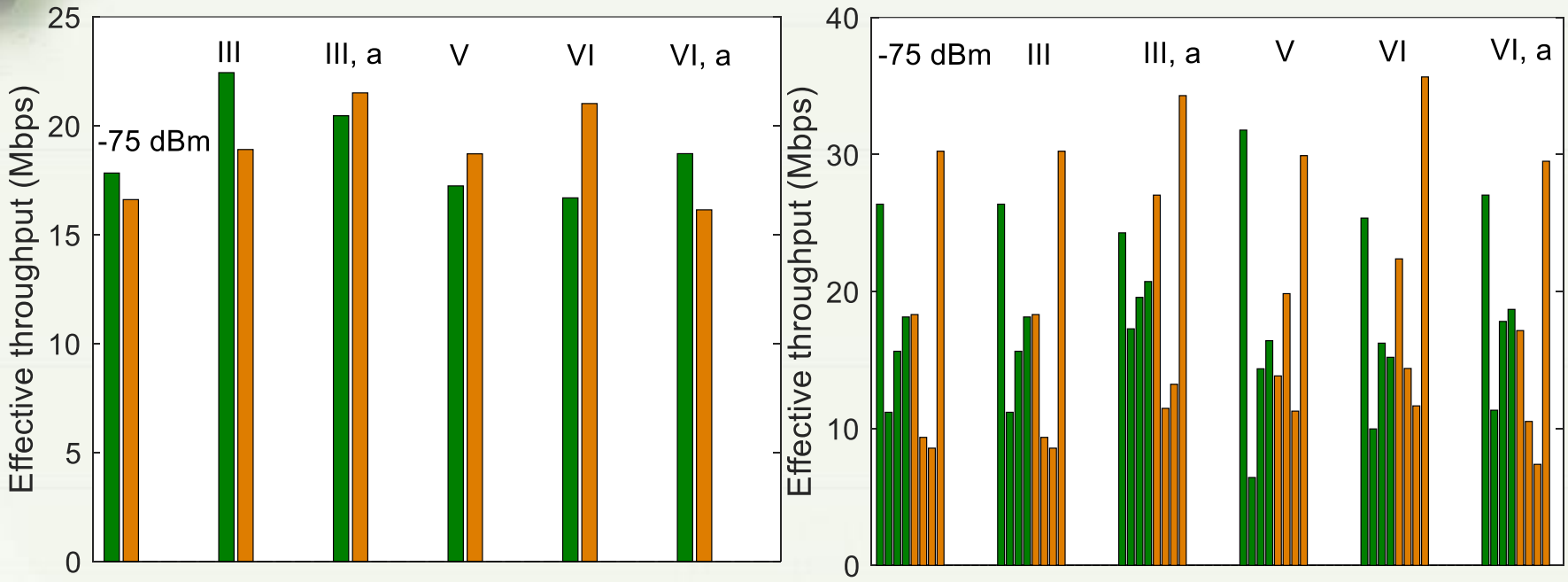
- ✓ Case III achieves a pretty good performance.
- ✓ “Decreasing by 1” for each collision is too much for LAA.

Adaptive Threshold: Collisions

- According to collisions (per base station), Case V
  - ✓ All LAA eNBs begin with a high ED (-62 dBm)
  - ✓ If the number of collisions happens to one user is larger than 3, its associated LAA eNB decrease its ED by 1
  - ✓ After a certain period, all EDs go back to -62 dBm.

- According to collisions (per base station), Case VI
  - ✓ All LAA eNBs begin with a high ED (-62 dBm)
  - ✓ If collision happens to one user, its associated LAA eNB decrease its ED by 1/5 (the average ED in Case III)
  - ✓ After a certain period, all EDs go back to -62 dBm.

Adaptive Threshold: Collisions



- ✓ "Case III, a": If the number of collisions happens to one user is larger than 3, its associated eNB decrease the ED by 1 for this user.
- ✓ "Case VI, a": the initial LAA ED is set to -70 dBm.
- ✓ "Case VI" and "Case VI, a" can also improve the performance, but not as much as the per user case.

Next Step

- Work on the “per base station” case
- Study the channel selection problem in the multi-channel case