**IEEE P802.15**

**Wireless Personal Area Networks**

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) |
| Title | Text for Relative Positioning |
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| Re: | draft text of UWB PHY for 802.15.8 |
| Abstract | This is the work in progress text of the Relative Positioning for IEEE 802.15.8 group for PAC. |
| Purpose | This document provides the details of the PHY proposal to IEEE 802.15.8 |
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1. Relative positioning

## Symmetrical double-sided two-way ranging

This sub-clause describes principles of relative positioning between two devices in PAC networks. Regarding positioning the standard specifies only the time units used for ranging timestamps in clause 10.4.1 and SAP for relative positioning that is defined in previous sub-clause). Since the positioning calculation is done by higher layers, and the standard specifies only PHY and MAC, this clause only gives recommendation for the positioning methodology.

P12

P12

P22

P22

P21

*Tround*1

*Tprop*

*Treply*1

*t*

*Tprop*

*Tprop*

*t*

*Tround*2

*Treply*2

Device 1

Device 2

*Tprop*

P21

P11

P11

Figure : Principle of symmetrical double-sided two-way ranging.

The positioning method recommended is called symmetrical double-sided two-way ranging.

As Figure 1 shows, symmetrical double-sided two-way ranging is achieved by measuring two round trip times: round trip time from device 1 to device 2 denoted $T\_{round1}$ and round trip time from device 2 to device 1 denoted $T\_{round2}$. $T\_{prop}$ denotes propagation time that is being estimated, while $T\_{reply1}$ and $T\_{reply2}$ represent reply times of device 1 and 2 respectively. The time of sending a certain frame is defined as time of beginning of SFD. In order to measure $T\_{round1}$ device 1 sends frame P11. After receiving P11 and time period $T\_{reply2}$ device 2 sends frame P21 which device 1 receives. After that the same procedure is repeated with device 1 and device 2 switching places. Hence, the second part of the procedure is initiated by device 2 which sends frame P22. After receiving P22 and time $T\_{reply1}$ device 1 sends frame P12.

At the end, $T\_{prop}$ estimate should be calculated as follows

|  |  |  |
| --- | --- | --- |
|  | $$\hat{T}\_{prop}=\frac{1}{4}(T\_{round1}-T\_{reply1}+T\_{round2}-T\_{reply2})$$ | **(1)** |

If relative errors of timing at device 1 and 2 are denoted $e\_{1}$ and $e\_{2}$ it follows that

|  |  |  |
| --- | --- | --- |
|  | $$T\_{round1}=T\_{round}×\left(1+e\_{1}\right),$$ | **(2)** |
|  | $$T\_{round2}=T\_{round}×\left(1+e\_{2}\right),$$ | **(3)** |
|  | $$T\_{reply1}=T\_{reply}×\left(1+e\_{1}\right),$$ | **(4)** |
|  | $$T\_{reply2}=T\_{reply}×\left(1+e\_{2}\right).$$ | **(5)** |

Thus error of $T\_{prop}$ estimation is:

|  |  |  |
| --- | --- | --- |
|  | $$\hat{T}\_{prop}=T\_{prop} \left(1+\frac{e\_{1}+e\_{2}}{2}\right).$$ | **(6)** |

Hence, relative error of the range estimation is also in the same order of magnitude as $e\_{1}$ and $ e\_{2}$, which for crystal oscillators are usually in tenths of ppm.