**The CoIoT Protocol for Shelly devices**

The CoIoT is optimized for IoT solutions and based on the [CoAP](https://tools.ietf.org/html/rfc7252) as an industry standard. UDP is used on the transport layer to acknowledge the limited resources of IoT resources.

Every CoIoT device is expected to handle a set of request URIs and generate responses in predefined format. Also, every device is required to periodically send a multicast CoAP request with option code 0.30 that describes it’s state.

Every CoAP request package and every response with payload should also carry some mandatory CoAP options (headers). The

**CoIoT Device Communication**

The Shelly implementation of the CoIoT protocol covers the following aspects of the communication between an application like the Shelly Apps or 3rd party Apps and the Shelly devices.

### Device Discovery: The Shelly series of devices support the mDNS standard allowing an application to discover devices on the local network. The REST API is announced as service of type “\_http.\_tcp.local.”. This includes the unique device id (which is also used as hostname, mDNS TXT record). By default: <device type>-<last 6 digits of the device’s MAC address), e.g. shellyswitch25-686ec1 Note: The application should not use the device IP address as unique identifier if dynamic IP addresses are used (DHCP).

* Once the device is discovered you could send a CoAP message to retrieve the CoIoT device description. This provides information on the logical components of the device, sensors and actors in a JSON format. See section “Device description (/cit/d)” for details on the format.
* Finally the application subscribes to status updates (per device, only once). Those updates are published periodically on the local network. For efficiency purposes those messages are send using the IP Multicast protocol using multicast IP 224.0.1.187 and port 5683. Send out once, but received by all devices listening to the multicast socket.
* Status updates are send out periodically (default every 15sec). The application needs to implement some kind of dispatching if multiple devices should be supported. Due to the fact that only a single multicast IP and port are used the messages from all devices are received from the same socket. The application needs to identify the sending device by decoding the CoAP option GLOBAL\_DEVID (3332), the sending IP address or some other mechanism. See n“Device status (/cit/s)” for details on the received message.
* A device could be considered rebooted (e.g. after a power failure) if no status updates are received over a longer period of time (e.g. 3\*15sec). In this case the subscription to status updates needs to be renewed. If the device is not responding it could be considered as dead or not available.
* Each packet has a serial (CoAP option 3420). This will be incremented each time a status value has changed. Receiving a packet with the same serial indicates a regular status update, but none of the sensors have changed. In this case the application could ignore the packet.

In general your implementation should be fault tolerant and able to recover from communication issues. CoIoT by itself does not integrate any recovery mechanisms, e.g. a packet loss.

**CoIoT mandatory CoAP options**

Some non-standad CoAP options are required to be transmitted to help quickly identify the remote device and determine if further processing is needed. Those are transmitted using CoAP Code 0.30.

Important: The CoAP implementation has support this non-standard code, otherwise the application is not able to receive the messages. For example: Java developers using the Californium framework need to use version 2.0.0 or newer to get this pre-requisite full-filled.

To follow CoAP standard, options are numbered above 2048 where proprietary options should reside. LS Bits carry some CoAP proxy flags so we guard them with spacing the numbers with increment of 8.

|  |  |  |
| --- | --- | --- |
| CoAP Option | Code | Description |
| COIOT\_OPTION\_GLOBAL\_DEVID | 3332 | A unique device identifier including the device type and the last 6 digits of the device.  <devtype>#<devid>#<version>  for example “SHSEN-1#4B3F9E#1” |
| COIOT\_OPTION\_STATUS\_VALIDITY | 3412 | Maximal time between this and the next status publish, see section COIOT\_OPTION\_STATUS\_VALIDITY for details. |
| COIOT\_OPTION\_STATUS\_SERIAL | 3420 | Indicates a change in the status report when changed from the last packet, see section COIOT\_OPTION\_STATUS\_SERIAL for details. |

**COIOT\_OPTION\_GLOBAL\_DEVID**

First defined option is COIOT\_OPTION\_GLOBAL\_DEVID This is global option and must be present in all CoIOT packages with request or payload.

Its value is string in format <devtype>#<devid>#<version>, for example SHSEN-1#4B3F9E#1

The whole option should be less than 50 bytes.

Other mandatory options are COIOT\_OPTION\_STATUS\_VALIDITY and COIOT\_OPTION\_STATUS\_SERIAL this are mandatory only in status responses or publishes.

**COIOT\_OPTION\_STATUS\_VALIDITY**

COIOT\_OPTION\_STATUS\_VALIDITY is uint16\_t in network byte order (big endian) that states the maximal time between this and the next status publish. This way a device can state its report interval. If a report is not received from this device after the interval has passed the device should be considered offline. The LS bit of this option controls how the values is scaled. if the LS bit is 0 the value is number of 1/10 of seconds in the validity period so 2 is 0.2 seconds, 10 is a second, 600 is a minute, 65534 is 109 minutes and 13 seconds. If the LS bit of COIOT\_OPTION\_STATUS\_VALIDITY is 1 the value is number of 4 seconds interval in the whole interval. So 3 is 12 seconds 11 is 44 seconds and 65535 is more than 3 days.

**COIOT\_OPTION\_STATUS\_SERIAL**

This option is mandatory in status response and publishes. It is a uint16\_t in network byte order which indicates a change in the status report. When a new status report is handled all payload processing can be skipped if the serial number does not change from the last processed payload. The value 0 is reserved and should not be send. This allows easy initialization in the receiving devices.

**Reserved options numbers**

Devices are free to define and use their own options but we reserve some for future protocol development.

**Device description (/cit/d)**

Every device should response to CoAP GET request with URI /cit/d and return JSON payload describing the device. Throughout the description all <id> values should be non-overlapping integers that are used as unique identifiers of blocks and sensors

The top-level object should look like:



{

"blk": [....],

"sen": [....],

"act": [....]

}

**blk array** should hold list of all "blocks" of the device. Each device should have at least one block.  
For example, if you're device exposes just few sensors it needs just one block, but if you have a multi-channel relay you should define a block for each relay. Each sensor or action should be linked to one or many blocks to help users better understand what is measured and what is executed in more complex devices.

blk elements should be objects with structure



{"I":<id>, "D":<desctiption>}

**sen array** should hold list of all sensors and states in the device. These should be objects with structure:



{"I":<id>, "T":<type>, "D":<description>, "R":<range>, "L":<links>}

T field is mandantory and provides the type of the sensor, see below.

D field is mandatory giving a description of the sensor.

L field is mandatory array of int or single integer with IDs of device blocks to which this sensor relates (you can have two relays with single power meter).

R is an optional describing the value range in text form either "from/to" value or in form <I|U><8|16|32> showing expected signed or Unsigned integer size

**Supported sensor types:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **<type>** |  | **<description>** | **Measuring Unit** | **Remarks** |
| A | Air Quality |  | Index | 0..10: best to worst |
| B | Battery Percentage | Battery | Percent (%) | 100:battery is fully charged; 20 and below Battery need to be changed/charged |
| H | Humidity | humidity | Percent (%) | Relative humidity |
| L | Luminosity | lux | Lux |  |
| M | Motion | motion | Integer | 1: Motion detected; 0: No motion |
| Red | RGB value | n/a | Integer | 0..255 |
| Green | RGB value | n/a | Integer | 0..255 |
| Blue | RGB value | n/a | Integer | 0..255 |
| White |  | n/a | Integer | 0..255 |
| Temp |  | n/a | Kelvin (K) | Depending on device, e.g. 2700K..6500K |
| Gain |  | n/a | Percent (%) | 0..100% |
| Brightness |  | n/a | Percent (%) | 0..100% |
| P | Power |  | Watt (W) | Power consumption at the moment |
| VSwitch |  |  | Integer |  |
| S | Status | Input | Integer | Depending in relay mode: 0=open, 1=closed or  When in momentary button mode: 0=open/no button pushed, 1=short button push, 2=long button push |
|  |  | State  ~~Switch~~ | Integer | 0=open/OFF, 1=closed/ON |
|  |  | motion | Integer | 1=motion detected |
|  |  | charger | Integer | 1=charger connected |
|  |  | Energy counter 0 [W-min] | Watt-minute | Energy counter value for the last minute |
|  |  | Energy counter 1 [W-min] | Decimal | Energy counter value for the minute before |
|  |  | Energy counter 2 [W-min] | Decimal | Energy counter value 3 minutes ago |
|  |  | Energy counter total [W-min] | Decimal | Total energy consumed by the attached electrical appliance in Watt-minute |
|  |  | External temperature C | Celsius (C) | Different sensor IDs are used to provide the measurement for sensor 1-3. |
|  |  | Position | Percent (%) | Roller position: 0%=open, 100%=closed |
|  |  | Overtemp | Integer | 1=device detected an overheating condition |
| T | Temperature | Temperature |  | Sensor temp (in C or F) |
|  |  | Temperature C / tC | Fahrenheit (F) | Internal device temperature in F |
|  |  | Temperature C / tF | Celsius (C) | Internal device temperature in C |
| E | Event | Button power motion sensor roller\_up/down/moving charging settings | String | button=Device wakeup by button power=Device was power-up roller\_up, roller\_moving,roller\_down settings=Settings updated charging=Device is charging |
| E |  | Alarm | Integer | Alarm condition detected flood=Flood condition detected overload load\_error overpower=power consumption high overtemp=over temperature battery=Low battery detected |

**Example sensor description:**



{

"blk": [

{

"I": 1,

"D": "sensors"

}

],

"sen": [

{

"I": 11,

"D": "motion",

"T": "S",

"R": "0/1",

"L": 1

},

{

"I": 22,

"D": "charger",

"T": "S",



"R": "0/1",

"L": 1

},

{

"I": 33,

"D": "temperature",

"T": "T",

"R": "-40/125",

"L": 1

},

{

"I": 44,

"D": "humidity",

"T": "H",

"R": "0/100",

"L": 1

},

{

"I": 66,

"D": "lux",

"T": "L",

"R": "0/1",

"L": 1

},

{

"I": 77,

"D": "battery",

"T": "B",

"R": "0/100",

"L": 1

}

]

}

**act elements** will describe actions possible with the device in future extension of CoIoT protocol

**Device status (/cit/s)**

Every device should response to CoAP GET request with URI /cit/s and return JSON payload describing the device. Every device should periodically "publish" its status using multicast packet in the form of non-confirmable request with code 0.30 and request path /cit/s. This code is nonstandard CoAP code and all CoAP complaint servers should silently ignore it. Throughout the status report all <id> values should match sensors ids from device description. The JSON payload should follow the form:



{

"G":

[

[0,<senid>,<value>],

[0,<senid>,<value>],

....

]

}



The G key stands for Generic. Currently all sensor values are generic and non-encrypted. Future extensions of the protocol might add P for Private and define some encryption scheme.

First 0 in sensor values tuples stand for the channel number. All sensors are required to be "emitted" in channel 0. Future extensions of the protocol might define a way for the users to define extra "mapping" for sensors to channels that will be **added** to the status after the values from channel 0. This will allow for easy reconfiguration of peer to peer network. For example a multi zone alarm system can be configured to react based on channel number activity and not to have to explicit list every sensor on every siren. Currently the first position in the sensor value tuple is reserved and should be 0.

The second position is for the sensor id, and the third is for the sensor's current value.

Given the description of the sensor above here is the status of the same sensor:



{

"G":[

[0,11,0],

[0,22,0],

[0,33,24.58],

[0,44,59.90],

[0,66,11.68],

[0,77,100]

]

}

The first tuple is for sensor id 11 that in description have D:"motion". The second is for 22 - "charger", third for "temperature" and so on

**Future plans for the CoIoT protocol**

We intend to devise a scheme for device actions to be described in the device descriptor and executed latter on. We're also considering implementing mechanism for securely publishing of private sensor data intermixed with publicly available sensor data. We dream of pure peer-to-peer automation where each actuator is **flexibly** programmed to react to one or many sensors and where adding or replacing senor or actuator does not involve reconfiguration of the whole network.

Any suggestions are welcomed!

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