Improving WLAN reliability

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Authors:

Name	Affiliations	Address	Phone	email
Antonio de la Oliva	InterDigital, UC3M	Avda. de la Universidad 30, 28911, Leganes, Madrid, Spain	+34916248803	aoliva@it.uc3m.es
Xiaofei Wang	InterDigital,			
Rui Yang	InterDigital,			
Robert Gazda	InterDigital,			

Abstract

This presentation tackles the need for Ultra-reliable communications in IEEE 802.11, it surveys current approaches already identified in the RTA SIG and proposes new topics for collaboration between IEEE 802.11 and IEEE 802.1TSN

The need for ultra high reliability in IEEE 802.11

- The upcoming of Ultra Reliable and Low Latency Communications (URLLC) is one of the pivotal new technologies behind a lot of different use cases → in fact driving 5G
- Although usually only discussed in terms of latency, URLLC has a second leg on the reliability domain
  - Applications needing even more than carrier grade → 99.9999% of reliability
- Some applications cannot be developed without extremely high reliability (as initially identified in 11-18-2009-05-0rta-report-draft, RTA study, and extended by other sources)
  - Industrial control (robot control, digital twinning, sensors)
  - Intelligent transportation (autonomous vehicles, road safety, emergency)
  - Remote healthcare (health sensors, remote dosing)

Reliability in IEEE 802.11

- Sources of un-reliability in WLAN come from:
  - Collisions
  - Radio impairments: channel fading, interference → Errors
- The mechanisms current in place to increase reliability are mainly focusing on:
  - Time diversity: send multiple copies of the frame sequentially in time.
    - Standard Ack policy
    - GCR UR (Groupcast Unsolicited Retries), GCR BAR/BA
  - Rate adaptation: reduce the rate to increase the probability of reception
    - Mechanism used in key frames such as beacons and part of the rate adaption mechanism in IEEE 802.11

Reliability in TSN

- IEEE 802.1 TSN has already defined several mechanisms for increasing the reliability of bridged networks:
  - Qci: Per-stream filtering and policing
    - Reliability increased by error containment
  - Qca: Path control and reservation
    - Reliability increased by stablishing multiple paths between nodes
  - CB: Frame replication and elimination for reliability
    - Complete framework for the on-path duplication of frames, which are sent through separated paths

IEEE 802.1CB in IEEE 802.11

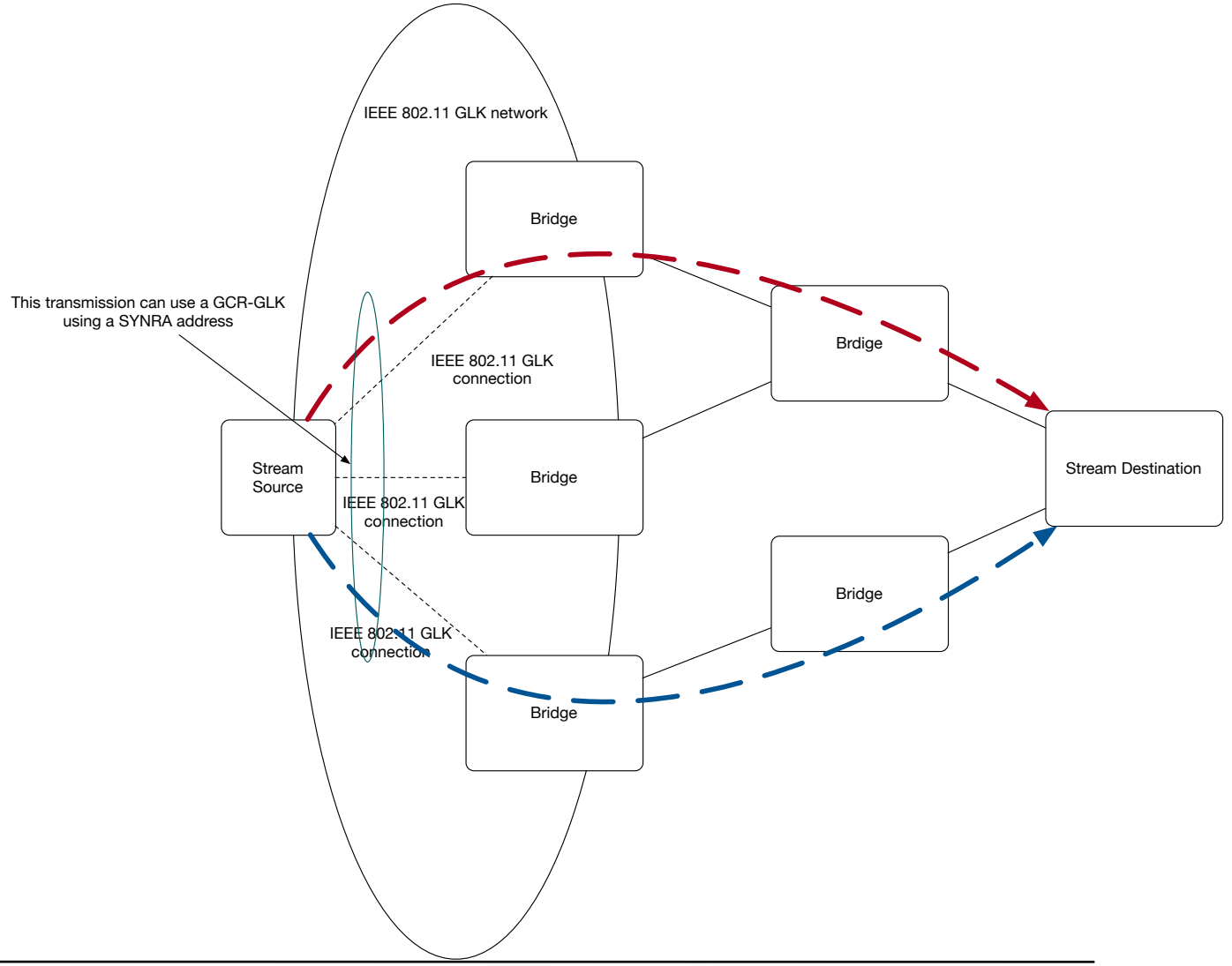
- IEEE 802.11ak defined the mechanisms so IEEE 802.11 can behave as an IEEE 802.1 bridged network
  - Therefore IEEE 802.1CB can be applied to IEEE 802.11
- Main problem is the applicability to specific scenarios
  - IEEE 802.1CB will increase the reliability of a path composed of several hops
  - The wireless path reliability is not improved using FRER

Proposal

- Definition of new mechanisms in IEEE 802.11 to improve the reliability of the wireless links
  - Which can be used in conjunction with IEEE 802.1CB
- We propose to study the use of the following mechanisms to increase the reliability of IEEE 802.11 and how they can be incorporated to the options in IEEE 802.1CB
  - Multi-link: use of separated bands to transmit same frame
    - Multiple channel diversity: simultaneous transmission of multiple copies of a frame through several channels → Our proposal
  - Multi-AP: use of joint transmission to improve the reception probability

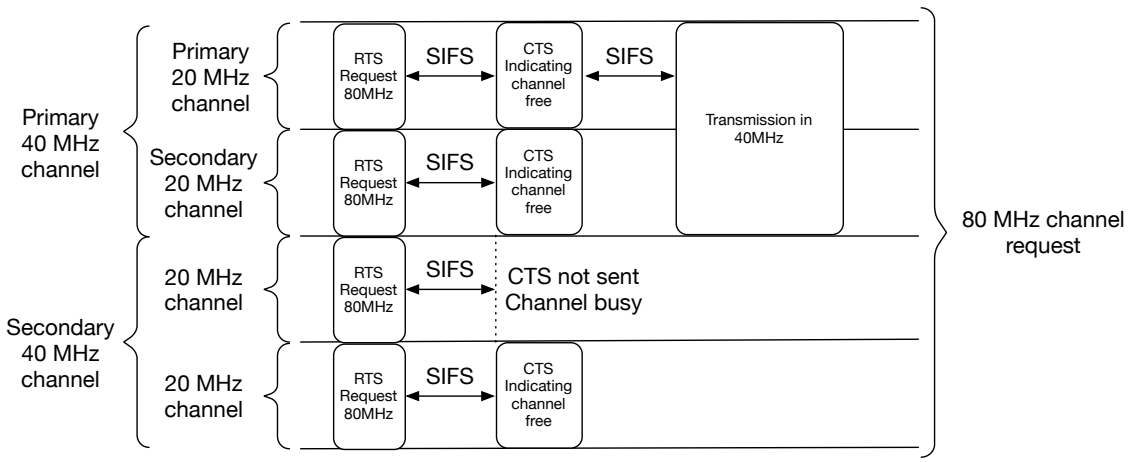
IEEE 802.11 and IEEE 802.1CB

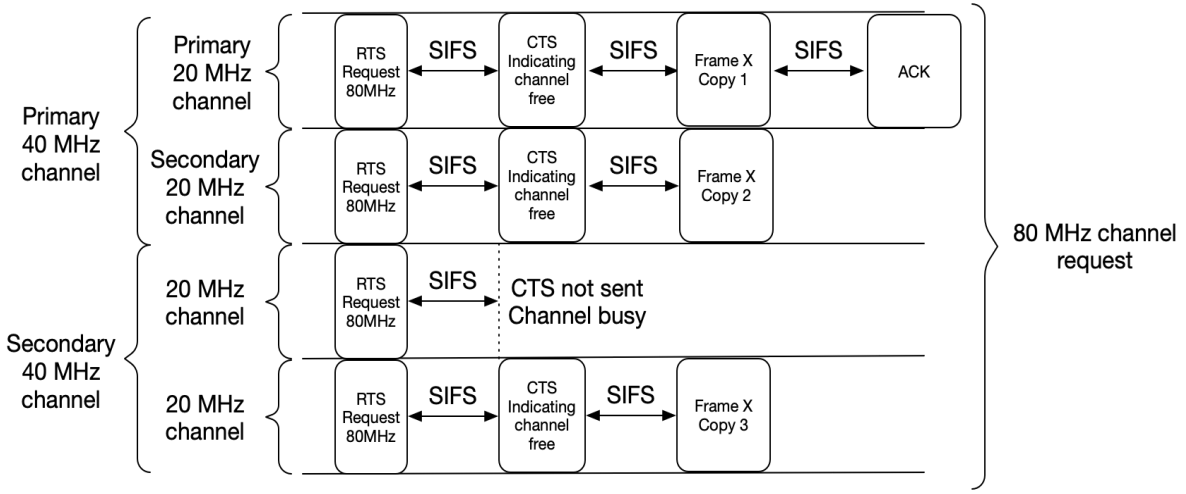
- IEEE 802.11CB can be used within a wireless domain
- Main idea would be to replicate frames before transmitting them in the wireless channel
- Disjoint paths can be created in the wireless channels by using IEEE 802.11ak and creating e.g., groups of stations
- Transmission to each group of stations can use time or frequency diversity
- Joint work between TSN and 802.11 can lead to better mechanisms



Frequency diversity

- Approach that can be used to increase diversity for unicast or potentially for groups of stations
- Current IEEE 802.11ac/ax are able to obtain a view of the channels available between two stations and adapt the operation bandwidth
  - This mechanism is called Dynamic Bandwidth Operation
- Once the channels available are clear, instead of transmitting a single frame through all channels, we can transmit multiple copies of the frames, one per channel





Further Improvement to Frequency Diversity

- HARQ is being discussed as a candidate feature for 802.11be
- Typically HARQ is conducted over time domain, but HARQ packets may be transmitted concurrently over different channels/links to ensure low latency
- HARQ with incremental redundancy (IR) may provide additional benefit over simply repeating the same packet over different channels/links
  - May provide higher throughput in addition to reliability
  - Higher throughput may be desirable for some real-time traffic applications such as VR and AR