**IEEE P802.15**

**Wireless Personal Area Networks**

|  |  |
| --- | --- |
| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | **Proposed Resolution Draft 1.0 comments CID – 1251, 138, 1319, 273, 274, 1258, 260, 1377** |
| Date Submitted | January 2025 |
| Sources | Aniruddh Rao Kabbinale, Ankur Bansal (Samsung), Frank Leong, Andreas Gruber (NXP)aniruddh.rao@samsung.com, frank.leong@nxp.com |  |
| Re: |   |
| Abstract |  |
| Purpose | To propose resolution for comments related to Sensing CIDs – 1251, 138, 1319, 273, 274, 1258, 260, 1377 for “P802.15.4ab™ Draft 1.0 Standard for Low-Rate Wireless Networks” .  |
| Notice | This document does not represent the agreed views of the IEEE 802.15 Working Group or IEEE 802.15.4ab Task Group. It represents only the views of the participants listed in the “Sources” field above.It is offered as a basis for discussion and is not binding on the contributing individuals. The material in this document is subject to change in form and content after further study. The contributors reserve the right to add, amend or withdraw material contained herein. |

Rev 0: Initial version.

***Comment Indices in 15-24-0371-34-04ab-consolidated-comments-draft-1-0 related to sensing:***

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Index #** | **Category** | **Page** | **Sub-clause** | **Line #** | **Comment** | **Proposed Change** | **Must Be Satisfied?** | **Disposition Status (Accepted, Rejected, Revised)** | **Disposition Detail** |
| Billy Verso | **1251** | **Technical** | **148** | 10.39.6.1 | 10 | Should the term "speed" be used rather than velocity, just to avoid people thinking it is a vector with a direction?  | Change velocity to speed. |  | Revised | Propose to change “velocity” to “radial velocity” at suggested line and related figure for which description applies to. |
| Rojan Chitrakar | **138** | **Technical** | **159** | 10.39.6.6 | **3** | When EOL field is zero, how is the target list continued in a subsequent frame, is the target list the only content of the next report, or are the preceding control fields also present? Details are missing. Also which target list, full or short? | Add detail of the procedure used to continue the target list in the next report when the EOL field is zero. Details are missing. Also specify if the target list is full or short? |  | Revised | Text added to describe how the subsequent frames would be structured. For part of comment on whether it is full or sparse target list – This is taken care by specifying the number of full targets and number of sparse targets in the IE. |
| Pablo Corbalán Pelegrín | **1319** | **Technical** | **160** | 10.39.6.6 | **17** | Shouldn't the Elevation angle range from -90º to 90º instead of -180º to 180º? If we do make this change, the resolution for Azimuth and Elevation angles will be different. | Change "-pi to +pi radians" to "-pi/2 to +pi/2 radians". |  | Accepted | Changed as per proposed change |
| Li-Hsiang Sun | **273** | **Technical** | **161** | 10.39.6.6 | **1** | what is the reference for Delay field? i.e. what 0 means? What is the unit? | Please clarify |  | Accepted | Units for Delay is Nano-Seconds. Added text to explain resolution and what 0 means. |
| Li-Hsiang Sun | **274** | **Technical** | **161** | 10.39.6.6 | **3** | what is the unit of the velocity? | Please clarify |  | Accepted | Updated text.  |
| Billy Verso | **1258** | **Technical** | **161** | 10.39.6.6 | **3** | "Velocity field reports the velocity of the target (4 bits, signed integer, zero padded to an octet)"…. Units are missing. Also maybe could uses whole octet as a singed integer, and/or sign extend it rather than zero padding, for easier use. | Specify units. Make full octet signed value. (and change name to "Speed" instead of velocity as it is not a velocity vector.  |  | Revised | Name changed from velocity to radial velocity at suggested line and related figure.Units are explained in description. Would like to keep it a 4 bit signed value.  |
| Pooria Pakrooh | **1377** | **Technical** | **159** | 10.39.6.6 | **20** | Unclear what the definition of "Rotation" and "Elevation" fields are | Clarify the definition and range of values |  | Accept | Added text to clarify |
| Li-Hsiang Sun | 260 | Technical | 148 | 10.39.6.1 | 19 | what is the reference for receiver orientation? | Please clarify | No | Accept | Added details to text about reference for receiver orientation. |

**Discussion for 273, 274:**

Why do we have a Range-Doppler representation as Delay and Velocity with units as in D01?

It is important to understand that 802.15.4ab should be able to serve both mono-static and multi-static sensing.

Much of the literature is on mono-static sensing, and in that case the conversion from delay to range is straightforward (i.e., multiply by speed of light and divide by two). This approach typically does not work for multi-static sensing. In multi-static sensing, the transmitter and receiver are typically not co-located, and the target may be away from the direct line between the two nodes. Therefore, the distance to the line of sight (and/or the angles to the line of sight) needs to be taken into account when calculating range from delay. The accuracy of this kind of conversion may depend on the accuracy with which the radio nodes can localize each other.

In 15.4ab, we are taking the approach that the delay-to-range conversion may not be possible locally, and therefore we transmit the delay information as-is, with the unit [seconds]. The velocity is also on the basis of delay, so instead of [meters]/[seconds], this is expressed in [seconds]/[seconds], meaning this value is dimensionless.

**Discussion for 1251, 1258:**

Billy: CID 1251 proposed changing “velocity” to “speed” which was “accepted” in 15-24-0660r1. However, “velocity” appears 15 times in the sensing clause, so I am thinking about changing them all to “speed”. Please can you take a look and advise me on this.

CID 1258, not resolved yet, which is asking for “velocity” to be changed to “speed” but also looking for the units to be specified. And, as I look at the line in question I see it saying it is a signed value which is confusing since a negative speed does not make sense to me, (while a signed value does not convey a vector direction).

Pooria: I think even though the estimated target speed/velocity is not a vector; it can still take negative values. For example, in monostatic sensing, if the target is getting closer/farther to the sensing device, the radial velocity would be negative/positive, respectively. I am not sure how exactly that goes in bi-static case, which is the topic of this discussion in 4ab.

Frank: We are talking about a radial projection of a velocity, so it can be either positive or negative.

Regarding velocity vs. speed, I believe we are in a sort-of gray area. Typically, “speed” is meant to describe an absolute value, and “velocity” typically has a unit vector specified or implied. Our quantity conforms to neither – in fact, I believe it conforms to the definition of “speed” even less than to the definition of “velocity”. We could sidestep this whole discussion by calling it “projected radial rate of motion”.

Billy: Okay to call it “radial velocity”

Additional clarification:

The term “radial velocity” may potentially be better understood by looking at the following diagram.



This diagram shows a transmitter and a receiver, assumed infinitesimally small but indicated by solid dots, spaced apart by a distance of 1.0 and featuring a solid line drawn directly between them. The ellipses represent isorange contours, each contour representing a set of potential target locations in 2D space for which the distance TX-to-Target-to-RX has a specific value (this value shown as label in the diagram). The curves become less flat as the targets are spaced further away from transmitter and receiver.

What we mean by “radial velocity” is the rate at which a target moves through the isorange contours, the receiver only observing motion that is perpendicular to the isorange contours. This means that an actual velocity may result in different values of radial velocity depending on the location of the target. For example, the two arrows in the diagram, indicating real target velocities proportional to the lengths of the arrows, represent the same radial velocity as observed by the receiver.

For a real system, one can think of isorange contours being represented by spheroid surfaces in 3D space. As in the 2D example, actual velocities in 3D space cannot be directly determined from single radial velocity measurements.

In 15.4ab, we are taking the approach that the delay-to-range conversion may not be possible locally, and therefore we transmit the delay information as-is, with the unit [seconds] (the resolution being proposed is in the order of nanoseconds). The velocity is also on the basis of delay, so instead of [meters]/[seconds], this is expressed in [seconds]/[seconds], meaning this value is dimensionless (here, we are proposing a resolution of 2 nanoseconds/second). On a higher layer, the system may be able to compute the actual target velocity when combining multiple radial velocity and/or Angle-of-Arrival inputs.

References for isorange contours and radial velocity:

Isorange Countours are described in Chapter 2 of Hugh D. Griffiths, Christoph J. Baker, “An Introduction to Passive Radar”, ISBN 978-1-63081-036-8.

Bistatic Doppler and Isodoppler Contours are described in Chapter 23 of Merrill Skolnik, “Radar Handbook (Third Edition)”, ISBN 978-0-07-148547-0.

**Discussion for comment 260:**

Regarding Comment 260: For Azimuth and Elevation – reference is “according to celestial navigation conventions” – This implies that a device has a direction in which it is naturally pointing, specified by the manufacturer. For rotation, it is a clockwise rotation w.r.t. the natural orientation specified by the device manufacturer. Rotation is always around the axis defined by azimuth and elevation (clockwise is defined as seen looking along the device’s defined direction).

**For Comment 273, 274, 1251, 1258:**

**Text changes:** Highlighted in Yellow

**10.39.6.1**

**Change at page 148, Figure 155**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits: 0** | **1** | **2** | **3**  | **4**  | **5**  | **6**  | **7**  |
| Angle of Arrival (Azimuth) | Angle of Arrival (Elevation) | Delay | Radial Velocity | RSSI | Span | Span Reference | Receiver Orientation |

**Change at page 148, Figure 156**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits: 0–51** | **2-3** | **4-13**  | **14-15** | **16-17** | **18-24** | **25** | **26** | **27** | **28**  | **29**  | **30**  | **31**  | **32**  | **33-39** | **Octets:****0/4/8/16/32** |
| CBW | Bitmap | Bitmap Offset | Reference Tap | Length | Mode dependent Parameter | Angle of Arrival (Azimuth) | Angle of Arrival (Elevation) | Delay | Radial Velocity | RSSI | Span | Span Reference | Receiver Orientation | Reserved | Bitmap |

**Change at Page 148, line 10**

The Radial velocity field value when one means that a radial velocity report is requested, and a value of zero means that

this is not requested.

**10.39.6.6**

**Change at page 158, Line 24:**

The Processed Target Feature Report IE enables the exchange of a processed report for sensing independently of the CIR report. The Processed Target Feature Report IE enables exchange of parameter values for AOA, angle span, delay, delay span, radial velocity, RSSI and receiver orientation. The Processed Target Feature Report IE shall be formatted as shown in Figure 172.

**Change at Page 159, Line 9:**

The Number of Sparse Targets field is an unsigned integer indicating the number of targets for which only a sparse target report is available. A sparse target report contains only delay and Radial velocity information

**Change at Page 160, Figure 173:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits: 0-5** | **6-13** | **14-15** | **Octets: 0/1**  | **0/1**  | **Bits: 0/12**  | **0/4** | **Octets:0/1**  | **0/1** | **0/1** | **0/1** |
| Target ID | FullTargetReportPresenceBitmap | Reserved | Azimuth | Elevation | Delay | Radial Velocity | Delay Span | RSSI  | Angle Span (Azimuth) | Angle Span (Elevation) |

**Change at Page 160, Figure 174:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Bits: 0-5** | **6-7** | **Bits: 0/12** | **0/4**  |
| Target ID | Sparse Target Report Presence Bitmap | Delay | Radial Velocity |

**Change at Page 160, Figure 175:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits:1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| AzimuthfieldPresent | ElevationfieldPresent | DelayfieldPresent | DelaySpan fieldPresent | Radial VelocityfieldPresent | RSSIfieldPresent | Angle Span(Azimuth)field Present | Angle Span(Elevation)field Present |

**Change at Page 160, Figure 176:**

|  |  |
| --- | --- |
| **Bits: 1** | **1** |
| Delay fieldPresent | Radial Velocity field present |

**Change at Page 161, Line 1:**

The Delay field gives the delay of a target in the units of 1/8 nano-seconds (t\_chip/16), with line of sight transmission between transmitter and receiver as reference. This is a 12-bit unsigned integer. A delay value is sent for each

target in both full and sparse target lists.

**Change at Page 161, Line 3:**

The Radial Velocity field reports the velocity of the target (4 bits, signed integer, zero padded to an octet). A

Radial velocity value is sent for each target identified. Radial velocity is on the basis of delay, indicating the rate of change in delay, with a resolution of 2 nanoseconds/second.

**For Comment 1319:**

**Text changes:** Highlighted in Yellow

**10.39.6.6**

**Change at Page 160, line 17**

The Elevation field value gives the elevation-of-arrival of the target. This is a 7-bit signed value linearly representing an angle from –π/2 to +π/2 radians. Optionally, one Elevation field is sent for each target in the full target list.

**For Comment 138:**

**Text changes:** Highlighted in Yellow

**10.39.6.6**

**Change at Page 159, line 3**

The EOL field is an end-of-list indicator. If the EOL field value is zero it indicates that the target list will be continued in a subsequent report frame. The subsequent report frame would be of the same structure as the earlier report frame as defined in Figure 172. If the EOL field value is one, the current report frame completes the target list.

**For Comment 260, 1377:**

**Text changes:** Highlighted in Yellow

**10.39.6.6**

**Change to Figure 172 and at Page 159, line 19**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits: 0–5**  | **6**  | **7–12**  | **13–16**  | **17** | **18** | **19** | **20** | **21-23** | **Octets: 0/2** | **0/2** | **0/2**  | **0/Variable**  | **0/Variable**  | **0/Variable** |
| Number of Targets | EOL | Number of Full Targets | Number of Sparse Targets | Compression | Presence indication Receiver Orientation (Azimuth) | Presence indication Receiver Orientation (Elevation) | Presence indication Receiver Orientation (Rotation) | Reserved | Receiver Orientation (Azimuth) | Receiver Orientation (Elevation) | Receiver Orientation (Rotation) | Full Target Report List | Sparse Target Report List | DEFLATECompressed Report |

The Receiver Orientation (Azimuth) field reports the receiver orientation in azimuth relative to the transmitter. The unit is 2π/(216 – 1), with 0 radians being directly in front of the transmitter.

The Receiver Orientation (Elevation) field reports the receiver orientation in elevation relative to the transmitter. The unit is π/(216 – 1), with 0 radians being in the horizontal plane of the transmitter.

The Receiver Orientation (Rotation) field reports the receiver rotation relative to the transmitter.

Rotation is considered clockwise looking along its natural orientation as specified by the manufacturer, around axis of Azimuth and Elevation. The unit is 2π/(216 – 1), with 0 radians being the receiver’s natural orientation aligned to that of Transmitter.

**Change at Page 160, Figure 173:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bits: 0-5** | **6-13** | **14-15** | **Octets: 0/2**  | **0/2** | **0/1**  | **0/1** | **0/1**  | **0/1** | **0/2** | **0/2** |
| Target ID | FullTargetReportPresenceBitmap | Reserved | Azimuth | Elevation | Delay | Delay Span | Radial Velocity | RSSI  | Angle Span (Azimuth) | Angle Span (Elevation) |