Bluenet protocol v0.12.0

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Setup mode

When a Crownstone is new or factory reset, it will go into setup mode.

Setup mode turns down the power of the antenna (low TX) so you can only communicate with it when you're close by. The purpose of this mode is to configure the Crownstone so only you, or people in your group, can communicate with it.

The protocol here is as follows:

1. Crownstone is in setup mode (low TX, Setup Service active)
2. Phone is close and connects to the Crownstone
3. Phone reads the Crownstone MAC address (required for iOS). This characteristic is not encrypted.
4. Phone reads the session key and session nonce from the setup service. These characteristics are not encrypted. The values are only valid for this connection session. The session key and the session nonce will be used to encrypt the rest of the setup phase using AES 128 CTR as explained here.
5. Phone starts setting up the Crownstone using the config control characteristic
   - Phone gives Crownstone its identifier
   - Phone gives Crownstone the Admin key
   - Phone gives Crownstone the Member key
   - Phone gives Crownstone the Guest key
   - Phone gives Crownstone the Mesh Access Address
   - Phone gives Crownstone its iBeacon UUID
   - Phone gives Crownstone its iBeacon Major
   - Phone gives Crownstone its iBeacon Minor
6. Phone commands Crownstone to leave setup mode

Encryption

By default, Crownstones have encryption enabled as a security and privacy measure.

Using encryption after setup (normal mode)

When encryption is enabled the following changes:

- The scan response packet service data will be encrypted using the Guest key.
- Values that are **read from** the characteristics will be encrypted
- Values that are **written to** the characteristics will have to be encrypted

Session nonce

After connecting, you first have to read the session nonce from the Crownstone service. The session nonce is ECB encrypted with the guest key. After decryption, you should verify whether you have read and decrypted succesfully by checking if the validation key in the data is equal to **0xCAFEBABE**. If so, you now have the correct session nonce.

The session nonce has two purposes: - Validation: the first 4 bytes of the session nonce is what we call the validation key, it is used for any encrypted packet. - Encryption: the whole 5 bytes are used for the nonce, which is used for CTR encryption. The first 3 bytes of the nonce are the packet nonce (which should be randomly generated each time you write to a characteristic), the last 5 are the session nonce. The session nonce and validation key are only valid during the connection.

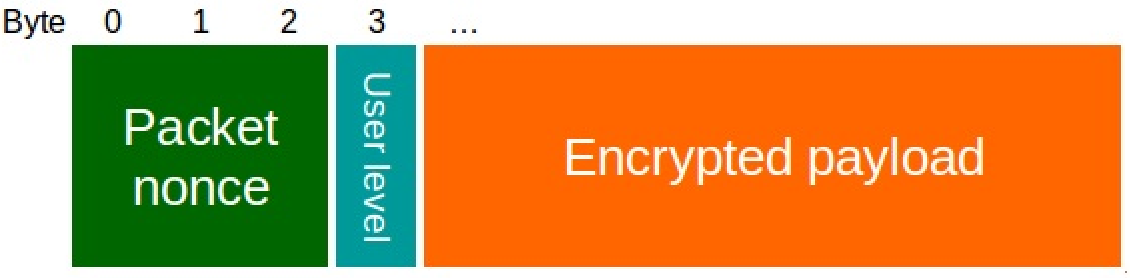
Session nonce after ECB decryption

Type	Name	Length	Description
uint 32	Validation key	4	0xCAFEBABE as validation.
byte array	Session nonce	5	The session nonce for this session.
byte array	Padding	7	Zero-padding so that the whole packet is 16 bytes.

Reading and writing characteristics

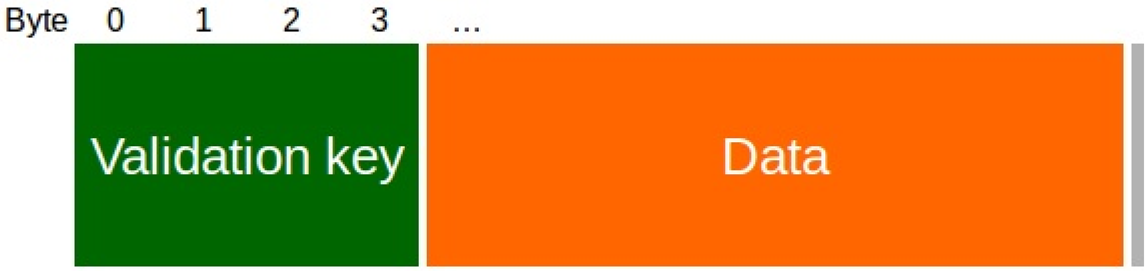
We use the AES 128 CTR method to encrypt everything that is written to- and read from characteristics. For this you need an 8 byte number called a **nonce**. The first 3 bytes of the nonce are sent with each packet, we call this the packet nonce. When writing to a characteristic, you should generate a new random packet nonce each time. The last 5 bytes of the nonce are called the session nonce, which should be read after connecting. When reading a characteristic, you should check if the (decrypted) validation key is equal to the validation key that was read after connecting.

Encrypted Packet



Type	Name	Length	Description
byte array	Packet nonce	3	First 3 bytes of nonce used in the encryption of this message.
uint 8	User level	1	0: Admin, 1: Member, 2: Guest, 100: Setup
Encrypted Payload	Encrypted Payload	N*16	The encrypted payload of N blocks.

Encrypted payload



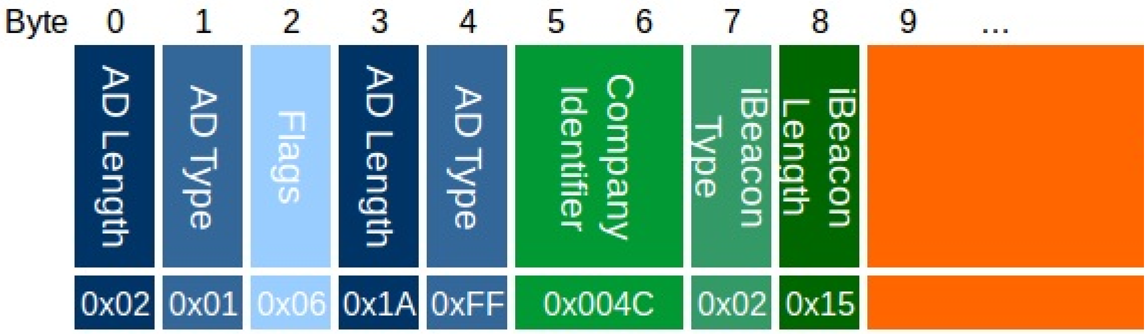
Type	Name	Length	Description
uint 32	Validation key	4	Used to verify that the correct key was used for decryption/encryption.
byte array	Payload		Whatever data would have been sent if encryption was disabled.
byte array	Padding		Zero-padding so that the whole packet is of size N*16 bytes.

Advertisements and scan response

When no device is connected, advertisements will be sent at a regular interval (100ms by default). A device that actively scans, will also receive a scan response packet. This contains useful info about the state.

iBeacon advertisement packet

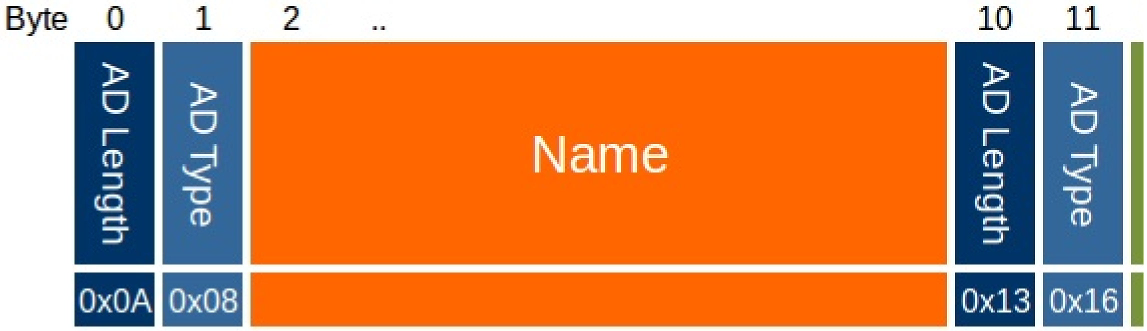
This packet is according to iBeacon spec, see for example here.



Type	Name	Length	Description
uint 8	AD Length	1	Length of the Flags AD Structure (0x02)
uint 8	AD Type	1	Flags (0x01)
uint 8	Flags	1	
uint 8	AD Length	1	Length of the Manufacturer AD Structure (0x1A)
uint 8	AD Type	1	Manufacturer Specific Data (0xFF)
uint 8	Company Id	2	Apple (0x004C)
uint 8	iBeacon Type	1	IBeacon Type (0x02)
uint 8	iBeacon Length	1	IBeacon Length (0x15)
uint 8	Proximity UUID	16	
uint 16	Major	2	
uint 16	Minor	2	
int 8	TX Power	1	Received signal strength at 1 meter.

Scan response packet

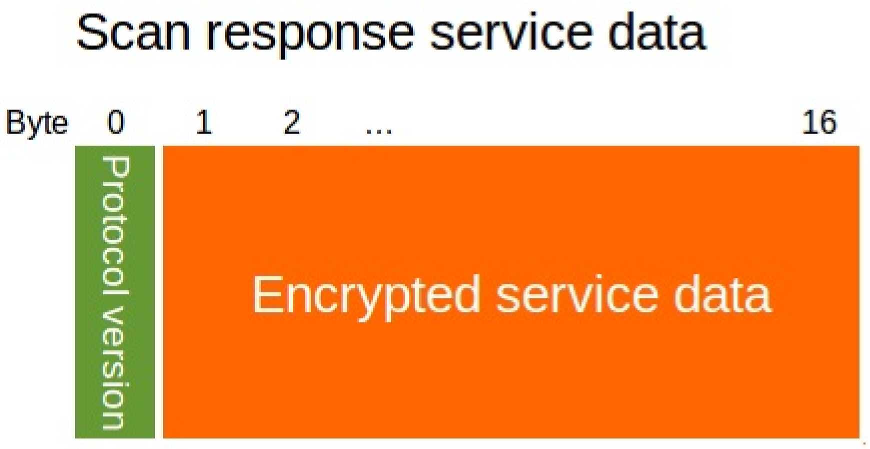
The packet that is sent when a BLE central scans.



Type	Name	Length	Description
uint 8	AD Length	1	Length of the Name AD Structure (0x0A)
uint 8	AD Type	1	Shortened Local Name (0x08)
char []	Name Bytes	8	The shortened name of this device.
uint 8	AD Length	1	Length of the Service Data AD Structure (0x13)
uint 8	AD Type	1	Service Data (0x16)
uint 16	Service UUID	2	Service UUID
Service data	Service Data	17	Service data, state info.

Scan response service data packet

This packet contains the state info. If encryption is enabled, the last 16 bytes will be encrypted using AES 128 ECB using the guest key. You receive a MAC address on Android and an UUID on iOS for each advertisement packet. This allows you to get the Crownstone ID associated with the packet and you verify the decryption by checking the expected Crownstone ID against the one in the packet.

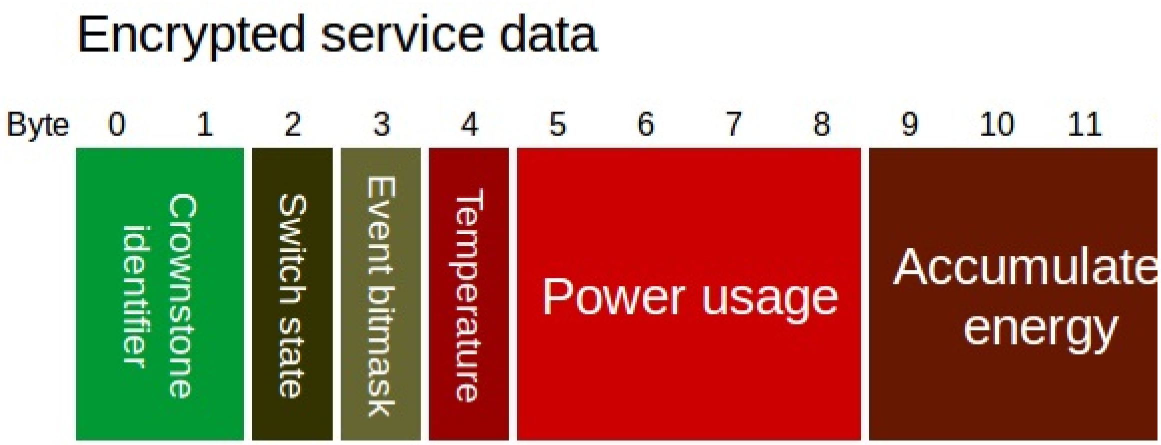


The Protocol version determines how to parse the remaining 16 bytes.

Version	Packet
1	Version 1, initial version.
2	Version 2, with power factor.

Encrypted service data packet v1

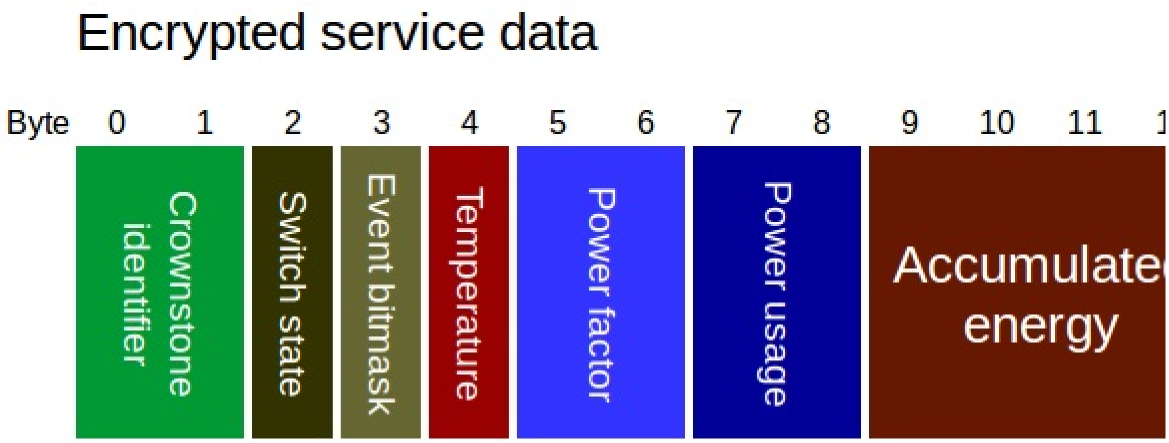
This packet contains the state info. If encryption is enabled, it's encrypted using AES 128 ECB using the guest key. You receive a MAC address on Android and an UUID on iOS for each advertisement packet. This allows you to get the Crownstone ID associated with the packet and you verify the decryption by checking the expected Crownstone ID against the one in the packet.



Type	Name	Length	Description
uint 16	Crownstone ID	2	ID that identifies this Crownstone.
uint 8	Switch state	1	The state of the switch.
uint 8	Event bitmask	1	Bitflags to indicate a certain state of the Crownstone.
int 8	Temperature	1	Chip temperature (°C).
int 32	Power usage	4	The power usage at this moment (mW). Divide by 1000 to get power usage in Watt.
int 32	Accumulated energy	4	The accumulated energy (Wh).
uint 8[]	Rand	3	Random bytes.

Encrypted service data packet v2

This packet contains the state info. If encryption is enabled, it's encrypted using AES 128 ECB using the guest key. You receive a MAC address on Android and an UUID on iOS for each advertisement packet. This allows you to get the Crownstone ID associated with the packet and you verify the decryption by checking the expected Crownstone ID against the one in the packet.



Type	Name	Length	Description
uint 16	Crownstone ID	2	ID that identifies this Crownstone.
uint 8	Switch state	1	The state of the switch.
uint 8	Event bitmask	1	Bitflags to indicate a certain state of the Crownstone.
int 8	Temperature	1	Chip temperature (°C).
int 16	Power factor	2	The power factor at this moment. Divide by 1024 to get the actual power factor.

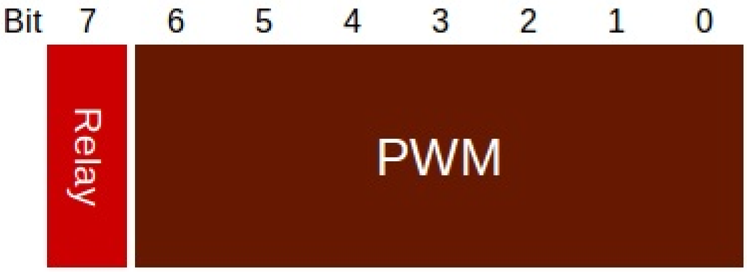
Type	Name	Length	Description
uint 16	Power usage	2	The apparent usage at this moment. Divide by 16 to get power usage in VA. Multiply with power factor to get real power usage in Watt.
int 32	Energy used	4	The total energy used. Divide by 64 to get the energy used in Joule.
uint 8[]	Rand	3	Random bytes.

Event Bitmask

Bit	Name	Description
0	New data available	If you request something from the Crownstone and the result is available, this will be 1.
1	Showing external data	If this is 1, the shown ID and data is from another Crownstone.
2	Error	If this is 1, the Crownstone has an error, you should check what error it is by reading the error state.
3	Reserved	Reserved for future use (switch locked).
4	Reserved	Reserved for future use.
5	Reserved	Reserved for future use.
6	Reserved	Reserved for future use.
7	Setup mode active	If this is 1, the Crownstone is in setup mode.

Switch State Packet

To be able to distinguish between switching with relay and switching with PWM, the switch state is a bit struct with the following layout



Bit 7 is used for the relay flag, where 0 = OFF, 1 = ON. Bits 6-0 are used for PWM, where 100 is fully ON, 0 is OFF, dimmed in between.

Services

When connected, the following services are available.

The AUG columns indicate which users can use these characteristics if encryption is enabled. The access can be further restricted per packet. Dots (..) indicate encryption is not enabled for that characteristic.

- A: Admin
- M: Member
- G: Guest

The following services are available (depending on state and config): - Crownstone service. Contains all you need: control, config and state. - Setup service. Similar to the crownstone service, replaces it when in setup mode. - General service. Contains reset and temperature characteristics. - Power service. Contains dimmer and relay control, and reading out power samples and power usage. - Indoor localization service. Contains tracked devices and scan control. - Schedule service. Contains the schedule control. - Mesh service. Contains direct mesh control, and mesh configuration.

Crownstone service

The crownstone service has UUID 24f00000-7d10-4805-bfc1-7663a01c3bff and provides all the functionality of the Crownstone through the following characteristics:

Characteristic	UUID	Date type	Description	A	M	G
Control	24f00001-7d10-4805-bfc1-7663a01c3bff	Control packet	Write a command to the control characteristic	x	x	x
Mesh control	24f00002-7d10-4805-bfc1-7663a01c3bff	Mesh control packet	Write a command to the mesh control characteristic to send into the mesh	x	x	
Config control	24f00004-7d10-4805-bfc1-7663a01c3bff	Config packet	Write or select a config setting	x		
Config read	24f00005-7d10-4805-bfc1-7663a01c3bff	Config packet	Read or Notify on a previously selected config setting	x		
State control	24f00006-7d10-4805-bfc1-7663a01c3bff	State packet	Select a state variable	x	x	
State read	24f00007-7d10-4805-bfc1-7663a01c3bff	State packet	Read or Notify on a previously selected state variable	x	x	
Session nonce	24f00008-7d10-4805-bfc1-7663a01c3bff	uint 8 [5]	Read the session nonce. First 4 bytes are also used as session key.			ECB
Recovery	24f00009-7d10-4805-bfc1-7663a01c3bff	uint32	Used for recovery.			

Recovery

If you lose your encryption keys you can use this characteristic to factory reset the Crownstone. This method is only available for 20 seconds after the Crownstone powers on. You need to write **0xDEADBEEF** to it. After this, the Crownstone disconnects and goes into Low TX mode so you'll have to be close to continue the factory reset. After this, you reconnect and write **0xDEADBEEF** again to this characteristic to factory reset the Crownstone.

Return values

The control characteristics (Control, Mesh Control, Config Control and State Control) of the Crownstone service return a uint16 code on execution of the command. The code determines success or failure of the command. If commands have to be executed sequentially, make sure that the return value of the previous command was received before calling the next (either by polling or subscribing). The possible values of the return values are listed in the table below

Value	Name	Description
0	SUCCESS	completed successfully
1	VALUE_UNDEFINED	no value provided
2	WRONG_PAYLOAD_LENGTH	wrong payload lenght provided
3	UNKNOWN_OP_CODE	unknown operation code, e.g. notify for config read
5	BUFFER_LOCKED	buffer is locked, failed queue command

Value	Name	Description
6	BUFFER_TOO_SMALL	buffer is too small to execute command
256	COMMAND_NOT_FOUND	command type not found
257	NOT_AVAILABLE	command not available in this mode
258	WRONG_PARAMETER	wrong parameter provided
259	COMMAND_FAILED	other failure
260	NOT_IMPLEMENTED	command not implemented (only debug version)
512	INVALID_MESSAGE	invalid mesh message provided
768	READ_CONFIG_FAILED	read configuration failed
769	WRITE_CONFIG_DISABLED	write configuration disalbed for this type
770	CONFIG_NOT_FOUND	config type not found
1024	STATE_NOT_FOUND	state type not found
1025	STATE_WRITE_DISABLED	writing to state disabled

Setup service

The setup service has UUID 24f10000-7d10-4805-bfc1-7663a01c3bff and is only available after a factory reset or when you first power on the Crownstone. When encryption is enabled, the control and both config characteristics are encrypted with AES CTR. The key and session Nonce for this are gotten from their characteristics.

Characteristic	UUID	Date type	Description
Control	24f10001-7d10-4805-bfc1-7663a01c3bff	Control packet	Write a command to the control characteristic
MAC address	24f10002-7d10-4805-bfc1-7663a01c3bff	uint 8 [6]	Read the MAC address of the device
Session key	24f10003-7d10-4805-bfc1-7663a01c3bff	uint 8 [16]	Read the session key that will be used to encrypt the control and config characteristics.
Config control	24f10004-7d10-4805-bfc1-7663a01c3bff	Config packet	Write or select a config setting
Config read	24f10005-7d10-4805-bfc1-7663a01c3bff	Config packet	Read or Notify on a previously selected config setting
GoTo DFU	24f10006-7d10-4805-bfc1-7663a01c3bff	uint 8	Write 66 to go to DFU
Session nonce	24f10008-7d10-4805-bfc1-7663a01c3bff	uint 8 [5]	Read the session nonce. First 4 bytes are also used as validation key.

The control characteristics (Control, and Config Control) of the Setup Service return a uint 16 code on execution of the command. The code determines success or failure of the command. If commands have to be executed sequentially, make sure that the return value of the previous command was received before calling the next (either by polling or subscribing). The possible values are the same as for the Crownstone Service, see above.

General service

The general service has UUID 24f20000-7d10-4805-bfc1-7663a01c3bff.

Characteristic	UUID	Date type	Description	A	M	G
Temperature	24f20001-7d10-4805-bfc1-7663a01c3bff	int 32	Chip temperature in Celcius. Notifications are available.	x		

Characteristic	UUID	Date type	Description	AMG
Reset	24f20002-7d10-4805-bfc1-7663a01c3bff	uint 8	Write 1 to reset. Write 66 to go to DFU mode.	x

Power service

The power service has UUID 24f30000-7d10-4805-bfc1-7663a01c3bff. **Should be encrypted but it is not at the moment due to implementation.**

Characteristic	UUID	Date type	Description	AMG
PWM	24f30001-7d10-4805-bfc1-7663a01c3bff	uint 8	Set PWM value. Value of 0 is completely off, 255 (100 on new devices) is completely on.	x
Relay	24f30002-7d10-4805-bfc1-7663a01c3bff	uint 8	Switch Relay. Value of 0 is off, other is on.	x
Power samples	24f30003-7d10-4805-bfc1-7663a01c3bff	Power Samples	List of sampled current and voltage values.	...
Power consumption	24f30004-7d10-4805-bfc1-7663a01c3bff	uint 16	The current power consumption.	x

Indoor localization service

The localization service has UUID 24f40000-7d10-4805-bfc1-7663a01c3bff.

Characteristic	UUID	Date type	Description	AMG
Track control	24f40001-7d10-4805-bfc1-7663a01c3bff	Tracked device	Add or overwrite a tracked device. Set threshold larger than 0 to remove the tracked device from the list.	x
Tracked devices	24f40002-7d10-4805-bfc1-7663a01c3bff	Tracked device list	Read the current list of tracked devices.	x
Scan control	24f40003-7d10-4805-bfc1-7663a01c3bff	uint 8	Start or stop scanning. write 0 to stop, 1 to start.	x
Scanned devices	24f40004-7d10-4805-bfc1-7663a01c3bff	Scan result list	After stopping the scan, you can read the results here.	x
RSSI	24f40005-7d10-4805-bfc1-7663a01c3bff	uint 8	RSSI to connected device. Notifications are available.	x

Schedule service

The schedule service has UUID 24f50000-7d10-4805-bfc1-7663a01c3bff.

Characteristic	UUID	Date type	Description	AMG
Set time	24f50001-7d10-4805-bfc1-7663a01c3bff	uint 32	Sets the time. Timestamp is in seconds since epoch.	x
Schedule write	24f50002-7d10-4805-bfc1-7663a01c3bff	Schedule command	Set or clear a schedule entry. To clear: only write the	x

Characteristic	UUID	Date type	Description	A M G
			index.	
Schedule read	24f50003-7d10-4805-bfc1-7663a01c3bff	Schedule list	Get a list of all schedule entries.	x

Mesh Service

The mesh service comes with OpenMesh and has UUID 0000fee4-0000-1000-8000-00805f9b34fb

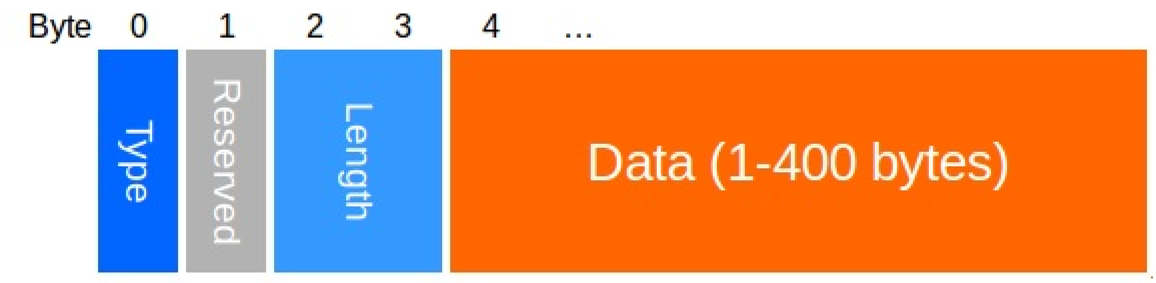
Characteristic	UUID	Date type	Description	A M G
Meta data	2a1e0004-fd51-d882-8ba8-b98c0000cd1e		Get mesh configuration.	x
Value	2a1e0005-fd51-d882-8ba8-b98c0000cd1e		Characteristic where the mesh values can be read.	x

Data structures

Index:

- Control. Used to send commands to the crownstone.
- Config. Used to configure a crownstone.
- State. Used to read the state of a crownstone.
  - Scheduler. Scheduler packets.
  - Scans. Packets of devices scanned by the crownstone.
- Mesh. Packets sent over the mesh.

Control packet



If encryption is enabled, this packet must be encrypted using any of the keys where the box is checked. In the case of the setup mode, only the Validate Setup command is available unencrypted.

Type	Name	Length	Description
uint 8	Type	1	Command type, see table below.
uint 8	Reserved	1	Not used: reserved for alignment.
uint 16	Length	2	Length of the payload in bytes.
uint 8	Payload	Length	Payload data, depends on type.

The AUGS columns indicate which users have access to these commands if encryption is enabled. Admin access means the packet is encrypted with the admin key. Setup access means the packet is available in setup mode, and encrypted with the temporay setup key, see setup. - A: Admin - M: Member
- G: Guest - S: Setup

Available command types:

Type nr	Type name	Payload type	Payload Description	A	M	G	S
0	Switch	uint 8	Switch power, 0 = OFF, 100 = FULL ON	x	x	x	
1	PWM	uint 8	Set PWM to value, 0 = OFF, 100 = FULL ON	x	x	x	
2	Set Time	uint 32	Set time to value, where value is seconds since 1970-01-01 00:00:00	x	x		
3	Goto DFU	-	Reset device to DFU mode	x			
4	Reset	-	Reset device	x			
5	Factory reset	uint 32	Reset device to factory setting, needs Code 0xdeadbeef as payload	x			
6	Keep alive state	Keep alive payload	Keep alive with state	x	x		
7	Keep alive	-	Keep alive without state, uses last state transmitted with Keep alive state command	x	x	x	
8	Enable mesh	uint 8	Enable/Disable Mesh, 0 = OFF, other = ON	x			
9	Enable encryption	uint 8	Enable/Disable Encryption, 0 = OFF, other = ON. Only has effect after a reset.	x			
10	Enable iBeacon	uint 8	Enable/Disable iBeacon, 0 = OFF, other = ON	x			
11	Enable continuous power measurement	uint 8	Enable/Disable continuous power measurement, 0 = OFF, other = ON. **Deprecated**	x			
12	Enable scanner	Enable Scanner payload	Enable/Disable scanner	x			
13	Scan for devices	uint 8	Scan for devices, 0 = OFF, other = ON. **Deprecated**	x			
14	User feedback	...	User feedback. **Not implemented yet**	x			
15	Schedule set	Schedule command payload	Set (overwrite) a schedule entry	x	x		
16	Relay	uint 8	Switch relay, 0 = OFF, 1 = ON	x	x	x	
17	Validate setup	-	Validate Setup, makes sure everything is configured, then reboots to normal mode				x
18	Request Service Data	-	Causes the crownstone to send its service data over the mesh. **Not implemented yet**	x	x		
19	Disconnect	-	Causes the crownstone to disconnect	x	x	x	
20	Set LED	??	Enable or disabled LEDS. **Deprecated**	x			
21	No operation	-	Does nothing, merely there to keep the	x	x	x	

Type nr	Type name	Payload type	Payload Description	A	M	G	S
			crownstone from disconnecting				
22	Increase TX	-	Temporarily increase the TX power when in setup mode				x
23	Reset errors	Error bitmask	Reset all errors which are set in the written bitmask.	x			
24	Keepalive repeat	-	Repeat the last keep alive message on the mesh.	x	x	x	
25	Multi switch	Multi switch packet	Switch multiple crownstones with a command over the mesh.	x	x	x	
26	Schedule remove	uint 8	Clear the Nth schedule entry of the list.	x	x		
27	Keepalive mesh	Keep alive mesh packet	Send keep alives via the mesh.	x	x		
28	Mesh command	Command mesh packet	Send a generic command over the mesh. Required access depends on the command.	x	x	x	

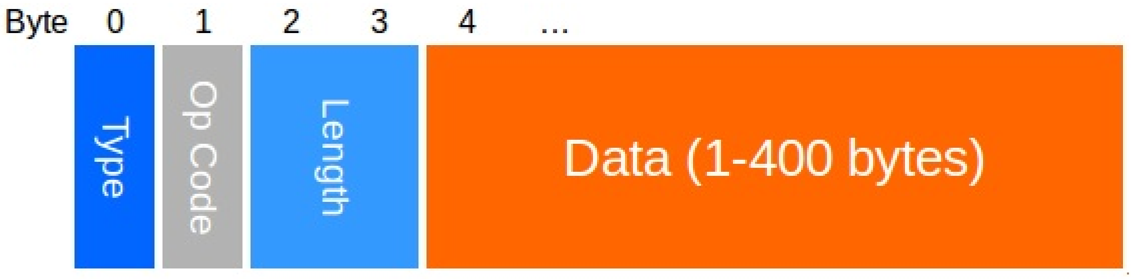
Enable Scanner payload

Type	Name	Description
uint 8	enable	0 = OFF, other = ON
uint 16	delay	Start scanner with delay in ms, (required, but not used when stopping the scanner).

Keep alive payload

Type	Name	Description
uint 8	Action	Action, 0 = No Change, 1 = Change
uint 8	Switch	Switch power, 0 = OFF, 100 = FULL ON
uint 16	Timeout	Timeout in seconds after which the Switch should be adjusted to the Switch value

Configuration packet



If encryption is enabled, this packet must be encrypted using the admin key.

Type	Name	Length	Description
uint 8	Type	1	Type, see table with configuration types below.
uint 8	OpCode	1	The op code determines if it's a write or a read operation, see table with op codes below
uint 16	Length	2	Length of the payload in bytes.
uint 8	Payload	Length	Payload data, depends on type.

Most configuration changes will only be applied after a reboot. Available configurations types:

Type nr	Type name	Payload type	Description
0	Device name	char []	Name of the device.
1	Device type	char []	**Deprecated.**
2	Room	uint 8	**Deprecated.**
3	Floor	uint 8	Floor number. **Deprecated**
4	Nearby timeout	uint 16	Time in ms before switching off when none is nearby.
5	PWM period	uint 32	Sets PWM period in μs. **Setting this to a wrong value may cause damage.**
6	iBeacon major	uint 16	iBeacon major number.
7	iBeacon minor	uint 16	iBeacon minor number.
8	iBeacon UUID	uint 8 [16]	iBeacon UUID.
9	iBeacon Tx Power	int 8	iBeacon signal strength at 1 meter.
11	TX power	int 8	TX power, can be: -40, -20, -16, -12, -8, -4, 0, or 4.
12	Advertisement interval	uint 16	Advertisement interval between 0x0020 and 0x4000 in units of 0.625 ms. *Not implemented yet.*
13	Passkey	uint 8 [6]	Passkey of the device: must be 6 digits.
14	Min env temp	int 8	If temperature (in degrees Celcius) goes below this value, send an alert. *Not implemented yet.*
15	Max env temp	int 8	If temperature (in degrees Celcius) goes above this value, send an alert. *Not implemented yet.*
16	Scan duration	uint 16	Scan duration in ms. *Setting this too high may cause the device to reset during scanning.*
17	Scan send delay	uint 16	Time in ms to wait before sending scan results over the mesh. *Setting this too low may cause the device to reset during scanning.*
18	Scan break duration	uint 16	Waiting time in ms between sending results and next scan. *Setting this too low may cause the device to reset during scanning.*
19	Boot delay	uint 16	Time to wait with radio after boot (ms). **Setting this to a wrong value may cause damage.**
20	Max chip temp	int 8	If the chip temperature (in degrees Celcius) goes above this value, the power gets switched off. **Setting this to a wrong value may cause damage.**
21	Scan filter	uint 8	Filter out certain types of devices from the scan results (1 for GuideStones, 2 for CrownStones, 3 for both).
22	Scan filter fraction	uint 16	If scan filter is set, do *not* filter them out each every X scan results.
23	Current limit	uint 8	Set current limit. **Deprecated**
24	Mesh enabled	uint 8	Stores if mesh is enabled. *read only*

Type nr	Type name	Payload type	Description
25	Encryption enabled	uint 8	Stores if encryption is enabled. *read only*
26	iBeacon enabled	uint 8	Stores if iBeacon is enabled. *read only*
27	Scanner enabled	uint 8	Stores if device scanning is enabled. *read only*
28	Continuous power measurement enabled	uint 8	Stores if continuous power measurement is enabled. *read only*
29	Tracker enabled	uint 8	Stores if device tracking is enabled. *read only*
30	ADC sample rate	...	**Deprecated**
31	Power sample burst interval	...	**Deprecated**
32	Power sample continuous interval	...	**Deprecated**
33	Power sample continuous number samples	...	**Deprecated**
34	Crownstone Identifier	uint 16	Crownstone identifier used in advertisement package.
35	Admin encryption key	uint 8 [16]	16 byte key used to encrypt/decrypt owner access functions.
36	Member encryption key	uint 8 [16]	16 byte key used to encrypt/decrypt member access functions.
37	Guest encryption key	uint 8 [16]	16 byte key used to encrypt/decrypt guest access functions.
38	Default ON	uint 8	Set's the default switch state to 255 if true, or to 0 if false. Value is 0 for false, or any other for true. **Deprecated**
39	Scan Interval	uint 16	Set the scan interval to ...
40	Scan Window	uint 16	Set the scan window to ...
41	Relay High Duration	uint 16	Set the time/duration that the relay is set to high (ms). **Setting this to a wrong value may cause damage.**
42	Low Tx Power	int 8	Set the tx power used when in low transmission power for bonding (can be: -40, -20, -16, -12, -8, -4, 0, or 4).
43	Voltage Multiplier	float	Set the voltage multiplier (for power measurement). **Setting this to a wrong value may cause damage.**
44	Current Multiplier	float	Set the current multiplier (for power measurement). **Setting this to a wrong value may cause damage.**
45	Voltage Zero	int 32	Set the voltage zero level (for power measurement). **Setting this to a wrong value may cause damage.**
46	Current Zero	int 32	Set the current zero level (for power measurement). **Setting this to a wrong value may cause damage.**
47	Power Zero	int 32	Set the power zero level in mW (for power measurement). **Setting this to a wrong value may cause damage.**
48	Power Average Window	uint16	**Deprecated**
49	Mesh Access Address	uint32	The access address of the mesh

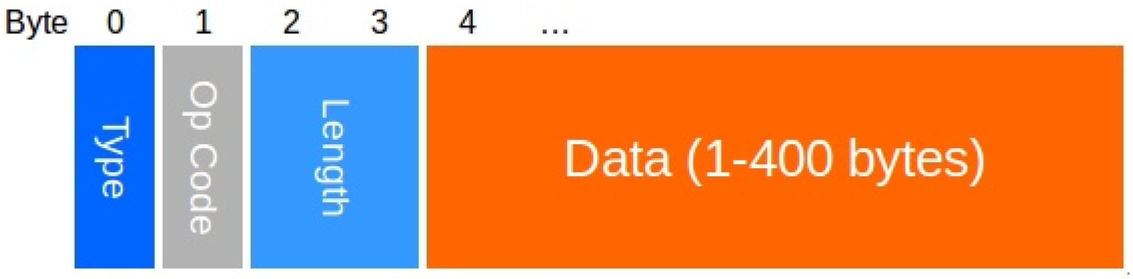
Type nr	Type name	Payload type	Description
			messages. This ensures that mesh messages of other groups will not interfere with your group.
50	Current consumption threshold	uint 16	At how much mA the switch will be turned off (soft fuse).
51	Current consumption threshold dimmer	uint 16	At how much mA the dimmer will be turned off (soft fuse). **Setting this to a wrong value may cause damage.**
52	Dimmer temp up voltage	float	Voltage of upper threshold of the dimmer thermometer. **Setting this to a wrong value may cause damage.**
53	Dimmer temp down voltage	float	Voltage of lower threshold of the dimmer thermometer. **Setting this to a wrong value may cause damage.**

OpCodes:

OpCode	Name	Description
0	Read	Select the configuration setting for reading. will load it from storage, then write it to the Config Read Characteristic. Length and payload of the configuration packet will be ignored
1	Write	Write the configuration setting to storage.

Note: On the Config Read Characteristic, the OpCode is set to Read (0), and the length and payload will have actual data depending on the type.

State packet



Type	Name	Length	Description
uint 8	Type	1	Type, see table with configuration types below.
uint 8	OpCode	1	The op code determines if it's a write, read, or notify operation, see table with op codes below
uint 16	Length	2	Length of the payload in bytes.
uint 8	Payload	Length	Payload data, depends on type.

Available state variables:

Type nr	Type name	Payload type	Description	Persistent
128	Reset counter	uint 32	Counts the number of resets (DEBUG).	x
129	Switch state	uint 8	Current Switch state.	
130	Accumulated energy	uint 32	Accumulated energy in Wh	x
131	Power usage	uint 32	Current power usage in mW	
132	Tracked devices	Tracked devices	List of tracked devices.	x
133	Schedule	Schedule List	Schedule list.	x

Type nr	Type name	Payload type	Description	Persistent
134	Operation Mode	uint 8	..., TBD	x
135	Temperature	int 32	Chip temperature in °C.	
136	Time	uint 32	Get the current time.	
139	Error bitmask	uint 32	Get the current error bitmask.	

OpCodes:

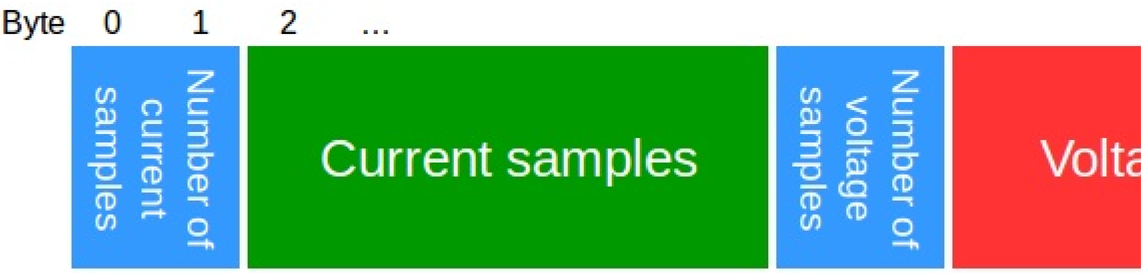
OpCode	Name	Description
0	Read	Select the configuration setting for reading. will load it from storage, then write it to the Config Read Characteristic. Length and payload of the configuration packet will be ignored
1	Write	Write the state variable **disabled**
2	Notify	Enable/Disable notifications for state variable. Every time the state variable is updated, the new value is written to the State Read Characteristic. To use effectively, enable GATT Notifications on the State Read Characteristic. Length has to be 1, and payload is 0 = disable, other = enable

Note: On the State Read Characteristic, the OpCode is also set to distinguish between a one time read, and a continuous notification. In return, the length and payload will have actual data depending on the type.

Error Bitmask

Bit	Name	Description
0	Overcurrent	If this is 1, overcurrent was detected.
1	Overcurrent dimmer	If this is 1, overcurrent for the dimmer was detected.
2	Chip temperature	If this is 1, the chip temperature is too high.
3	Dimmer temperature	If this is 1, the dimmer temperature is too high.
4-31	Reserved	Reserved for future use.

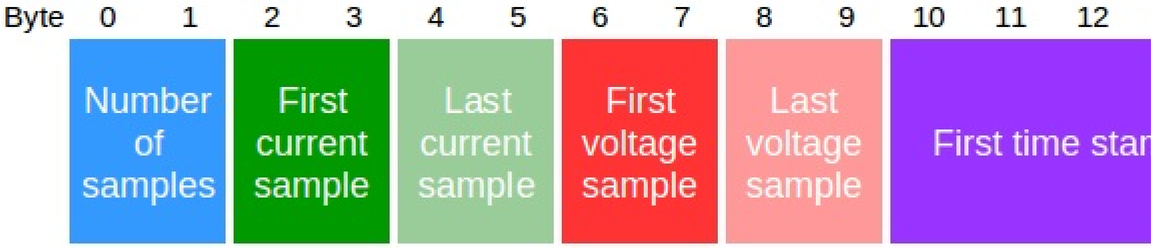
Power samples packet



Type	Name	Length	Description
uint 16	numCurrentSamples	2	Number of current samples.
uint 16 []	currentSamples	numCurrentSamples * 2	Array of current samples.
uint 16	numVoltageSamples	2	Number of voltage samples.
uint 16 []	voltageSamples	numVoltageSamples * 2	Array of voltage samples.
uint 16	numCurrentTimeStamps	2	Number of current timestamps.
uint 32	firstCurrentTimeStamp	4	Timestamp of first current sample.
uint 32	lastCurrentTimeStamp	4	Timestamp of last current sample.
int 8 []	currentTimeDiffs	numCurrentTimeStamps-1	Array of differences with previous timestamp.
uint 16	numVoltageTimeStamps	2	Number of voltage

Type	Name	Length	Description
			timestamps.
uint 32	firstVoltageTimeStamp	4	Timestamp of first voltage sample.
uint 32	lastVoltageTimeStamp	4	Timestamp of last voltage sample.
int 8 []	voltageTimeDiffs	numVoltageTimeStamps-1	Array of differences with previous timestamp.

Power curve packet, deprecated

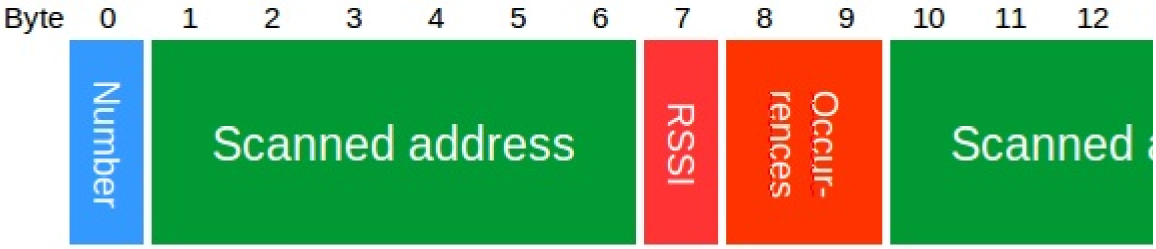


Type	Name	Length	Description
uint 16	numSamples	2	Number of current samples + voltage samples, including the first samples.
uint 16	firstCurrent	2	First current sample.
uint 16	lastCurrent	2	Last current sample.
uint 16	firstVoltage	2	First voltage sample.
uint 16	lastVoltage	2	Last voltage sample.
uint 32	firstTimeStamp	4	Timestamp of first current sample.
uint 32	lastTimeStamp	4	Timestamp of last sample.
int 8 []	currentDiffs	numSamples/2-1	Array of differences with previous current sample.
int 8 []	voltageDiffs	numSamples/2-1	Array of differences with previous voltage sample.
int 8 []	timeDiffs	numSamples-1	Array of differences with previous timestamp.

Scan result packet

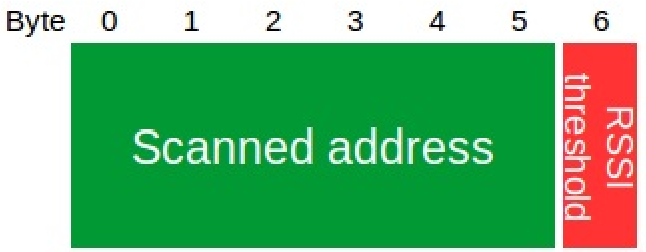
Type	Name	Length	Description
uint 8 []	Address	6	Bluetooth address of the scanned device.
int 8	RSSI	1	Average RSSI to the scanned device.
uint 16	Occurrences	2	Number of times the devices was scanned.

Scan result list packet



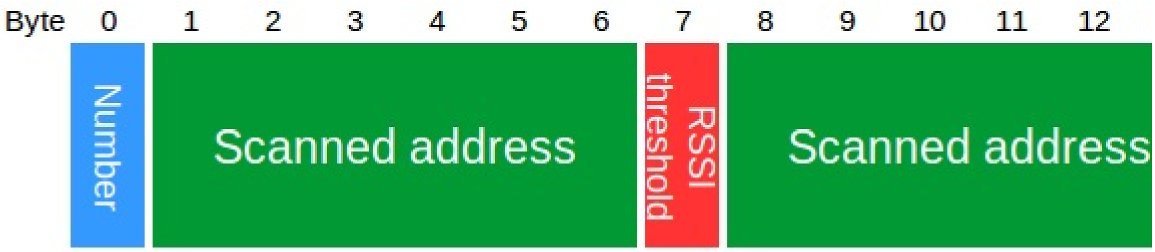
Type	Name	Length	Description
uint 8	size	1	Number of scanned devices in the list.
Scan result		size * 9	Array of scan result packets.

Tracked device packet



Type	Name	Length	Description
uint 8 []	Address	6	Bluetooth address of the tracked device.
int 8	RSSI threshold	1	If the RSSI to this device is above the threshold, then switch on the power.

Tracked device list packet



Type	Name	Length	Description
uint 8	size	1	Number of tracked devices in the list.
Tracked device	size * 7	Array of tracked device packets.	
uint 16 []	Counters	size * 2	Counter that keeps up how long ago the RSSI of a device was above the threshold (for internal use).

Schedule list packet

Type	Name	Length	Description
uint 8	Size	1	Number of entries in the list.
schedule entry	Entries	size * 12	Schedule entry list. Entries with timestamp=0 can be considered empty.

Schedule command packet

Type	Name	Length	Description
uint 8	index	1	Index of the entry (corresponds to the Nth entry in the list).
schedule entry	Entry	12	Schedule entry.

Schedule entry packet

Type	Name	Length	Description
uint 8	reserved	1	Reserved for future use.
uint 8	Type	1	Combined repeat and action type. Defined as `repeatType + (actionType << 4)`.
uint 8	Override mask	1	Bitmask of switch commands to override.
uint 32	Next timestamp	4	Timestamp of the next time this entry triggers. Set to 0 to remove this entry.
schedule repeat	Repeat data	2	Repeat time data, depends on the repeat type.
schedule action	Action data	3	Action data, depends on the action type.

Schedule override mask

Bit	Name	Description
0	All	Ignore any switch command. **Not implemented yet.**
1	Location	Ignore any switch command that comes from location updates (enter/exit room/sphere). **Not implemented yet.**
2-7	Reserved	Reserved for future use.

Schedule repeat packet

Repeat type 0

Perform action every X minutes.

Type	Name	Length	Description
uint 16	Repeat time	2	Repeat every `<repeat time>` minutes, 0 is not allowed.

Repeat type 1

Perform action every 24h, but only on certain days these days of the week.

Type	Name	Length	Description
uint 8	Day of week	1	Bitmask, with bits 0-6 for Sunday-Saturday and bit 7 for all days.
uint 8	Reserved	1	Reserved for future use.

Repeat type 2

Perform action only once. Entry gets removed after action was performed.

Type	Name	Length	Description
uint 8	Reserved	2	Reserved for future use.

Schedule action packet

Action type 0

Set power switch to a given value.

Type	Name	Length	Description
uint 8	Switch	1	Power switch value. Range 0-100, where 0 is off and 100 is fully on.
uint 8	Reserved	2	Unused.

Action type 1

Fade from current power switch value to a given power switch value, in X seconds. Starts fading at *next timestamp*. **Not implemented yet.**

Type	Name	Length	Description
uint 8	Switch end	1	Power switch value after fading (at timestamp + fade duration).
uint 16	Fade duration	2	Fade duration in seconds.

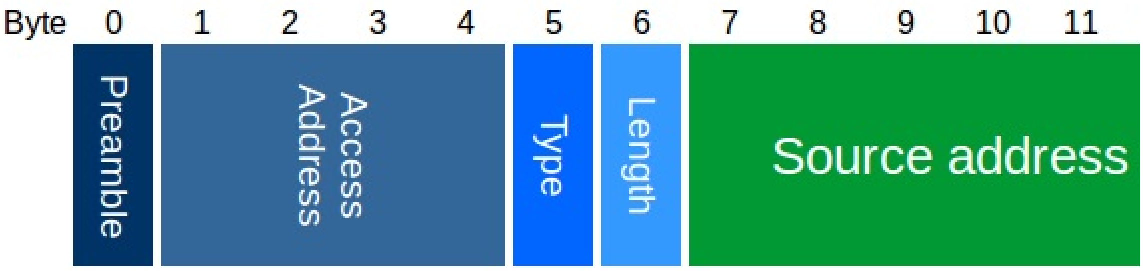
Action type 2

Toggle the power switch.

Type	Name	Length	Description
uint 8	Reserved	3	Reserved for future use.

Mesh message

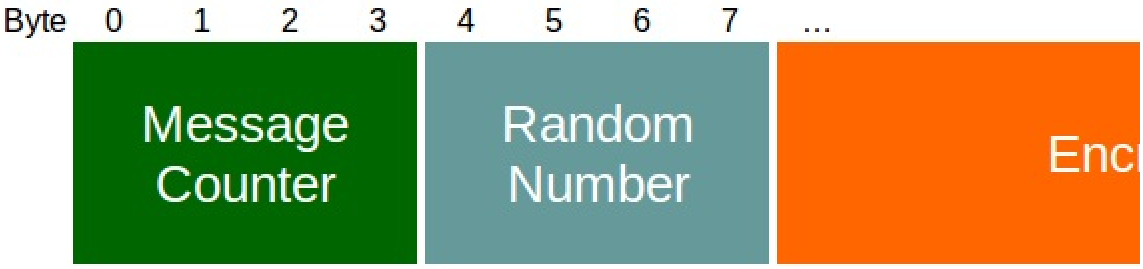
This packet is a slightly modified version of the one used in OpenMesh; we simply increased the content size.



Type	Name	Length	Description
uint 8	Preamble	1	
uint 32	Access address	4	Number used to find relevant messages, set by application.
uint 8	Type	1	
uint 8	Length	1	
uint 8 []	Source address	6	Address of the node that put this message into the mesh.
uint 8	AD Length	1	Length of data after this field, excluding CRC.
uint 8	AD type	1	
uint 16	Service UUID	2	Mesh service UUID.
uint 16	Handle	2	Handle of this message.
uint 16	Version	2	Used internally.
Encrypted mesh packet	Payload	104	The encrypted mesh message.
uint 8 []	CRC	3	Checksum.

Encrypted mesh packet

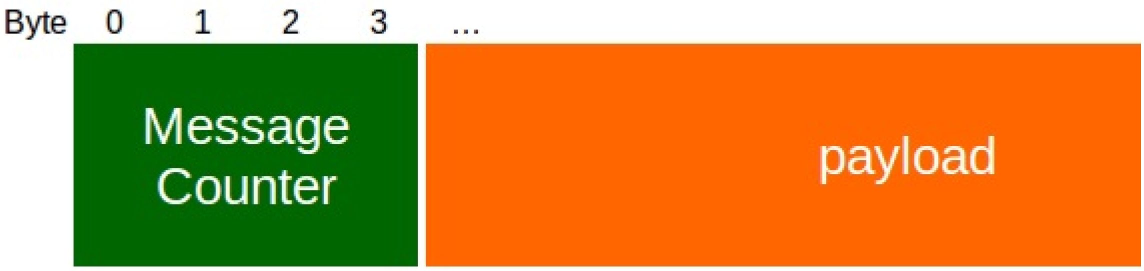
This packet is sent over the mesh as payload in the mesh message.



Type	Name	Length	Description
uint 32	Message counter	4	The message counter used to identify the message. Counter values are kept up seperately per handle. Note: This value is in plain text (unencrypted)
uint 32	Random number	4	The random number used for encryption/decryption, is sent itself unencrypted
Mesh packet	Encrypted payload	96	The encrypted mesh packet.

Mesh packet

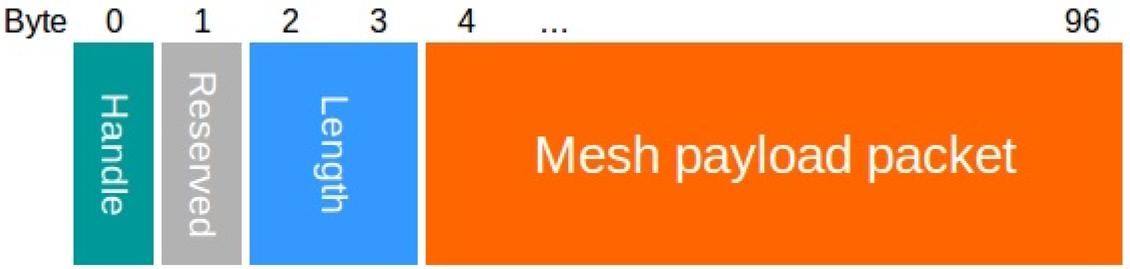
This packet is encrypted and sent as payload in the encrypted mesh packet.



Type	Name	Length	Description
uint 32	Message counter	4	The message counter used to identify the message. Counter values are kept up seperately per handle. Note: This value will be compared after decryption to the message counter of the encrypted mesh message to make sure the message was not tampered with.
Mesh payload	Payload	92	Payload data

Mesh control packet

This packet is sent to the Mesh control characteristic



Type	Name	Length	Description
uint 8	Handle	1	Handle on which to send the message.
uint 8	Reserved	1	Not used: reserved for alignment.
uint 16	Length	2	Length of the data.
Mesh payload	Payload	0 - 92	Payload data, max 92 bytes, but actual length is determined by the handle

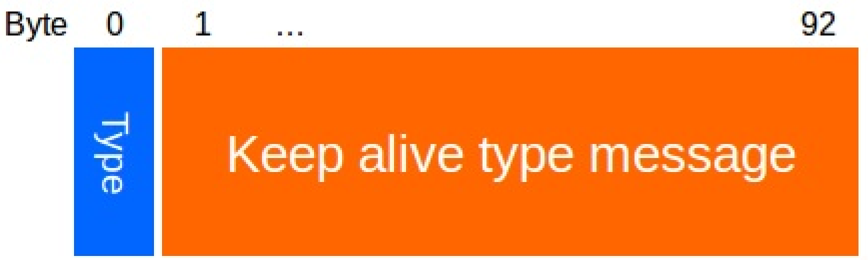
Mesh payload packet

The mesh payload packet is defined by the handle. We have the following handles

Handle	Name	Type	Description
11	Keep alive channel	Keep alive	Channel on which the keep alive messages are sent. A message consists of a global timeout and a number of keep alive items (on per stone which is addressed). If the length of the mesh control packet is 0, the existing keepalive message will be repeated.
9	State channel	State	Each stone sends its state periodically, and on significant state change, over the mesh. The message is designed as a circular buffer and a new item is added at the end

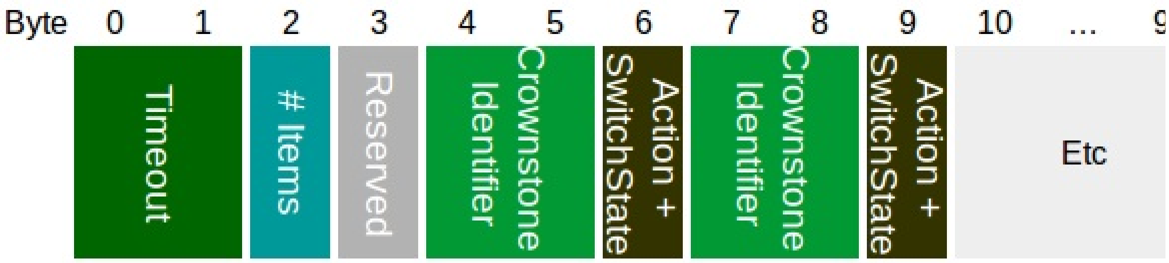
Handle	Name	Type	Description
			(throwing out the oldest when full).
10	State channel	State	Each stone sends its state periodically, and on significant state change, over the mesh. The message is designed as a circular buffer and a new item is added at the end (throwing out the oldest when full).
13	Command channel	Command	Commands can be sent to one, multiple or all stones sharing the mesh network. Once a stone receives a command it will send a reply on the reply channel
5	Command reply channel	Command reply	Every stone that was targeted with a command adds its reply to the reply message.
6	Scan result channel	Scan result	If a stone is scanning for devices it adds its scanned devices periodically to this list to be sent over the mesh
7	Big data channel	-	This channel is for the case when a stone needs to send big data, such as the history of eneregy usage, etc.
12	Multi switch channel	Multi switch	This channel is used to send different switch commands with individual timeouts, switch states and intents to different crownstones in one message

Keep alive packet



Type nr	Type name	Payload type	Description
1	Same timeout	Keep alive same timeout	Keep alive with same timeout for each Crownstone.

Keep alive same timeout packet



Type	Name	Length	Description
uint 16	Timeout	2	Timeout (in seconds), applies to all stones present in the list.
uint 8	Count	1	Number of items in the list.

Type	Name	Length	Description
uint 8	Reserved	1	Reserved for future use.
Keep alive item []	List	N	The keep alive same timeout items.

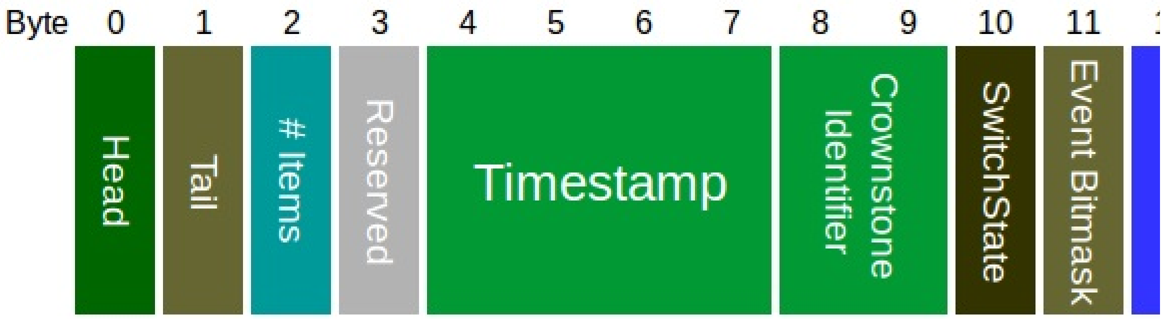
Keep alive same timeout item

Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone to which this keep alive item is targeted
Action + switch state	Action + switch state	1	A combined element for action and switch state, which should be executed by the targeted crownstone when the keep alive times out

Action + switch state

Value	Name
255	No action
...	...
0-100	Switch power: 0 = off, 100 = on, dimmed in between.

Crownstone state packet

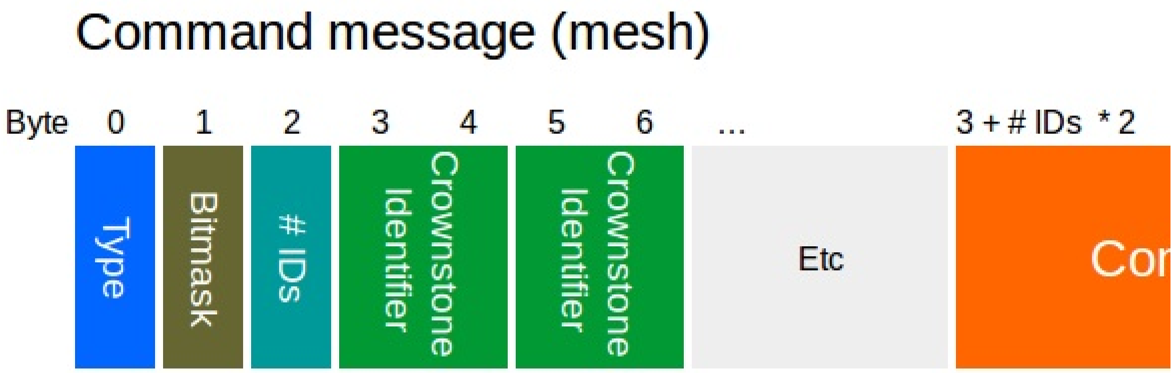


Type	Name	Length	Description
uint 8	Head	1	Keeps the index of the oldest element in the list (read pointer)
uint 8	Tail	1	Keeps the index where the next element can be inserted in the list (write pointer)
uint 8	Size	1	Number of elements in the list
uint 8	Reserved	1	Reserved for future use
uint 32	Timestamp	4	Posix timestamp at which this message was originally sent (0 for unknown time)
Crownstone state item []	List	84	Circular list with Crownstone state items

Crownstone state item

Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone which has this state
uint 8	Switch state	1	The current Switch state of the crownstone
uint 8	Event bitmask	1	The current Event bitmask of the crownstone
int 16	Power factor	2	The power factor at this moment. Divide by 1024 to get the actual power factor.
uint 16	Power usage	2	The apparent power usage at this moment. Divide by 16 to get power usage in Watt.
int 32	Energy used	4	The total energy used. Divide by 64 to get the energy used in Joule.

Command packet



Type	Name	Length	Description
uint 8	Type	1	Type of command, see table below.
uint 8	Bitmask	1	Options of command, see table below.
uint 8	Count	1	The number of IDs provided as targets, 0 for broadcast.
uint16 []	List of target IDs	Count * 2	Crownstone Identifiers of the devices at which this message is aimed, for broadcast, no IDs are provided and the command follows directly after the Number of IDs element.
uint 8	Command payload	N	The command payload data, which depends on the type.

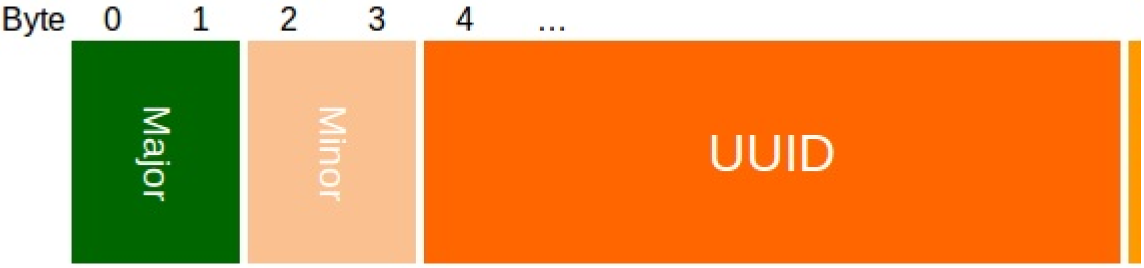
Command types

Type nr	Type name	Payload type	Payload description
0	Control	Control	Send a control command over the mesh, see control packet.
1	Beacon	Beacon Config	Configure the iBeacon settings.
2	Config	Configuration	Send/Request a configuration setting, see configuration packet.
3	State	State	Send/Request a state variable, see state packet.

Command bitmask

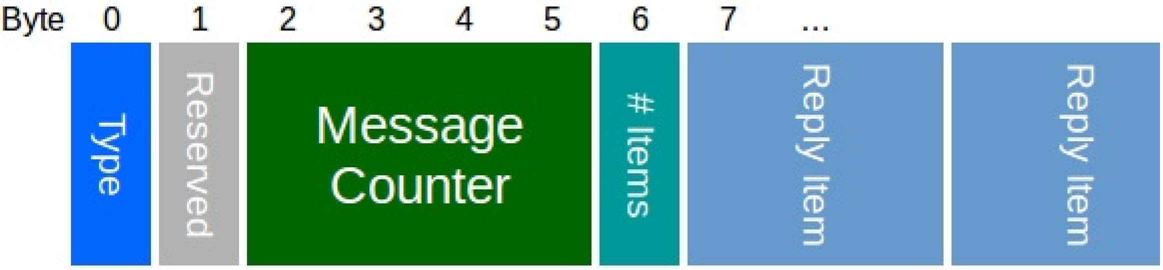
Bit	Name	Description
0	Reply request	Set this to 1 to get a command reply.
1	Reserved	Reserved for future use.
2	Reserved	Reserved for future use.
3	Reserved	Reserved for future use.
4	Reserved	Reserved for future use.
5	Reserved	Reserved for future use.
6	Reserved	Reserved for future use.
7	Reserved	Reserved for future use.

Beacon config packet



Type	Name	Length	Description
uint 16	Major	2	iBeacon major number
uint 16	Minor	2	iBeacon minor number
uint 8	Proximity UUID	16	iBeacon UUID
int 8	TX power	1	iBeacon signal strength at 1 meter.

Command reply packet

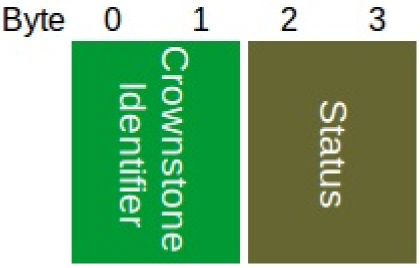


Type	Name	Length	Description
uint 8	Reply type	1	Type of reply, see table below.
uint 8	Reserved	1	Reserved for future use.
uint 32	Message counter	4	The message number of the command to which this reply belongs.
uint 8	Count	1	Number of items in the list.
uint 8	List	85	List of replies, the format is defined by the type of reply.

Reply types

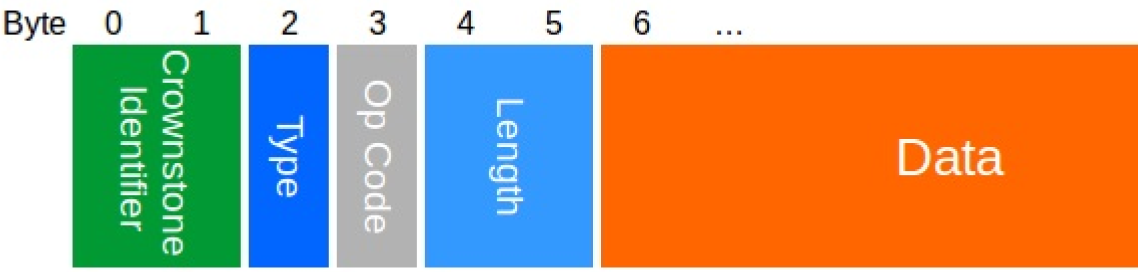
Type nr	Type name	Payload type	Payload description
0	Status reply	Status reply item	Send a status code back, used to report errors. And to report success for control and config write commands.
1	Config reply	Config reply item	Return the requested config.
2	State reply	State reply item	Return the requested state variable.

Status reply item



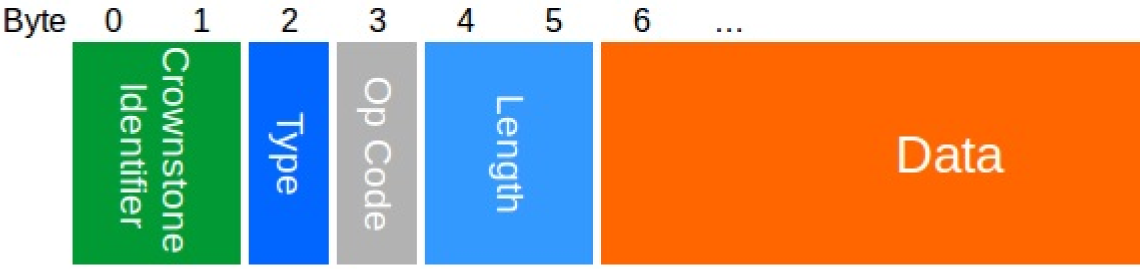
Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone which sent the status reply
uint 16	Status	2	The status code of the reply, see Return Values

Config reply item



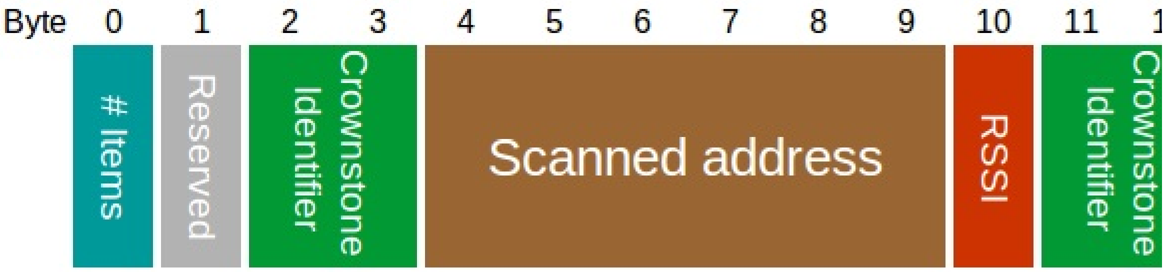
Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone which sent the status reply
uint 8	Type	1	see Configuration Packet
uint 8	OpCode	1	see Configuration Packet
uint 16	Length	2	see Configuration Packet
uint 8	Payload	Length	see Configuration Packet

State reply item



Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone which sent the status reply
uint 8	Type	1	see State Packet
uint 8	OpCode	1	see State Packet
uint 16	Length	2	see State Packet
uint 8	Payload	Length	see State Packet

Scan result packet



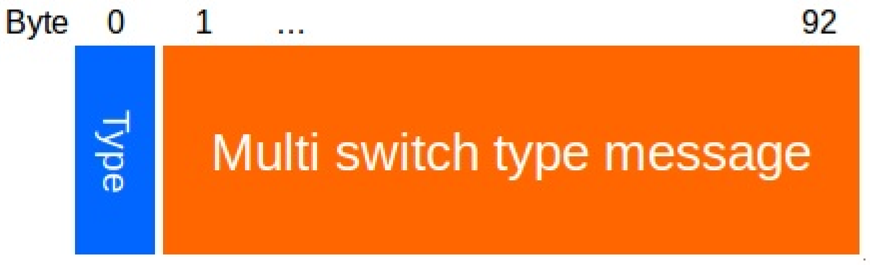
Type	Name	Length	Description
uint 8	Number of results	1	Number of scan results in the list

Type	Name	Length	Description
uint 8	Reserved	1	Reserved for future use
Scan Result item []	List	N	A list of scanned devices with the ID of the crownstone that scanned the device

Scan result item

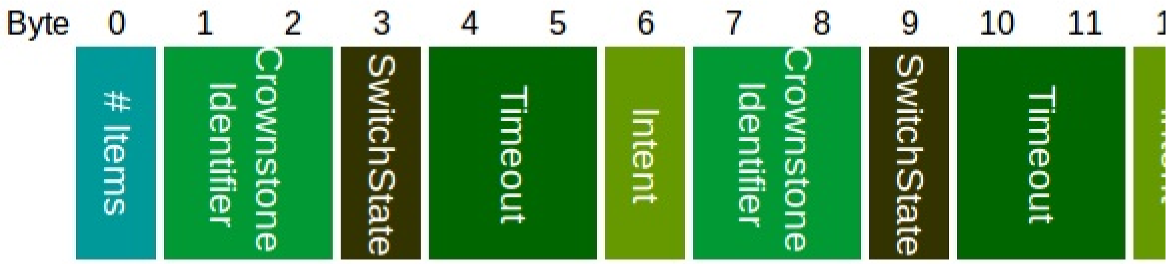
Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the Crownstone which scanned the device
uint 8 [6]	Scanned device address	6	The MAC address of the scanned device
int 8	RSSI	1	The averaged RSSI value of the scanned device

Multi switch packet



Type nr	Type name	Payload type	Description
0	List	Multi switch list	Different switch command for each Crownstone.

Multi switch list packet



Type	Name	Length	Description
uint 8	Count	1	Number of multi switch list items in the list.
Multi switch list item []	List	N	A list of switch commands.

Multi switch list item

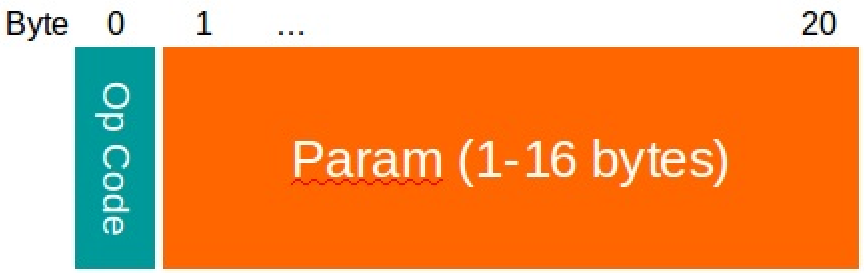
Type	Name	Length	Description
uint 16	Crownstone ID	2	The identifier of the crownstone to which this item is targeted.
uint 8	Switch state	1	The switch state to be set by the targeted crownstone after the timeout expires. 0 = off, 100 = fully on.
uint 16	Timeout	2	The timeout (in seconds) after which the state should be set.
uint 8	Intent	1	The intent of the switch, see the table below.

Intent

Value	Name
0	Sphere Enter
1	Sphere Exit
2	Enter
3	Exit
4	Manual

Mesh notification packet

This packet is used to get the mesh messages pushed over GATT notifications.

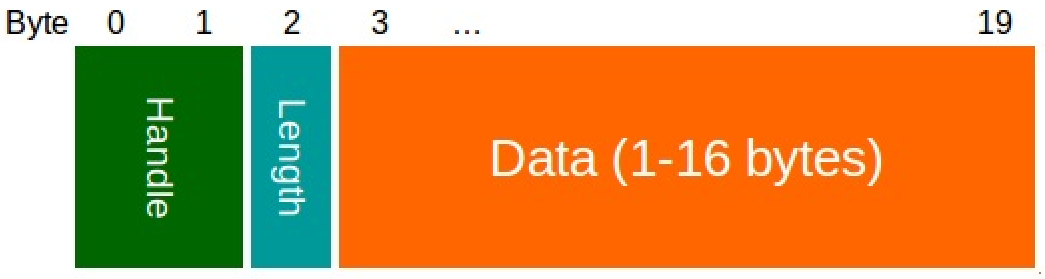


Type	Name	Length	Description
uint 8	OpCode	1	See available op codes in table below
uint 8	Payload		

Opcode	Type name	Payload type	Payload Description
0	Data	Mesh data update	Single part notification (if all data fits in one packet).
1	Flag Set		Not used.
2	Flag Req		Not used.
17	Cmd Rsp		Not used.
18	Flag Rsp		Not used.
32	MultipartStart	Mesh data update	First part of the multi part notification.
33	MultipartMid	Mesh data update	Middle part of the multi part notification.
34	MultipartEnd	Mesh data update	Last part of the multi part notification.

Mesh data update packet

Each mesh data message is notified in multiple pieces, as a notification can only be 20 bytes. The op code of the Mesh notification tells whether it is a single, or the first, last or a middle piece of a multipart message.



Type	Name	Length	Description
uint 16	Handle	2	Handle on which the messages was sent or received.
uint 8	Length	1	Length of the data of this part.
uint 8	Data	Length	Data of this part. If OpCode is Data, it is the length of the whole mesh message, otherwise it is the length of the current part.