uPart Protocol
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uPart Protocol Version 00 Rev 000

Status of this Memo

This document is an Particle Protocol
Status: Draft 150805

Abstract

This memo describes Link Layer and ConCom Layer of the uPart Protocol

Conventions used in this document
To be done.

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1. Protocol Overview

The uPart protocol follows the general AwareCon protocol specification. This especially means that the uPart protocol is datagram oriented. The uPart protocol suite consists of the following parts:

```
+------------------------------+
|      ConCom-u Protocol       |
+------------------------------+
|        uPart LL-Protocol     |
+------------------------------+
|     uPart RF-Protocol       |
+------------------------------+
```

uPart Protocol Suite

Figure 1.

This document describes the LL and AwareCon Parts of the uPart protocol only. The MAC part and the RF part of the protocol are described in a separate document.
1.1 UPart Protocol, other AwareCon implementations and Internet based applications interoperability

UParts are very resource restricted sensor devices that are only able to transmit and not to receive data. Still the uPart protocol is compatible with the AwareCon protocol suite at ConCom layer but optimized for operation at the uPart sensor node platform.

Figure 2 shows the interoperation between the uPart, Particle and IP based AwareCon applications and services.

| uPart Protocol | uBridge | Internet
|----------------+---------|-------------|
| uPart          | uBridge | +---------------------+
| ---------------|---------| IP based application|
| <-----          | <-------| or services         |
| <----------| <------|---------------------|
| Particle Protocol |

AwareCon Interoperation Example

Figure 2
2. uPart Protocol: Link Layer (LL)

A summary of the contents of the uPart LL header and footer follows:

```
[0]  [1]                  
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+-----------------------------+
|Ver|Payloadlen|FS|SeqNo|
+-----------------------------+
|ID (MSB)|ID       |
+-----------------------------+
|ID       |ID (LSB) |
+-----------------------------+
// ConCom-u //
+-----------------------------+
|Checksum (MSB)|Checksum(LSB)|
+-----------------------------+
```

uPart LL Datagram Header
Figure 3.
Note that each tick mark represents one bit position.

Ver: 4 bits
The Version (Ver) field indicates the format of the uPart LL header. Version 00 specifies 00 as the only valid entry

Payloadlen: 6 bits
The Payloadlen field is the length of the payload datagram, measured in bytes (octets). The payload is the ConCom part of the datagram

FS: 2 bits
The fieldstrength (FS) field indicates the fieldstrength of sent data from the uPart device. Version 000 specifies:
- 00: smaller than -12 dBm
- 01: between -12 and -5 dBm
- 10: between -4 and +4 dBm
- 11: larger than 5 dBm

The field-strength may be set according to the configuration (see configuration) which should be set according to the hardware selected field-strength or may be set fixed by the firmware. In the latter case a suitable firmware with the correct set field-strength must be used by the device.

SeqNo: 6 bits
The Sequence number allows to distinguish packets. Every time a packet is sent the SeqNo is counted up.
ID: 32 bits
The 4-byte Identifier of the uPart device
Checksum: 16 bits
A Checksum of the whole LL packet. The checksum follows the CRC16 CCITT algorithm.

3. uPart Protocol: ConCom

Version 00 of the uPart protocol implements a very restricted ConCom protocol. The following restrictions apply:

- only 1 ConCom-Tuple and therefore only one ConCom-Datatype (CCDT) is allowed
- The allowed CCDT is fixed to Artefact Mu-Part (AMP = (185,94))

A summary of the contents of the uPart datagram follows:

```
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|CCDT-Type=185 | CCDT-Type=94 | CCDT-Length | Config (MSB) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Config | Config (LSB) | BatLevel | Sensor1 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Sensor2 | Sensor3 | Prec(4) | Res(4) |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
//
// Sensor Readings History (Array)
```

uPart ConCom Datagram Header
Figure 4.

Note that each tick mark represents one bit position.

CCDT-Type: 16 bits
The CCDT type indicates the ConCom Datatype of the following data. Here fixed to 185(MSB),94(LSB). This value corresponds to a AMP (Artefact Mu-Part) ConCom Datatype.

CCDT-Length: 8 bits
The CCDT length indicates is the length of the following CCDT payload, measured in bytes (octets). The CCDT payload starts with the byte after the CCDT-Length. In Version 00 the payload ends either with the Reserved (Res) field or the Sensor Readings History.

Config: 24 bits
The Config describes the configuration of the AMP-Tuple. The AMP-Tuple Configuration is described in section 3.1.

**BatLevel:** 8 bits

The BatLevel corresponds to the battery level of the uPart device. The is encoded as Batter-Level(V) = Batlevel*0.1

**Sensor1:** 8 bits

The Sensor1 corresponds to the first sensor of the uPart. The value corresponds to the number of pulses read every 144 ms in the uPart device.

**Sensor2:** 8 bits

The Sensor2 corresponds to the second sensor of the uPart. The value corresponds to the first 8 most significant bit of the 10 bit analog reading interpreted as temperature in °C. The value is given as a signed byte.

**Sensor3:** 8 bits

The Sensor3 corresponds to the third sensor of the uPart. The value corresponds to the first 8 most significant bit of the 10 bit Analog reading.

**Precision:** 4 bits

Precision of Sensor2 and Sensor3 readings. Defined as

```
0 1 2 3
+-+-+-+-+
|P2 |P3 |
+-+-+-+-+-
```

P2: 2-bit precision of sensor2 reading,
P3: 2-bit precision of sensor3 reading

**Res:** 4 bits

Future use

**Sensor Readings History (Array)**

The Sensor Readings History Array is an optional array that contains past /compressed sensor readings from 2 sensors. See section Past-Compressed Sensor Readings

3.1 AMP-Tuple Configuration Description
Config description for AMP

Figure 6

Note that each tick mark represents one bit position.

Ver:  2 bits
  Fixed to 00 for Version 00

Res:  3 bits
  In Version 00 Rev 000 of the protocol reserved bits are used to set
  the fieldstrength bits. Usage is as follows:
  0 1 2
  +-----+
  | R | FS |
  +-----+
  where R is a reserved bit and FS are the fieldstrength bits.
  Encoding of the FS bits is as described in the FS field in section 2
  of this protocol description.

TB:  3 bits
  Time base for sensor readings. The following time bases are
  defined:
    TB  TIMEBASE
    000  18 Milliseconds
    001  36 Milliseconds
    010  72 Milliseconds
    011 144 Milliseconds
    100 288 Milliseconds
    101 576 Milliseconds
    110 1152 Milliseconds
    111 2304 Milliseconds
Sens1:  4 bits
Type of sensor 1 when transferring Past/compressed data. Meaning as follows (other values are not allowed)

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No compressed sensor values should be transferred</td>
</tr>
<tr>
<td>1</td>
<td>Temperature sensor</td>
</tr>
<tr>
<td>2</td>
<td>Light sensor</td>
</tr>
<tr>
<td>4</td>
<td>Acceleration sensor 1</td>
</tr>
</tbody>
</table>

IMPORTANT: This value MUST BE set to 0 in Version 00 Rev 000 of the protocol. If Sens2 is not set to 0 Past/compressed data contains the movement value in Sens1

Sens2:  4 bits
Type of sensor 1 when transferring Past/compressed data. Meaning as follows (other values are not allowed)

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No compressed sensor values should be transferred</td>
</tr>
<tr>
<td>1</td>
<td>Temperature sensor</td>
</tr>
<tr>
<td>2</td>
<td>Light sensor</td>
</tr>
<tr>
<td>3</td>
<td>Movement sensor</td>
</tr>
<tr>
<td>4</td>
<td>Acceleration sensor 2</td>
</tr>
</tbody>
</table>

IMPORTANT: If Sens1 is set to 0 OR Sens2 is set to 0 also Sens2 OR Sens1 MUST BE set to 0 respectively.

ReadCyc:  4 bits
ReadCyc indicates the reading cycle for sensor readings on the uPart networked sensor device. Sensor values are read every SENSORCYCLE = 2^ReadCyc * TIMEBASE. The maximum value is then 75497472 Milliseconds. Typical SENSORCYCLES for a TIMEBASE of 144 Milliseconds are:

<table>
<thead>
<tr>
<th>ReadCycle</th>
<th>SENSORCYCLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>288 Milliseconds</td>
</tr>
<tr>
<td>2</td>
<td>576 Milliseconds</td>
</tr>
<tr>
<td>3</td>
<td>1.152 Seconds</td>
</tr>
<tr>
<td>4</td>
<td>2,304 Seconds</td>
</tr>
<tr>
<td>5</td>
<td>4,608 Seconds</td>
</tr>
<tr>
<td>6</td>
<td>9,216 Seconds</td>
</tr>
<tr>
<td>7</td>
<td>18,432 Seconds</td>
</tr>
<tr>
<td>8</td>
<td>36,864 Seconds</td>
</tr>
<tr>
<td>9</td>
<td>73,728 Seconds</td>
</tr>
<tr>
<td>10</td>
<td>ca. 147 Seconds</td>
</tr>
<tr>
<td>11</td>
<td>ca. 295 Seconds</td>
</tr>
<tr>
<td>12</td>
<td>ca. 9.8 Minutes</td>
</tr>
<tr>
<td>13</td>
<td>ca. 19 Minutes</td>
</tr>
<tr>
<td>14</td>
<td>ca. 39 Minutes</td>
</tr>
<tr>
<td>15</td>
<td>ca. 78 Minutes</td>
</tr>
</tbody>
</table>

Compr:  4 bits
Compr is the compression cycle when collecting past sensor values (see below).
3.2 Sensor Readings History Array

The Sensor Readings History Array is an optional 2n-byte array that contains past sensor readings from 2 sensors. The structure of the array is as follows:

```
+--------------------+--------------------+
|   oldest reading   |   oldest reading   |
|  sens1              |  sens2              |
+--------------------+--------------------+
|  next reading       |  next reading       |
|  sens1              |  sens2              |
+--------------------+--------------------+
    ...    
+--------------------+--------------------+
|  newest reading     |  newest reading     |
|  sens1              |  sens2              |
+--------------------+--------------------+
```

Figure 7

In total n old readings from 2 sensors are build the Past-Compressed Sensor Reading Array. The length of the sensor array is therefore 2*n (or 2n). If the Sens2 field in the Config-field of the uPart Protocol ConCom Datagram is set to 0 no Past-Compressed Sensor Reading Array is transferred.

The Sens fields of the Config-field of the uPart Protocol ConCom Datagram indicate the type of sensor that should be used for sensor1 or 2 respectively.

IMPORTANT: In protocol Version 00 Rev 000 Sens1 MUST be assigned to the Motion sensor
IMPORTANT: In protocol Version 00 Rev 000 n is set to 12 (arraylength is set to 24)

Stored data in Sensor Readings History Array are merged and compressed. The Compr-field in the Config-field of the uPart Protocol ConCom Datagram is used to calculate the number of sensor readings that are used to be compressed into one Sensor Array value. Each past compressed sensor reading is a combination of $2^{\text{Compr}}$ sensor readings. This means that each sensor value in the Past-Compressed Sensor Array represents readings from a timespan of

$$\text{CTIMESPAN} = \text{SENSORCYCLE} \times 2^{\text{Compr}} \text{ Milliseconds}$$

The total time covered by the array can then be computed as
The algorithm used to generate the sensor values in the Past-Compressed Sensor Array depends on the sensor type used. The format of the values is as follows:

Motion Sensor Values:

```
0 1 2 3 4 5 6 7
+-+-+-+----------+
| Mean | Max-Min |
+-+-+-+----------+
```

where Mean is the 4-bit MSB of the Mean value of the sensor readings in CTIMESPAN and Max-Min is the 4-bit MSB of the difference between the minimum and maximum sensor value in CTIMESPAN. In Version 00 Rev 000 Sensor readings are number of counted motions detected while detecting motion every 144 Milliseconds if SENSORCYCLE <= 32 Seconds or number of counted motions detected while detecting motion every 36864 Milliseconds otherwise.

Light Sensor Values:

```
0 1 2 3 4 5 6 7
+-+-+-+----------+
| Mean | Max-Min |
+-+-+-+----------+
```

where Mean is the 4-bit MSB of the Mean value of the sensor readings in CTIMESPAN and Max-Min is the 4-bit LSB of the difference between the minimum and maximum sensor value in CTIMESPAN. If the difference between the minimum and maximum sensor value is greater than 15 the Max-Min value is set to 15.

Temperature Sensor Value

Is the 8-bit MSB of the mean of the sensor values in CTIMESPAN. Range is from -127 to 127 °C.
4. **Summary of uPart protocol packet**

This section provides a condensed summary of the packet.

\[
\text{<u-packet[19 or} \\
\text{19+length(Past-compressed sensor readings array)}\text{]}>= \\
\text{<LLHeader[6]} \text{=} \\
\text{<Ver(2) Payloadlen(6) FS(2) SeqNo(6) ID(32)}\text{>} \\
\text{<ConCom Payload [11+2n]> =} \\
\text{PrecisionSensor2(2) PrescisionSensor3(2) Res(4)} \\
\text{Past-compressed sensor readings array [2n]} > \\
\text{<LLFooter[2]} \text{=} \text{<CRC(16)}\text{>}
\]

**where**

\[
\text{<Config[3]} \text{=} \text{<Version(2) Reserve(3) TB(3) Sens1(4) Sens2 (4)} \\
\text{ReadCyc(4) Compr(4)}> \\
\]

Note that numbers in [brackets] mean size in byte while numbers in (brackets) mean size in bit.