NEXT GENERATION VEHICULAR NETWORKS: IEEE802.11bd

WAY OF WORKING AND PROGRESS

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PUBLIC

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Background

- Recognition need for longer-term roadmap, continuation of IEEE802.11-OCB (“802.11p”)
- Thousands of cars equipped with IEEE 802.11p are already on the road, and several major auto manufacturers have announced massive 802.11p roll-outs
  - including e.g. Toyota, VW, and GM on vehicles; Siemens, Kapsch on infrastructure
- Improvements to IEEE 802.11p by NGV need to take into account the large number of 802.11p systems that will be in service by the time NGV is adopted and deployed
- In the 5.9GHz band, NGV needs to be fully interoperable with “legacy 802.11p”
  - We cannot segment the safety critical V2X applications between “legacy” and “NGV users” – millions of lives are at stake
  - **Therefore, it is highly desirable to identify and adopt techniques which improve performance while retaining full interoperability with the IEEE 802.11p PHY**

Way of Working – IEEE 802 LMSC

- IEEE 802 **L**AN/**M**AN **S**tandards **C**ommittee is part of IEEE Standards Association
  - IEEE 802 standards become international standards via the ISO PSDO process
  - IEEE 802.11 is the Working Group for Wireless Local Area Network standards
    - This includes the standards defining Wi-Fi™ (802.11a, 11b, 11e, 11g, 11n, 11ac, *p11ax*); Wi-Fi HaLo™ (802.11ah); Wi-Gig™ (802.11ad, *p11ay*); and DSRC (802.11p, *p11bd*)
    - Anybody may attend, the only costs are meeting registration fees plus $10/year for IEEE-SA
      - Voting is by individuals, NOT companies. Voting rights are earned by attending three out of four consecutive meetings, and retained by continuing to attend at least two out of each four, as well as returning all mandatory letter ballots.
      - All documents except drafts are publicly available at https://mentor.ieee.org/802.11/documents
    - Each 802.11 standard or amendment is developed by a Task Group. The Next-Generation V2X (NGV) standard is being developed by Task Group bd, and is expected to be published in 2021.
      - The NGV standard will be IEEE 802.11bd, but until publication should be referred to as “P802.11bd”

Way of Working – IEEE ‘SG NGV’ → ‘TG bd’

- Proposal IEEE March 2018 to start Study Group Next Generation V2X (NGV)
  - Study Group (SG): generate exactly 2 documents
    - The Project Authorization Request (PAR), containing scope, time line etc
    - Criteria for Standards Development (CSD), containing required sections as on market potential, compatibility (with related standards), distinct identity, technical feasibility, and economic feasibility
  - SG first meeting May 2018
    - Many contributions: Marvel, NXP, Toyota, Autotalks, DLR, Intel, C2C, BlackBerry, …
    - SAE Liaison Request 2018-12-04: calling for “seamless evolution strategy”
  - Nov 2018: NGV PAR approved by Executive Committee
- Dec 5 2018, IEEE-SA New Standards Committee (NESCOM) accepted PAR
  - **Task Group bd**, resulting amendment will be published as 802.11bd
    - The proper way to refer to this standard prior to approval is “P802.11bd”
- TG first meeting January 2019

Definitions of Terms: Coexistence, Interoperability, Compatibility

The following definitions appear in IEEE document 11-18-1323r0 (page 5)
This document was prepared by the Study Group before Task Group bd began operation, and were adopted unanimously (vote of 44-0) by the Task Group at its initial meeting in January 2019

- **Interoperability** – IEEE 802.11p devices to be able to decode at least one mode transmission of NGV device, and NGV devices to be able to decode IEEE 802.11p transmissions
- **Co-existence** – IEEE 802.11p devices to be able to detect NGV transmissions (and hence defer from transmissions during NGV transmissions causing collisions) and vice versa
- **Backward compatibility** – Ability of NGV devices to operate in a mode in which they can interoperate with IEEE 802.11p devices
- **Fairness** – Ability of IEEE 802.11p devices to have the same opportunities as NGV devices to access the channel

The document is available at: https://mentor.ieee.org/802.11/dcn/18/11-18-1323-02-0ngv-ngv-sg-use-cases.pptx

Approach in defining IEEE 802.11bd

- **No revolution**: reuse of overall IEEE toolkit as proven and tested in VHT (11ac)
  - Essential to capitalize on the VHT work instead of defining new schemes
  - Examples of backwards compatible extensions
    - Repetition
    - Packet extension (VHT)
  - Example items under discussion (non-backwards) for new services (VHT)
    - Exploit more data subcarriers (48+4 → 52+4)
    - Advanced modulation schemes like 256QAM and codecs (LDPC)
    - Spatial streams schemes: MIMO (single-user & multiple-users), STBC, Beamforming
    - Features have been thoroughly tested and vastly used, providing rock-solid toolkit for IEEE802.11bd, **but are potentially not robust against mobility**
      - Presentation on mobile channel models in March 2019 IEEE meeting
  - Includes also **60 GHz** ITS communication
- Most building blocks available → standardization effort is limited
  - Target to have definition end of the year, and is expected to be published in 2021

Enhancement examples on IEEE 802.11p

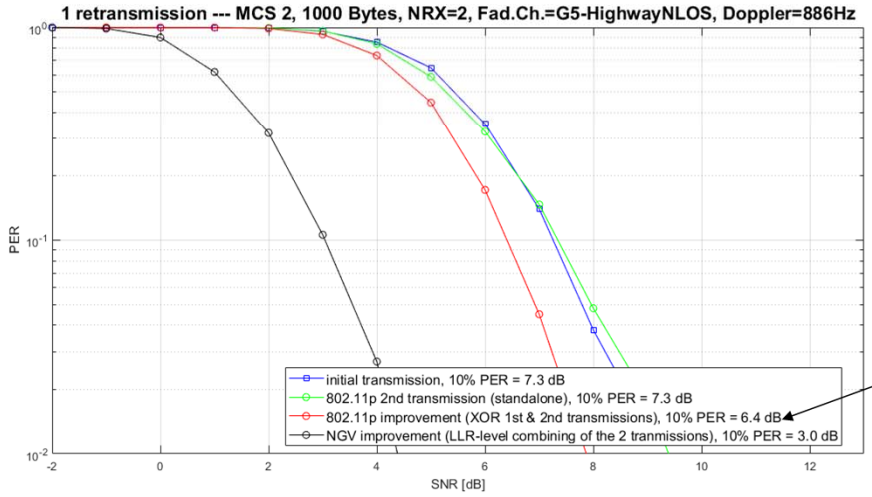
- New PHY-level methods
  - Improved implementation (more strict requirements)
    - Improves multi-channel operation by e.g. better adjacent channel rejection, spectral mask
  - Adaptive message repetition [voice-over: NXP proposal]
    - Legacy stations: Performance improvement due to channel diversity (1 to 2 dB)
      - Retransmissions seen as standalone messages by legacy 802.11p stations
    - NGV stations +3dB (1 retransmission) to +7dB (3 retransmission)
- New MAC-level methods
  - Using till-now reserved fields in existing header to indicate new capabilities
  - Piggy back new encoding/modulation on existing message format
    - Every section has self-contained identical payload

Example: Message Repetition

- Ongoing investigation on achievable gain
- Simulation results
  - NGV stations +3dB (1 retransmission) to +7dB (3 retransmission)
  - legacy 802.11p stations improvement due to channel diversity (+1 to +2 dB)
  - More robust against local deep fades etc

Initial simulation results

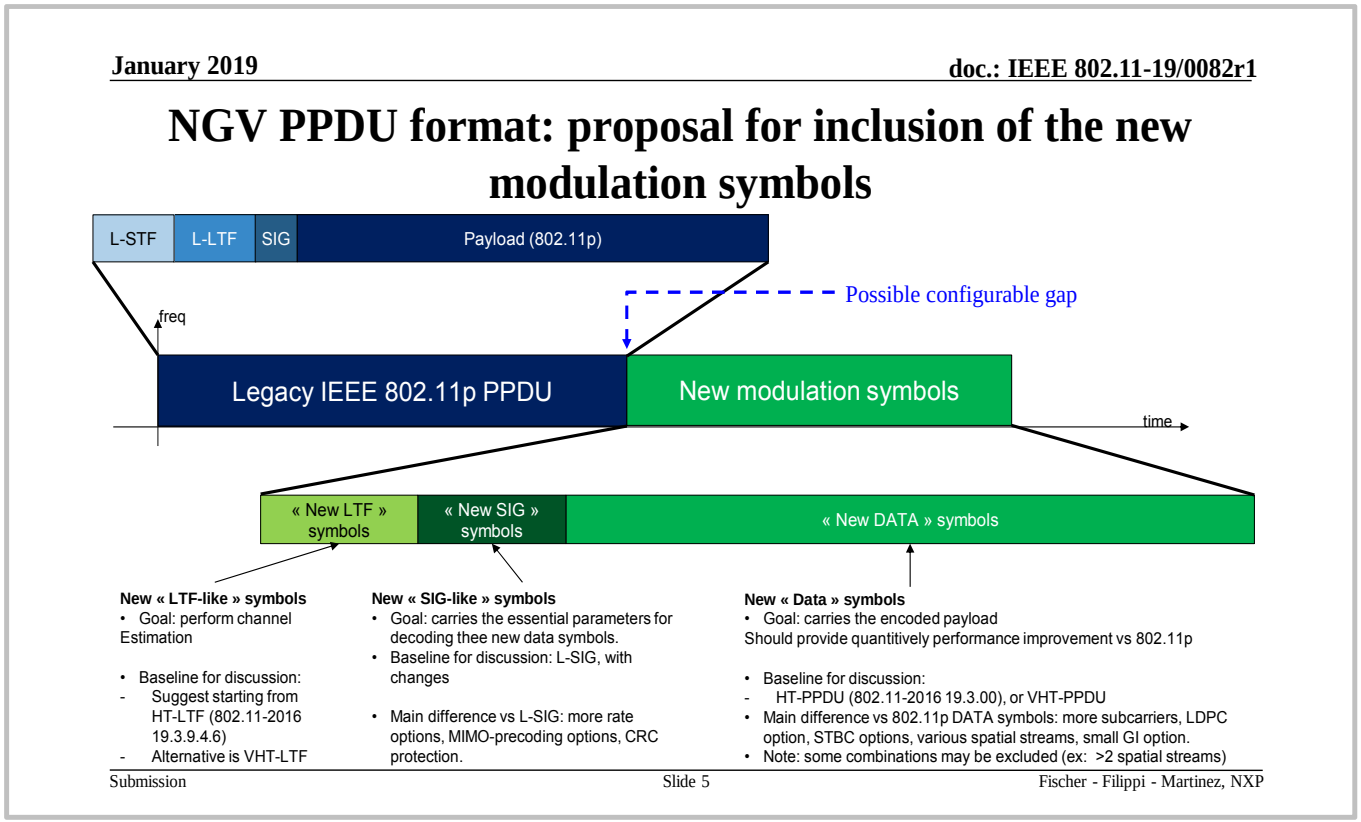
Simulations with one retransmission indicate ~1 dB improvement for 802.11p stations and ~4 dB improvement for NGV stations



Should be understood as « Boolean OR of the CRC-pass results », we take the best of the 2 tries:
- trans#1 FAIL + trans#2 FAIL = FAIL
- trans#1 FAIL + trans#2 PASS = PASS
- trans#1 PASS + trans#2 FAIL = PASS
- trans#1 PASS + trans#2 PASS = PASS

Example: Extended messages

- Extend existing legacy PPDU with information in improved modulation schemes
- Based on HT-PPDU or VHT-PPDU
  - Baseline 802.11-2016 19.3.00
  - more subcarriers, LDPC option, STBC options, various spatial streams, …
  - maintaining full backward compatibility
- Including path definition for gradual transition to future
- However: behavior under mobile conditions to be verified



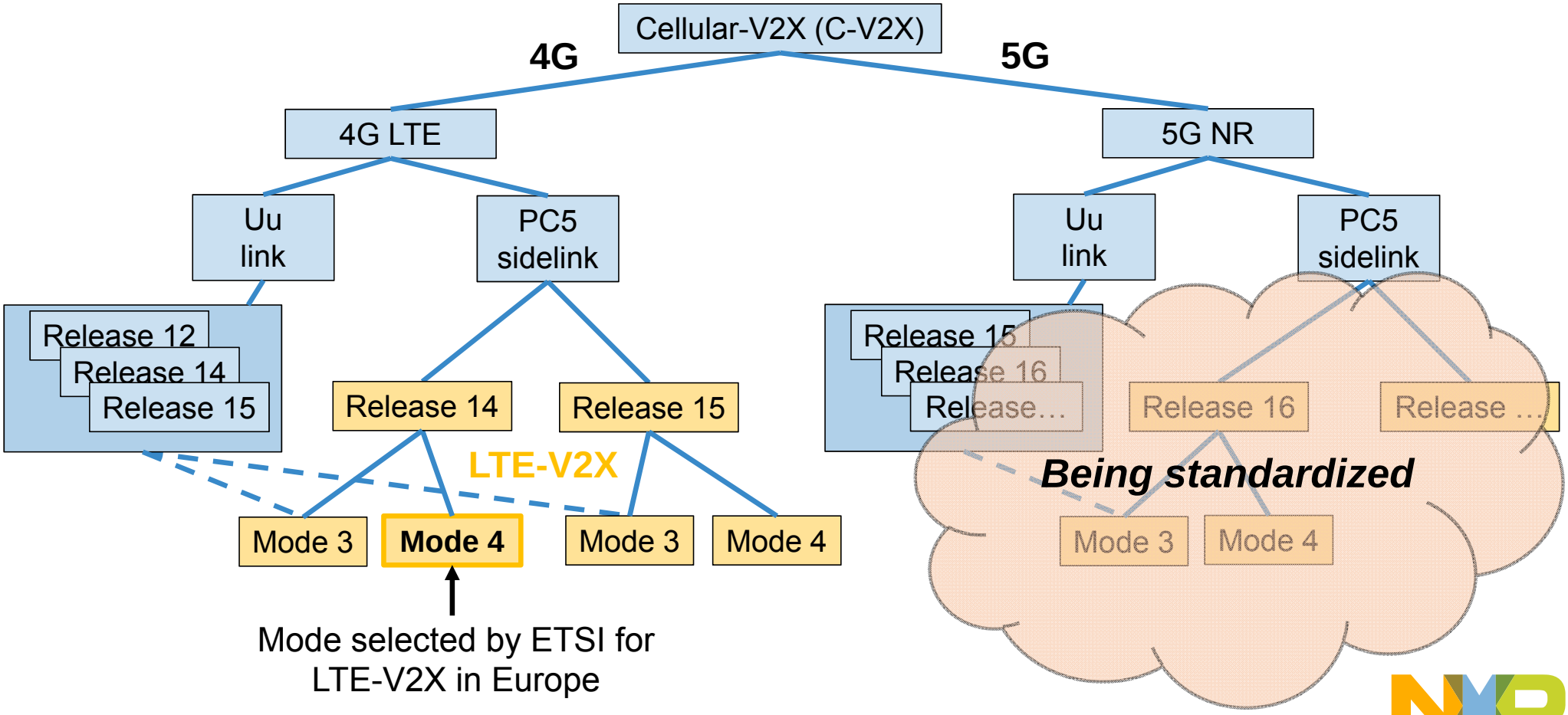
Positioning Cellular and ITS-G5

- European Approach (Delegated Act*): let's get started, using 'hybrid communication'
  - Short range V2V IEEE 802.11p, **complemented** by long distance/V2I cellular LTE/Uu
  - Evaluate/allow other technologies in near future (review period defined)
- 5GAA proposal: also include LTE-V2V using PC5 mode 3,4
  - Similar performance, incompatible technology

- Coexistence and interoperability: ETSI New Work Items
  - **Coexistence** in ETSI **TC ERM** (TG37), link via TC-ITS WG4
    - Initial report with proposed methods available (ERMTG37(18)000072r1) after long discussions
    - Request from EC via CEPT to look especially at **co-channel** coexistence: NWI DTR/ERM-TG37-273
    - Proposal by cellular to also look at separate-channel coexistence (spectrum split): NWI …TG37-274
  - **Interoperability** in TC ITS
    - TR 103 576-2 "Interoperability among heterogeneous ITS systems and backward compatibility" currently in drafting
    - Not trivial, as ITS-G5 is different system compared to cellular LTE-V2X

*: D.A. PART-2018-563311V4 section 3.3

Cellular V2X standards



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