Cisco Cooperative Project

Survey of LTE and Wi-FI Co-existence in Unlicensed Band

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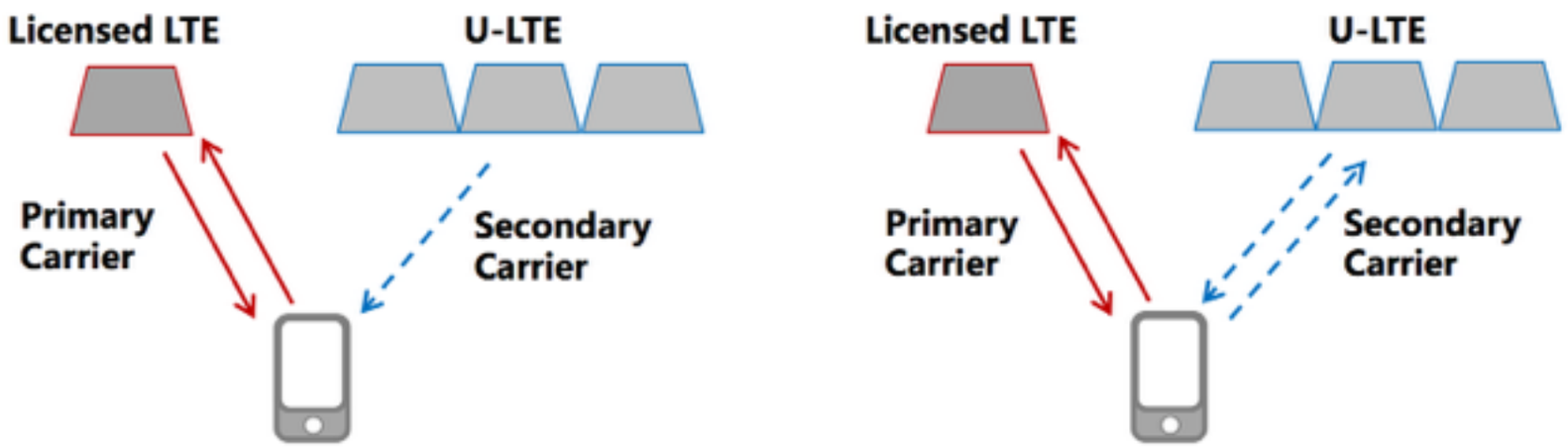
What is LTE-based Unlicensed Carrier Offloading?

As a secondary carrier, U-LTE is integrated to LTE licensed Network

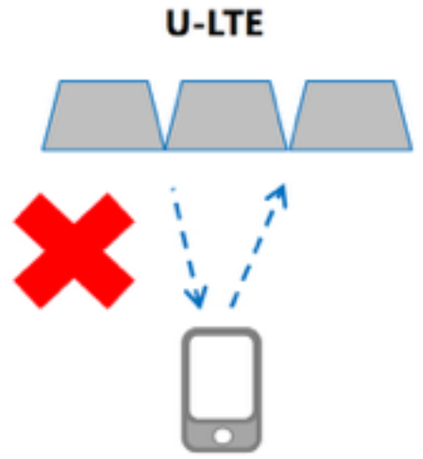
Non-Standalone



Carrier Aggregation into Licensed LTE

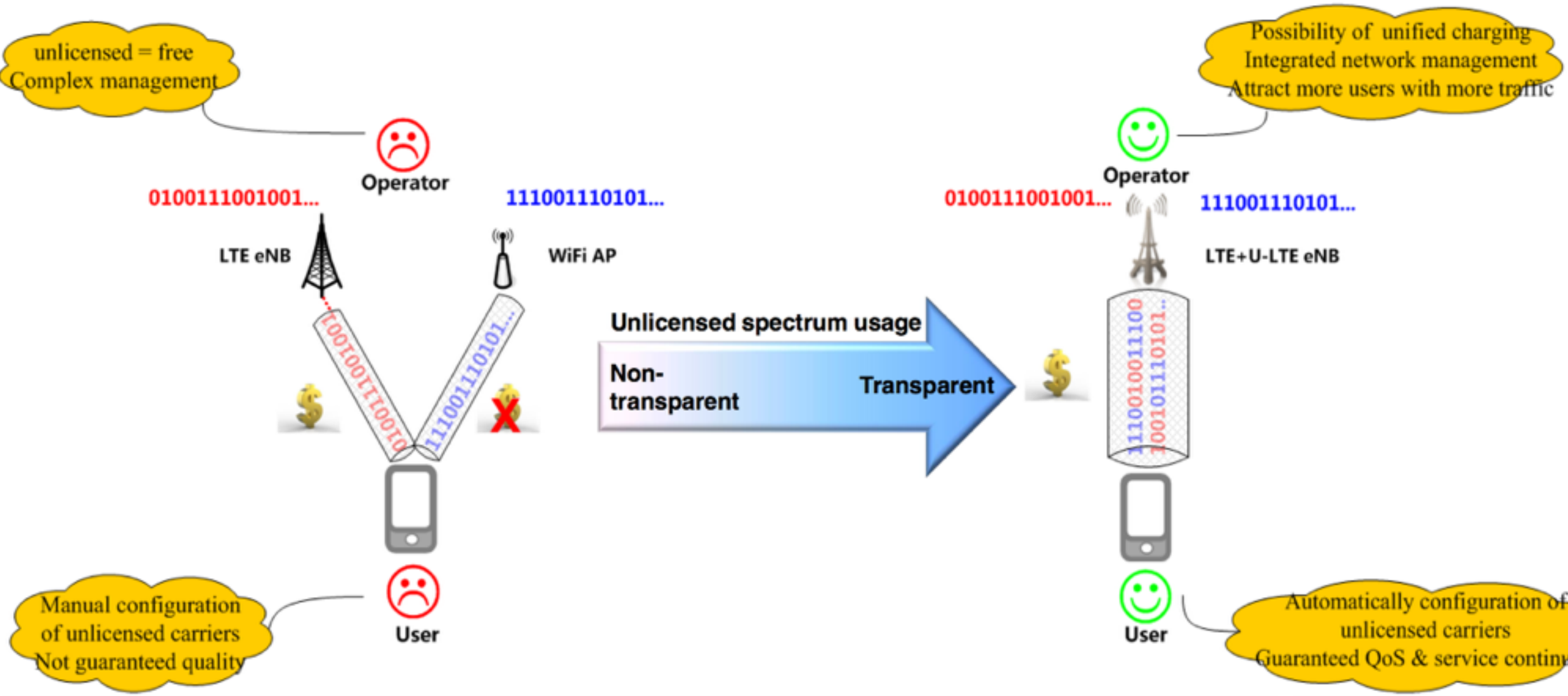
Controlled by Operator Network

Standalone



Without Licensed LTE, U-LTE will lose these advantages

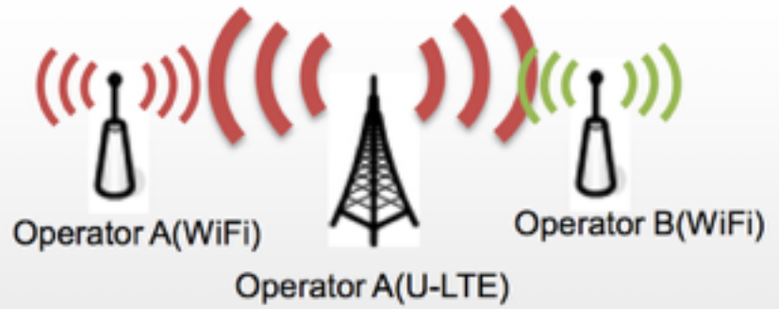
Easy and transparent usage of unlicensed spectrum



Co-existence Issue of Unlicensed LTE

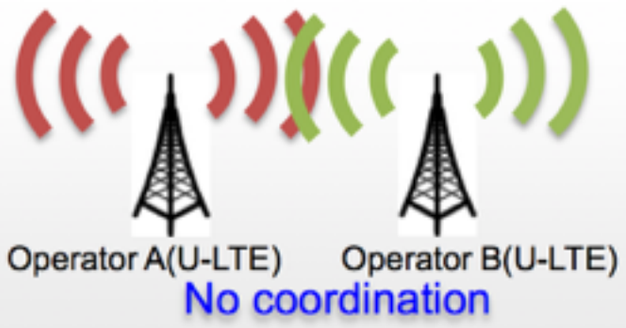
U-LTE & WiFi Co-existence

- Intra-operator with planned deployment:
  - Inter-site isolation among U-LTE & WIFi
  - Co-site: Potential in-device co-existence can be avoided by coordinated scheduling
- Inter-Operator & Intra-operator independent deployment of U-LTE and WiFi:
  - Ensure the accessibility of existing WiFi APs similar level of inter-opertor WiFi to WiFi coexistence



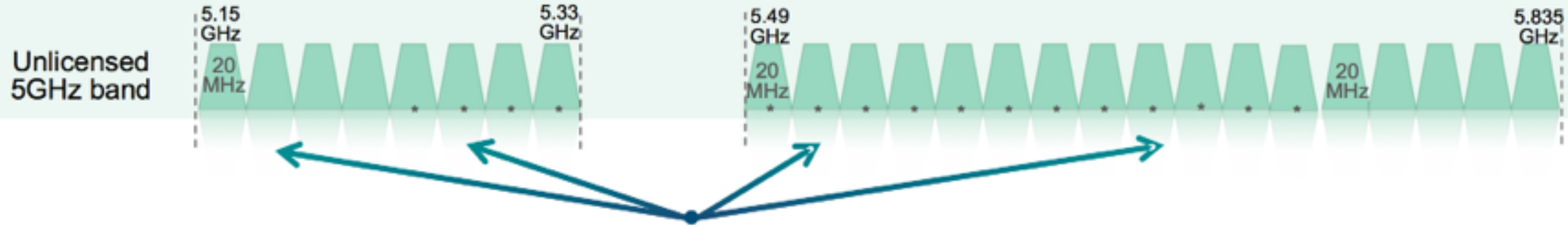
U-LTE & U-LTE Co-existence

- Intra-operator:
  - Controlled by LTE licensed
- Inter-Operator:
  - Each operator has the equal right to access the unlicensed spectrum
  - No inter-operator coordination and independent deployment



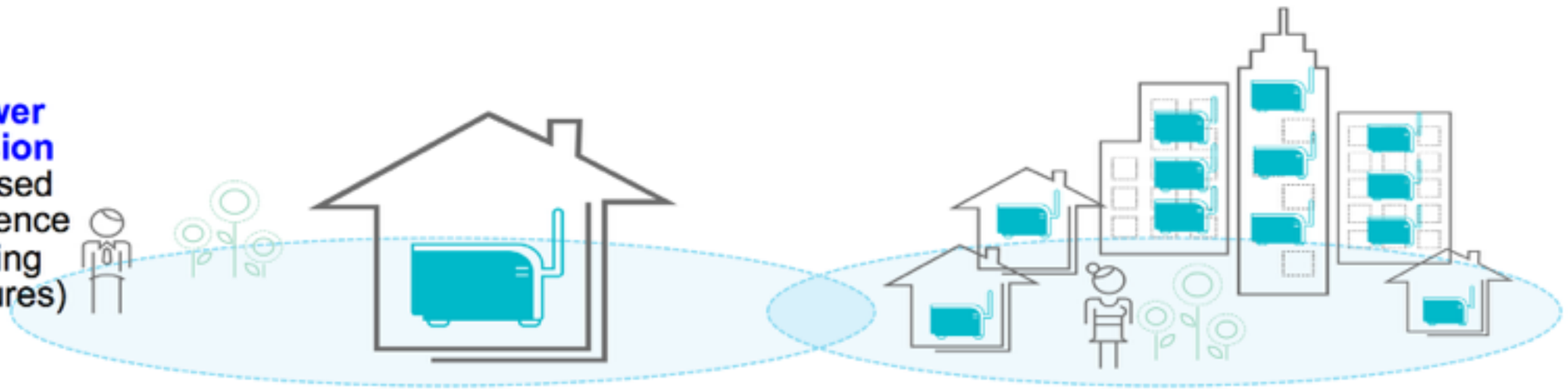
Wi-Fi coex based on channel selection & power adjustment

- Coexistence mechanisms based on existing protocol features



Dynamic channel selection based on interference
(Small cell chooses LTE-U channel based on unlicensed channel RSSI)

Adjust transmit power and **adapt transmission opportunistically** based on load to limit interference to other users (by using existing standard features)



Observations:

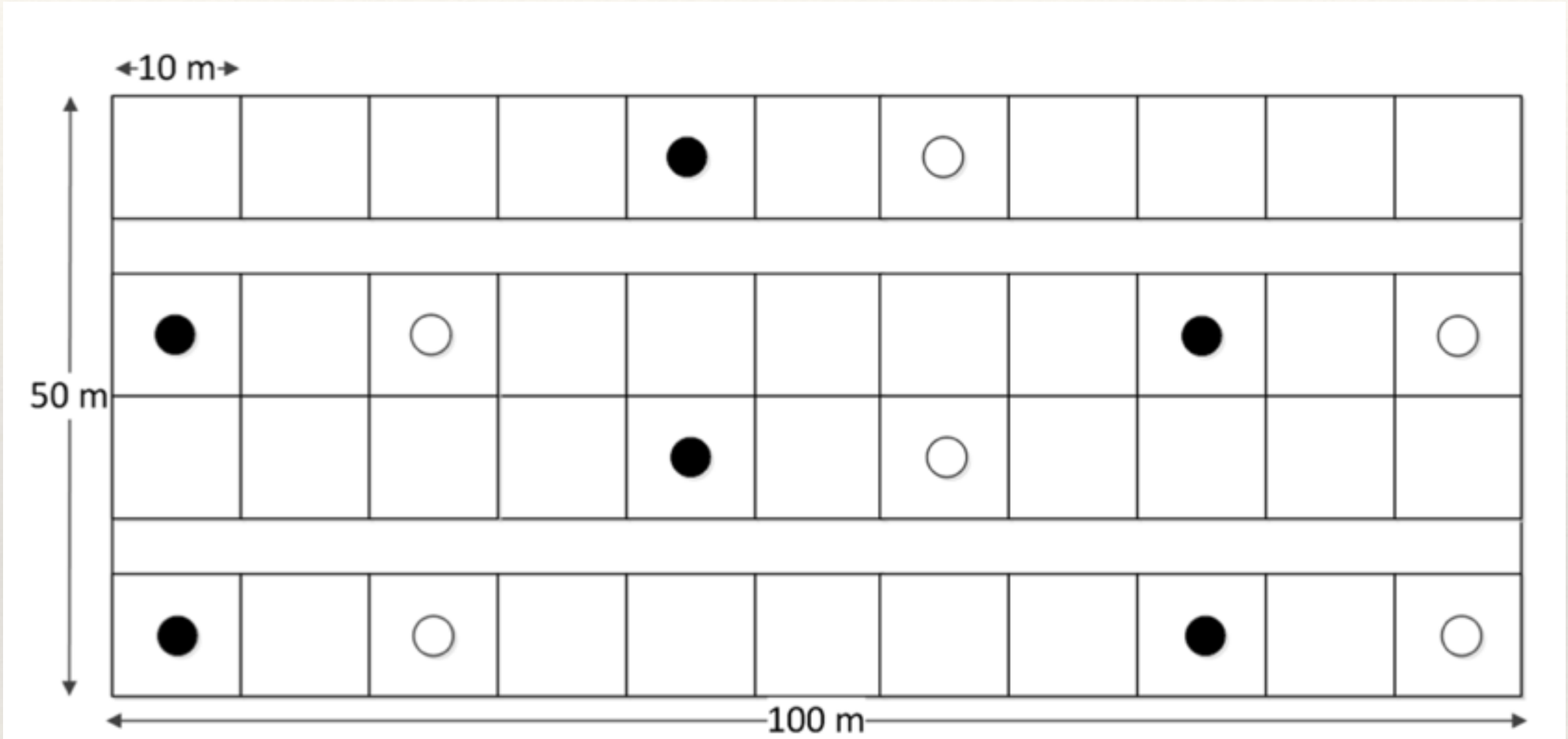
LTE – 802.11 WLAN could interfere each other

- In some deployment configurations, WLAN's CCA sensing can not detect the presence of LTE eNB, which leads to LTE DL performance degradation.
  - When RTS/CTS is not enabled in WLAN (e.g. in small packet size transmission), the impact to LTE DL performance will be more severe;
  - LTE's continuous DL transmission degrades WLAN performance.

Muting-Pattern

- To allow WLAN a chance to transmit, LTE presence is limited on the bandwidth by allocating only a fraction of the time for it
- Nokia [1] uses muting pattern to evaluate how to lower the LTE-U impacts on Wi-Fi performance
- Prevent transmission during ***n*** out of 5 *Transmission Time Intervals (TTI)*
  - $n \in [0, 1, 2, 3, 4, 5]$
  - 0 meaning LTE ***allow*** to transmit all the TTI
  - 5 meaning LTE ***disallow*** to transmit data in TTI

Simulation Scenario



LTE eNodeBs (black) and WLAN APs (white)

Simulation Common Parameters

Parameter	Value
Simulation time ($T_{simulation}$)	70 s (avg)
Traffic direction	Downlink
Transport protocol	UDP
Traffic application	File transfer
Max. PDU Size	1500 bytes
File size	2 Mbytes
Call arrival	Poisson distributed
User mobility	Static
Signal propagation	Indoor-COST 231 [10]
Antenna pattern (AP/eNB/MT)	Omni-directional

Simulation WLAN Parameters

Parameter	Value
802.11 version	ac
Bandwidth	20 MHz
Tx power (AP & MT)	20 dBm
RTS/CTS	Enabled
TXOP limit	2 ms
Min CW	15
Max CW	63

Simulation LTE Parameters

Parameter	Value
Bandwidth	20 MHz (DL)
Mode	FDD
Tx power	20 dBm
Scheduler (Time / Frequency Division)	PF/PF
Max. scheduled users (TD/FD)	20/20

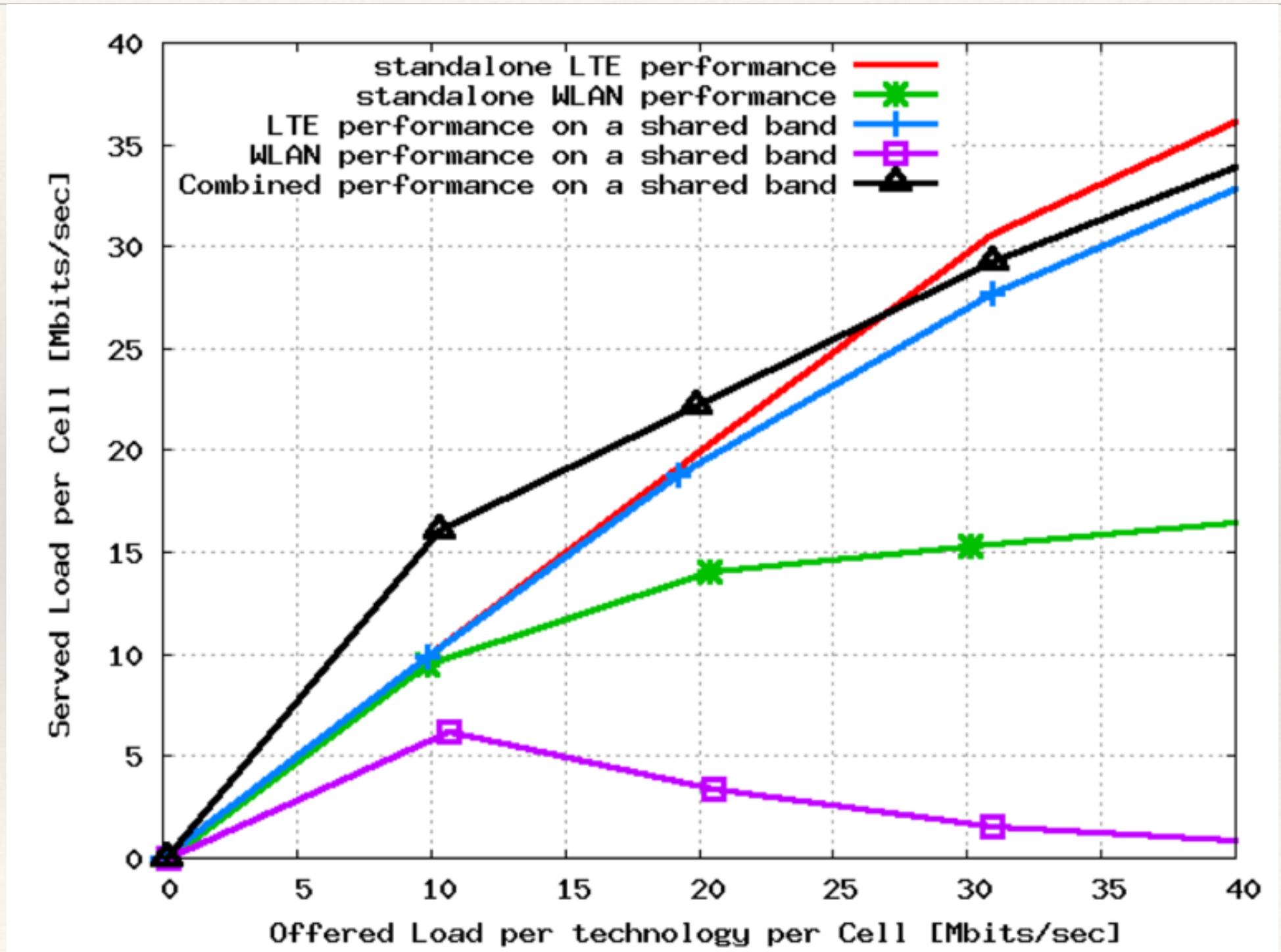
Conclusions

- It was shown that the co-existence has a negative impact on WLAN system performance
- But the severity of the impact can be controlled by restricting LTE activity (Muting)
- In the situation where a lot of WLAN users try to access the network at the same time, the users may spend a long time in backoff while the medium is idle
- **If** LTE could exploit these silent times the WLAN performance would not necessarily degrade but instead the bandwidth utilization efficiency could increase and thus also the total combined system throughput

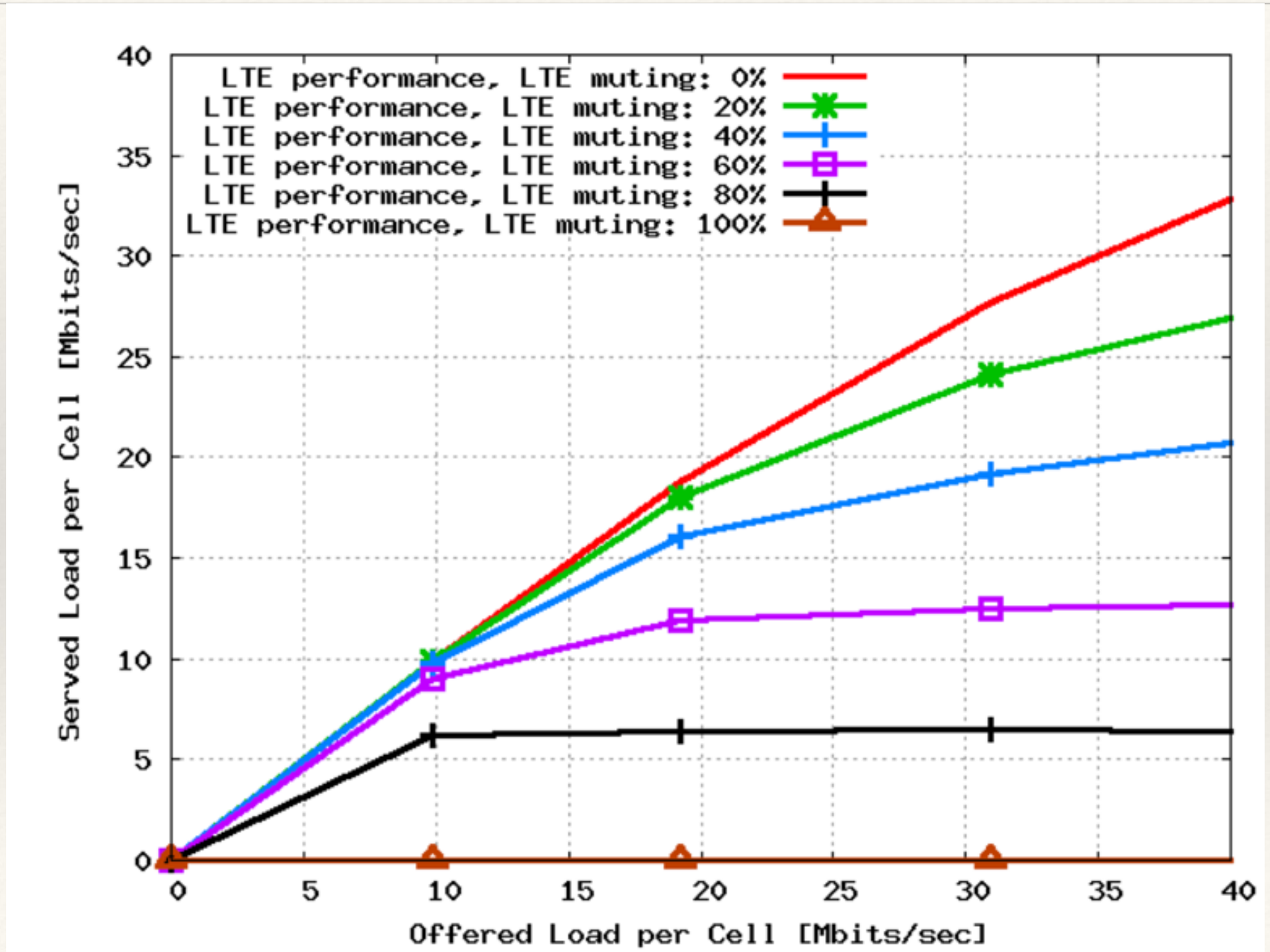
➢ ***Future research is needed in order to find sophisticated co-existence handling algorithms***

Simulation Result

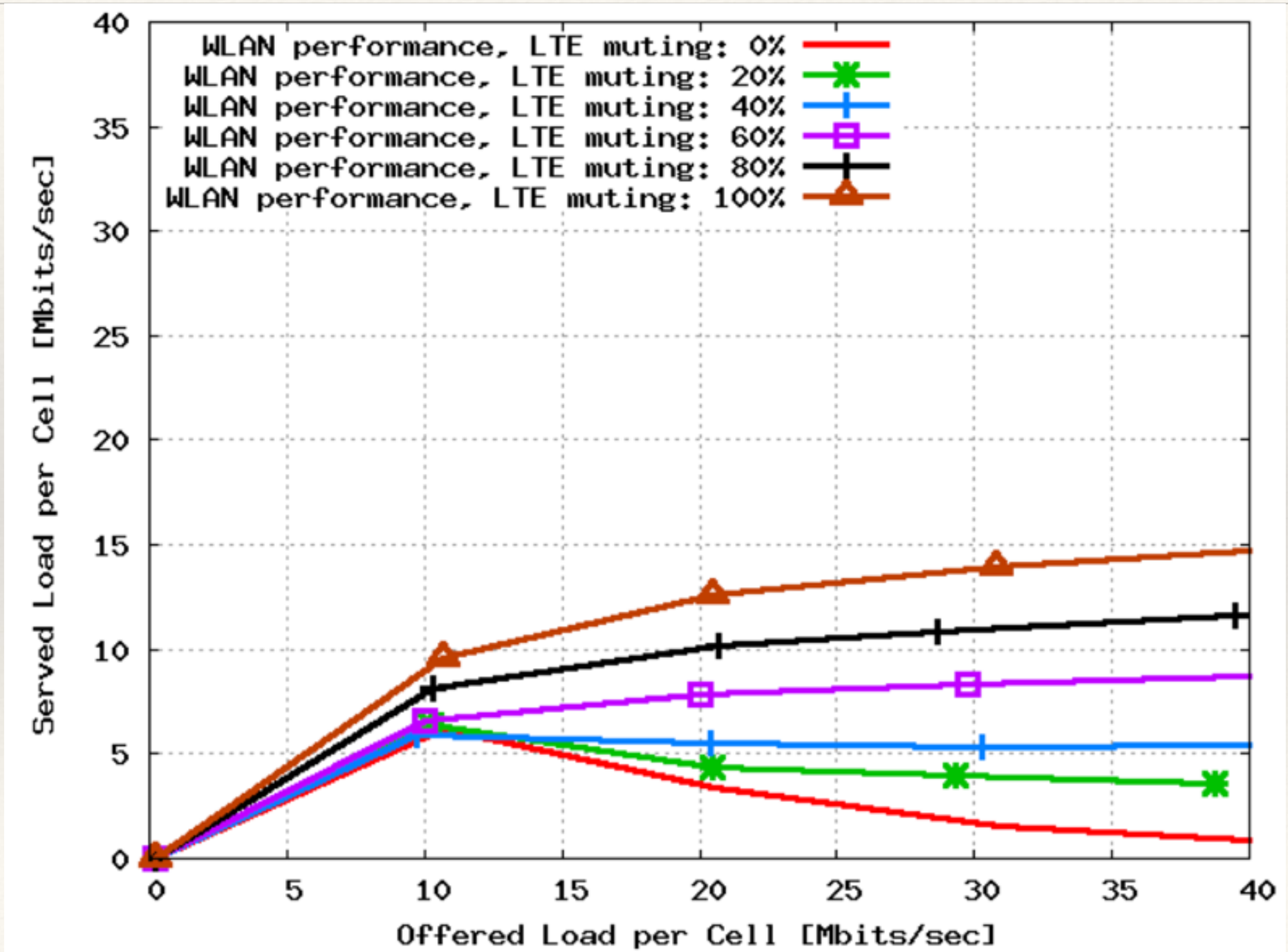
LTE and WLAN performance. Standalone and shared frequency band cases



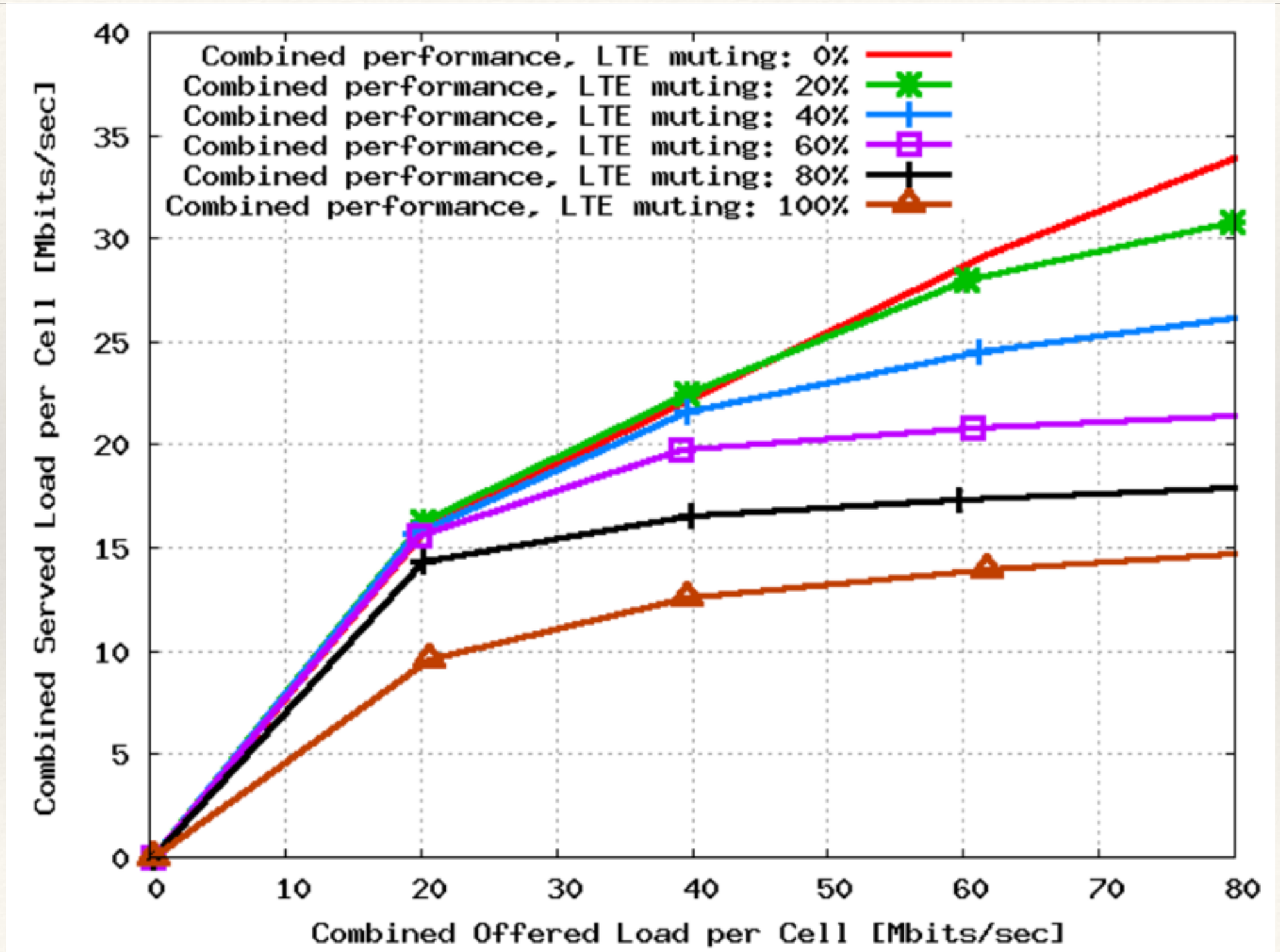
LTE performance with LTE muting



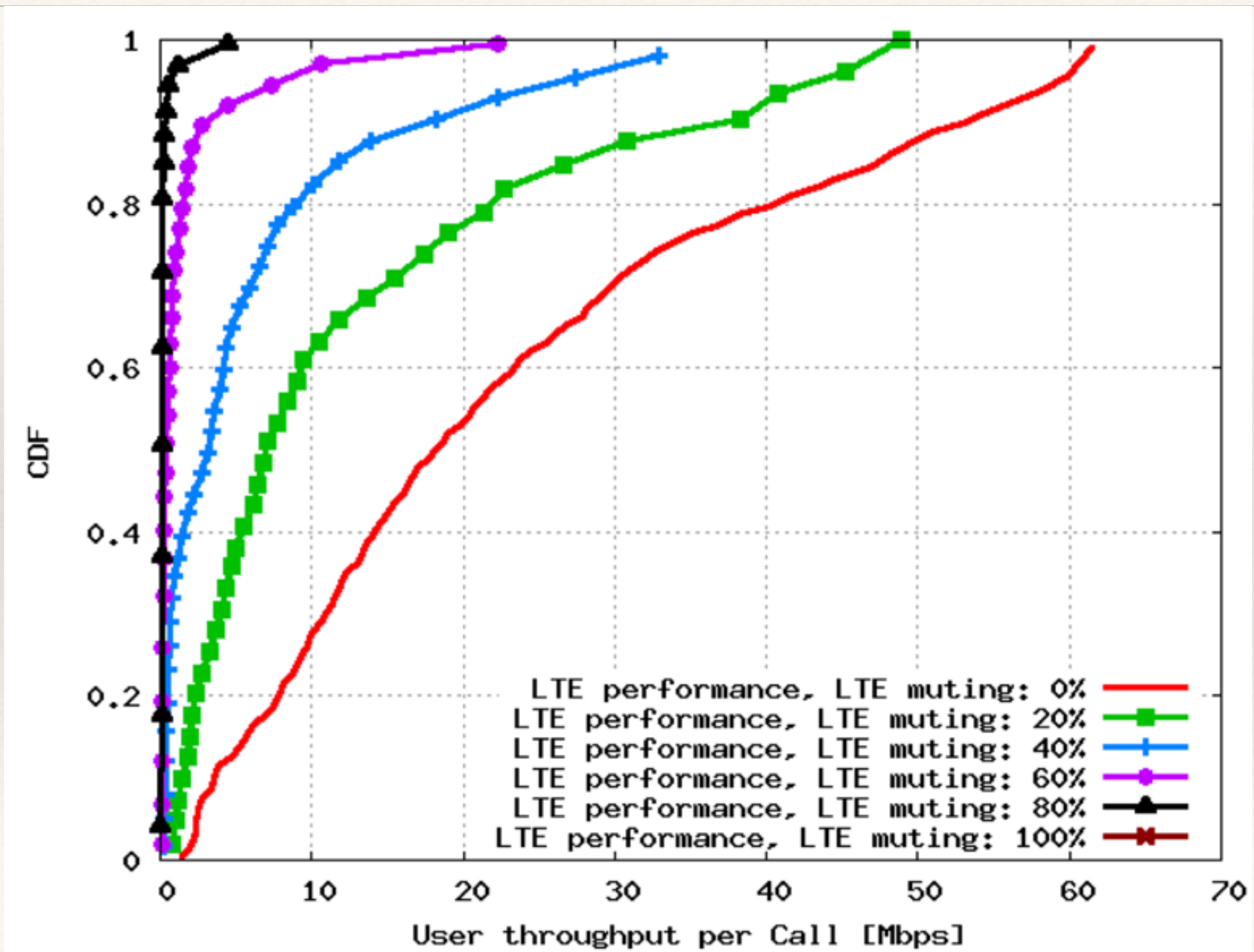
WLAN performance with LTE muting



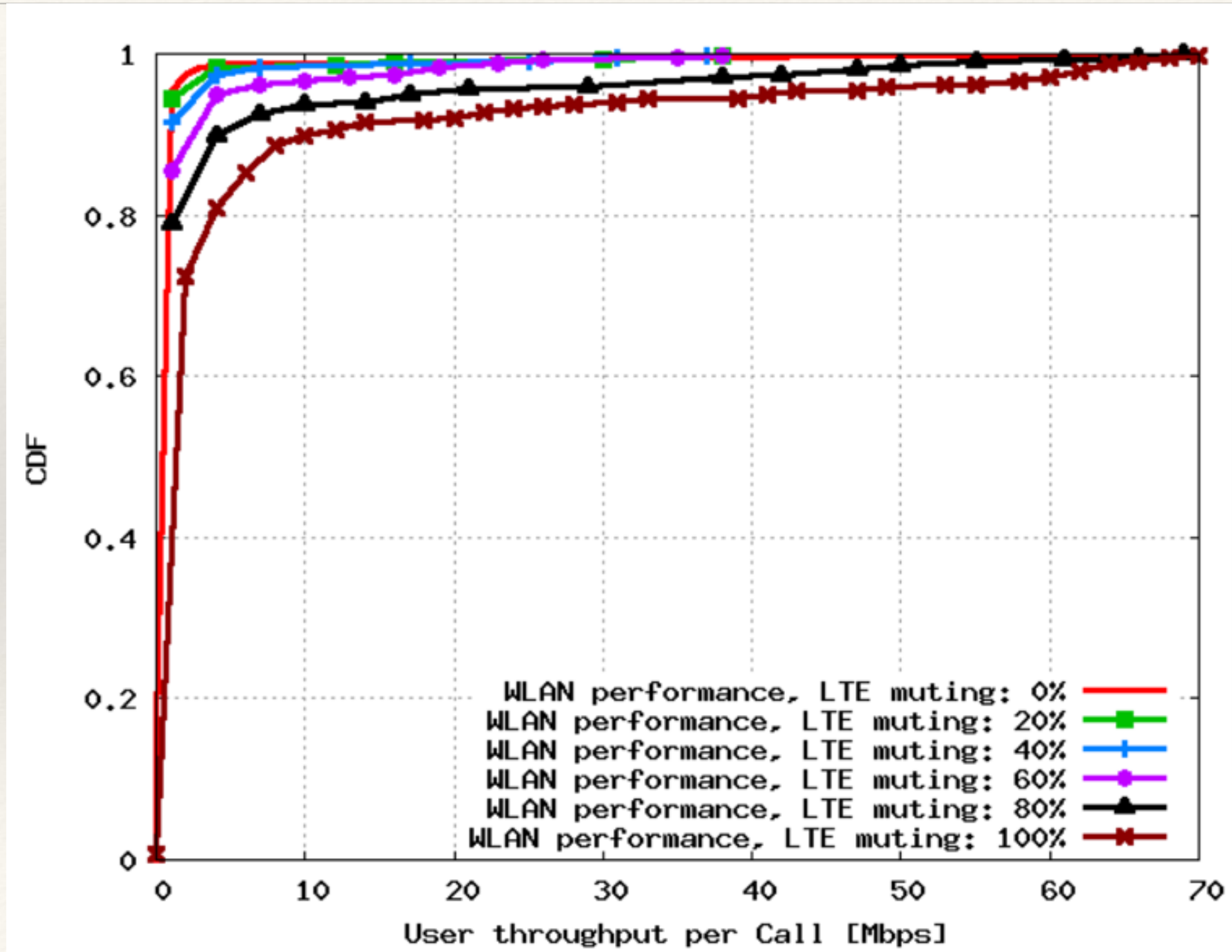
Combined performance with coexistence mechanism



LTE user throughput with 20 Mbps offered load



WLAN user throughput with 20 Mbps offered load



Reference

- [1] Timo Nihtila, Vitaliy Tykhomyrov, Olli Alanen, Mikko A. Uusitalo, Antti Sorri, Martti Moisio, Sassan Iraji,Rapeepat Ratasuk and Nitin Mangalvedhe,"System performance of LTE and IEEE 802.11 coexisting on a shared frequency band" in 2013 IEEE Wireless Communications and Networking Conference (WCNC): NETWORKS
- [2] Mihaela Beluri, Erdem Bala, Yuying Dai, Rocco Di Girolamo, Martino Freda, Jean-Louis Gauvreau, Scott Laughlin, Debashish Purkayastha, Athmane Touag, "Mechanisms for LTE Coexistence in TV White Space" in 2012 IEEE International Symposium on Dynamic Spectrum Access Networks
- [3] Andre´ M. Cavalcante, Erika Almeida, Robson D. Vieira, Sayantan Choudhury, Esa Tuomaala and Klaus Doppler Fabiano Chaves, Rafael C. D. Paiva and Fuad Abinader, "Performance Evaluation of LTE and Wi-Fi Coexistence in Unlicensed Bands" in Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th
- [4] Karim Khalil, Golnaz Farhadi and Akira Ito, "Coexistence Management for Heterogeneous Networks in White Spaces" in 2014 International Conference on Computing, Networking and Communications, Wireless Networks Symposium