IEEE P802.15

Wireless Personal Area Networks

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | Changes to be done in revision | |
| Date Submitted | 15th January 2023 | |
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| Re: | January TG4me meeting | |
| Abstract | Provide list of changes to be done in revision. | |
| Purpose | TG4me discussion | |
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1. Document restructuring
   1. Create new clause 10 Optional features

We want to move all of the optional features to separate clause, so that will make format a bit flatter. This will cause all later clause numbers to be renumbered. We can now consider that clauses 1-4 are generic, clause 5-10 are the MAC, and (new) 11-32 are PHY.

The clause 10 will have one subclause for each optional feature.

10.1 Overview will explain that all subclauses here are optional features for the base MAC, and implementors can take any number of them and implement them, but none of them are mandatory to implement. Each subclause is written in way that any mandatory requirements expressed there are only applicable if that optional feature is implemented, i.e., when it says “To reduce the probability of repeated collisions when the packets are retransmitted, the retransmission backoff algorithm shown in Figure 6-6 shall be implemented for shared links.” that only applies if the TCSH feature is implemented even when it does not say in the beginning “If using TSCH mode” etc.

From 10.2 forward there will be one subclause for each optional feature. List of optional features to include here is:

* Superframes
* DSME – deterministic and synchronous multichannel extension
* TSCH – timeslotted channel hopping
* TMCTP – TVWS multichannel cluster tree PAN
* MPM – multi-PHY management
* LECIM – low-energy, critical infrastructure monitoring
* PCA – priority channel access
* LE – low energy
* RCCN – rail communications and control network
* GTS – guaranteed timeslot
* CSL – coordinated sampled listing
* RIT – receiver initiated transmission
* I-RIT – implicit receiver initiated transmission
* TVWS – television white space
* SRM – Spectrum Resource Measurement
* SUN – Smart utility metering
* RS-GFSK – rate switch Gaussian frequency shift keying
  + This includes 7.4.4.33 Link Margin IE and 7.4.4.34 RS-GFSK Device Capabilities IE
* Ranging – Ranging
  + I think the ranging could be separated even more, there are some common stuff, but for example multi-node ranging could be separate feature from base ranging.
* ACRR – Authenticated challenge-response ranging
* Beacon-enabled ranging with ERDEV
* 6.3.2 PAN ID conflict resolution
  + This is currently mandatory, but not often implemented, should we make it optional and move it as separate feature
* 6.3.1.4 Orphan channel scan
  + This is currently mandatory, but not often implemented, should we make it optional and move it as separate feature
* 6.4 Association and disassociation
  + This is currently mandatory, but not implemented in certain environments, should we make it optional and move it as separate feature
* 6.4.3 Fast association
* 6.7.3 Extracting pending data from a coordinator
* 6.7.7 Promiscuous mode
* 6.7.9 Device announcement
* 6.10 PHY parameter change notification procedure
* 7.4.4.7 MAC Metrics IE and 7.4.4.8 All MAC Metrics IE
  + There is only two IEs related to this, but no functional description at all, listed as optional in PICS

If some of the features require some other features to work, this is explained in the beginning of that feature, for example the Beacon-enabled ranging with ERDEV do require to implement things explained in the Ranging section.

Each optional feature will be expressed in similar structure using following table of contents:

1. Overview of XXX
2. Channel access
3. Starting and maintaining PANs
4. Association and disassociation
5. Synchronization
6. Transmission
7. Reception
8. Each special feature offered by this optional feature as separate subsections (or this might be the only subsection here if this is feature that does not modify standard operations at all)
9. Header IEs
10. Nested IEs
11. MAC Commands
12. MAC management service primitives
13. MAC constants and PIB attributes

If any of those subsections does not have any content it is left out.

My guess is that after this the Clause 6 will be about 50 pages instead of 150 pages like now, Clause 7 would most likely shrink from 250 pages down to 100 pages.

1. Split Table 11-2 PHY PIB attributes

Table 11-2 PHY PIB attributes has came quite unmanageable. It is now 8 pages long, and the items in it are not in any logical order. I propose that we split that to multiple tables so that each separate feature is in separate table. We could have like following tables:

* Generic PHY PIB attributes
  + phyCcaMode, phyCurrentChannel, phyTxPower, phyCurrentPage, phyModeSwitchEnable, phyModeSwitchParameterEntries, phyRanging, phyCcaDuration (Only for 920 MHz Band?), phyBroadcastTxPower, phyUnicastTxPower, phyPeersTxPower, phyRxRmarkerOffset, phyTxRmarkerOffset
* Fragmentation relaed PIB attributes
  + phyFragmentSize, phyPsduFragSecure, phyFragmentFrameCounter, phyFrakProgressTimeout, phyPsduFragPadValue, phyPsduFragmentationEnabled
* FSK PHY related PIB attributes
  + phyFskFecEnabled, phyFskFecInterleavingRsc, phyFskFecScheme, phyFskPreambleLength, phySunFskSfd, phyFskScramblePsdu
* HrpUwb related PIB attributes
  + phyHrpUwbDataRatesSupported, phyHrpUwbCurrentPulseShape, phyHrpUwbLcpWeight1, phyHrpUwbLcpWeight2, phyHrpUwbLcpWeight3, phyHrpUwbLcpWeight4, phyHrpUwbLcpDelay2, phyHrpUwbLcpDelay3, phyHrpUwbLcpDelay4, phyHrpUwbScanBinsPerChannel, phyHrpUwbInsertedPreambleInterval, phyHrpUwbCcConstraintLength, phyHrpUwbPhrA0, phyHrpUwbPhrA1, phyHrpUwbPhrDataRate, phyHrpUwbPsduSize, phyHrpUwbPsr, phyHrpUwbSfdSelector, phyHrpUwbStsKey, phyHrpUwbStsPC2RxGap0, phyHrpUwbStsPC2RxGap1, phyHrpUwbStsPC2RxGap2, phyHrpUwbStsPC2RxGap3 (description is missing italics in some pib names), phyHrpUwbStsPC2TxGap (description is missing italics in some pib names), phyHrpUwbStsRxPacketConfig, phyHrpUwbStsRxSegLen, phyHrpUwbStsRxSegNum, phyHrpUwbStsTxPacketConfig, phyHrpUwbStsTxSegLen, phyHrpUwbStsTxSegNum, phyHrpU-wbStsVCounter, phyHrpUwbStsVUpper96
* LrpUwb related PIB attributes
  + phyLrpUwbFixedDelayFactor, phyLrpUwbFixedReplyTime, phyFixedReplyTimeSupported, phyLrpUwbPrp, phyLrpUwbSfdSelector, phyLrpUwbSignaling
* LecimDsss related PIB attributes
  + phyLecimDsssPpduModulationRate, phyLecimDsssPpduTxAt, phyLecimDsssPsduSize, phyLecimDsssPreambleSize, phyLecimDsssSfdPresent, phyLecimDsssPsduSpreadingFactor, phyLecimFecTailBitingEnabled, phyLecimDsssPsduOvsfSpreadingFactor, phyLecimDsssPsduOvsfCodeIndex
* Lecim FSK related PIB attributes
  + phyLecimFskPreambleLength, phyLecimFskPsduPositionMod, phyLecimFskSpreading, phyLecimFskSpreadingFactor, phyLecimFskSpreadingPattern, phyLecimFecEnabled (Should be renamed to ...LecimFskFec… as it is only LecimFsk related), phyLecimFskInterleavingEnabled, phyLecimFskSplit, phyLecimFskSplitBurstDistribution, phyLecimFskSplitChannelMultiplier, phyLecimFskSplitFec, phyLecimFskSfdSpreading, phyLecimFskSymbolRate
* Tvws related PIB attributes
  + phyTvwsFskSpreadingEnabled, phyTvwsFskWhiteningEnabled, phyTvwsSfdLength, phyTvwsFskFecScheme, phyTvwsChannelAggregation
* RS-GFSK related PIB attributes
  + phyRsGfskShortPhrEnabled, phyRsGfskPreambleLength, phyRsGfskPrecode, phyRsGfskSfd
* PIB attributes related to multiple specific PHYs
  + phyCurrentCode, phyLecimCurrentBand, phyCurrentLecimPhyType, phyLecimChannelSpacing, phyCmbModulation
* Other PIB attributes related to specific PHYs
  + phyOfdmInterleaving, phyLmrCodingRate

1. Clarify the channel pages

Channel pages in the document are not really clear and there is no real description what they mean. In the IEs or MAC Commands it is either 7-bit (7.5.10 Coordinator Realignment command) or 8-bit field (7.4.4.32 Channel hopping IE, 7.5.26 SRM Request command). Table 8-112 MAC PIB attributes for hopping sequence says its range is 0x00-0x1f (5-bits).

The Chennel number is most often 16-bit field, but there are cases where it is 8-bit field which is extended to 15 bit field, allowing 32767 maximum channels.

The current definition if Channel page is:

Channel assignments are defined through a combination of channel numbers and channel pages.

Also the text continues:

If the requested PHY PIB attribute is the phyCurrentPage, the attribute was successfully set to a different value from the current value, and the channel is no longer valid, then the PHY shall also set the phyCurrentChannel to the lowest valid channel for the requested page.

Meaning that if phyCurrentPage PIB attribute is changed then phyCurrentChannel is also reset to lowest valid channel on requested page. The problem is that there is no selection of band anywhere in our specification so after setting phyCurrentChannel it is impossible to know which frequency is going to be used as band is unknown.

Note, that in 802.15.4-2006 the Channel Page was defined to be from 0 to 31.

The table of channel pages is:

|  |  |  |  |
| --- | --- | --- | --- |
| **Channel Page** | **Bands used in** | **Number of Channels** | **Notes** |
| 0 | 868 MHz, 915 MHz, 2450 MHz | 1/10/16 | Does not specify which PHY.  From 802.15.4-2006 the 868 MHz and 915 MHz were for BPSK PHY, and 2450 was for O-QPSK |
| 1 | 868 MHz, 915 MHz, 2450 MHz | 1/10/11 | Does not specify the PHY. From 802.15.4-2006 the 868 MHz and 915 MHz were for ASK, and 2450 was for O-QPSK  Text says that channel pages one and two 11 channels are available across the two frequency bands to support the O-QPSK PHY, respectively.  The O-QPSK supports 5 frequence bands: 780 MHz band, 868 MHz band, 915 MHz band, 2380 MHz band, and 2450 MHz band. If we leave out 915 and 868 MHz bands we are left with 780 MHz, 2380 and 2450 MHz bands, which is more than 2. Perhaps the channel page 5 is used for the 780 MHz band, which would mean that the 2450 MHz would actually cover both 2380 MHz and 2450 MHz bands, but it does not tell which one of them is channel page 1 and which is 2.  From the 802.15.4-2011 we can see that this used to say “For channel pages one and two, 11 channels numbered zero to ten are available across the two frequency bands to support the ASK and O-QPSK PHYs, respectively.”, i.e., channel page 1 is for ASK, and channel page 2 is for O-QPSK for 2540 MHz band.  As ASK was removed the channel page 1 for 2540 band is not used. Note, that this does NOT match 802.15.4-2006 which said channel page 1 for 2540 was O-QPSK, on the other hand we already have channel page 0 for 2540 MHz band for O-QPSK |
| 2 | 868 MHz, 915 MHz, 2450 MHz | 1/10/11 | Does not specify the PHY. From 802.15.4-2006 the 868 MHz and 915 MHz were for O-QPSK PHY.  See channel page 1 notes. |
| 3 | CSS PHY (2412-2484 MHz) | 13 |  |
| 4 | HRP UWB | 15 |  |
| 5 | 780 MHz | 8 |  |
| 6 | (Was 950 MHz band), current unused. |  |  |
| 7 | MSK PHY 433 MHz, 2450 MHz | 15 + 42 + 16 = 73 | Channel numbers are not overlapping, thus 433 MHz band have first 15 channel numbers, then 2450 MHz band has 42 next channel numbers for one data rate, and last 16 channel numbers for another data rate. |
| 8 | LRP UWB | 10 |  |
| 9 | SUN PHY | 6+1599+199+793+397+199+199+39+19+153+77+39+19+9+6+39+4+69+35+137+35+35+19+10+37+10+10+29+15+7+57+15+7+15+3+59+29+117+29+29+399+397+393+79+77+73+129+64+513+257+129+64+31+20+129+12+129+64+513+257+129+64+31+20+129+12+91+45+358+180+91+45+21+13+91+8+64+32+253+127+64+32+15+9+64+6+29+15+133+57+29+15+29+14+7+53+27+14+7+3+1+14+32+16+8+5+32+16+125+63+32+3+19+10+73+37+19+10+4+3+19+38+18+12+149+75+38+18+9+5+37+20+77+39+20+20+24+12+93+47+24+12+6+3+24+2559+2557+2553+7279+7277+7273+416+207+416+207+97+64+16+34+17+12+12+7 = 43123 used channels | SUN PHY has lots different bands, different PHYs (SUN FSK, SUN OFDM, SUN O-QPSK), and each having multiple modes. The number of channels indicated here is sum of all possible channel numbers in all different SUN PHYs and all different modes, but only taking account channels that are in use.  The channel number actually used does not carry information about the Band, PHY or the mode, thus max channel number is 7279 (1427 MHz band using SUN FSK operating mode #3).  This means that there are lots of overlapping channel numbers, thus channel number x does not identify the actual frequency in any way. |
| 10 | SUN FSK Generic PHY mode |  | No idea what is the channel numbers in this case. |
| 11 | 2380 MHz | 15 |  |
| 12 | LECIM PHY | LECIM DSSS: 16+8+199+39+69+34+129+32+36+34+64+416 = 1076  LECIM FSK:  8+199+39+34+129+32+36+34+64+16+399+79+69+259+69+129+156+28+835+723+16795+3347+2926+10907+2715+3345+2925+5445+14+417+361+8397+1673+1463+5453+1357+1672+1462+2722+7+208+180+4198+836+731+2726+678+836+731+1361+3+104+90+2099+418+365+1363+339+418+365+680 = 95469 | For LECIM DSSS channel numbers start from 1, channel number 0 is not used.  For LECIM FSK the channel numbers start from 0, and there are lots of different bands channel spacings and modes, and just giving out channel number, does not indicate the actual frequence to be used. Note, that max channel number is 16795 from 470 MHz band using lecimBaseMultiplier. |
| 13 | RCC PHY | 187+159+479+400+3199+960+960+51+5119+416+249 = 12179 + some which are defined in 47 CFR, Part 90, Subpart S, Section 90.613 and 90.1213. | Same as SUN PHY and LECIM, i.e., lots of channel numbers with same number, but different band. |

In addition to those we have CMB PHYs which have 3 bands for CMB O-QPSK PHY having 21, 9 and 11 channels, and 3 bands for CMB GFSK PHY having 84, 6, and 44 channels. The channel page is not defined at all for CMB PHYs.

And then there is TASK and RS-GFSK PHYs not defining which channel page they are using. For TASK there is 6 different bands using Frequence band identifiers 1, 3, 4, 5, 8 and 13, and having 4, 50, 4, 6, 10, and 16 channels. For RS-GFSK there is 14 bands, each having multiple MCS modes, and different number of channels.

Btw total combinations of phy/band/channel/operating mode is 152042.

**Proposal:**

1. We add table like above to the 10.1.3.1 and remove all channel page text from the rest of subclauses.
2. We rename “10.1.3.2 Channel numbering for 780 MHz band” to include PHY, and remove the text exempting it for some PHYs
3. We do same for “10.1.3.3 Channel numbering for 868 MHz, 915 MHz, and 2450 MHz bands”, but split it in pieces so that each PHY (BPSK, O-QPSK) has separate sections. Or more likely change 10.1.3.2 to cover BPSK and 10.1.3.3 to cover O-QPSK.
4. We do same for “10.1.3.10 Channel numbering for 2380 MHz band”, i.e., specify which PHY it is for.
5. We allocate channel pages for CMB (one for CMB O-QPSK, and another for CMB GFSK).
6. We allocate channel pages for TASK and RS-GFSK PHYs.
7. We explain in 10.1.3.1 that Channel number and Channel page does not include the band or operating mode information thus they are not sufficient for certain PHYs to indicate the actual operating frequency.
8. Do we want to solve the band and operating mode issue?