Wireless and Sensor Technologies
Enable Smart City and Smart Home

life.augmented

Wireless Technology Enables Smart City

Demo implementation details

STM32 Nucleo development & expansion boards

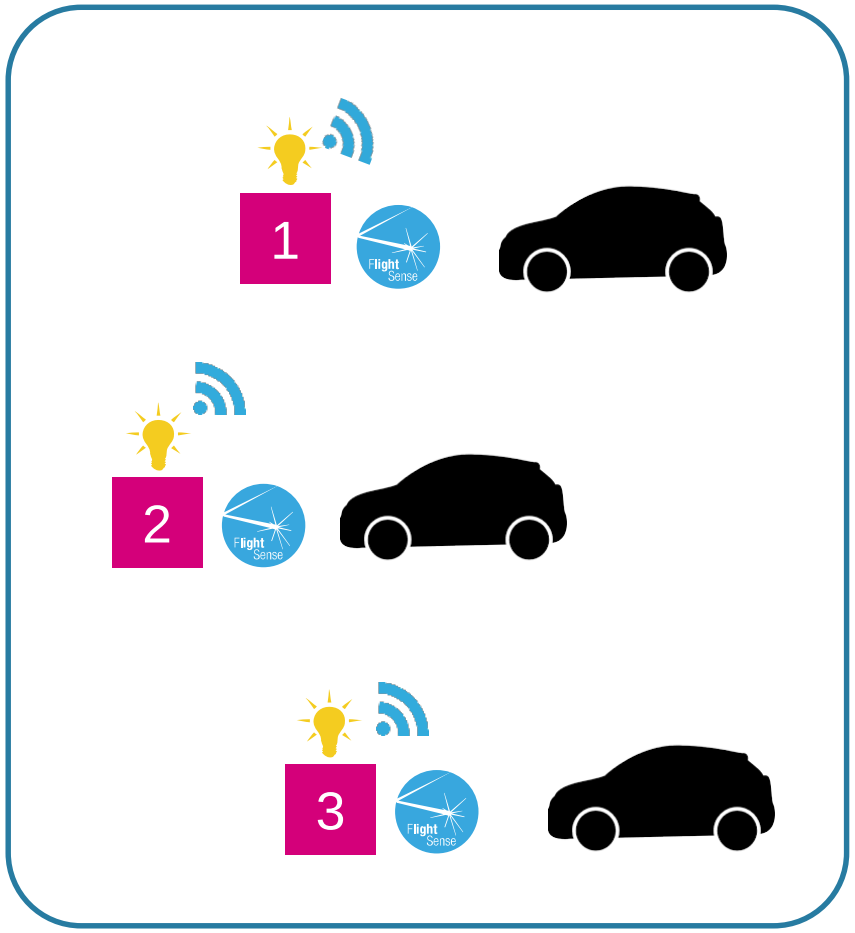
ST Portfolio for SMART CITY

Leshan
OMA Lightweight M2M

Contiki
6LoWPAN

life.augmented

Wireless Mesh Network



Smart Street Lights
Smart Parking

Wi-Fi Gateway

IPv6
6LoWPAN

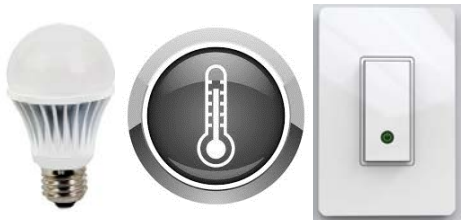
Cloud

Leshan
OMA Lightweight M2M

Ambient sensors

life.augmented

ST augmenting the Smart Home experience



Connect
sensors, thermostats, lights

Nodes over Bluetooth Smart

Bluetooth SMART

Access
smart devices remotely

WiFi to Cloud

Wi Fi

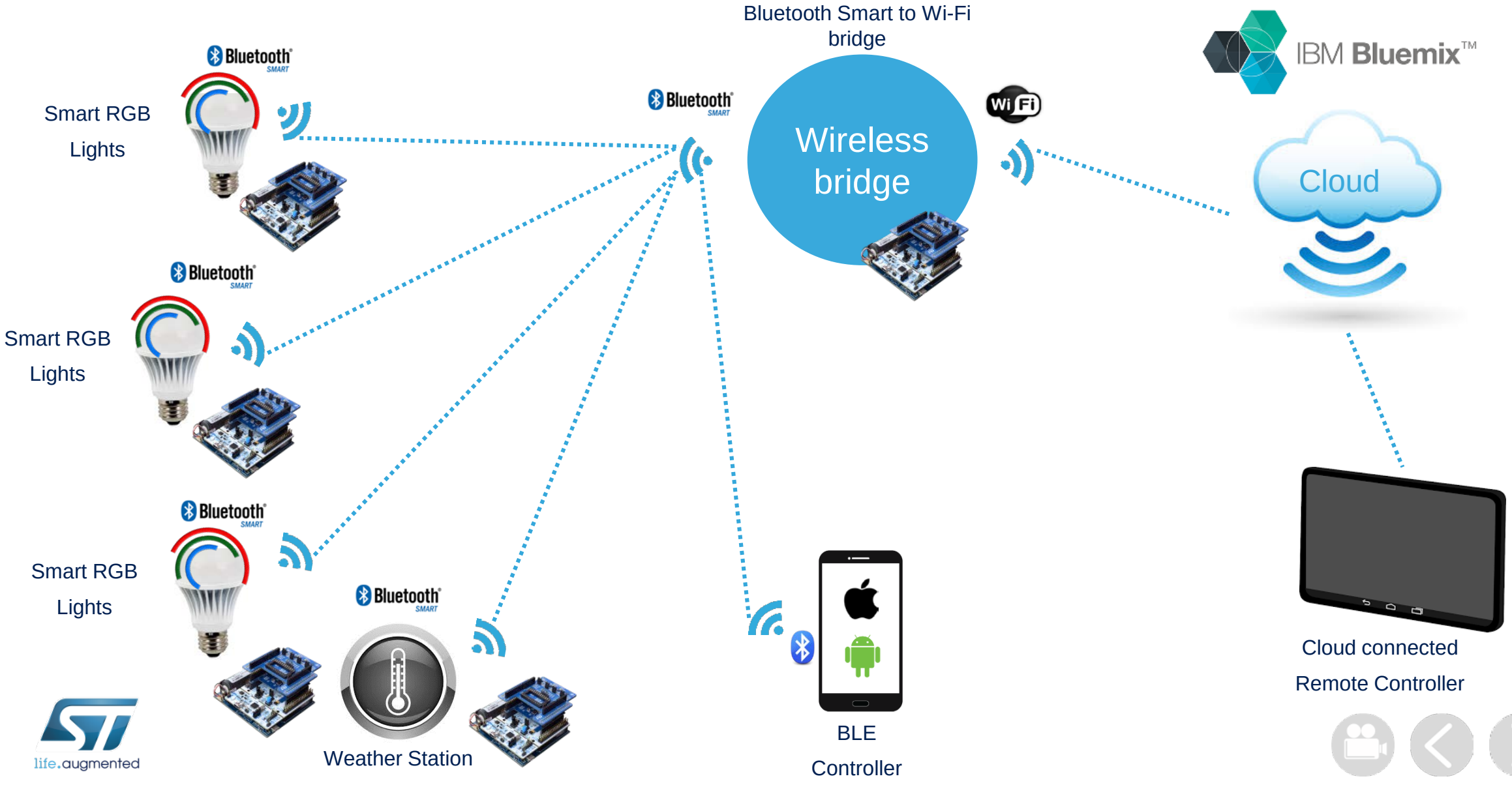
Control
smart devices

BLE SDK
For smart phones

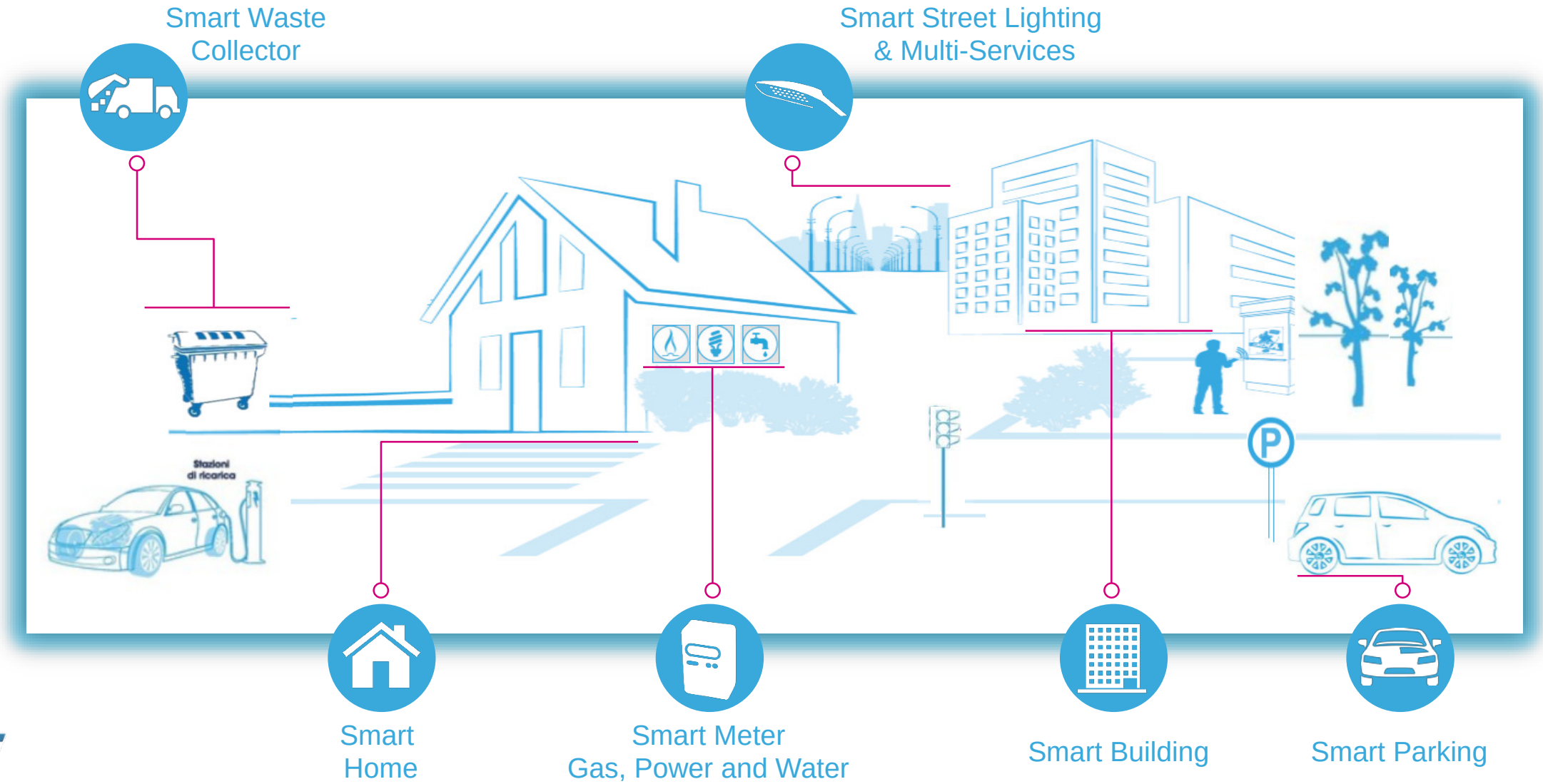
life.augmented

ST augmenting the Smart Home experience

BlueNRG-MS *low-power BLE Sensor Node Network connected to the Cloud*



Wireless Technology Enables Smart City



life.augmented

Wireless Mesh Network for Smart City

Sensor nodes everywhere

Wireless network

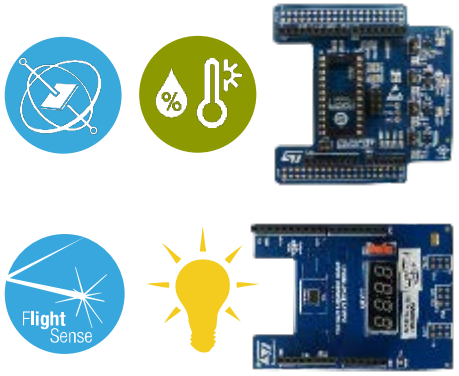
Efficient Energy Management

Monitor & Control Infrastructure

life.augmented

Network System Architecture

Motion / Environmental / Proximity Sensors / Lighting



32bit MCU

STM32 Nucleo

Wireless Network Module

X-NUCLEO-IDS01Ax

IPv6
6LoWPAN

Nucleo Gateway

Monitoring & Control

life.augmented

Smart City: Contiki 6LowPan

Contiki Solution for SubGHz 6LoWPAN

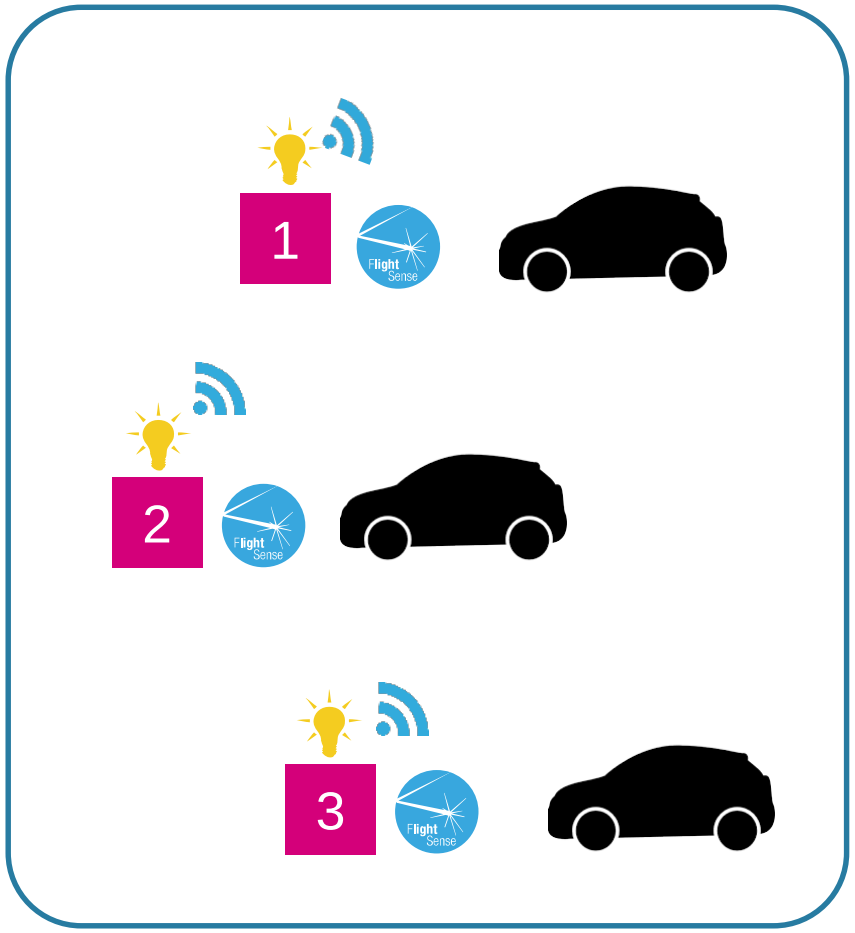
Smart City 6LoWPAN Network
Smart light
Smart dumpster
Earthquake
Ambient Sensor

Broad portfolio of ST components

- Nucleo board with STM32L1 ultra-low power MCU
- Nucleo board with STM32F4 High performance MCU
- Distance ranging STM32 Nucleo expansion board
- Motion & Environmental sensors STM32 Nucleo expansion board
- Sub-GHz wireless transceiver

life.augmented

Wireless Mesh Network



Smart Street Lights
Smart Parking

Wi-Fi Gateway

IPv6
6LoWPAN

Cloud

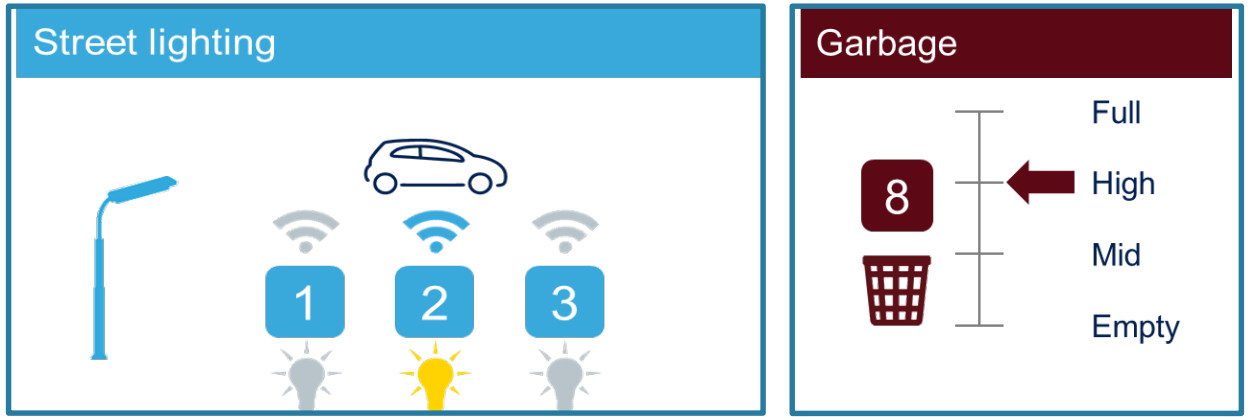
Leshan
OMA Lightweight M2M

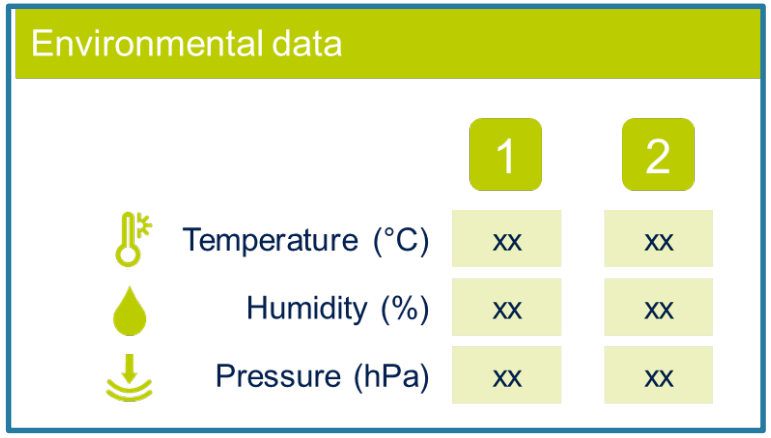
Ambient sensors

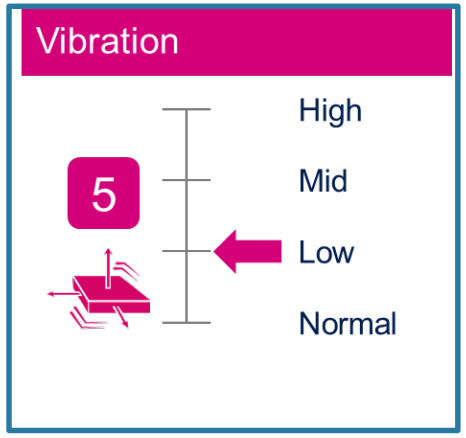
life.augmented

Smart City: Contiki 6LowPan

- 3x Smart street light
- 2x Smart ambient sensor
- 1x Garbage collector
- 1x Earthquake Sensor







life.augmented

STM32 Nucleo Board

Open development platform with STM32 Microcontroller

- High performance 32bit MCU: STM32F4
- Fast development of Software & Hardware
- Add-on functions through expansions

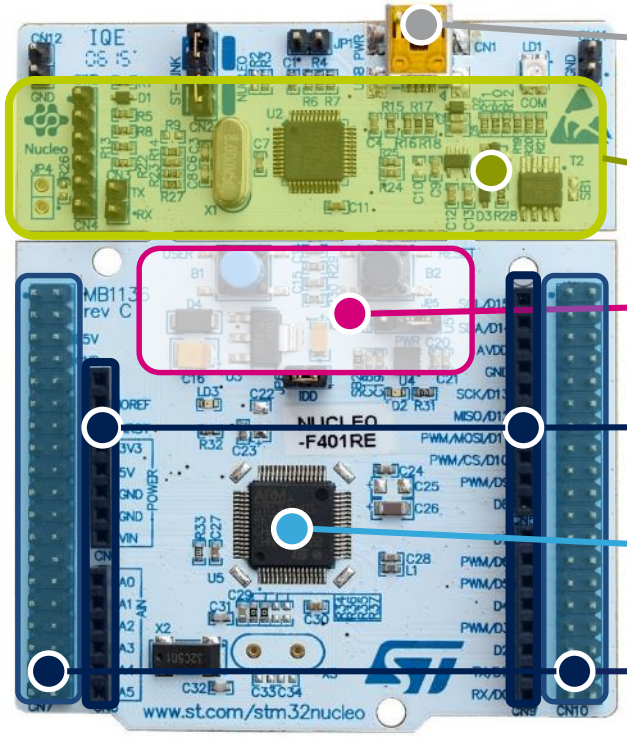
STM32

STM32 Nucleo

life.augmented

STM32 Nucleo Development Board

- Powered by ST's 32-bit ARM® Cortex®-M based STM32 microprocessors
- A complete product range from ultra-low power to high-performance
- Integrated hardware for programming and debug
- Two connectors to connect to expansion boards



Power supply through USB
or external source

Integrated ST-Link/V2-1:
Mass storage device flash programming

2 Push button, 2 color Leds

Arduino Uno v3 extension connectors
Easy access for add-ons

One STM32 MCU flavor with 64 pins

ST morpho extension headers
Direct access to all MCU I/Os

STM32 L0 STM32 L1 STM32 L4 STM32 F0 STM32 F1 STM32 F2 STM32 F3 STM32 F4 STM32 F7

life.augmented

Motion & Environmental

STM32 Nucleo expansion board

- Easy to add-in functions to STM32 Nucleo
- 3 x Motion sensor & Environment sensors

6-axis
Motion Sensor
LSM6DS0

Temperature &
Humidity Sensor
HTS221

Pressure Sensor

LPS25H

life.augmented

FlightSense™ Distance Ranging

STM32 Nucleo expansion board

- Easy to add-in functions to STM32 Nucleo
- Proximity sensor based on Time-of-Flight (ToF) technology

FlightSense

Distance Ranging Sensor
VL6180X

life.augmented

Spirit1 SubGHZ Transceiver

STM32 Nucleo expansion board

- Easy to add-in functions to STM32 Nucleo
- Contiki 6LowPan ready

STM32 - Broadest 32-bit MCU Portfolio

Real time performance

ART Accelerator, up to1000 CoreMark and up to 200MHz/428DMPIS

Outstanding power efficiency

<1uA RTC, 188uA/MHz, 0.3uA standby

Standard and advanced peripherals

USB-OTG HS, Camera, Ethernet, CAN, CRYPTO, SD 16-bit ADC, PGA, SDRAM interface, TFT with Chrom-ART

Maximum integration

Up to 2MB Flash/256kB SRAM, Reset Circuit, Voltage Reg., Int. RC, PLL, PVD, POR

Extensive Ecosystem

ARM+ST ecosystem (EVAL boards, discovery kits, Arduino, SW lib, RTOS)

life.augmented

STM32L ULP Offer

STM32L4 completes the ultra-low-power family

Cost-smart ULP champion

Cortex-M0+ @ 32 MHz
Operating range: 1.65 to 3.6V
8/16-bit applications
Numerous pin counts

3 product lines
Cost-effective
Smaller packages
USB, LCD, Analog
16 to 192 Kbytes of Flash
Up to 20 Kbytes of SRAM

Broad range foundation

Cortex-M3 @ 32 MHz
Operating range: 1.65 to 3.6V
Wide choice of
memory sizes

3 product lines
USB, LCD, AES
Rich Analog
True EEPROM
Dual bank Flash (RWW)
32 to 512 Kbytes of Flash
Up to 80 Kbytes of SRAM

ULP with performance

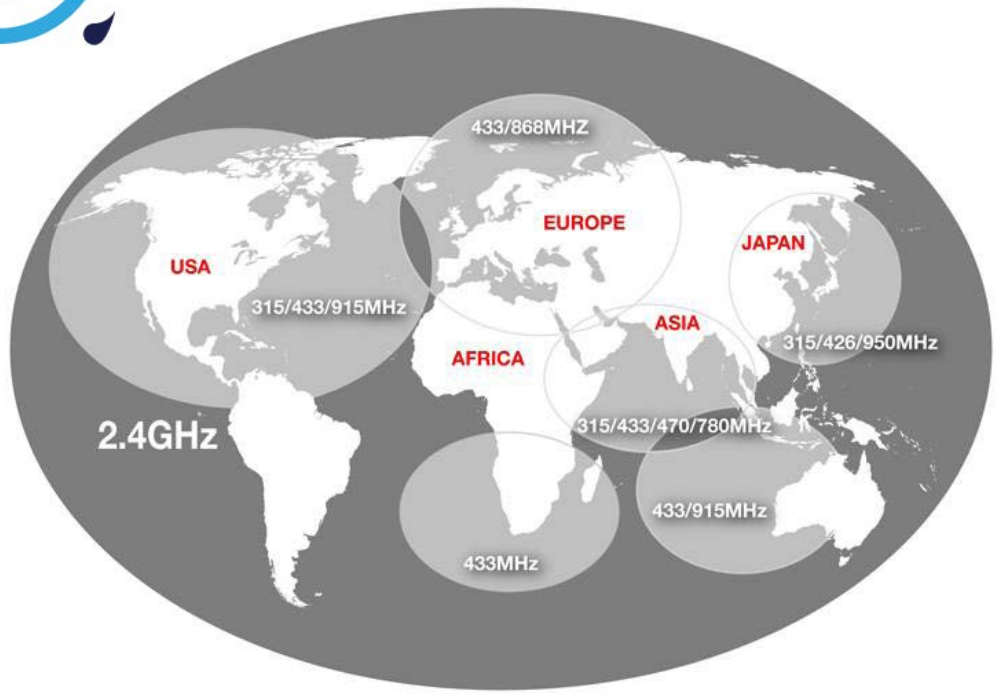
Cortex-M4 w/ FPU @ 80 MHz
Operating range: 1.71 to 3.6V
Advanced Peripheral Performance

3 product lines
ADC 5 Msps, PGA, Compar., DAC, op amp,
USB OTG, LCD, AES
256 Kbytes to 1 Mbyte of Flash
Up to 128 Kbytes of SRAM

life.augmented

SPIRIT1

Sub-GHz RF Transceivers Family



USA/Canada: ***FCC,*** *Europe:* ***ETSI,*** *Japan/Korea :* **ARIB** standard

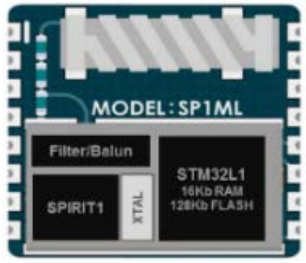
- Multi band : 150MHz, 433, 868 to 956Mhz
- Ultra low current consumption
- Mod.: 2-FSK, 2-GFSK, MSK, OOK, ASK
- Programmable output power up to +16dBm
- Excellent receiver Sensitivity: -121dBm
- Wireless MBUS, 6LoWPan
- Certified Modules:
  - **SP1ML-868/915**: SPIRIT1+STM32L1
  - **SPSGRF-868/915**: SPIRIT1

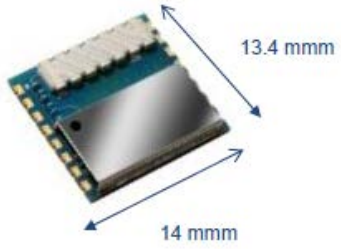
life.augmented

Sub GHz Modules

SP1ML-868 - (868 MHz)

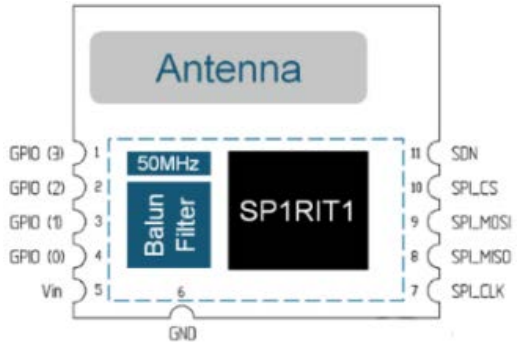
SP1ML-915 - (915 MHz)





SPSGRF-868 @ 868MHz

SPSGRF-915 @ 915MHz



11,5 x 13,5 mm

SPIRIT1 transceiver, STM32L1 MCU and BALF-SPI balun/filter

- AT Command
- Output power up to +11.6dBm
- CE compliant and FCC certified
- Air data rate up to 500kbps
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK,
- 1.8V to 3.6V supply
- Operating temperature: -40°C to 85°C

SPIRIT1 transceiver and BALF-SPI-01D3 balun/filter

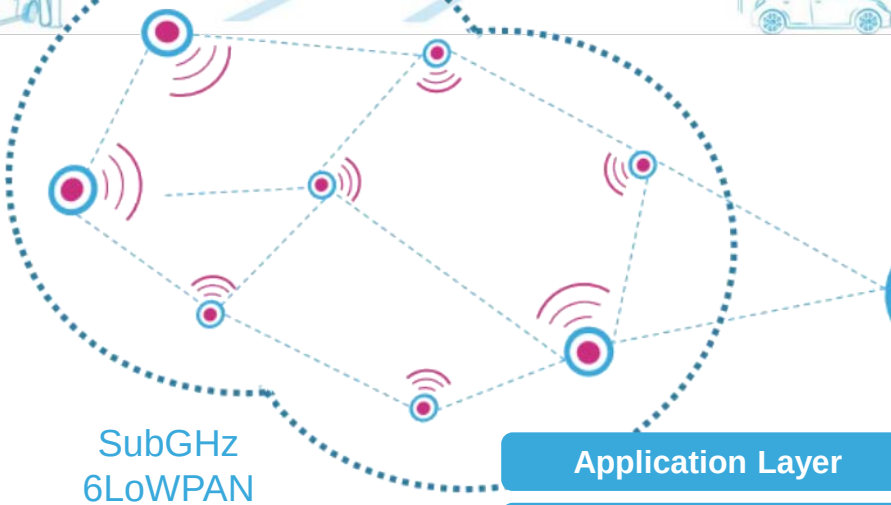
- SPI host interface
- Output power up to +11.6 dBm
- RX: 9mA, Tx: 21mA @ +11dBm
- CE compliant and FCC certified
- Air data rate up to 500kbps
- Receiver sensitivity: -118 dBm
- Shut Down: 2.5nA
- Operating temperature: -40°C to 85°C

life.augmented

RF SubGHz

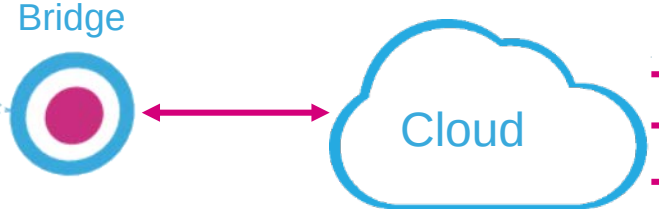
6LoWPAN Wireless MESH

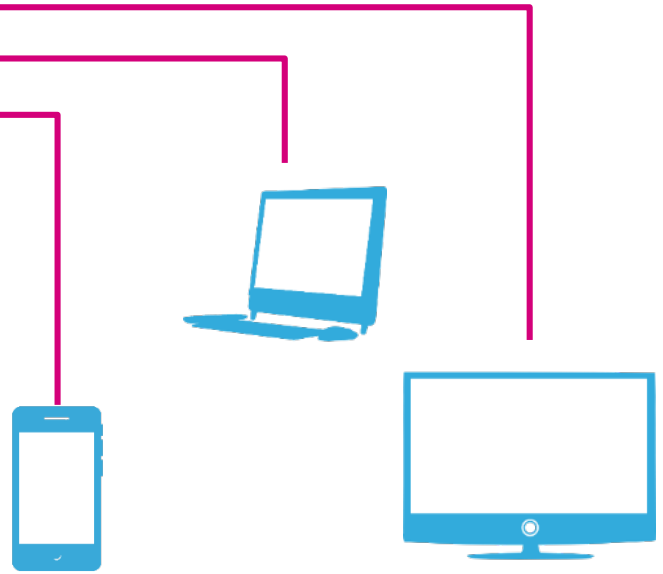
- Contiki 3.0 open source code based
- Contiki OS based
- HTTP, WebSocket, CoAP
- UDP and TCP socket APIs
- IPv4/IPv6 stack, RPL, 6LoWPAN, 802.15.4



SubGHz
6LoWPAN
network

Bridge

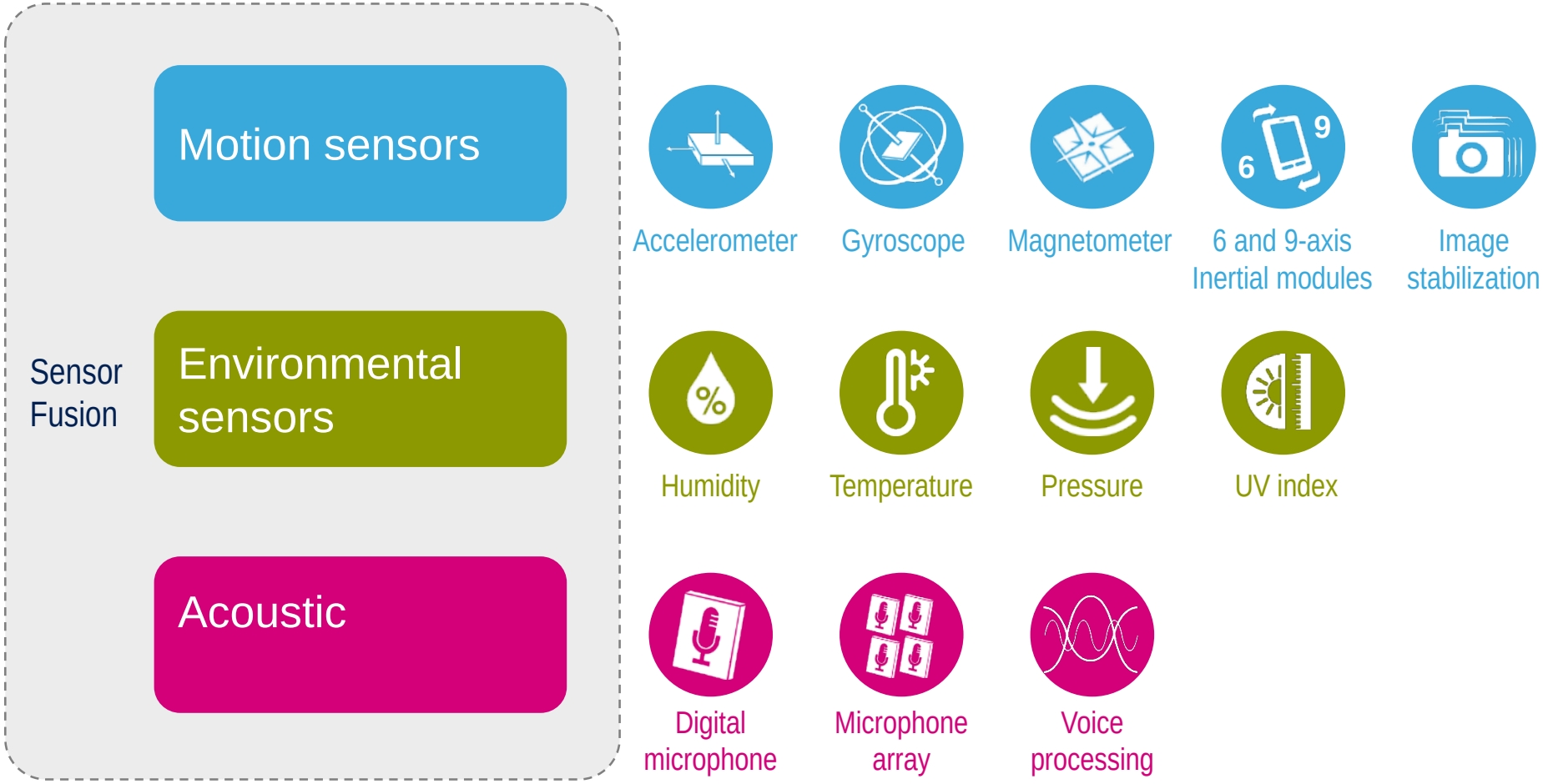




Application Layer	Custom Application (CoAP)
Transport Layer	UDP
Network Layer	uIPv6 and ContikiRPL
Adaptation Layer	6LoWPAN
MAC Layer	CSMA/CA
Radio Duty Cycle	ContikiMAC, Sleepy meshing
Radio Layer	SPIRIT 868MHz or 915 MHz

life.augmented

Sensors – A Complete Offering



life.augmented

Motion MEMS

Accelerometers and e-Compasses

Accelerometer

- Free fall condition
- Direction detection
- Spatial orientation
- Step counter
- Gesture recognition

Accelerometers

- **Small footprint for ultra-compact solutions**
- **Low power consumption and ultra-low power operating modes that allow advanced power saving and smart sleep-to-wake functions**
- **Embedding motion recognition algorithm**

MEMS inertial sensor 3-axis
LIS2DH12: LGA 2x2mm; FS ±2g/±4g/±8g/±16g; ODR 1 Hz to 5.3 kHz; I2C/SPI
LIS3DSH: LGA 3x3mm; FS ±2g/±4g/±6g/±8g/±16g; ODR 3.125 Hz to 1.6 kHz, I2C/SPI
H3LIS331DL: TFLGA 3x3mm; FS ±100g/±200g/±400g,ODR 0.5 Hz to 1 kHz; I2C/SPI.
LIS344ALH: LGA 4x4mm; FS ±2 g / ±6 g; max ODR 1.8 kHz; Analog OUT

e-compass

- Pointing
- Positioning
- Absolute heading
- Maps orientation & LBS

e-compass (Accelerometer + Magnetometer)

- **Superior sensing precision combined with low power consumption**
- **Very small package to address footprint reduction**
- **Temperature detection for advanced thermal drift compensation**

3D magnetometer
LIS3MDL : LGA-12 (2.0x2.0x1.0 mm); FS ±4/ ±8/ ±12/ ±16 gauss magnetic; 16-bit data output; I2C/SPI
3D accelerometer and 3D magnetometer module
LSM303C : LGA-12 (2.0x2.0x1.0 mm); Acc. FS ±2/±4/±8 g; FS ±16 gauss magnetic, 16-bit data output, SPI / I2C

life.augmented

MEMS Gyroscopes
and Inertial Modules

Gyroscope

- Advanced & smart motion detection
- Gaming
- Optical image stabilization

Digital Gyroscopes

- **Wide full-range for optical image stabilization and smart user interfaces**
- **High performance combines with low power consumption to address demanding application and extend battery life**
- **Embedded FIFO for smart data storage and power saving**
- **L3GD20H**: LGA-16 (3x3x1 mm); ±245/±500/±2000 dps; 16 bit rate value data output; I2C/SPI

6 and 9-axis
Inertial modules

- Complex gesture recognition
- Smart pointers
- Motion recognition

iNEMO Inertial Modules (Gyroscope + Accelerometer + Magnetometer)

- **More sensors in a single package for a smaller form facor**
- **Thermal and mechanical stability**
- **Enhanced user experience and motion-sensing realism in wearable devices**

iNEMO inertial modules
LSM330: 3D accelerometer and 3D gyroscope; ±2/±4/±6/±8/±16 g; ±250/±500/±2000 dps
LSM6DS0: : 3D accelerometer and 3D gyroscope; ±2/±4/±8 g; ±245/±500/±2000 dps;
LSM9DS0: 3D accelerometer, 3D gyroscope, 3D magnetometer; LGA-24 (4x4x1.0 mm); ±2g/±4g/±6g/±8g/±16g; ±2/±4/±8/±12 gauss ; ±245/±500/±2000 dps

life.augmented

Environmental Sensors

Pressure and Humidity

Pressure

Humidity

Temperature

LPS25HB: Absolute pressure sensor

- **Unique ultra thin full-molded package**
- **Dust-free and water resistant**
- **High shock survivability**
- 260 to 1260 hPa absolute pressure range
- High resolution mode: 1 Pa RMS
- Embedded FIFO (noise reduction), interrupts, thresholds and auto-zero

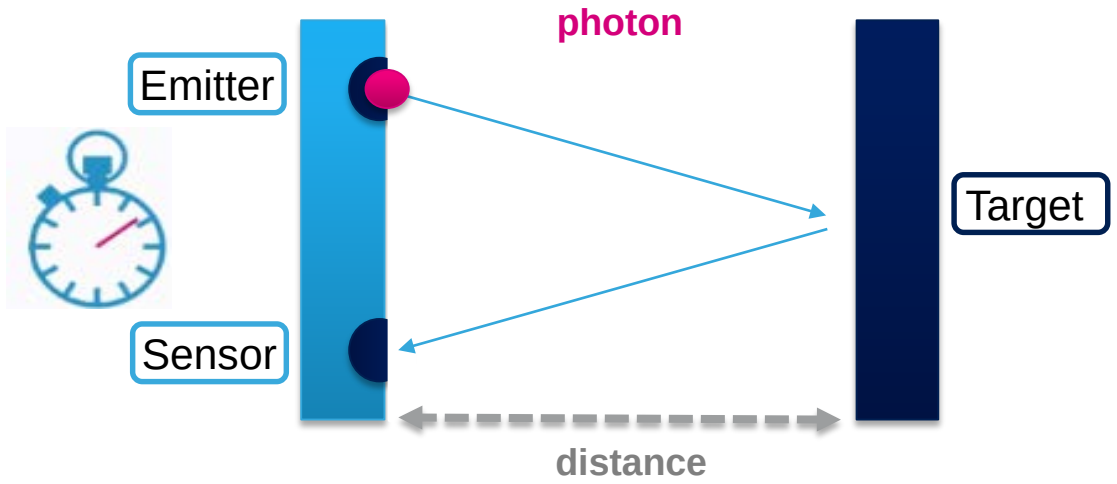
HTS221: Relative humidity and temperature sensor

- **Worldwide lowest power consumption**
- **3.5% RH accuracy**
- 0 to 100% RH range
- -40 to 120 °C temperature range
- Low Power Consumption: 1 µA @ 1Hz ODR
- 16 bit ADC measurement

life.augmented

FlightSense™ Breakthrough Technology

FlightSense™ Principle



Measured distance = Photon travel time / 2 x Speed of light

Fully Integrated Time of Flight Module
ST #1 World Wide Supplier

True distance measurement
Independent of target size, color & reflectance

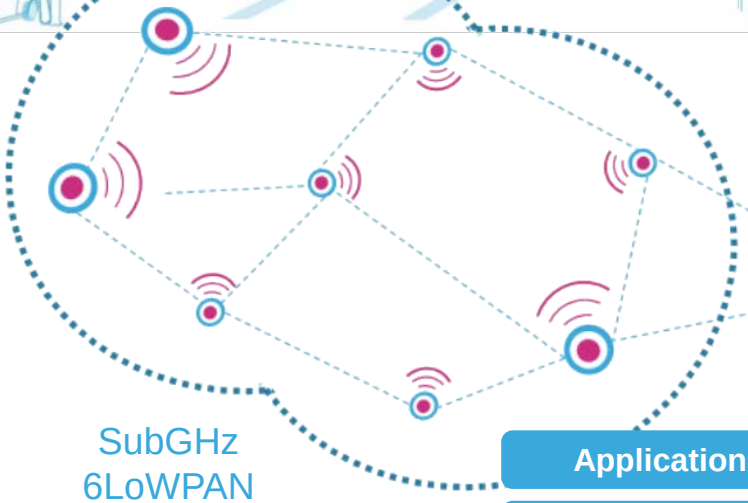
Measurement at the speed of light ! 1cm round-trip at 67ps

life.augmented

Contiki 3.0

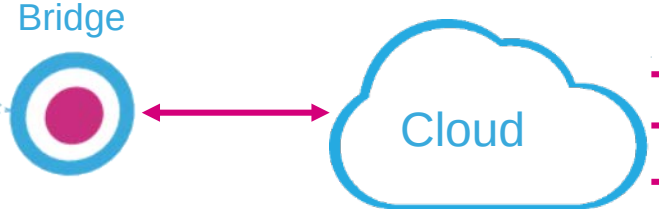
6LoWPAN Wireless MESH

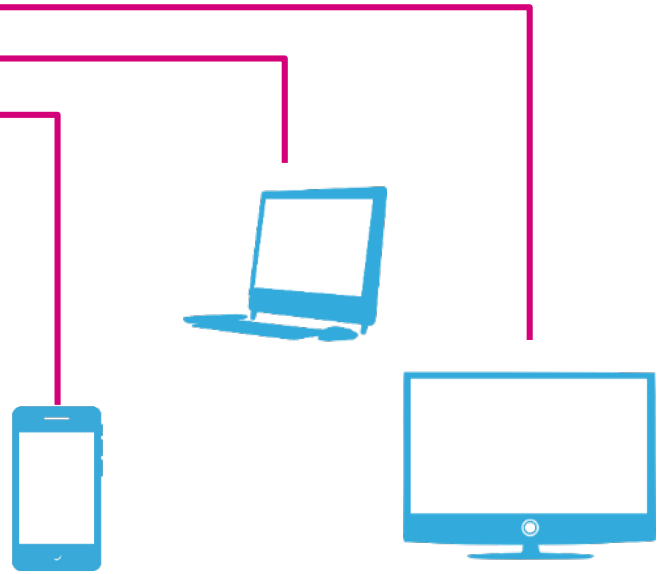
- Contiki 3.0 open source code based
- Contiki OS based
- HTTP, WebSocket, CoAP
- UDP and TCP socket APIs
- IPv4/IPv6 stack, RPL, 6LoWPAN, 802.15.4



SubGHz
6LoWPAN
network

Bridge



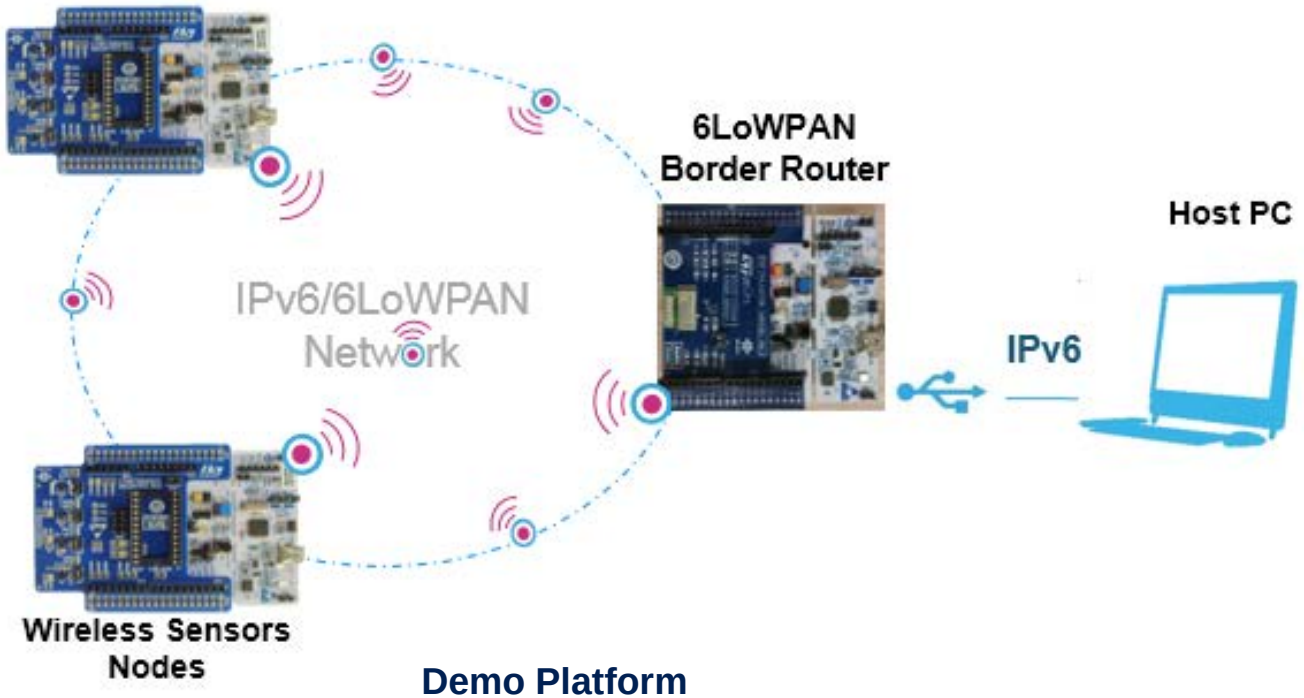


Application Layer	Custom Application (CoAP)
Transport Layer	UDP
Network Layer	uIPv6 and ContikiRPL
Adaptation Layer	6LoWPAN
MAC Layer	CSMA/CA
Radio Duty Cycle	ContikiMAC, Sleepy meshing
Radio Layer	SPIRIT 868MHz or 915 MHz

life.augmented

Contiki OS/6LoWPAN on STM32 Nucleo

STSW-CONTIKI6LP



Demo Platform

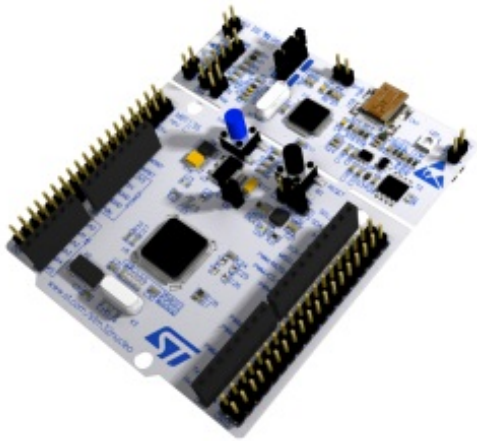
- 6LoWPAN Border Router
  - NUCLEO-L152RE
  - X-NUCLEO-IDS01A4/5 (sub-1GHz)
- Wireless Sensors Nodes
  - NUCLEO-L152RE
  - X-NUCLEO-IDS01A4/5 (sub-1GHz)
  - X-NUCLEO-IKS01A1 (sensors) [optional]

- Based on Contiki OS
- Contiki 6LoWPAN protocol stack 3.x
- Applications running on a STM32 Nucleo
- Support for mesh networking technology, RPL protocol
- CoAP based REST server (Erbium)
- Free user-friendly license terms

life.augmented

Contiki 3.0 Nodes

NUCLEO-L152RE



based on the STM32L152RET6 ultra-low power microcontroller

+

X-NUCLEO-IDS01A4 or X-NUCLEO-IDS01A5

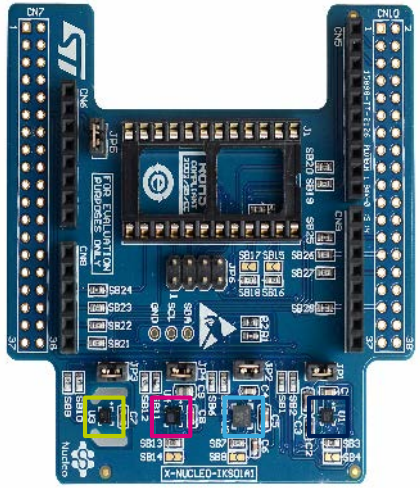
- SPSGRF-868 or SPSGRF-915
- EEPROM

SPIRIT1 868 and 915MHz RF SubGHz module evaluation board

+

X-NUCLEO-IKS01A1

- HTS221
- LPS25HB
- LSM6DS0
- LIS3MDL



Motion MEMS and environmental sensor evaluation board

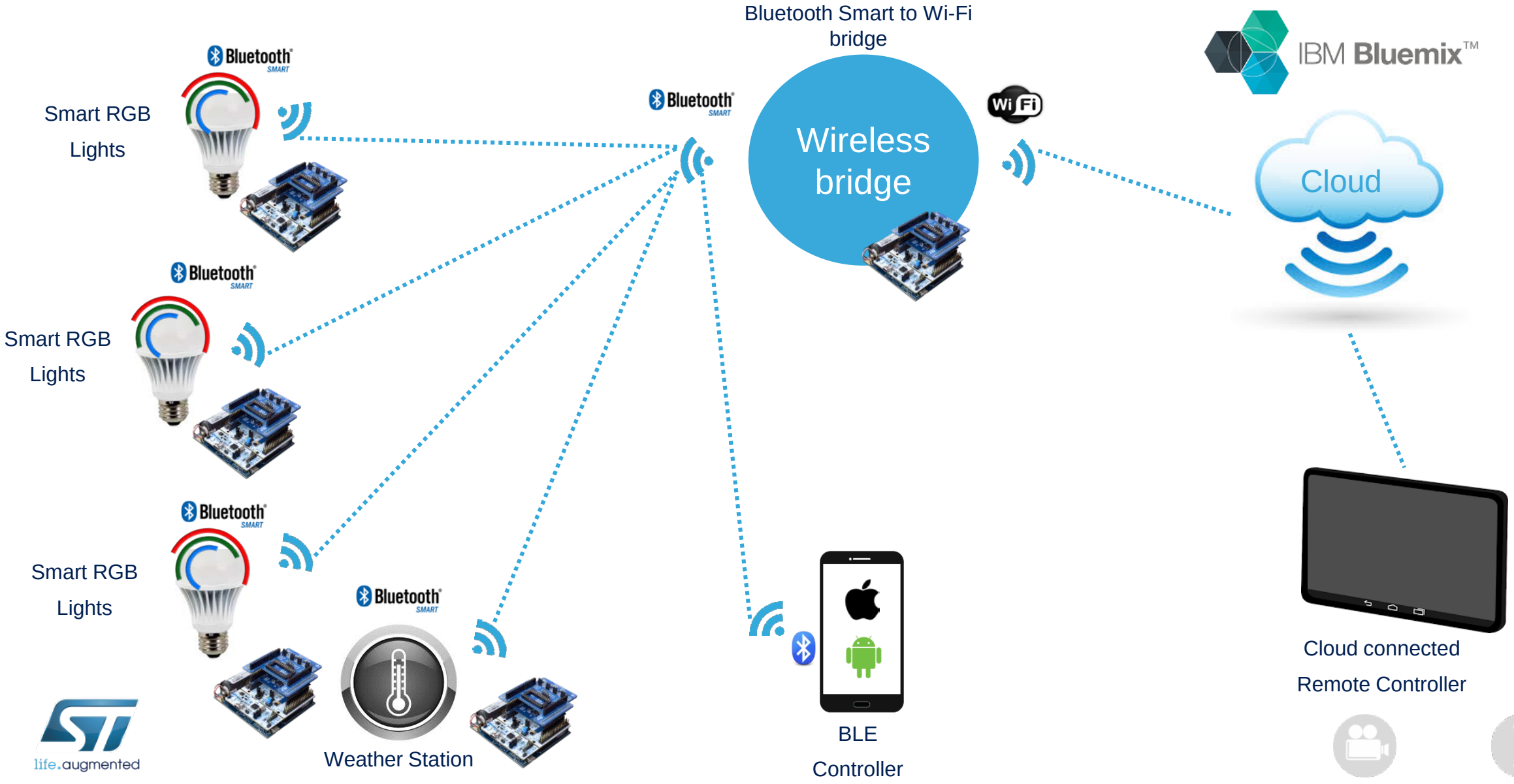
=

- **STM32L1RB** Ultra-low-power MCU
- **SPIRIT1** 868 MHz, sub-GHz
- **LPS25H** MEMS pressure sensor
- **LSM3DS0** 3D accel.+ 3D gyroscope
- **LIS3DMDL** 3D magnetometer
- **HTS221** Humidity & temperature sensor

life.augmented

ST augmenting the Smart Home experience

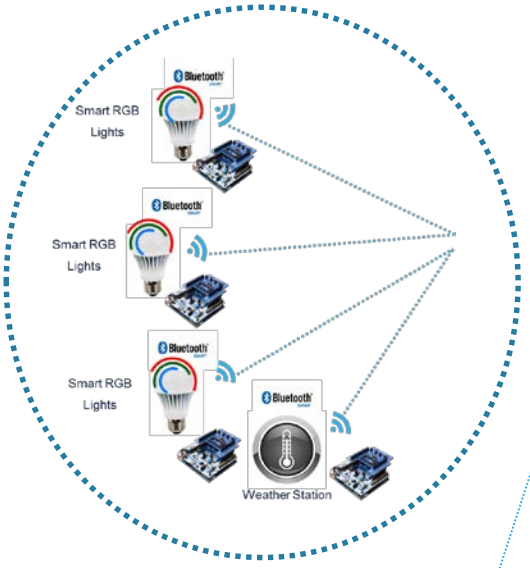
BlueNRG-MS *low-power BLE Sensor Node Network connected to the Cloud*



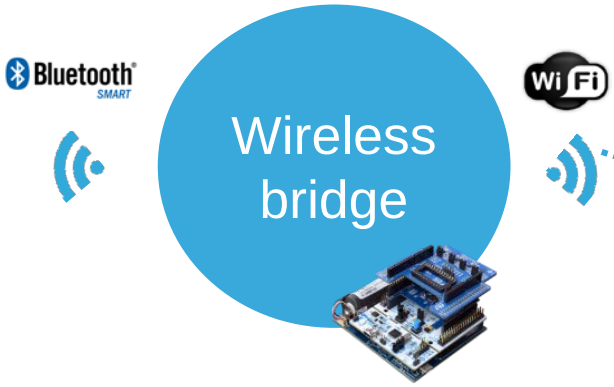
ST augmenting the Smart Home experience

***BlueNRG-MS** low-power BLE Sensor Node Network connected to the Cloud*

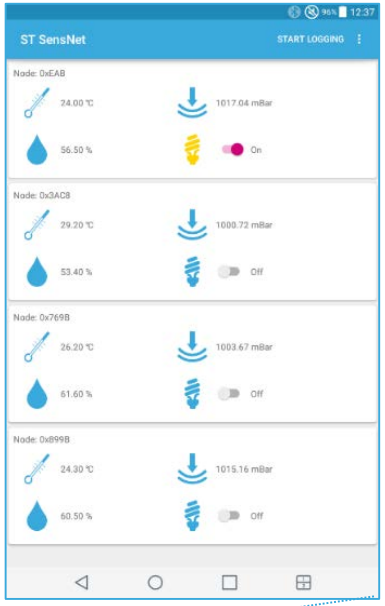
Smart Home Network



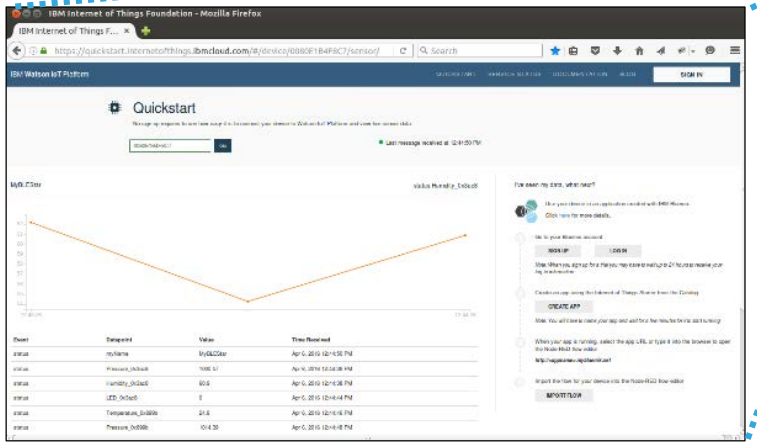
Bluetooth Smart to Wi-Fi bridge



IBM Bluemix™



BLE Controller

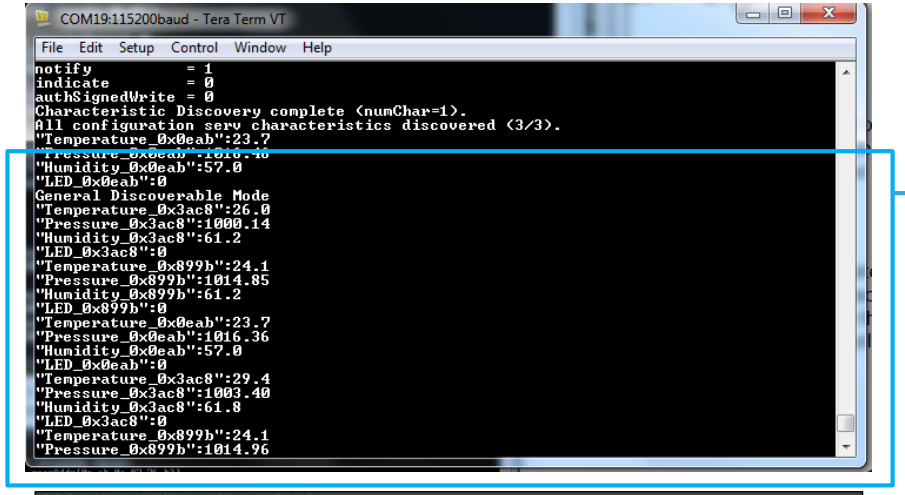


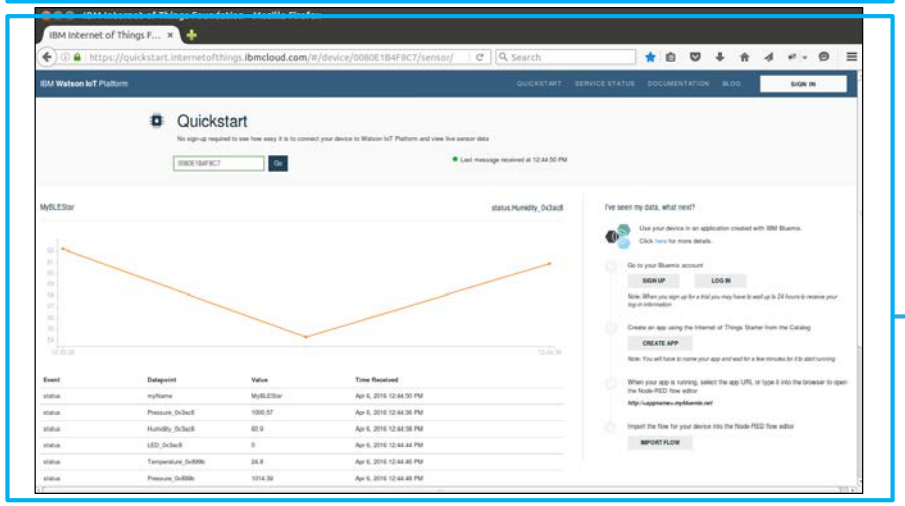
Cloud connected Remote Controller

life.augmented

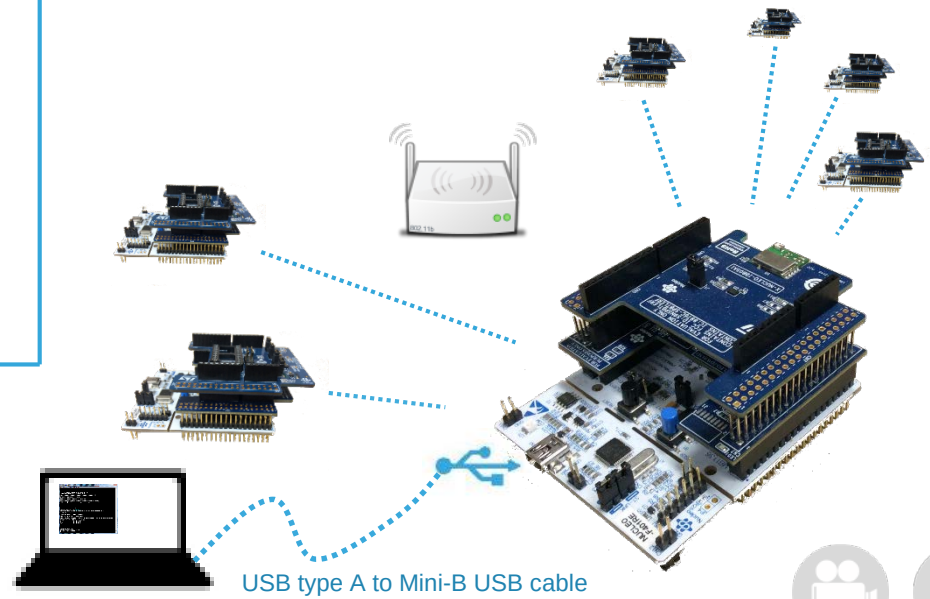
FP-NET-BLESTAR1
IBM Cloud Platform

FP-NET-BLESTAR1 for NUCLEO-F401RE





- Once all BLE Services and Characteristics are discovered, the STM32 Nucleo starts receiving sensor data from peripheral nodes.
- Data received by the STM32 Nucleo from peripheral nodes are sent to the IBM Cloud Platform and can be remotely controlled by means of a cloud connected client at the URL shown during the Wi-Fi initialization phase on the serial console.



USB type A to Mini-B USB cable

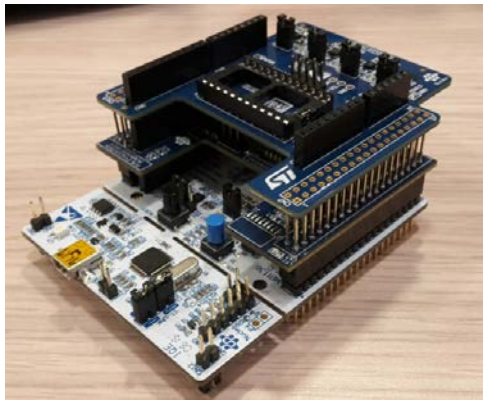
life.augmented

Wi-Fi IDW01M1- IBM Cloud vertical

End-to-end application to transmit sensors data to a cloud service based on IBM Bluemix, visualize them on a web page and receive commands back to Nucleo

TLS

MQTT



X-Nucleo-ICS01A1

X-NUCLEO-IDW01M1

Nucleo F4/L0

MQTT

IBM Bluemix™

Telemetry, data visualization, alerts, rules etc.

MQTT library running on Nucleo + TLS

Cube based

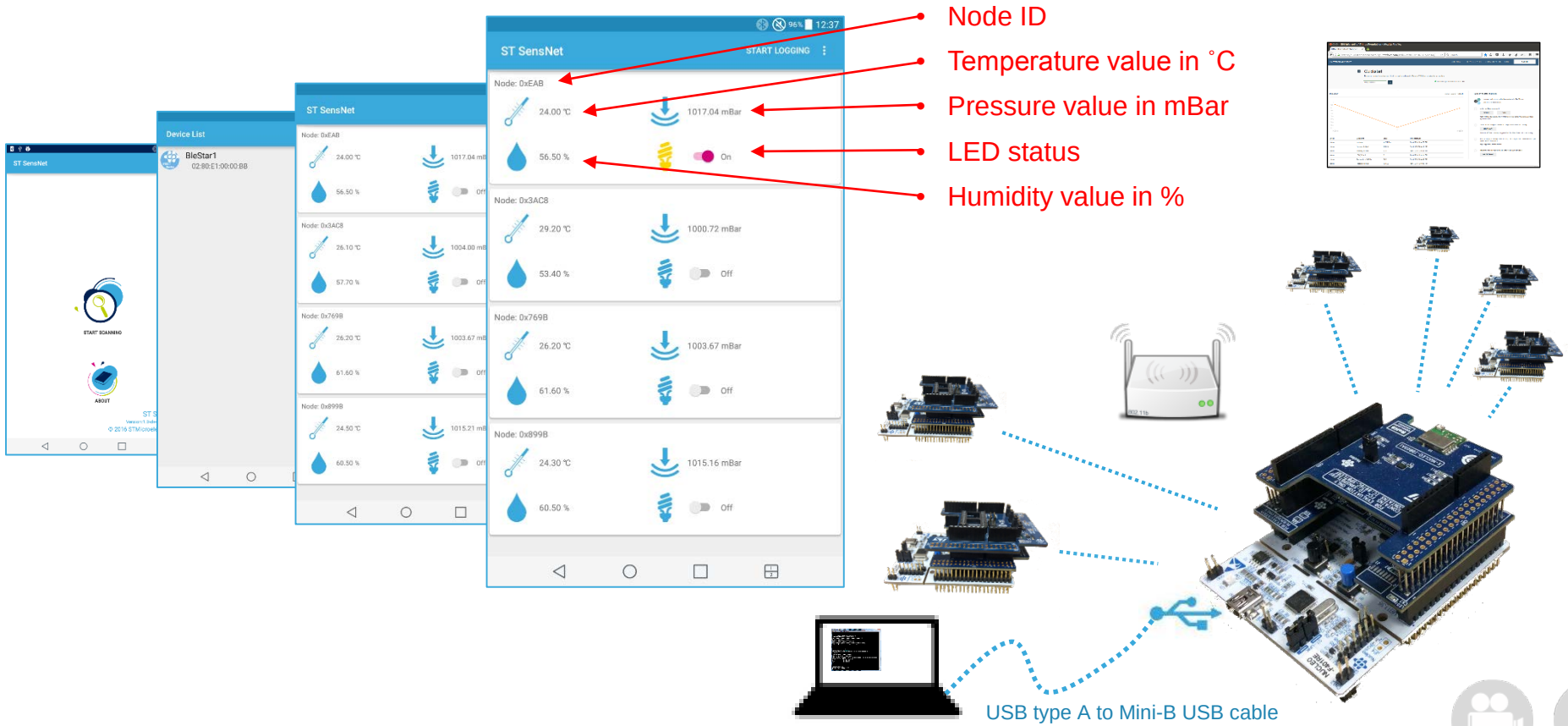
Nucleo + Wi-Fi + Sensor board

life.augmented

FP-NET-BLESTAR1

STSensNet app for Android/iOS

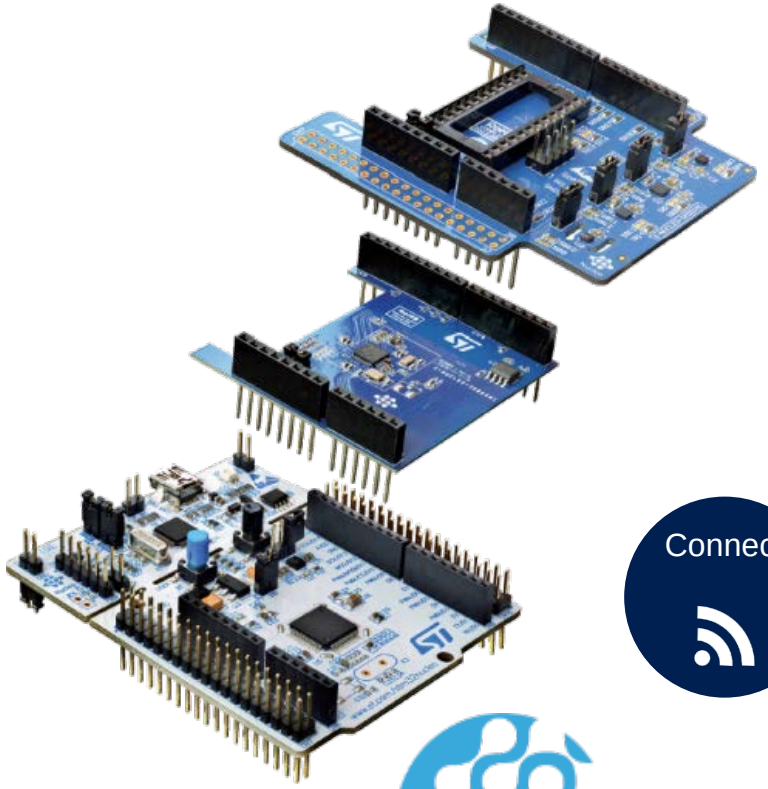
- After starting to receive data from peripheral nodes, the STM32 Nucleo, acting simultaneously as BLE Master and Slave, is able to accept connection from a BLE client (an Android/iOS device).
- After downloading and installing the STSensNet app available both on the Google Store and on the Apple Store, the Android/iOS device can be used to locally monitor and control the BLE network.



life.augmented

BlueNRG Sensor Node

BlueNRG-MS** low-power BLE connectivity with **LED Driver



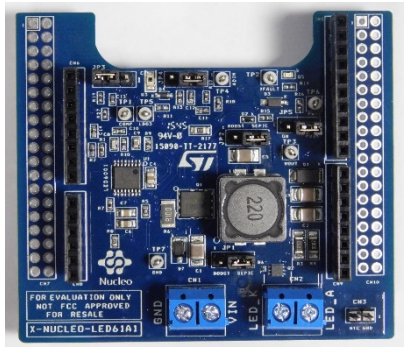
Motion sensor
Environmental sensor

Sense

Connect

Bluetooth® SMART

STM32 Nucleo



LED Driver

BlueNRG-MS

Bluetooth 4.1 **Bluetooth Smart** network processor:

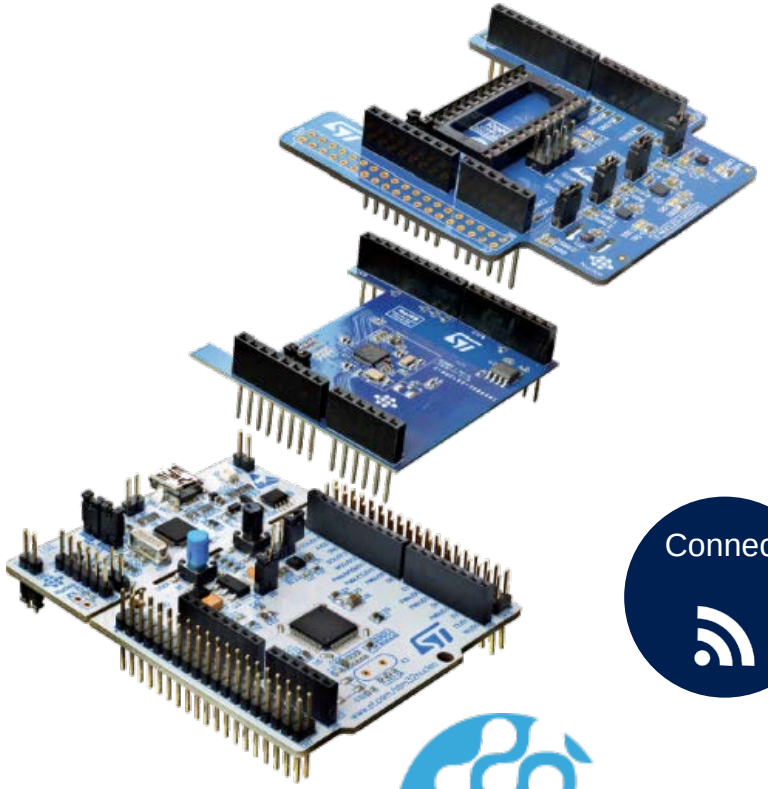
Key features

- **Embedded BLE stack**
- **supply voltage**: from 1.7 to 3.6 V
- **TX current**: 8.2 mA (@0 dBm, 3.0 V)
- **Sleep current:** Down to 1.7 µA (with active BLE stack)
- **Output Power:** Up to +8 dBm
- Excellent RF link budget (up to 96 dB)
- Accurate RSSI to allow power control
- Full link controller and host security
- 32-bit based architecture core
- On-chip non-volatile Flash memory
- AES security co-processor
- Low power modes

life.augmented

BlueNRG Sensor Node

BlueNRG-MS** low-power BLE connectivity with **LED Driver



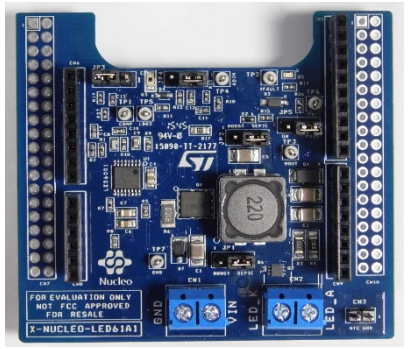
Motion sensor
Environmental sensor

Sense

Connect

Bluetooth® SMART

STM32 Nucleo



LED Driver

Sensors

X-NUCLEO-IKS01A1: motion MEMS and environmental sensor evaluation board system

Key features

- All sensor sensors are connected on a single I²C bus
- Sensor I²C address selection
- Each sensor has separate power supply lines allowing power consumption measurement
- Sensor disconnection (disconnect the I²C bus as well as the power supply)
- Interrupt and DRDY signals from sensors
- DIL24 socket (Compatible to STEVAL-MKI***V* MEMS adapter boards, i.e. STEVAL-MKI160V1)

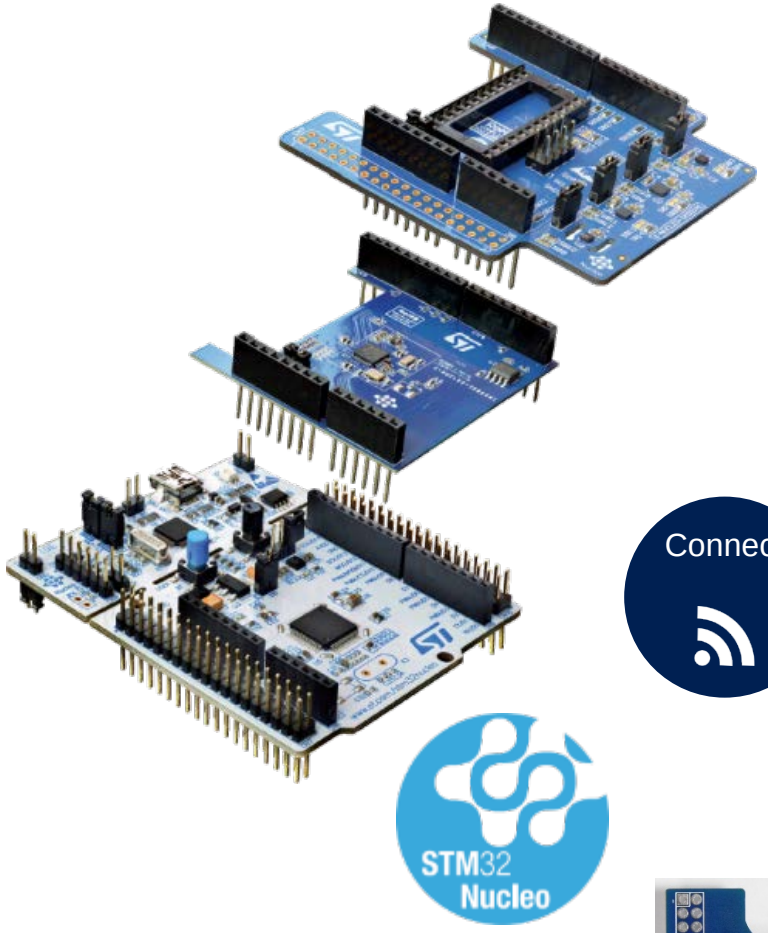
Key Product on board

- **LSM6DS0:** MEMS 3D accelerometer
- **LIS3MDL:** MEMS 3D magnetometer
- **LPS25HB:** MEMS pressure sensor
- **HTS221:** humidity and temperature

life.augmented

BlueNRG Sensor Node

BlueNRG-MS** low-power BLE connectivity with **LED Driver

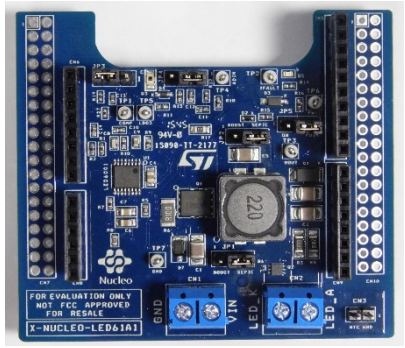


Motion sensor
Environmental sensor

Sense

Connect

Bluetooth® SMART



LED Driver

LED6001

PWM dimmable single channel LED driver with integrated boost controller

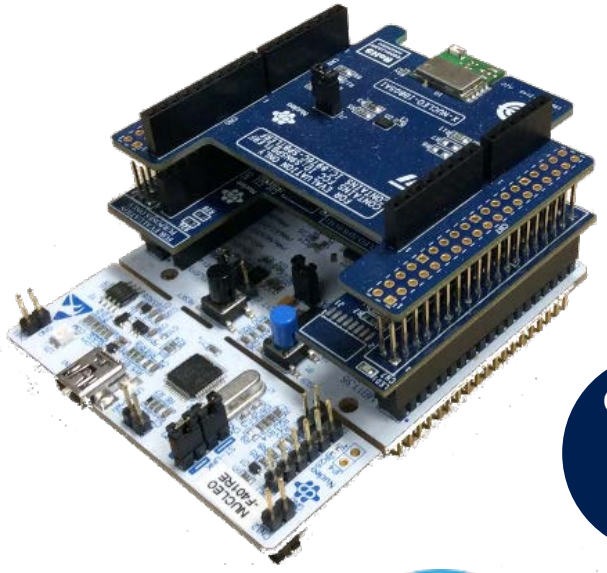
Key features

- Main Features
- Wide DC input voltage range: 8 V – 24 V
- Single channel LED Driver, 350 mA constant current
- PWM and analog brightness control with the STM32 Nucleo board
- Selectable boost or SEPIC converter topology
- Up to 92% efficiency (boost converter)
- Compatible with Arduino™ UNO R3 connectors
- Compatible with STM32 Nucleo boards

life.augmented

Bluetooth Smart to WiFi Gateway

***BlueNRG-MS** low-power BLE and **SPWF01S** Wi-Fi module*



Connect

Wi Fi

Connect

Bluetooth SMART

STM32 Nucleo

SPWF01S

Wi-Fi Module

Key features

- High efficiency Antenna on board and FCC, IC, CE certified
- ST low-power Wi-Fi bgn certified SoC
- Complete software IP stack making the module “cloud compatible”
- TLS and SSL to ensure end-to-end security
- REST API (HTTP Get and Post)
- Can operate as socket server and socket client
- WEB Server functionality
- Operates as a client STA, or miniAP; as a miniAP, the module features a very simple method to transfer SSID and PWD
- FW update Over The Air (FOTA)

life.augmented