neOCampus IoT | end-devices API & MQTT rules

End-devices API and MQTT rules

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Abstract

This guide explains how to authenticate against the neOCampus IoT chain and then how to publish / subscribe data through the neOCampus **MQTT broker** and its associated device management application named **sensOCampus**.

Modifications table

Date	Note
feb.24	modified attendance messages
jan.23	Minor corrections about outdoor positioning MQTT topic for end-devices relabelled outside → outdoor (outdoor is a virtual building for everything located outside a building within a <site>)
apr.22	removed **LoRaWAN devaddr** end-device type replaced with with **generic** (UUID) type added **geoloc** as a new <kind> (mostly mobile devices) cleanup some config examples showing end-devices config for sensOCampus v1 & **V2** `get_config` → there's only one BASE_TOPIC ⇒ optional to specify "topic" value in config `get_location` → new API to retrieve the **BASE_TOPIC** field
sep.21	added specifications for sensOCampus**V2**
aug.21	added types and fronts specifications for digital inputs configuration (senOCampus)
Apr.21	updated **attendance** class
Feb.21	replaced 'location' with 'site' in our terminology
Sep.20	expanded **display** class with TXT and IMG messages
Aug.20	updated **airquality** class
May.20	added 'value' field specifications; added **airquality** class
Apr.20	minor correction about weather topic → `outside/ambient/<rain|wind…>` clarify things about 'outside' MQTT topics, add **attendance** class topic
Mar.20	additional topics conventions
Feb.20	added **access** class topic
Jan.20	added **pressure**, **rain**, **wind** … classes (metropole weather station)
Mar.18	added **display** class messages
Nov.17	initial release

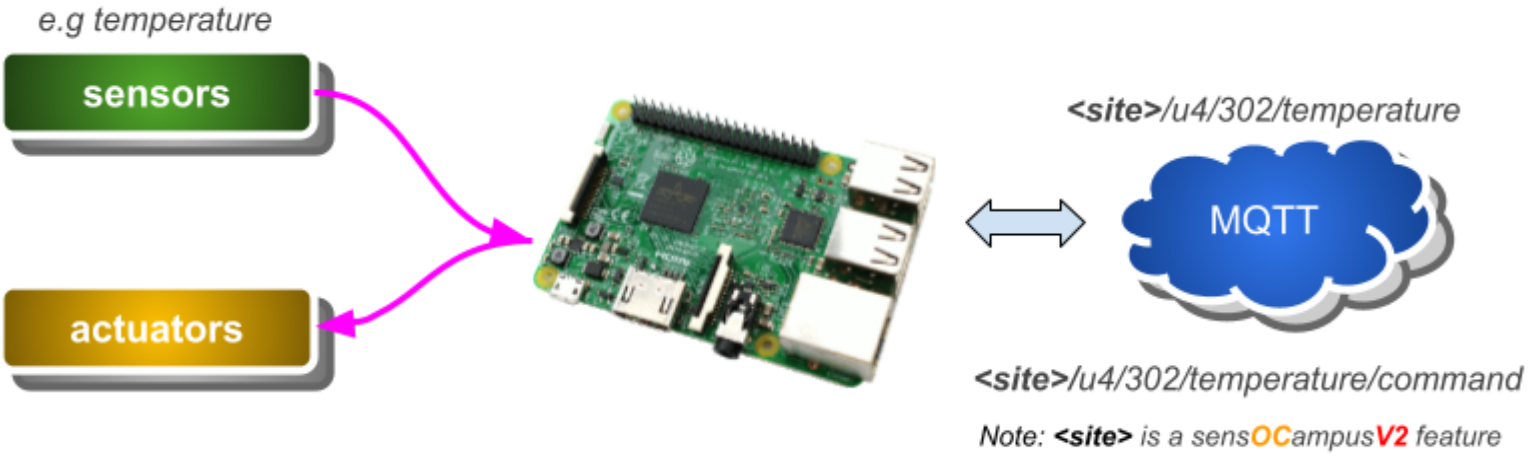
TODO list

Note	Done
Protect API through LDAP login/passwd → token API … this token will then get used in every piece of our APIs	

Table of contents

End-devices

What we call a **device (or end-device)** is a piece of **hardware connected to a network**.
Such a device may encompass one to several sensors / actuators. It is devices' firmware responsibility to publish sensor values to the proper topic and to subscribe to relevant topics.



In the upper example, the device is a Raspberry Pi that could be connected to either a wired / wireless network. Each kind of sensor / actuator maps to a topic class. However, to be able to publish / subscribe to the MQTT broker, the device's client needs credentials. To obtain these credentials, you first need to:

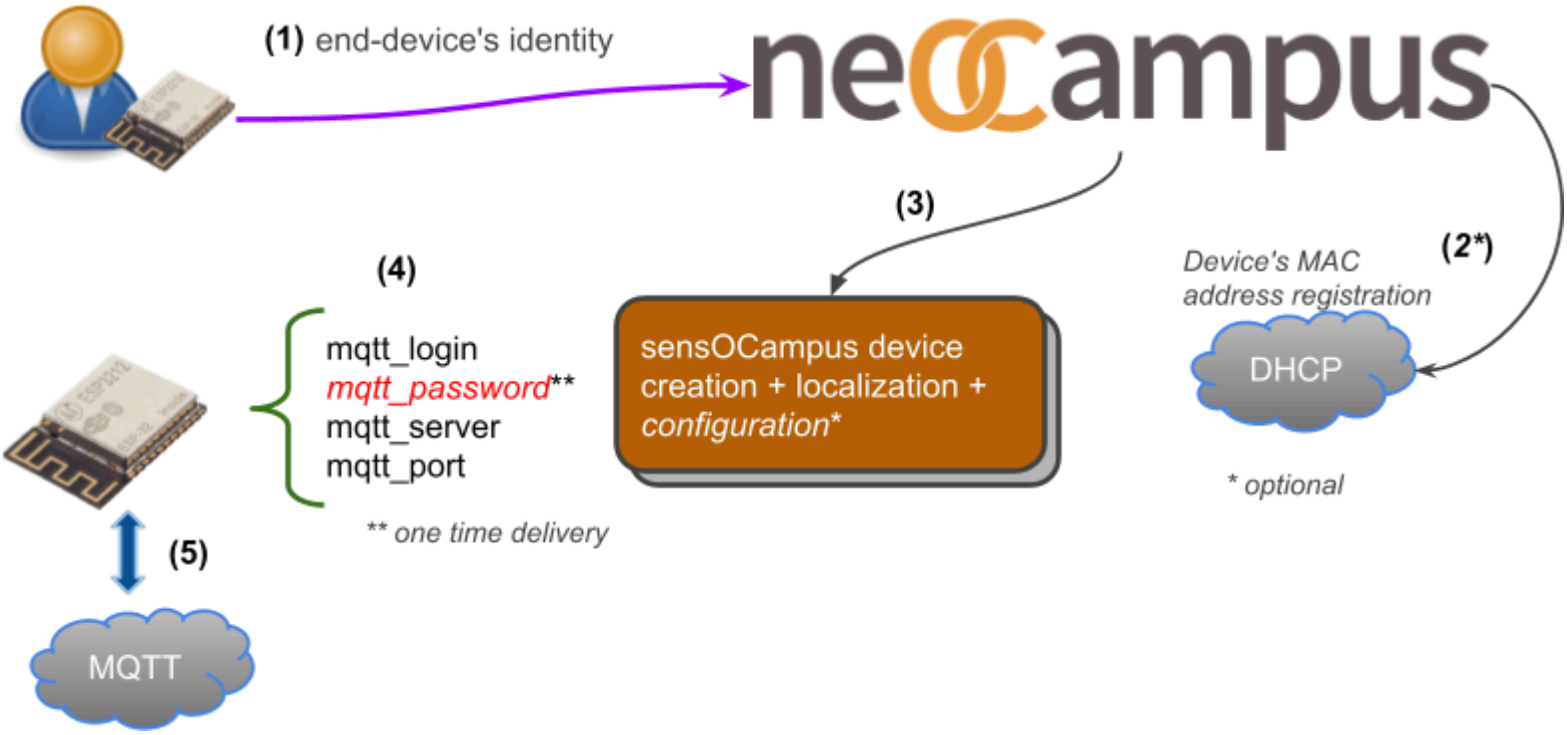
1. declare end-device's identity to the neOCampus technical staff,
2. interact with the sensOCampus application that will give you your credentials.

end-device identity types

The new sensOCampusV2 will be able to handle various kind of end-devices identity:

Type	Addr example	Note
Ethernet (mac)	01:23:45:67:89:AB	**6**bytes (48bits) hex mac address
LoRaWAN (deveui)	0123456789ABCDEF	**8**bytes (64bits) deveui address (OTAA devices) **>=V2**
generic (UUID)	e4809956-b354-11ec-b909-0242ac120002	**16**bytes (128bits) UUID **>=V2** useful for LoRaWAN ABP and others end-devices

sensOCampus is the main end-devices management application developed for neOCampus. It takes care of managing the device's own specific setup (MAC, configuration, status, topics etc).



sensOCampus devices API

sensOCampus devices API

We below describe the various involved steps that end-devices need to undertake with the sensOCampus application to retrieve their credentials.

1. `get_credentials` → will give your device its mqtt related credentials,
2. `get_config` → your device will be given a **MQTT base topic** along with optional configuration registered for each peculiar device at the sensOCampus level,
3. `get_location` → obtenir les informations de site, bâtiment, salle (i.e **BASE_TOPIC**) en fonction d'une adresse MAC / LoRaWAN / UUID

get_credentials

According to the various end-device identity types, find below the various sensOCampus URIs

Type	URL
Ethernet	https://sensocampus.univ-tlse3.fr/device/credentials?**mac**=<*device_mac_addr*>
LoRaWAN deveui	https://sensocampus**2**.univ-tlse3.fr/device/credentials?**lorawan_deveui**=<*deveui*> (>= **V2**)
generic (UUID)	https://sensocampus**2**.univ-tlse3.fr/device/credentials?**uuid**=<*UUID*> (>= **V2**)

… response will be in JSON format

```
{
   "login" : "<mqtt_login>",
   "password" : "<mqtt_password>",
   "server" : "neocampus.univ-tlse3.fr",
   "port" : 1883,
   "version" : 2
}
```

Note; "version" key is optional, only sensOCampus >=V2 will deliver

Please pay attention to the facts that:

- **password** field is a one-time delivery parameter → if you lose it, you need to apply for new credentials at the neOCampus technical staff,
- "**server**" and "**port**" fields are **optionals** → you ought to have these default values in your code if sensOCampus does not deliver them to your device.

It's the device's own responsibility to save these credentials in some non volatile hardware. If you apply for a credentials renewal operation, both login and password will change.

get_config

prepare HTTPS request with previously delivered credentials (https_auth) …
get https://sensocampus.univ-tlse3.fr/device/config

… response will be in JSON format

sensOCampus	
{ 'zones': [], 'topics': ['bu/hall'] }	*[sep.21] we never needed the multi-zone feature (i.e an end-device belonging to several locations)* ***TODO**: cleanup required*
sensOCampus V2	
{ *'version': 2,* 'zones': [], 'topics': ['**ut3**/bu/hall'] }	*[apr.22] no more 'zones' field, only the BASE_TOPIC as first element of the 'topics' list*

In this simple example, we have no specific configuration (empty zones) and we must take into account the **topics field as BASE_TOPIC ('ut3' is site specification, only >=V2)**
Note: in case 'topics' contains multiple fields, just select the first one

For clarity, please find in annexes a sample configuration:

- LCC sensor config **@ sensOCampus level**
  A-3 sensOCampus LCC's AirQuality configuration
- LCC sensor config retrieved **@ end-device level**
  A-4 end-device level retrieved sensOCampus config

get_location

Obtain location (i.e BASE_TOPIC) for a specified

Type	URL
Ethernet	https://sensocampus.univ-tlse3.fr/device/location?**mac**=<*device_mac_addr*> (>= **V2**)
LoRaWAN deveui	https://sensocampus**2**.univ-tlse3.fr/device/location?**lorawan_deveui**=<*deveui*> (>= **V2**)
generic (UUID)	https://sensocampus**2**.univ-tlse3.fr/device/location?**uuid**=<*UUID*> (>= **V2**)

… response will be in JSON format

{ *'version': 2,* 'topics': ['**ut3**/bu/hall'] }	*sends back the 'BASE_TOPIC' field*

summary

You now have the following:

login	"<*mqtt_login*>"
password	"<***mqtt_password***>"
server	neocampus.univ-tlse3.fr *or custom one*
port	1883 or 8883 (tls) *or custom one*
BASE_TOPIC	**<site>**/<building>/<room> (e.g **ut3**/bu/hall)

Later, this **BASE_TOPIC** means that you've been granted the following topics rules:

<site>/bu/hall/+	publish & subscribe (i.e write & read)
<site>/bu/hall/+/command	subscribe (i.e read)

In the next section, we'll start to talk about the MQTT conventions that apply to neOCampus.

MQTT topics conventions

>>>[sep.21] starting with sensOCampusV2, BASE_TOPIC will feature the 'site' token <<<

The following describes various rules about topics conventions that apply to the neOCampus IoT.

- Each **end-device** get specified a **BASE_TOPIC** through its `get_config` procedure,
- A **BASE_TOPIC** is named accordingly to **`<site>/`**`<building>/<room>`, eg. **ut3/u4/302**
- Each sensor / actuator belongs to a **class** (e.g temperature, co2, shutter …) that is **appended** to the device's **BASE_TOPIC** (e.g **ut3/**bu/hall/temperature), named a **class topic**,
- Each sensor / actuator subscribe to a **command topic** with a **command** token appended to the class topic (e.g **ut3/**bu/hall/temperature/**command**)
- The **end-device** itself publish to a **class topic** (e.g **ut3/**bu/hall/device) and subscribe to a **command topic** (e.g **ut3/**bu/hall/device/command)
- Each **end-device** is uniquely identified, see end-device identity types,
- A **sensor** is either identified by an ID specified at sensOCampus server or automatically discovered at startup (e.g i2c scan). Sensors automatically discovered have an ID prefixed with auto (e.g 'auto_C32F' with last 2 digits being end of device's MAC_ADDR),
- An **actuator** is identified by an ID specified at sensOCampus server (e.g **ut3/**u4/302/shutter with 3 shutters identified as "front", "center" and "back"),
- topics prefixed with '_' are of specific use (e.g `_lora`/… or `_weather`/…),
- ~~For outdoor end-devices located **within** the campus (e.g toulouse metropole weather station), **BASE_TOPIC** is `outdoor/<class>` (e.g `outdoor/ambient/wind` or `outdoor/access` ---access control gates of our university),~~
- ~~For abroad end-devices (i.e not located within the campus) **BASE_TOPIC** is `abroad/<location>` e.g `abroad/carcassonne/<building>/<room>/<kind>`~~
- JSON frames' keys are mostly lower case ;)

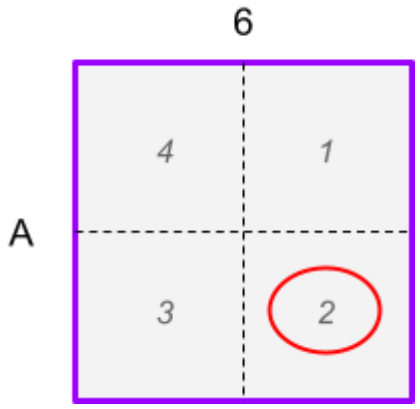
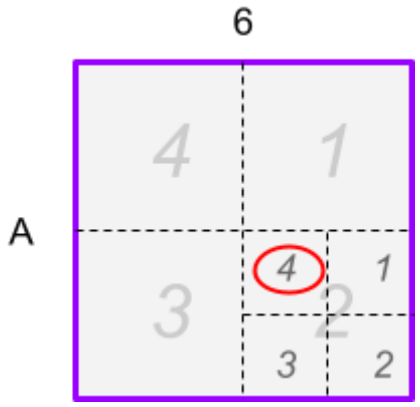
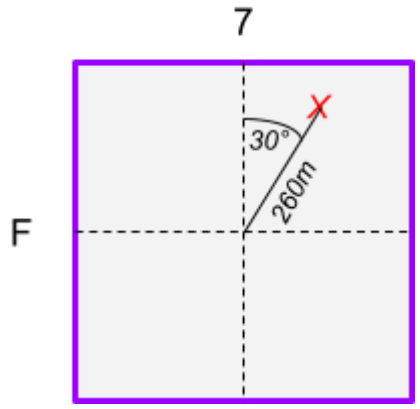
sensOCampus**V2**:

- For end-devices located outdoor (i.e out-of any building), they will belong to a special building named `'outdoor'`. The `<room>` field could be either `'none'`, an embedded gps location in the mqtt payload or an approximate position in campus (e.g D4_1 or …)

Site	Building	Room	Kind	Note
<site>	outdoor	*<outdoor_location>*	<kind>	outdoor end-device
<site>	<building>	<room>	<kind>	indoor end-device

Below are some examples of *<outdoor_location>*

BASE_TOPIC	Note
<site>/`outdoor`/`none`/<kind>	<kind> sensor (e.g temperature) located outside in <site> *usually, GPS coords are parts of the payload*

ut3/outdoor/d4/<kind>	'd4' may refers to our campus-map D4 bloc https://www.univ-tlse3.fr/plan-du-campus
ut3/outdoor/a6_2/<kind>	'a6_2' may refers to our campus-map A6 bloc subdivided in 4 sub-zones and referring to subzone 2 (and **possibly recursive**) 
ut3/outdoor/a6_2_4/<kind>	'a6_2_4' is **recursive** subzone 4 from a6_2 
ut3/outdoor/f7_30d_260m/<kind>	'f7_30d_260m' may refers to our campus-map F7 bloc, 30°, 260m from its centre 

Note: the MQTT payload may contain a GPS location key that will get saved in the mongoDB database.

Hence, for each device, each sensor and each actuator, there's:

- a **class topic** to publish to → BASE_TOPIC / CLASS
- a **command topic** to subscribe to → BASE_TOPIC / CLASS / **command**

msg to a command topic

Whenever a message is sent to a **command topic** (e.g **ut3**/bu/hall/shutter/command), the JSON frame **OUGHT** to contain a **'dest'** field.

- 'dest' : "**all**" → message is for all of those that subscribed to this command topic,
- 'dest' : "<*ID*>" → message is only for those whose ID matches

Example, if you wish to send an order to a specific **device**, 'dest' will contain its **MAC_ADDRESS** (or any others of the possible identities ---see end-device identity types).
If you wish to send an order to a shutter, 'dest' will contain its ID specified at the sensOCampus interface ("front" for example).

✔ Sending order to a shutter (with proper mqtt login / passwd)

```
order: "up"
dest: "all"
      or "<shutter_ID>"
```

Json frame as mqtt payload

ut3 / u4 / campusfab / shutter / command

In the example above, all shutters from **ut3** / u4 / campusfab will receive the "**up**" order thus opening all of them.

msg to a class topic

Whenever a device, a sensor or an actuator send a message to a **class topic** (e.g **ut3**/bu/hall/noise or **ut3**/u4/cfab/device), associated JSON frame **OUGHT** to contains a '**unitID**' field whose value reflect the sender's identity:

- 'unitID' : "<*ID*>"

'unitID' : "00:08:a2:1f:cb:3f"	'unitID' : 'auto_CB3F'	'unitID' : "front"
sender is a device. *Note* that for compatibility, a 'unit' key with the same value may be added.	sender is an auto-detected sensor usually associated with 'subID' : '*<i2c_addr>*' *Note* the last 2 digits are from device's MAC_ADDR	sender may be a sensor or actuator declared at sensOCampus level. *Note* a 'subID' will be added if it has been declared.

✔ … then shutter publish its status back

```
order: "idle"
unitID: "<shutter_ID>"
status: "open"
```

Json frame as mqtt payload

ut3 / u4 / campusfab / shutter

In the example above, a shutter identified by its 'unitID' sent back its status through the class topic.

REMEMBER: when declaring several devices in the same room (e.g **ut3**/u4/campusfab), it is the users' responsibility to manage identity uniqueness of sensors or actuators declared at the sensOCampus level.

unitID and subID

Whenever a sensor is automatically detected at startup (e.g i2c scan), it gets automatically attributed a 'unitID' (identity) and a 'subID' (informative only field ---e.g i2c addr)

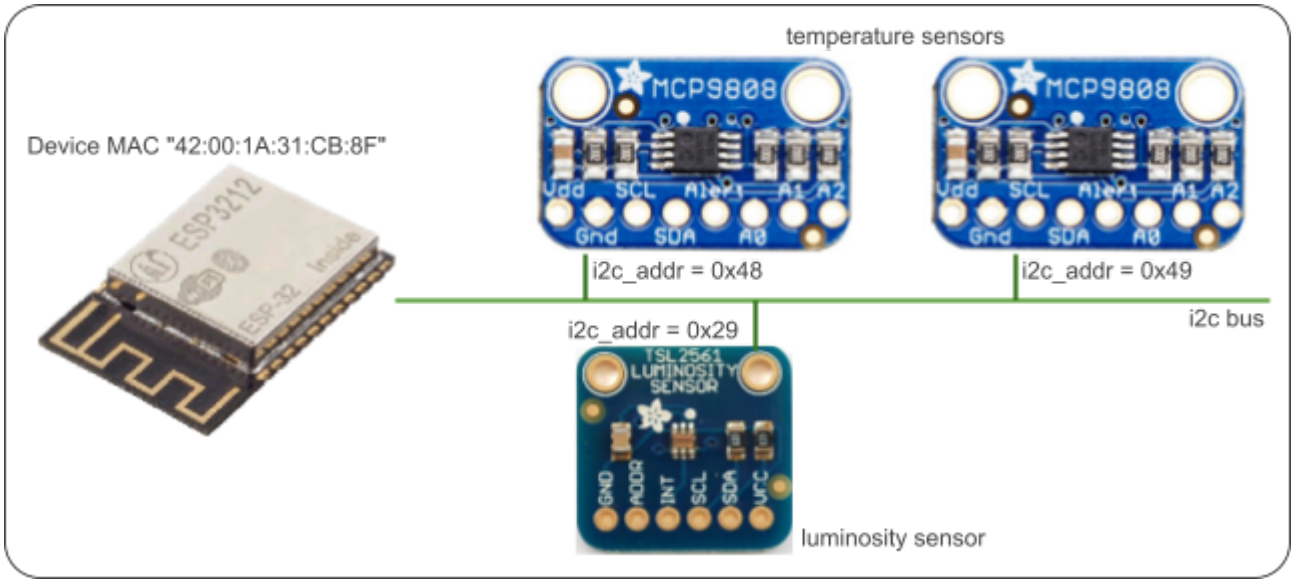
Example:

unitID	subID	Note
'unitID' : 'auto_CB8F'	'subID' : '32'	At least one auto-detected sensor with i2c addr 0x20. Device's MAC_ADDR end with CB8F
'unitID' : 'inside'	'subID' : 'ilot1'	A sensor or actuator declared at sensOCampus

Note: the nature of the sensor will be revealed according to it class topic publishing

scenario example

Considering the following device featuring 3 x i2c sensors.



This will result in the following identity of sensors:

'unitID'	'subID'	class & command topics
auto_CB8F	41	BASE_TOPIC/luminosity BASE_TOPIC/luminosity/command
auto_CB8F	72	BASE_TOPIC/temperature BASE_TOPIC/temperature/command
auto_CB8F	73	BASE_TOPIC/temperature BASE_TOPIC/temperature/command

sensors auto detection and messages publishing

Each sensor value is sent as a separate message. It means for example that if you feature 8 temperature sensors on the same device, you'll have 8 different messages when it comes to pushing the data.

sensors and actuators uniqueness

It is the IoT manager's responsibility to ensure unitID uniqueness at the room-level.
Of course, if you add to the same room two devices whose MAC_ADDR last 2 digits are the same … use another device ;)

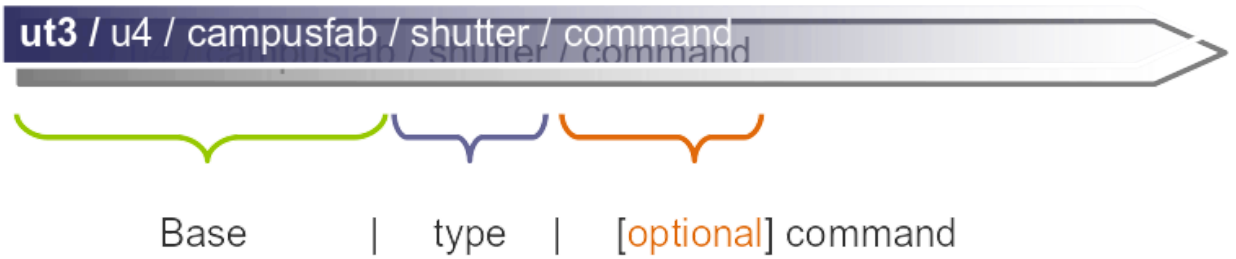
neOCampus MQTT sandbox

To ease testing of your sensor / actuator, you may give a try to the neOCampus MQTT sandbox:

login	test
passwd	<*ask for it!*>
server	neocampus.univ-tlse3.fr
port	1883
BASE_TOPIC	TestTopic/#

Hence, you won't need the sensOCampus credentials and you are free to create / read / write in any topic you want considering it is BASE_TOPIC biased.

example topics



Base : defined at *device* registration time according to location

e.g ut3 / u4 / 300 or bu / hall ...

Type : kind of sensor / actuator (*module*) defined by sensOCampus or automagically detected

e.g shutter, luminosity, temperature, sound, lighting ...

Command : to send orders to a sensor / actuator (*module*)

e.g orders to shutter like UP, STOP, DOWN

special case topics

BASE_TOPIC	Description
`_lora`	raw LoRaWAN messages from our LoRaWAN server
`_weather`	`/metropole` → Toulouse metropole weather station raw values `/omp` → OMP weather station raw values
`domoticz`	**[DEPRECATED]** only intended to communicate with domoticz UI
`owntracks`	**[DEPRECATED][apr.22]** owntracks geoloc app intended to test autOCampus-ICU
`TestTopic`	neOCampus sandbox
~~`'abroad/<site>'` MQTT topic prefix for **non-UT3 end-devices**~~	
~~`abroad`~~	**[DEPRECATED] by sensOCampusV2 new feature** ~~non **UT3** end-devices~~ ~~`abroad/<site>/...`~~ ~~e.g for indoor sensors at Carcassonne site~~ ~~`abroad/`**`carcassonne`**`/<building>/<room>/<kind>`~~ ~~e.g for outdoor sensors at Carcassonne site~~ ~~`abroad/`**`carcassonne`**`/outdoor/...`~~

[DEPRECATED] optional 'site' field

[DEPRECATED] by sensOCampusV2 new feature

~~Whenever a MQTT message is received **without** a `'site'` key in payload nor its topic beginning with `'abroad'`, it will get considered as an **UT3 site end-device**.~~

[DEPRECATED] outdoor/<xxx> topics rules

[DEPRECATED] by sensOCampusV2 new feature

~~When it's about out-of-building sensors, we consider them as 'outdoor'. We present below the various MQTT topics you may encounter :~~

~~Note~~	~~'outdoor' related MQTT topics @ neOCampus~~
~~deprecated~~	~~*case for sensors attached to a conCentratOr*~~ ~~u4/302/temperature { 'unitID':'outdoor', subID:'ouest', ... }~~
	~~*case for Toulouse metropole weather station @ UT3 site*~~ ~~outdoor/ambient/rain { 'unitID':'metropole', ... }~~
	~~*case for **abroad out-of-buildings** sensors*~~ ~~abroad/carcassonne/outdoor/ambient/rain { 'unitID':'davis', ... }~~
	~~*case for access control gates for our campus*~~

	~~outdoor/access { 'unitID':'carGate_main', ... }~~

virtual buildings

Whenever an equipment is located out-of a building (e.g beehives) we'll try to consider them as being part of a **virtual building**. For example, let's consider our Apiary: all beehives are part of the Apiary, even wherever those beehives are spread all over the campus.

e.g `ut3/apiary/beehive1/temperature` `site=ut3,building=apiary,room=beehive1,kind=temperature`

Class topics and command topics

Below is a description of the currently existing classes:

Class	Publish	Subscribe
device	BASE_TOPIC/device	BASE_TOPIC/device/command
temperature	BASE_TOPIC/temperature	BASE_TOPIC/temperature/command
luminosity	BASE_TOPIC/luminosity	BASE_TOPIC/luminosity/command
humidity	BASE_TOPIC/humidity	BASE_TOPIC/humidity/command
co2	BASE_TOPIC/co2	BASE_TOPIC/co2/command
energy	BASE_TOPIC/energy	BASE_TOPIC/energy/command
camera	BASE_TOPIC/camera	BASE_TOPIC/camera/command
digital	BASE_TOPIC/digital	BASE_TOPIC/digital/command
noise	BASE_TOPIC/noise	BASE_TOPIC/noise/command
weight	BASE_TOPIC/weight	BASE_TOPIC/weight/command
uv	BASE_TOPIC/uv	BASE_TOPIC/uv/command
rain	BASE_TOPIC/rain	BASE_TOPIC/rain/command
wind	BASE_TOPIC/wind	BASE_TOPIC/wind/command
attendance	BASE_TOPIC/attendance	BASE_TOPIC/attendance/command
airquality	BASE_TOPIC/airquality	BASE_TOPIC/airquality/command
geoloc	BASE_TOPIC/geoloc	BASE_TOPIC/geoloc/command
lighting	BASE_TOPIC/lighting	BASE_TOPIC/lighting/command
dali	BASE_TOPIC/lighting	BASE_TOPIC/lighting/command
shutter	BASE_TOPIC/shutter	BASE_TOPIC/shutter/command
display	BASE_TOPIC/display	BASE_TOPIC/display/command
access	BASE_TOPIC/access	BASE_TOPIC/access/command

e.g temperature sensor PUBLISH its value in `BASE_TOPIC/temperature`
… and it also SUBSCRIBE to `BASE_TOPIC/temperature/command` *to receive orders (e.g frequency acquisition change)*

device

Basis of all sensors / actuators, end-devices are connected to a network and are identified via their MAC address.
Each device ought to be able to:

- 'publish' some information (e.g status)
- 'subscribe' to a command topic

publish

BASE_TOPIC/device	JSON frame
status	*is **automatically** published every 30mn (default)* { 'unitID' : [MAC | DEVEUI | UUID], 'status': "OK", <optional fields> }

Note: there's no 'values' because a device is not supposed to deliver such items.

The **'status'** key:

OK	normal operation
FAIL	an error occurred

Note: since this is only a user informative message, you can send any string you want!

subscribe

BASE_TOPIC/device/**command**	JSON frame
order	{ 'dest' : [MAC | DEVEUI | UUID], 'order' : "*<action>*", <optional fields> }
upgrade (firmware/application)	{ 'dest' : [MAC | DEVEUI | UUID], 'order' : "upgrade", <optional fields> } *optional fields may contain* *- 'value' → url to firmware* *(e.g 'value' : 'http://xxx.bin')*
frequency change order	{ 'dest' : [MAC | DEVEUI | UUID], 'order' : "frequency", 'value' : *<integer seconds>*

	}

Note: 'frequency' is about 'status' delivery, not 'values' (whose message does not exist).

'order' command possible *actions*:

reset	reset application configuration and restart app.
restart	restart application
reboot	reboot the whole board
update	update application configuration (i.e json config from sensOCampus)
upgrade	upgrade firmware / application and restart
reinstall	[Raspberry Pi] start whole SDCard reinstallation
status	force immediate delivery of a status report to its class topic
frequency	change frequency of **status report** delivery (min. 10mn, max 6h)

Note that status report is automatically published for each device while it is only published on explicit request for the sensors and actuators.

temperature / luminosity / co2 / humidity / pressure / weight / uv

These classes of sensors send back ambient parameters. They are able to change their acquisition frequency and they transmit both 'value' of the sensor along with its physical unit (e.g 'value_units' : **'celsius'** or **'%r.H.'** or …)

We describe below the various types of the 'value' field:

CLASS	'value' field
temperature, pressure, weight	FLOAT
<others>	INT

publish

BASE_TOPIC / CLASS	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency': <*acquisition frequency seconds*>, <optional fields> } *optional fields may contain* *- 'sensors' → declared sensors* *- 'i2c_sensors' → automatically discovered sensors*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': <*value*>, 'value_units' : "<*string*>" <optional fields> } *optional fields may contain* *- 'subID' → either i2c addr of sensor or explicit value set at sensOCampus level*

subscribe

BASE_TOPIC/CLASS/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }

frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of status report delivery (min. 10mn, max 6h)
acquire	force immediate delivery of sensor value(s).

rain

This class of sensor sends back a broad range of values and values units (like energy). Beware that you could face changes in either name of units or number of items in lists (of course both will get consistent anyway).

- 'value' : ['0.0', '0.0', '0.0', '0.0', '0.0', '0.0']
- 'value_units' : ['stormRain_cm', 'dayRain_cm', 'rain24_cm', 'hourRain_cm', 'rainRate_cm_per_hour', 'monthRain_cm']

We describe below the various types of the 'value' field:

CLASS	'value' field
rain	LIST

publish

BASE_TOPIC / rain	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency': <*acquisition frequency seconds*>, <optional fields> } *optional fields may contain* *- 'sensors' → declared sensors* *- 'i2c_sensors' → automatically discovered sensors*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': [<*value*>, <*value*> …], 'value_units' : ["<*string*>", "<*string*>" …] <optional fields> } *optional fields may contain* *- 'subID' → either i2c addr of sensor or explicit value set at sensOCampus level*

subscribe

BASE_TOPIC/rain/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }

frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of status report delivery (min. 10mn, max 6h)
acquire	force immediate delivery of sensor value(s).

wind

This class of sensor sends back a broad range of values and values units (like energy). Beware that you could face changes in either name of units or number of items in lists (of course both will get consistent anyway).

- 'value' : [326.25, 3.79, 9.66, 315.0]
- 'value_units' : ['windDir', 'windSpeed_kph', 'windGust_kph', 'windGustDir']

Unless otherwise stated, wind directions are degrees (direction where the wind is blowing to) and wind speeds are kilometers per hour.

We describe below the various types of the 'value' field:

CLASS	'value' field
wind	LIST

publish

BASE_TOPIC / wind	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency': <*acquisition frequency seconds*>, <optional fields> } *optional fields may contain* *- 'sensors' → declared sensors* *- 'i2c_sensors' → automatically discovered sensors*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': [<*value*>, <*value*> …], 'value_units' : ["<*string*>", "<*string*>" …] <optional fields> } *optional fields may contain* *- 'subID' → either i2c addr of sensor or explicit value set at sensOCampus level*

subscribe

BASE_TOPIC/wind/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }
frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of status report delivery (min. 10mn, max 6h)
acquire	force immediate delivery of sensor value(s).

energy

Power and energy consumption is usually gathered from Modbus energy meters. This kind of sensor can't be automatically detected, hence requiring a sensOCampus definition.

Moreover, each sensor gives a bunch a data (power, freq, energy, power_factor, intensity, voltage …) all packed as a list in the 'value' field along with their corresponding units in 'value_units':

- 'value' : ['158426.00', '158420.00', '235.22', '0.14', '20.00', '20.00', '30.00', '0.70']
- 'value_units' : ['Wh', 'Ea+', 'V', 'A', 'W', 'VAR', 'VA', 'cosPhi']

We describe below the various types of the 'value' field:

CLASS	'value' field
energy	LIST

publish

BASE_TOPIC / energy	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency' : <*acquisition frequency seconds*>, 'backend' : <*backend type*>, <optional fields> } *optional fields may contain* *- 'link' : "/dev/usb0" (for example),* *- 'link_speed' : 9600,* *- 'nodes' : [(<modbus addr>,<meter_name>), …]*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': [<*value*>, <*value*> …], 'value_units' : ["<*string*>", "<*string*>" …] } *Note: see above for a description of 'value' and 'value_units'*

<*backend type*> possible values:

modbus	either RS-485 or TCP modbus energy meter
rf868	868MHz energy meter (from consOCampus project)
unknown	as you guess ;)

subscribe

BASE_TOPIC/energy/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }
frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of status report delivery (min. 10mn, max 6h)
acquire	force immediate delivery of sensor value(s).

camera

digital

This class of sensor is related to everything that is relevant to digital inputs (e.g open window detector, motion sensor etc). This kind of sensor ought to be declared at the sensOCampus level.

For each event on a digital input (i.e rising_edge and falling_edge), a message will be sent immediately (i.e no timer involved but direct hardware events management).

We describe below the various types of the 'value' field:

CLASS	'value' field
digital	INT

publish

BASE_TOPIC / digital	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'sensors': [[101, "button", "ilot1"], [102, "presence", "ilot1"]] } *'sensors' : [(input, type, subID), …] these values are coming from sensOCampus definitions*
value	*is **automatically** published for each event on input(s)* { 'unitID' : <*ID*>, 'value': 1, 'input' : 102, 'type' : <see codes further>, 'subID' : "IRsensor" }

subscribe

BASE_TOPIC/digital/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic

example of sensOCampus 'digital' config

```
[
  {
    "topic": "irit2/366",
    "modules":
    [
      {
        "module": "digital",
        "unit": "inside",
        "driver": "gpio",
        "params":
        [
          {
            "param": "subID",
            "value": "IRsensor"
          },
          {
            "param": "input",
            "value": 4
          },
          {
            "param": "type",
            "value": 1
          },
          {
            "param": "cooldown",
            "value": 60
          },
          {
            "param": "front",
            "value": 1
          }
        ]
      }
    ]
  }
]
```

The inner `modules` array may contains several descriptions (i.e one per input)

Params	Values
subID	string to name a sensor (up to 15 chars)
input	pin number (gpio driver)
type	1 → "presence" 2 → "on_off" 3 → "open_close"
cooldown	min. delay (seconds) between two consecutive sendings
front	-1 → "none" (means no MQTT sending at all) 0 → falling edge 1 → rising edge 2 → both rising and falling edges

noise

This sensor amplifies sound from a microphone and sets a threshold on a comparator delivering pulses when sound intensity goes beyond. Pulses count are recorded over a sliding window giving their total number for an elapsed time (default 5s). If this total number of pluses is higher than a user defined threshold, then a noise message is sent.
Thus, this sensor is driven by two threshold:

- **sensitivity** → 0 to 100%. Set DAC output to the comparator,
- **threshold** → noise limit (pulses count).

We describe below the various types of the 'value' field:

CLASS	'value' field
noise	INT

publish

BASE_TOPIC / noise	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'sensitivity' : <*0 to 100%*>, 'threshold' : <*integer*>, <optional fields> } *optional fields may contain* *- '_scan_window' → size of sliding window*
value	*is **automatically** published upon noise limit reached* { 'unitID' : <*ID*>, 'value': <*sum pulses count*>, 'value_units' : "pulses" <optional fields> } *optional fields may contain* *- 'input' → pin used to count pulses* *- 'subID' → DAC i2c addr*

subscribe

BASE_TOPIC/noise/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }

change sensitivity order	{ 'dest' : <*ID*>, 'order' : "sensitivity", 'value' : <*integer 0 to 100%*> }
change noise limit threshold order (i.e pulse count limit)	{ 'dest' : <*ID*>, 'order' : "threshold", 'value' : <*integer*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
sensitivity	set new value to DAC output used as input to the comparator
threshold	set noise limit through a maximum number of pulses count across the whole sliding windows
acquire	force immediate delivery of sensor value(s).

Note: there's no 'frequency' order because value delivery is not dependent on a timer.

attendance

This class of sensor is related to everything that is relevant to either **flow** or **count** of people, bicycles, cars etc. Hence, the following subtypes of data:

- **count** → instantaneous count of people/car/bicycle/other,
- **flow** → overall number of people/car/bicycle/other going in (forward) or going out (backward) for one day length. **WARNING**: these numbers may get reseted upon app. restart.

attendance CLASS: flow	attendance CLASS: count
'unitID' : <ID>	
'forward' : 2843, 'backward' : 2642	'value' : [15] 'value_units' : ['count']
'subID' : '<people/car/bicycle/…>'	

We describe below the various types of the 'value' field:

CLASS	'value' field
attendance	LIST

publish

BASE_TOPIC / attendance	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency': <*acquisition frequency seconds*> }
Counting mode value	*is **automatically** published, upon measures variations* { 'unitID' : <*ID*>, 'value': <*value*> 'value_units' : 'count' 'subID' : '<people/car/bicycle/…>' }
Flow mode value	*is **automatically** published, upon measures variations* { 'unitID' : <*ID*>, 'forward' : <*value*>, 'backward' : <*value*>, 'subID' : '<people/car/bicycle/…>' }

subscribe

BASE_TOPIC/attendance/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }
frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of data delivery (min. 30s, max. 900s)
acquire	force immediate delivery of sensor value(s)

airquality

This class of sensors may send back a broad range of values and values units. However, unlike energy, we'll keep the various values as standalone ones (i.e no lists of values and value_units). Since concentration of most organic components are given as 'ppm' units, we'll make use of the 'subID' field to create a distinguo between the various components:

```
{ "unitId":"lcc_sensor", "subId":"NO", "value":xxx, "value_units":"ppm" }
```

We describe below the various types of the 'value' field:

CLASS	'value' field
airquality	INT

publish

BASE_TOPIC / rain	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'frequency': <*acquisition frequency seconds*>, <optional fields> } *optional fields may contain* *- 'sensors' → declared sensors* *- 'i2c_sensors' → automatically discovered sensors* *- others items relevant to your kinds of sensors*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': <*value*>, 'value_units' : "ppm", 'subID' : "<string>", <optional fields> } *- 'subID' → either i2c addr of sensor or explicit value set at sensOCampus level*

subscribe

BASE_TOPIC/rain/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }

frequency change order	{ 'dest' : <*ID*>, 'order' : "frequency", 'value' : <*integer seconds*> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
frequency	change frequency of values messages.
acquire	force immediate delivery of sensor value(s).

geoloc

This class of sensor sends back a broad range of values and values units (like energy). Beware that you could face changes in either name of units or number of items in lists (of course both will get consistent anyway).

- 'value' : ['43.562205', '1.467680', '150.4', …]
- 'value_units' : [lat', 'lon', 'alt', …]

We describe below the various types of the 'value' field:

CLASS	'value' field
geoloc	LIST

publish

BASE_TOPIC / geoloc	JSON frame
status	*is published on request* { 'unitID' : <*ID*>, 'resolution': <min. cm. pos. change for sending>, <optional fields> } *optional fields may contain* *- 'sensors' → declared sensors* *- 'i2c_sensors' → automatically discovered sensors*
value	*is **automatically** published every <freq> seconds* { 'unitID' : <*ID*>, 'value': [<*value*>, <*value*> …], 'value_units' : ["<*string*>", "<*string*>" …] <optional fields> } *optional fields may contain* *- 'subID' → either i2c addr of sensor or explicit value set at sensOCampus level*

subscribe

BASE_TOPIC/geoloc/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : "status" }
resolution change order	{

	{ 'dest' : <*ID*>, 'order' : "resolution", 'value' : <centimetres> }
immediate acquisition order	{ 'dest' : <*ID*>, 'order' : "acquire" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
resolution	change resolution expressed as centimetres. If pos changes for more than 'resolution' cm, then publish. **0** means automatic mode (**default**)
acquire	force immediate delivery of sensor value(s).

ACTUATORS

lighting

Like all actuators, its setup is defined at the sensOCampus level.
This actuator drives various lighting command systems like **telerupteur** or **directly connected** lights sources.

We describe below the various types of the 'value' field:

CLASS	'value' field
lighting	*NONE*

publish

BASE_TOPIC / lighting	JSON frame
status	*is published on request **and** upon light event (on, off)* { 'unitID' : <*ID*>, 'status': '[ON | OFF | unknown]' }

subscribe

BASE_TOPIC/lighting/**command**	JSON frame
order	{ 'dest' : <*ID*>, 'order' : '[ON | OFF] or *status*' <optional fields> } *optional fields may contain* *- 'value' : '<0 to 100>' → percentage of luminosity*

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
ON or OFF	set output to ON or OFF. *Note: if teleruptor type, any order will just toggle the output (i.e we don't know whether it is on or off)* *Note: for variable lighting systems, an additional 'value' field may contains an integer ranging from 0 to 100 (percents)*

dali

shutter

Like all actuators, its setup is defined at the sensOCampus level.
This actuator is able to drive two kinds of shutters (blinds): **wired** and **wireless blinds** (difference is the way outputs are activated ---i.e short pulses for wireless).

We describe below the various types of the 'value' field:

CLASS	'value' field
shutter	*NONE*

publish

BASE_TOPIC / shutter	JSON frame
status	*is published on request **and** upon shutter event* { 'unitID' : <*ID*>, 'status' : '[CLOSED | OPENED | UNKNOWN]', 'order' : '[UP | DOWN | STOP | UNKNOWN]' } *'status' field reflect current state of the shutter* *'order' field is the action currently undertaken*

subscribe

BASE_TOPIC/shutter/**command**	JSON frame
order	{ 'dest' : <*ID*>, 'order' : '[UP | DOWN | STOP] or *status*' }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
UP **DOWN** **STOP**	Set action to open, close or stop shutter in its current position

display

This kind of actuator is able to display some web pages. Users can send a list of web pages that will get displayed according to a scheduling based on a timer value. This timer value may get changed along with the other parameters like time_on and time_off that define when to switch ON and when to switch OFF the display itself.

We describe below the various types of the 'value' field:

CLASS	'value' field
display	*NONE*

publish

BASE_TOPIC / display	JSON frame
status	*is published on request **and** upon page change **and** upon order received **and** upon power mode change* { 'unitID' : <*ID*>, 'status' : '[OK | KO]', 'pwr_status' : '[ON | OFF | UNKNOWN | FORCEON | FORCEOFF]', 'frequency' : '<*web pages timeout*>', 'time_on' : '<*when to set ON*>', 'time_off' : '<*when to set OFF*>', 'days_on' : '<*list of active days*>', 'cur_url' : '<*currently displayed url*>', 'def_url' : <True | False> } *'status' field reflect browser's status (alive/dead)* *'pwr_status' field reflect video output status* *'frequency' field is the time a web page is displayed* *'time_on' field is when we switch ON video (minutes of day)* *'time_off' field is when we switch OFF video (minutes of day)* *'days_on' list that starts with 1 --> monday* *'cur_url' field is the currently displayed web page (will get truncated to a maximum value)* *'def_url' tells whether we display the default urls list*

subscribe

BASE_TOPIC/display/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : '*status*'

	}
order to set mode	{ 'dest' : <*ID*>, 'order' : 'mode', 'value' : '[NORMAL | FORCEON | FORCEOFF]' }
order to set web pages frequency	{ 'dest' : <*ID*>, 'order' : 'frequency', 'value' : <*integer*> }
order to set URLs list	{ 'dest' : <*ID*>, 'order' : 'url', 'value' : 'url' or [url1, url2, … urlx]' }
order to display a TXT msg	{ 'dest' : <*ID*>, 'order' : 'txt', 'value' : '*<text to display>*' }
order to display an image	{ 'dest' : <*ID*>, 'order' : 'img', 'value' : '*<binary image to display*>*' } * *image format will be specified later*
order to set 'time_on' events	{ 'dest' : <*ID*>, 'order' : 'time_on", 'value' : "06:45" or "1-5 06:45" or "1,3,4 09:00" ... }
order to set 'time_off' events	{ 'dest' : <*ID*>, 'order' : 'time_off", 'value' : "19:30" }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
mode	Set display mode. At startup, we're in **NORMAL** mode (i.e ON or OFF). If mode is set to **FORCEON**, the display will switch ON and will then automatically switch back to normal mode on the next *'time_on'* event. If set to **FORCEOFF**, the display will stay OFF until the next

	reboot! or if you switch back to another mode.
frequency	set timeout (seconds) before changing web page to display
url(s)	Either set a single url (i.e string) or a list of urls
time_on	Kind of 'crontab' value: - hours:minutes - time of days (e.g 1-5) + hours:minutes e.g: "1-5 7:30"
time_off	hours:minutes to switch OFF video output e.g: "19:30"

access

This topic is dedicated to access control systems. These systems are usually installed on front doors for room access security or related to external gates when they're involved in vehicle access authorisation.

- end-device: **publish** to **BASE_TOPIC / access**
- end-device: **subscribe** to **BASE_TOPIC / access / command**

We describe below the various types of the 'value' field:

CLASS	'value' field
access	*NONE*

publish

BASE_TOPIC / access	JSON frame
status	*is published upon **status order** received* { 'unitID' : <*ID*>, 'status' : '[OK | KO]', <others> } *<others> could be a detected camera, a NFC reader etc. See accessOCampus developer guide.*
access	*is published upon a USER applying to an access* { 'unitID' : <ID>, 'seq_id' : '<access seq. number>, 'auth_type' : <see accessOCampus doc>, 'nfc_uid' : <see accessOCampus doc>, 'passcode' : <see accessOCampus doc>, 'thermal_detect' : <see accessOCampus doc>, 'image' : <see accessOCampus doc>, } *See accessOCampus developer guide for fields details.*

subscribe

BASE_TOPIC/access/**command**	JSON frame
send status order	{ 'dest' : <*ID*>, 'order' : '*status*' }

grant access order (i.e door/gate will open)	{ 'dest' : <*ID*>, 'seq_id' : <from access request seq_id field>, 'order' : 'grant' }
deny access order (i.e door/gate will remain closed)	{ 'dest' : <*ID*>, 'seq_id' : <from access request seq_id field>, 'order' : 'deny' }
ask_code order (people has not been recognized by the camera → ask for code)	{ 'dest' : <*ID*>, 'order' : 'ask_code' }
force_open order	{ 'dest' : <*ID*>, 'order' : 'force_open' }
force_close order	{ 'dest' : <*ID*>, 'order' : 'force_close' }
normal mode order (to cancel previous force_xxx orders)	{ 'dest' : <*ID*>, 'order' : 'normal' }

'order' command possible *actions*:

status	force immediate delivery of a status report to its class topic
grant	subsequently to an 'access request', will authorize access
deny	subsequently to an 'access request', will deny access
ask_code	people not recognized (camera), ask for an additional code
force_open	special_mode: system remains open (e.g journée portes ouvertes)
force_close	special_mode: system remains closed (e.g burglar emergency)
normal	end of 'special_mode': go back to regular ops

Annexe - A

A-1 ESP8266 credentials sample code

```
bool _http_get( const char *url, char *buf, size_t bufsize, const char *login, const char
*passwd ) {

  HTTPClient http;

  http.begin(url);
  log_debug(F("\n[HTTP] GET url : ")); log_debug(url); log_flush();

  // authentication ?
  if( login!=NULL and passwd!=NULL ) {
    http.setAuthorization( login, passwd);
  }

  // perform GET
  int httpCode = http.GET();

  // connexion failed to server ?
  if( httpCode < 0 ) {
    log_error(F("\n[HTTP] connexion error code : ")); log_debug(httpCode,DEC); log_flush();
    return false;
  }

  // check for code 200
  if( httpCode == HTTP_CODE_OK ) {
    String payload = http.getString();
    snprintf( buf, bufsize, "%s", payload.c_str() );
  }
  else {
    log_error(F("\n[HTTP] GET retcode : ")); log_debug(httpCode,DEC); log_flush();
  }

  // close connexion established with server
  http.end();

  yield();

  return ( httpCode == HTTP_CODE_OK );
}

// HTTP get
```

```
bool http_get( const char *url, char buf[], size_t bufsize ) {
    return _http_get( url, buf, bufsize, NULL, NULL );
}

// HTTP get with credentials
bool http_get( const char *url, char *buf, size_t bufsize, const char *login, const char
*passwd ) {
    return _http_get( url, buf, bufsize, login, passwd );
}
```

A-2 sensOCampus configuration U4/302

- [2020, March] sensOCampus configuration for u4/302 located end-device


```
[
	{
		"topic": "u4/302",
		"modules":
		[
			{
				"module": "Energy",
				"unit": "modbus_rs485",
				"params":
				[
					{
						"param": "frequency",
						"value": 0
					},
					{
						"param": "backend",
						"value": "modbus"
					},
					{
						"param": "link",
						"value": "/dev/ttyUSB0"
					},
					{
						"param": "link_speed",
						"value": 9600
					},
					{
						"param": "subIDs",
						"value": [
								"chauffage",
								"prises1",
								"prises2",
								"prises3"
							]
					},
					{
						"param": "addr",
						"value": [
								1,
								88,
								65,
								62
							]
					}
				]
			},
			{
				"module": "Shutter",
				"unit": "front",
				"params":
				[
					{
						"param": "shutterType",
						"value": "wired"
					},
					{
						"param": "courseTime",
						"value": 20
					},
					{
						"param": "upOutput",
						"value": 100
					},
					{
						"param": "downOutput",
						"value": 101
					}
```

```
                ]
        },
        {
                "module": "Shutter",
                "unit": "center",
                "params":
                [
                        {
                                "param": "shutterType",
                                "value": "wired"
                        },
                        {
                                "param": "courseTime",
                                "value": 20
                        },
                        {
                                "param": "upOutput",
                                "value": 102
                        },
                        {
                                "param": "downOutput",
                                "value": 103
                        }
                ]
        },
        {
                "module": "Shutter",
                "unit": "back",
                "params":
                [
                        {
                                "param": "shutterType",
                                "value": "wired"
                        },
                        {
                                "param": "courseTime",
                                "value": 20
                        },
                        {
                                "param": "upOutput",
                                "value": 104
                        },
                        {
                                "param": "downOutput",
                                "value": 105
                        }
                ]
        },
        {
                "module": "Digital",
                "unit": "inside",
                "params":
                [
                        {
                                "param": "frequency",
                                "value": 0
                        },
                        {
                                "param": "subIDs",
                                "value": [
                                                "ilot1",
                                                "ilot2",
                                                "ilot3",
                                                "window"
                                        ]
                        },
                        {
                                "param": "inputs",
                                "value": [
                                                101,
                                                106,
                                                111,
                                                115
```

```
                                        ]
                        },
                        {
                                "param": "types",
                                "value": [
                                                "presence",
                                                "presence",
                                                "presence",
                                                "open_close"
                                        ]
                        }
                ]
        },
        {
                "module": "Luminosity",
                "unit": "inside",
                "params":
                [
                        {
                                "param": "frequency",
                                "value": 0
                        },
                        {
                                "param": "subIDs",
                                "value": [
                                                "ilot1",
                                                "ilot2",
                                                "ilot3"
                                        ]
                        },
                        {
                                "param": "inputs",
                                "value": [
                                                100,
                                                105,
                                                110
                                        ]
                        },
                        {
                                "param": "min",
                                "value": [
                                                0,
                                                0,
                                                0
                                        ]
                        },
                        {
                                "param": "max",
                                "value": [
                                                1000,
                                                1000,
                                                1000
                                        ]
                        },
                        {
                                "param": "units",
                                "value": [
                                                "",
                                                "",
                                                ""
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                        }
                ]
        },
        {
                "module": "Luminosity",
                "unit": "outside",
                "params":
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                                "param": "frequency",
                                "value": 60
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                                "param": "subIDs",
                                "value": [
                                                "ouest"
                                        ]
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                                "param": "inputs",
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                                                "ilot2",
                                                "ilot3"
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                                                108,
                                                113
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                                "param": "min",
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                                                5,
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                        {
                                "param": "max",
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                                                40,
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```

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                                                ""
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        },
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                "unit": "outside",
                "params":
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                                "param": "frequency",
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                                        ]
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                ]
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                "unit": "inside",
                "params":
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                                "param": "frequency",
                                "value": 0
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                                                "ilot2",
                                                "ilot3"
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                                "param": "inputs",
                                "value": [
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                                                109,
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```
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                                "param": "max",
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                                                80,
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                                "param": "units",
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                                                "",
                                                "",
                                                ""
                                        ]
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                ]
        },
        {
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                "unit": "outside",
                "params":
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                                "param": "frequency",
                                "value": 0
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                        {
                                "param": "subIDs",
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                                                "ouest"
                                        ]
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                                "param": "inputs",
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                                "param": "max",
                                "value": [
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                                        ]
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        {
                "module": "CO2",
                "unit": "inside",
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                                        "param": "subIDs",
                                        "value": [
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                                                        "ilot2",
                                                        "ilot3"
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                                        "param": "inputs",
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                                                        107,
                                                        112
                                                ]
                                },
                                {
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                                        "value": [
                                                        0,
                                                        0,
                                                        0
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                                },
                                {
                                        "param": "max",
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                                                        2000,
                                                        2000
                                                ]
                                },
                                {
                                        "param": "units",
                                        "value": [
                                                        "",
                                                        "",
                                                        ""
                                                ]
                                }
                        ]
                }
        ]
    }
]
```

A-3 sensOCampus LCC's AirQuality configuration

- [2020, Aug.] sensOCampus configuration for LCC's AirQuality sensor

```
[
	{
		"topic": "irit2/366",	will become optional in sensOCampusV2
		"modules":
		[
			{
				"module": "airquality",
				"unit": "lcc_sensor",
				"frequency": 60,
				"driver": "lcc_sensor",
				"params":
				[
					{
						"param": "subIDs",
						"value": "CP1"
					},
					{
						"param": "inputs",
						"value": [ 16, 17, 5, 18, 35 ]
					},
					{
						"param": "outputs",
						"value": -1
					}
				]
			},
			{
				"module": "airquality",
				"unit": "lcc_sensor",
				"frequency": 60,
				"params":
				[
					{
						"param": "subIDs",
						"value": "CP2"
					},
					{
						"param": "inputs",
						"value": [ 19, 21, 22, 23, 34 ]
					},
					{
						"param": "outputs",
						"value": -1
					}
				]
			},
			{
				"module": "airquality",
				"unit": "lcc_sensor",
				"frequency": 60,
				"params":
				[
					{
						"param": "subIDs",
						"value": "CP3"
					},
					{
						"param": "inputs",
						"value": [ 13, 12, 14, 27, 33 ]
					},
					{
						"param": "outputs",
						"value": 25
					}
				]
			},
			{
```

```
                        "module": "airquality",
                        "unit": "lcc_sensor",
                        "frequency": 60,
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                                        "param": "subIDs",
                                        "value": "CP4"
                                },
                                {
                                        "param": "inputs",
                                        "value": [ 15, 2, 0, 4, 32 ]
                                },
                                {
                                        "param": "outputs",
                                        "value": 26
                                }
                        ]
                }
        ]
    }
]
```


Note: 'inputs' parameters are specified as lists; the latest element of the list is the analog input from the amplifier.

A-4 end-device level retrieved sensOCampus config

- [2020, Aug.] sensOCampus configuration for LCC's AirQuality sensor received at end-device's level


```
{
  "topics": [
    "irit2/366"
  ],
  "zones": [
    {
      "topic": "irit2/366",
      "modules": [
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          "unit": "lcc_sensor",
          "frequency": 60,
          "params": [
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              "param": "subIDs",
              "value": "NO2"
            },
            {
              "param": "inputs",
              "value": [
                  16,
                  17,
                  5,
                  18,
                  35
                ]
            },
            {
              "param": "outputs",
              "value": -1
            }
          ]
        },
        {
          "module": "airquality",
          "unit": "lcc_sensor",
          "frequency": 60,
          "params": [
            {
              "param": "subIDs",
              "value": "CO"
            },
            {
              "param": "inputs",
              "value": [
                  19,
                  21,
                  22,
                  23,
                  34
                ]
            },
            {
              "param": "outputs",
              "value": -1
            }
          ]
        },
        {
          "module": "airquality",
          "unit": "lcc_sensor",
          "frequency": 60,
          "params": [
            {
              "param": "subIDs",
```

```
              "value": "CH20"
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              "param": "inputs",
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                  12,
                  14,
                  27,
                  33
                ]
            },
            {
              "param": "outputs",
              "value": 25
            }
          ]
        },
        {
          "module": "airquality",
          "unit": "lcc_sensor",
          "frequency": 60,
          "params": [
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              "value": "NO2_alt"
            },
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              "param": "inputs",
              "value": [
                  15,
                  2,
                  0,
                  4,
                  32
                ]
            },
            {
              "param": "outputs",
              "value": 26
            }
          ]
        }
      ]
    }
  ]
}
```