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| Project | **IEEE 802.15 Wireless Specialty Networks Working Group <**<http://ieee802.org/15>**>** | |
| Title | **IEEE 802.15.16t Proposed Elements of the Air Interface Protocol** | |
| Date Submitted | **2021-09-14** | |
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| Re: | 16t Task Group: Licensed Narrowband Amendment | |
| Abstract | Peer-to-peer Communication Definitions and Q&A | |
| Purpose | To consider elements of the Air Interface Protocol for 802.16t | |
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**Peer-to-peer definition from the railroad perspective and some Q&A**

**Definition of peer-to-peer mode of operation:**

Communications directly between remote nodes (such as mobiles, handhelds, and/or waysides) without passing through any central/office components. Peer-to-peer communications must function when the two endpoint remote nodes are within direct communication range when there is no base coverage as well as with single or multiple base station relay. Peer-to-peer communications can be point-to-point (unicast), multicast, or broadcast.

**Definition of point-to-point communication:**

Communication between 2 and only 2 endpoint nodes, i.e., unicast - not broadcast and not multicast.

**Some questions with answers from the perspective of the Next Generation Head-of-Train/End-of-Train (NGHE) application**

* Should peer-to-peer mode co-exist with the base station control mode, or should it be a separate mode?
  + For the NGHE application, the primary mode of operation needs to be peer-to-peer mode between two remotes without involving a base station, but if the remotes cannot establish a direct communication link, then the messages should be relayed by base station if a base station is available.
  + A *dedicated* channel is assigned for Head of Train (HOT) to End of Train (EOT) communications, so no base station traffic other than that of all trains’ HOT-EOT links within range of a base station need to be accommodated.
  + While some messages between the HOT and EOT of a train are periodic, many of the messages are not and therefore are not suitable for scheduling. Consequently, CSMA or slotted-CSMA is the preferred link/media access method.
  + NGHE links must co-exist with legacy HOT-EOT links that use binary FSK modulation operating with pure Aloha (no carrier sensing) link/media access on the same channel.
* Should the remotes, while operating in peer-to-peer mode, support relay service?
  + Yes, there are cases where a locomotive (remote) is located in the middle of the train consist that could be used as a relay between the HOT and EOT.
* What is the maximum number of nodes that can be connected in the peer-to-peer mode of operation?
  + For the NGHE application, there will only be 2 end-point nodes involved in a link. i.e., no broadcast or multi-cast.
  + There can be one or more relay nodes between a pair of end-point nodes.
  + There can be several trains operating within
  + There can be several trains operating asynchronously within radio communications range of one another, with each train having one pair of end-point nodes.
* Next Generation - End-of-Train Device (NG-EOTD) application must be very efficient in terms of power consumption and bandwidth utilization. Therefore, a very streamlined protocol is needed.
* What channel bandwidth and throughput are required for NGHE?
  + The HOT-EOT function uses a single 12.5 kHz-wide channel at 450 MHz.
  + The channel throughput needs to be on the order of 9,600 to 16,000 bps.

**Some railroad-based use cases and applications that require peer-to-peer mode of communication:**

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| **Respondent** | **Market** | **ID** | **Use Case/Application** |
| Meteorcomm | Rail | Rail\_1\_Mete | Central Traffic Controller Communication |
| Meteorcomm | Rail | Rail\_2\_Mete | Differential GPS |
| Meteorcomm | Rail | Rail\_3\_Mete | Drone Communication |
| Meteorcomm | Rail | Rail\_4\_Mete | Employee-in-charge |
| Meteorcomm | Rail | Rail\_5\_Mete | End-of-Train Communication |
| Meteorcomm | Rail | Rail\_6\_Mete | Fault detector communication |
| Meteorcomm | Rail | Rail\_7\_Mete | Grade Crossing Communication |
| Meteorcomm | Rail | Rail\_8\_Mete | Grade Crossing Communication |
| Meteorcomm | Rail | Rail\_9\_Mete | Hy-rail Limits Compliance |
| Meteorcomm | Rail | Rail\_10\_Mete | Interoperable Train Control – Positive Train Control (ITC-PTC), e.g., Interoperable Electronic Train Management System (I-ETMS) |
| Meteorcomm | Rail | Rail\_12\_Mete | Locomotive Distributed Power |
| Meteorcomm | Rail | Rail\_13\_Mete | On-board Sensor Network |
| Meteorcomm | Rail | Rail\_14\_Mete | Remote Control Locomotive |
| Meteorcomm | Rail | Rail\_15\_Mete | Wayside Maintenance |
| Meteorcomm | Rail | Rail\_16\_Mete | Worksite protection |
| Siemens Mobility | Rail | Rail\_17\_Siem | Advanced Civil Speed Enforcement System (ACSES) Train control |
| Siemens Mobility | Rail | Rail\_18\_Siem | Defect detectors |
| Siemens Mobility | Rail | Rail\_19\_Siem | End-of-train (EOT)/Head-of-Train (HOT) |
| Siemens Mobility | Rail | Rail\_20\_Siem | Local DTMF crossing activation |
| Siemens Mobility | Rail | Rail\_21\_Siem | Positive Train Control (PTC)-enabled crossing |
| Siemens Mobility | Rail | Rail\_22\_Siem | Remote monitoring and systems mgmt |
| Siemens Mobility | Rail | Rail\_23\_Siem | Remote monitoring and systems mgmt |
| Siemens Mobility | Rail | Rail\_24\_Siem | Wayside signaling |
| Siemens Mobility | Rail | Rail\_25\_Siem | Wayside signaling |

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| Legend | Description |
|  | Applications with both end nodes requiring dynamic communication link. Peer-to-peer mode of communication is required for these applications. |
|  | Applications with one node requiring static communication link and the other with dynamic communication link. Peer-to-peer communication mode is required for these applications. |