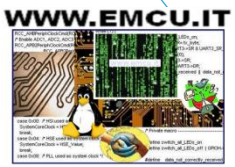
WAN Technologies and Connectivity Solutions

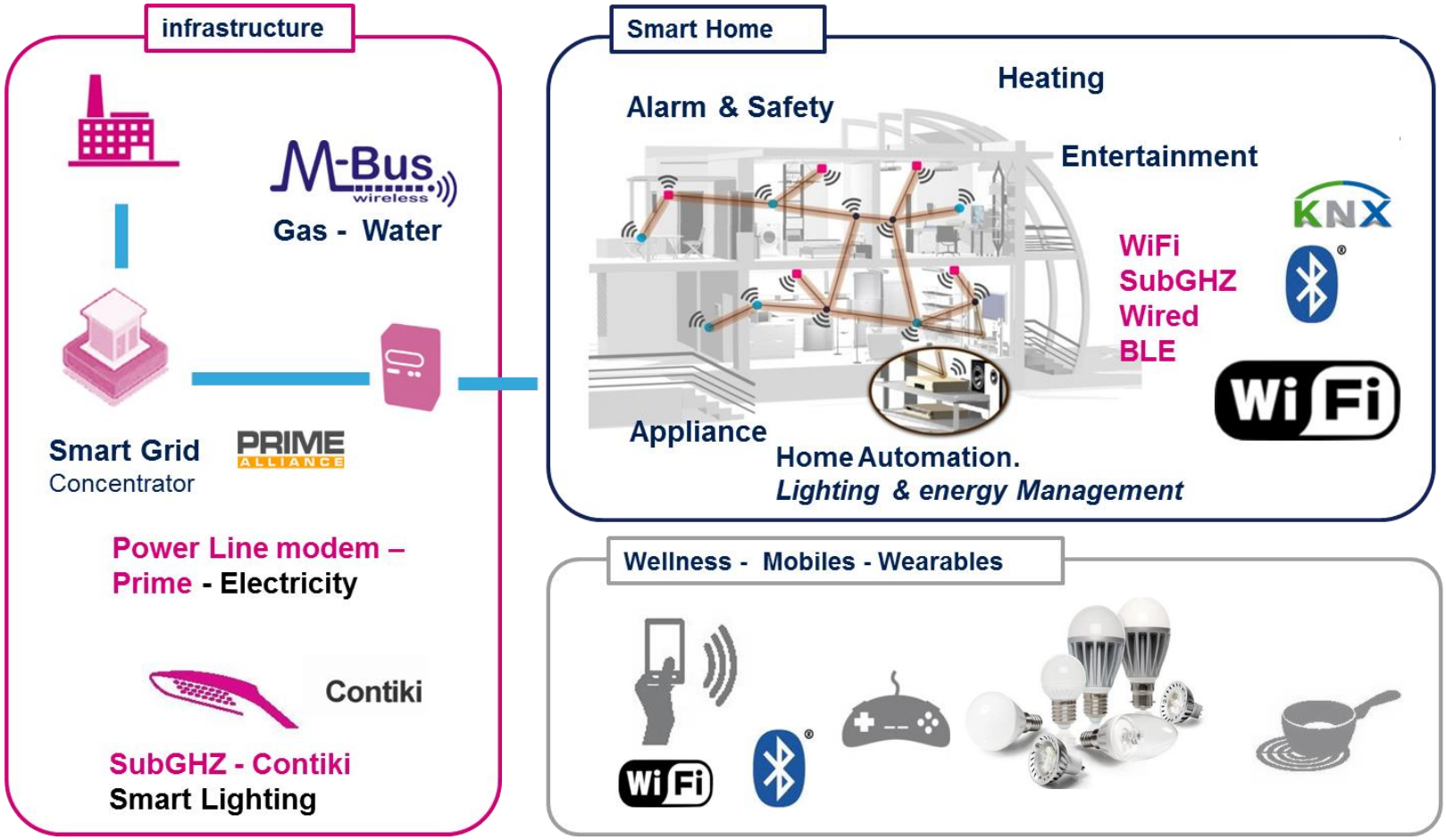
life.augmented

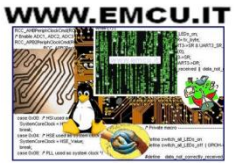


AVNET Memec

SILICA An Avnet Company

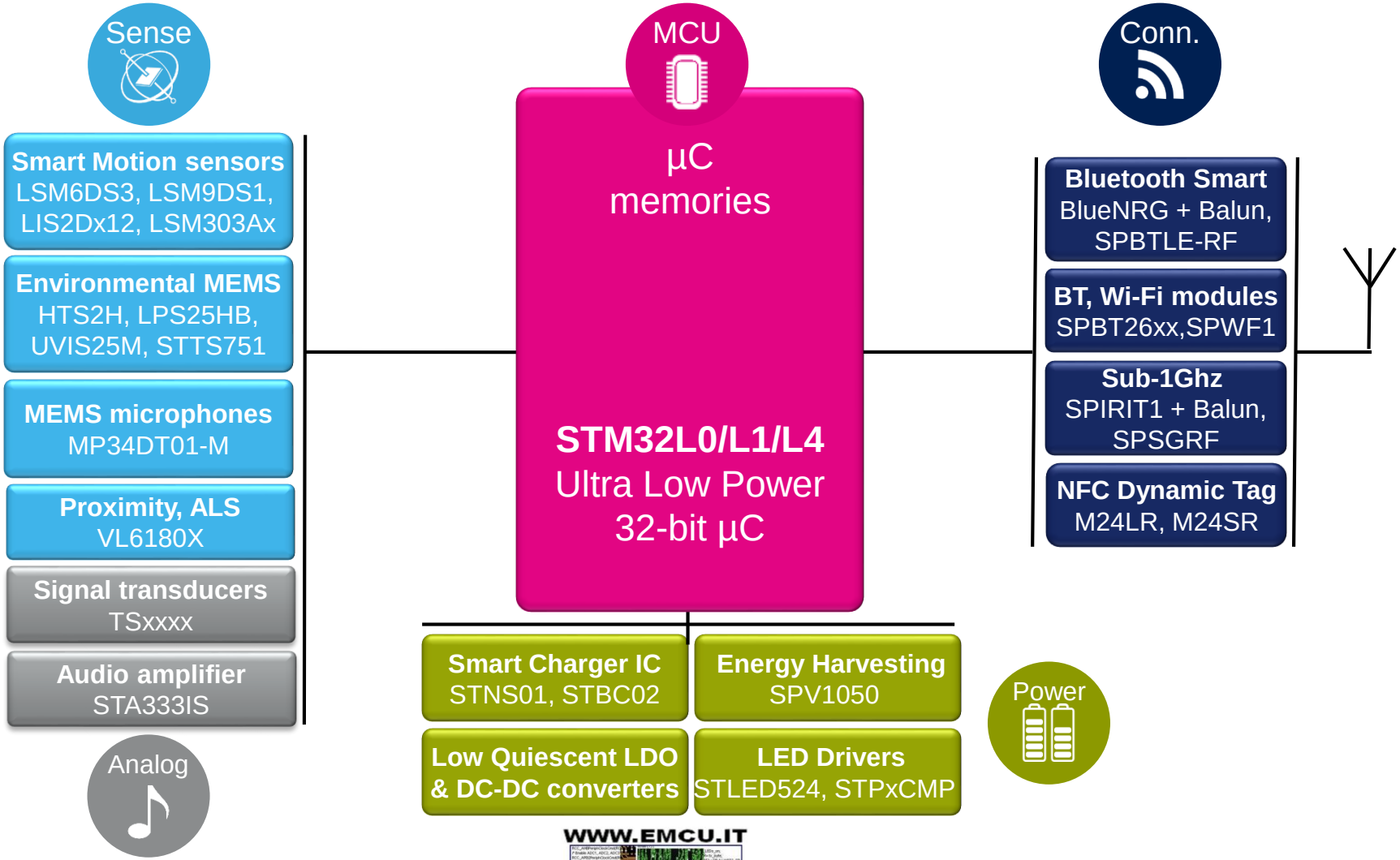
Connectivity at different levels



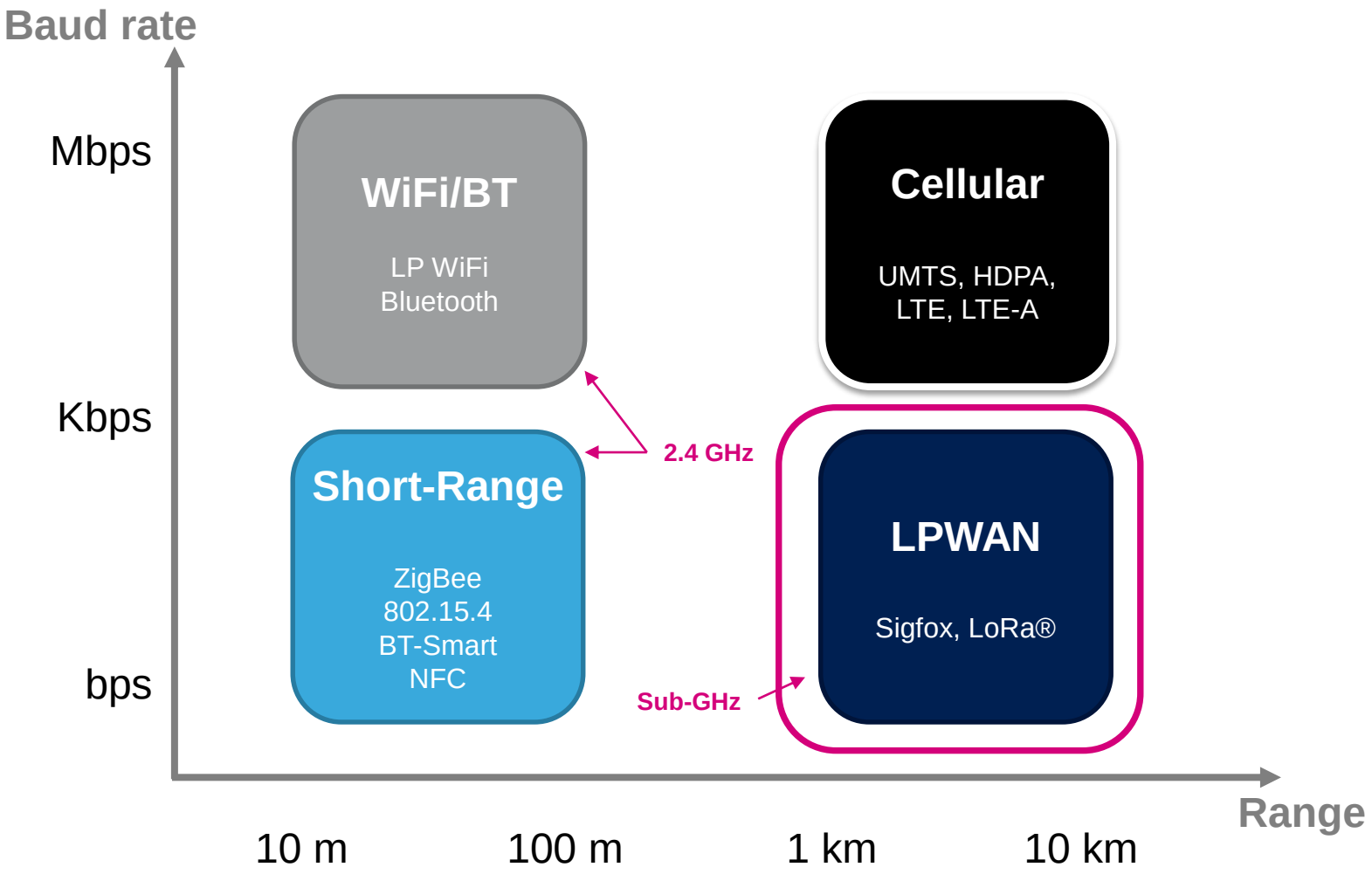


Wireless Sensor Node Block Diagram

Modular WSN solution



Communication Technologies - Overview



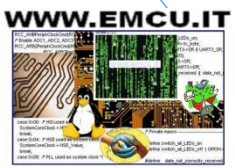
Challenges of LoWPAN

Impact Analysis	Addressing	Routing	Security	Network management
Low power (1-2 years lifetime on batteries)	Storage limitations, low overhead	Periodic sleep aware routing, low overhead	Simplicity (CPU usage), low overhead	Periodic sleep aware management, low overhead
Low cost (<$10/unit)	Stateless address generation	Small or no routing tables	Ease of Use, simple bootstrapping	Space constraints
Low bandwidth (<300kbps)	Compressed addresses	Low routing overhead	Low packet overhead	Low network overhead
High density (<2-4? units/sq ft)	Large address space – IPv6	Scalable and routable to *a node*	Robust	Easy to use and scalable
IP network interaction	Address routable from IP world	Seamless IP routing	Work end to end from IP network	Compatible with SNMP, etc

BlueNRG-MESH

ST/MSI BLE MESH Networking

life.augmented



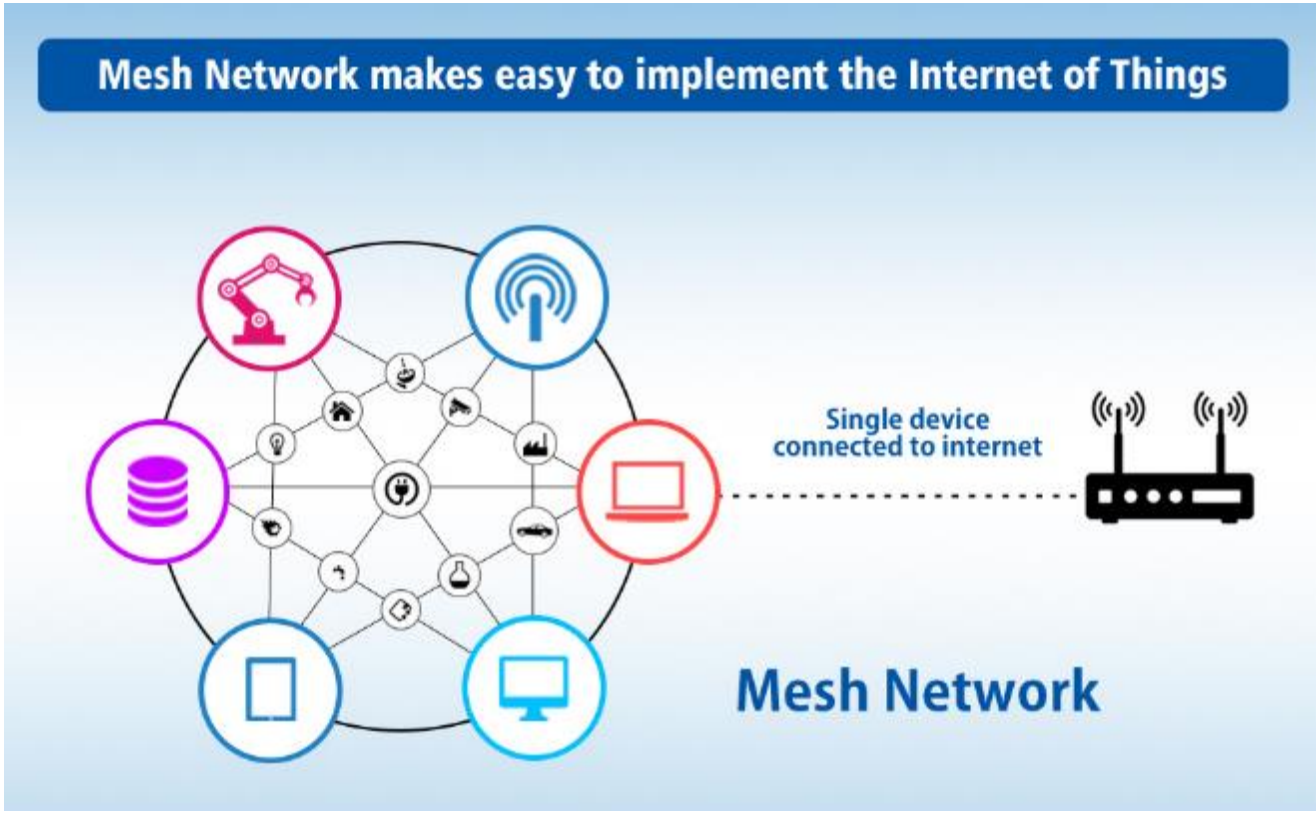
AVNET Memec

SILICA An Avnet Company

Bluetooth Networking

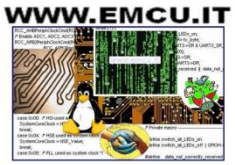
Bridging sensors to the Cloud

Bluetooth®
SPECIAL INTEREST GROUP



Powered by MOTOROLA

SDK public release: e/o **Q1'16**



life.augmented

AVNET Memec

SILICA An Avnet Company

BlueNRG-MESH - Bluetooth Networking

Rapid development kit - OpenSoftwareX

BlueNRG-MESH

OpenSoftwareX

BlueNRG-MESH SDK available as an **open.RF** package

STM32 + **BTLE** bundle package

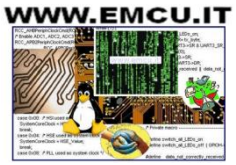
Triple phase deployment:

1. ST internal SDK availability: now
2. Alpha customers: now
3. Open market release: e/o Q1’16

MM Release e/o **Q1’16**

Announced @ **CES’16**

life.augmented



AVNET Memec

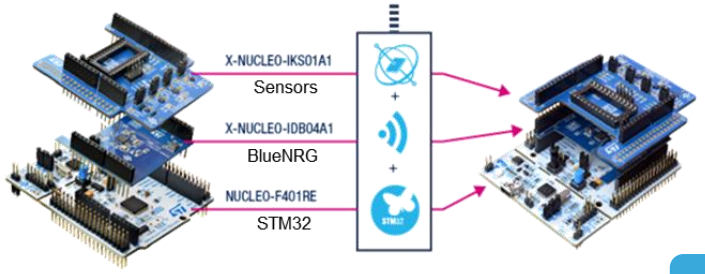
SILICA An Avnet Company

BlueNRG-MESH

STMicroelectronics and Motorola Solutions

__BlueNRG-MS__ low-power BLE connectivity with __MoBLE__ Mesh network capability

life.augmented



BlueNRG-MS

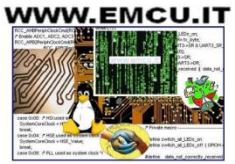
Bluetooth 4.1 **Bluetooth Smart** network processor:

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



MoBLE

Mesh over Bluetooth Low Energy stack

- Control oriented mesh network
- Fast commands transmission
- Small-sized data operation

Key features

- Runs on top of Bluetooth Low Energy
- Low power consumption
- Multi-hop data routing
- Optimized data path selection
- Flexible configuration mechanism
- Cross-platform, highly portable solution for Mesh applications
- Native C API for embedded
- Java API for mobile devices
- Small footprint

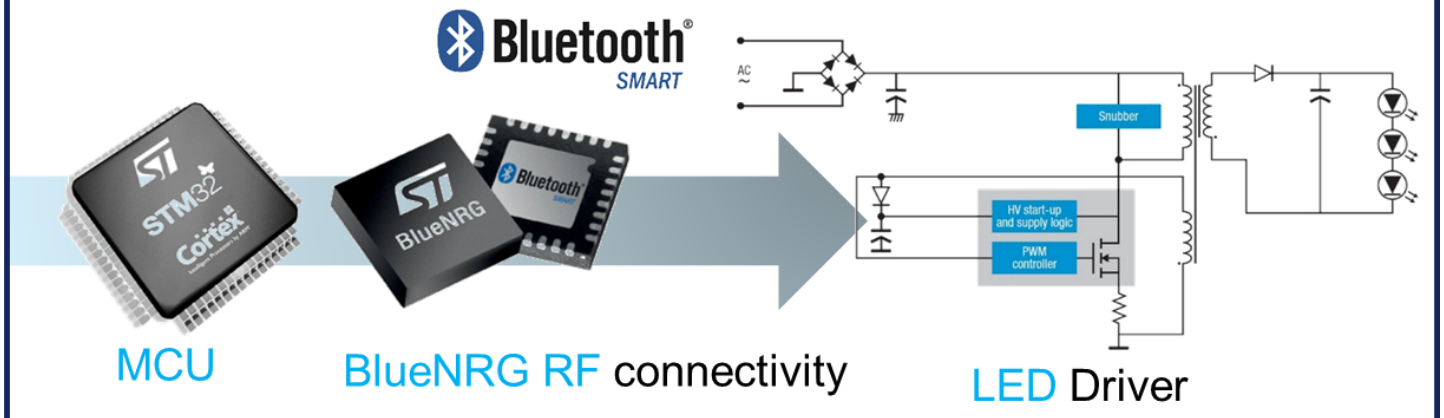
life.augmented

AVNET Memec

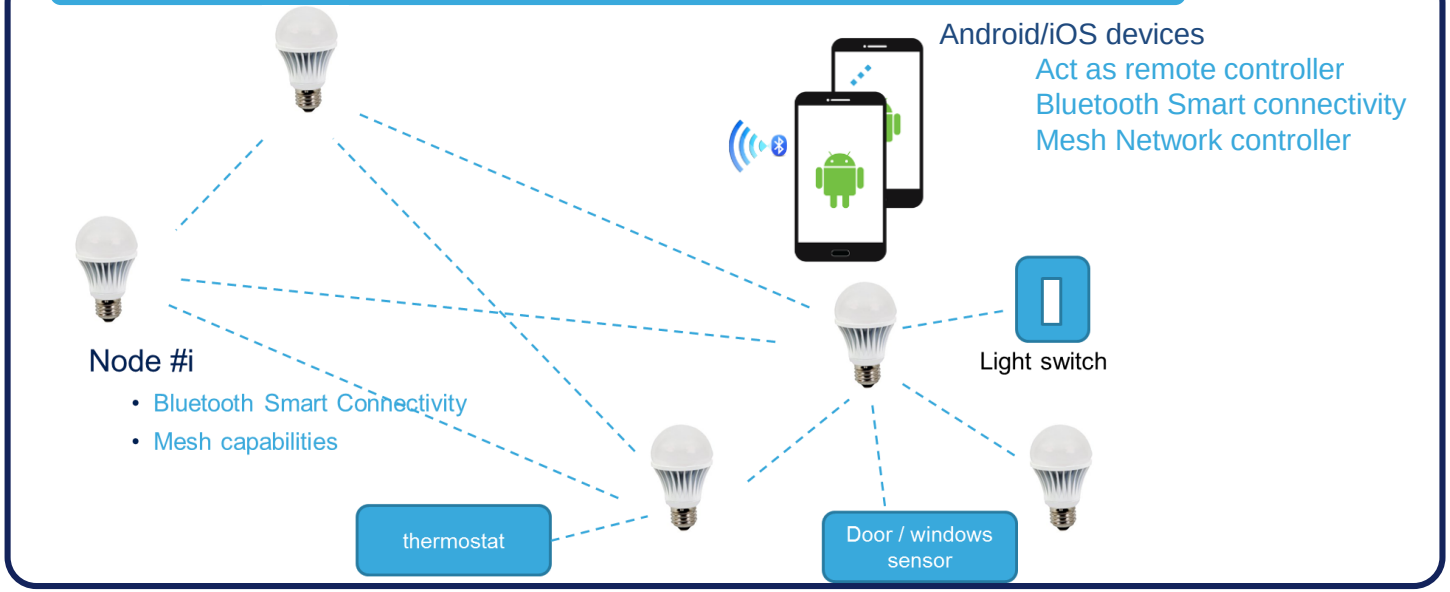
SILICA An Avnet Company

BlueNRG-MESH Scenario

BlueMesh Light Bulb Architecture



BlueMesh Light Bulbs Demo



life.augmented

life.augmented

AVNET Memec

SILICA An Avnet Company

Sub-GHZ Solutions

life.augmented

WWW.EMCU.IT

AVNET Memec

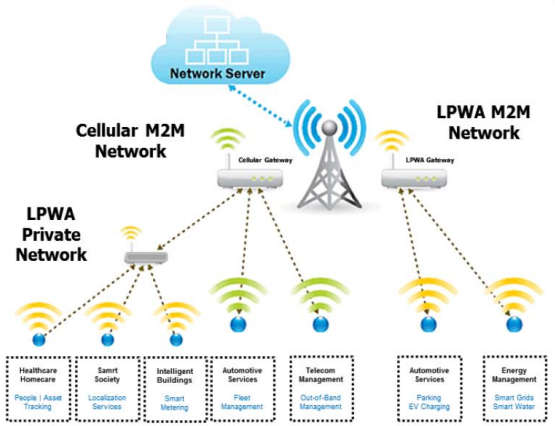
SILICA An Avnet Company

LPWA: Low Power Wide Area

Wide area network for M2M & IoT

Low power & Long range

- Ultra low power tailored for battery powered devices
- Optimized for long range RF propagation
- Cheaper subscription cost than Cellular network



Private Network

LoRa™ Alliance
Wide Area Networks for IoT

Multiple private networks

(Veolia, Areva, La Poste, ...)

4 pilots with Telcos

(Orange, Bouygues, Senet (US), The Lace cpy (Ru))

Public Network

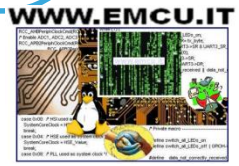
SIGFOX
One network A billion dreams

10 countries already deployed

(France, UK, Spain, Italy, ...)

20 countries in progress

50 Countries within 5 years



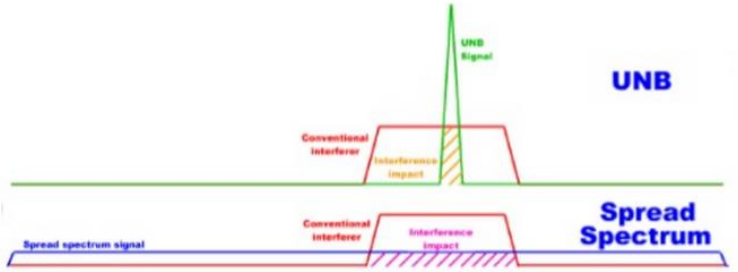
life.augmented

AVNET Memec

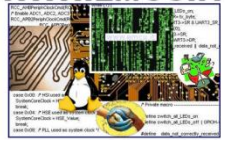
SILICA An Avnet Company

Sigfox and LoRa® - Overview

- A different approach:
  - Ultra Narrow Band (UNB) → SIGFOX One network A billion dreams
  - Spread Spectrum (SS) → LoRa™



	Sigfox	LoRa®
Modulation	UNB	DSS-like
Throughput	100bps	300bps to 50Kbps
Payload	12bytes	64bytes
Link Adaptation	No (BPSK)	VSF (SF7-Sf12)
BW	100Hz	125KHz
DutyCycle Limited	Yes	Yes
Channel Hopping	Yes	Yes
Best Sensitivity (dBm)	-142	-142
Bi-Directional	No (1)	Yes
Battery Life	10years	10Years
Localization	No	Yes (30m)
Encryption	AES-128	AES-128
SDR	Yes	N/A
Benefits	Robustness to RF coexistence Multi Radio vendor	2 to 3x longer Range Less sensitive to noise and environment Birectional
Drawbacks	Limited baud rate (->limited application) Limitation in the USA Not Bidirecrectional	Single radio provider High module cost $3+ Network needs to be deployed

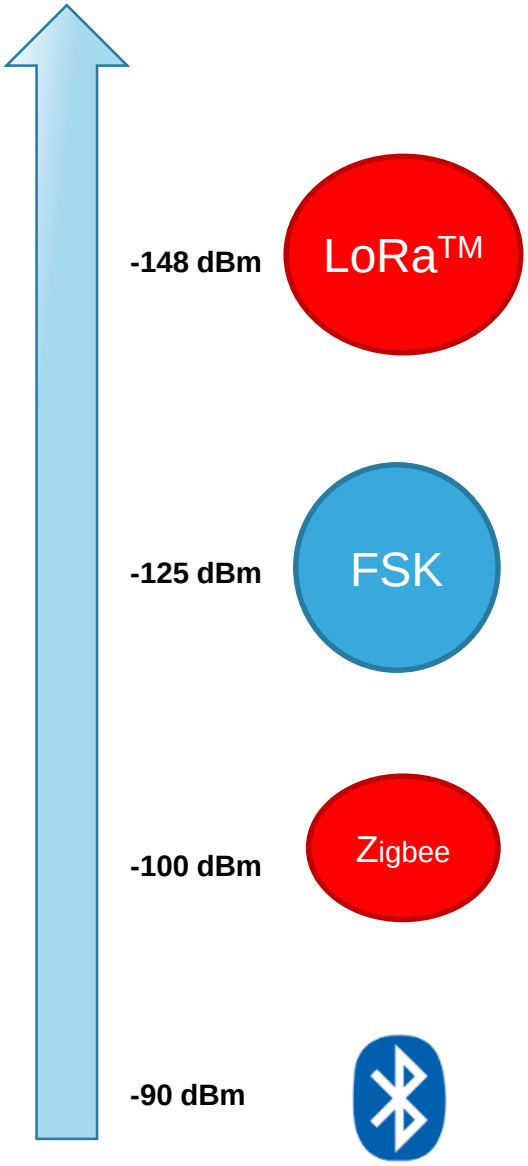


ST and Semtech LoRa® agreement

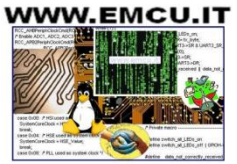
- Semtech Corporation and STMicroelectronics announce agreement on Semtech's Lora® long-range wireless RF technology
- Intends to boost STM32 MCUs with LoRa® technology to target internet of things deployments by mobile network operators and large-scale private networks

http://www.st.com/web/en/press/c2790

What is LoRa™?



- Long Range, Low Power & Small form factor
  At +14dBm output power, 868MHz
  - In Sub-GHz: > 2km dense urban, > 15km suburban, > km VLOS
  - More than 10 years in operation without changing battery
- Concentrator with Network Capacity & Security
  - Star Network / Link rate Adaptation / Fully Scalable Network
  - More than 4M transaction per day per GTW
- Fully bidirectional
  - Acknowledge / Request from user or from sensor
  - High Security Network Level
  - Easy Network Management
  - Fast Channel Activity
  - Allow broadcasting
- Robust Communication
  - Robust to interferer / coexistence with other ISM
  - Robust to Jamming
  - Suitable for Mobile, Nomadic & fixed nodes
  - Indoor / Outdoor coverage
- High accuracy localization and ranging
  - Modulation format permits high accuracy localization
  - Not RSSI based and accounts for multi-path and fading



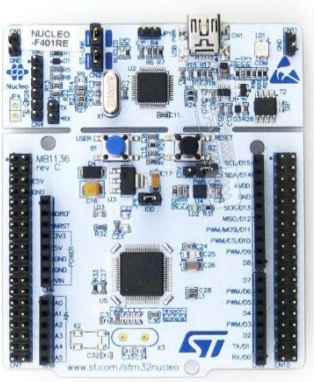
life.augmented

AVNET Memec

SILICA An Avnet Company

Let's get started!

- HW Tools are already available



STM32 Nucleo

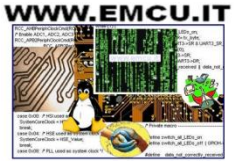
Semtech LoRa Shield

- Enjoy a quick plug'n play example (point-to-point demo) on ARM mbed

SX1276MB1xAS

The SX1276MB1MAS and SX1276LB1LAS are both fitted with the SX1276 transceiver which, added to a high-performance FSK / OOK RF transceiver modem, features the LoRa™ long range modem.

Hello World



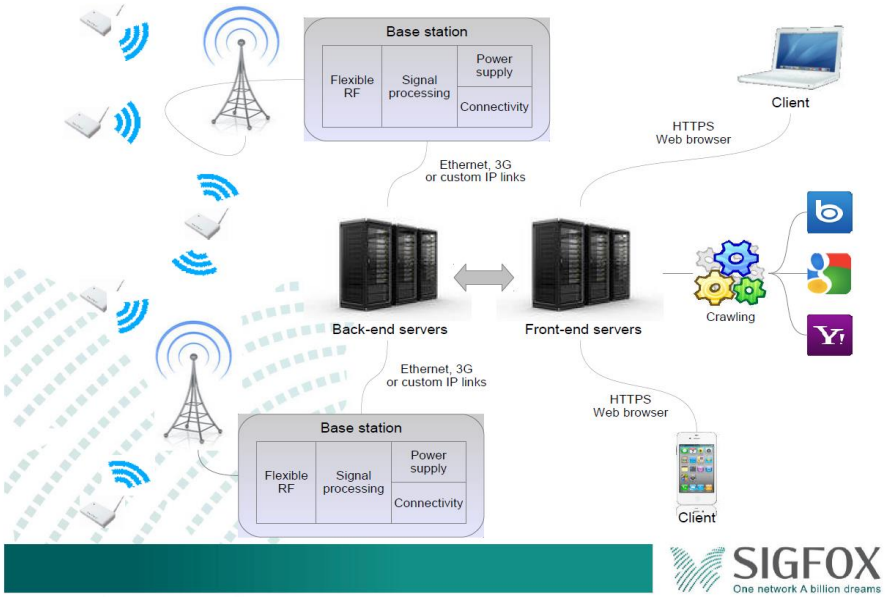
life.augmented

AVNET Memec

SILICA An Avnet Company

SIGFOX basic concept

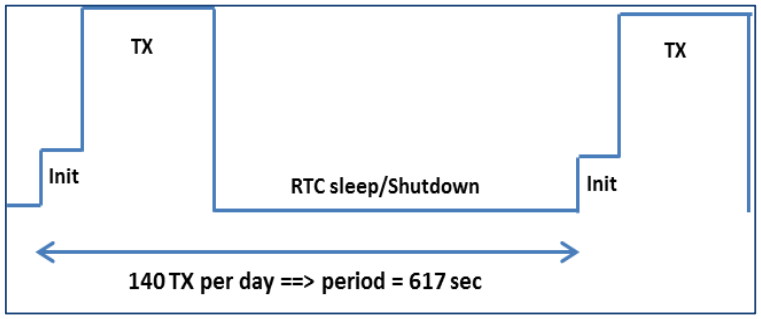
- SIGFOX long-range low-throughput wireless network solution is based on ultra-narrow band (UNB) radio technology. The use of UNB is key to providing a scalable, high-capacity network, with very low energy consumption, while maintaining a simple and easy to rollout star-based cell infrastructure.
- The network operates in the globally available ISM bands (license-free frequency bands). SIGFOX currently uses the most popular European ISM band on 868MHz (as defined by ETSI and CEPT) as well as the 902MHz in the USA (as defined by the FCC).



SIGFOX
One network A billion dreams

SPIRIT2 for SigFox

Sensor in transmit mode

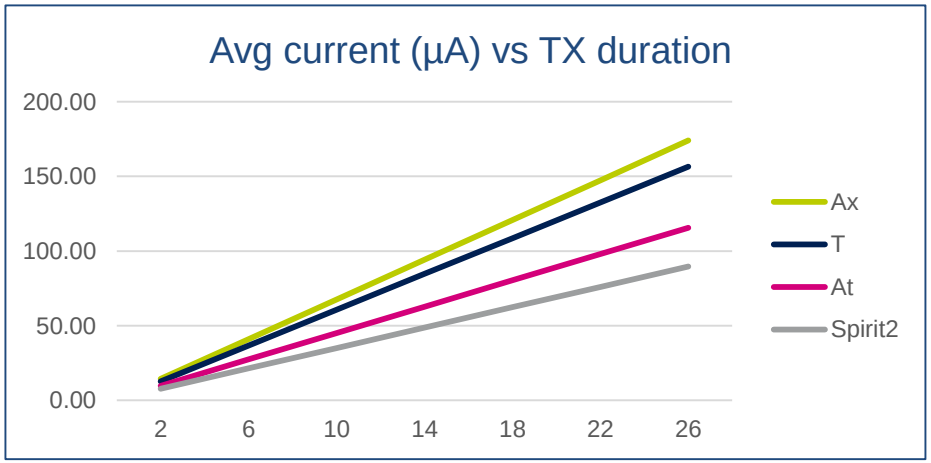


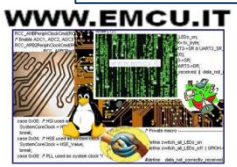
SigFox: Key parameters

- 140 messages transmitted every day (1 message every ~10,3 min)
- Frame length from 2 up to 26 bytes @ 100 bps
- External MCU needed to wake-up radio after shutdown periods
  - When no TX: RF chipset in shutdown mode & MCU in RTC mode
  - When TX : MCU & RF ON, (SPI @ 8MHz)

System average current in µA (Spirit2 vs. competition)

TX bytes	Spirit2	At	T	Ax
2	7,82	9,82	12,83	14,35
6	21,46	27,45	36,76	40,95
10	35,10	45,08	60,68	67,55
14	48,73	62,71	84,61	94,15
18	62,37	80,34	108,54	120,75
22	76,01	97,97	132,47	147,35
26	89,64	115,60	156,40	173,95



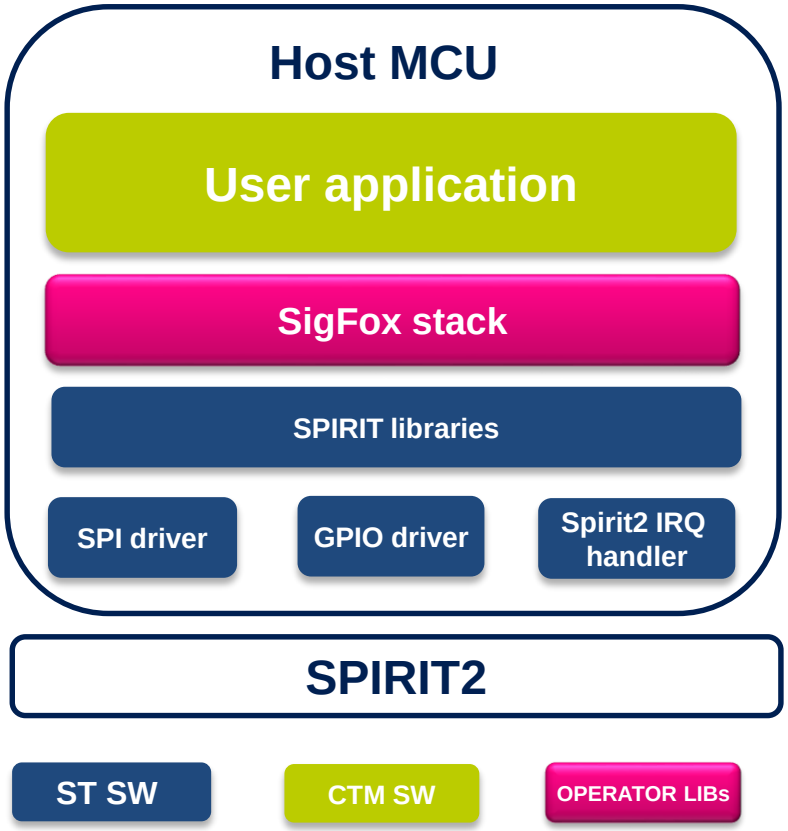


life.augmented

AVNET Memec

SILICA An Avnet Company

SPIRIT2 for SigFox



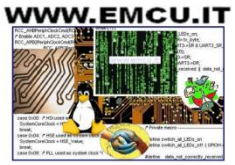
SigFox

- S2-LP is SigFox compliant
- ST to certify solution with STM32L1
  - Hosting SigFox stack
  - Target schedule: end of Q2

Wireless links

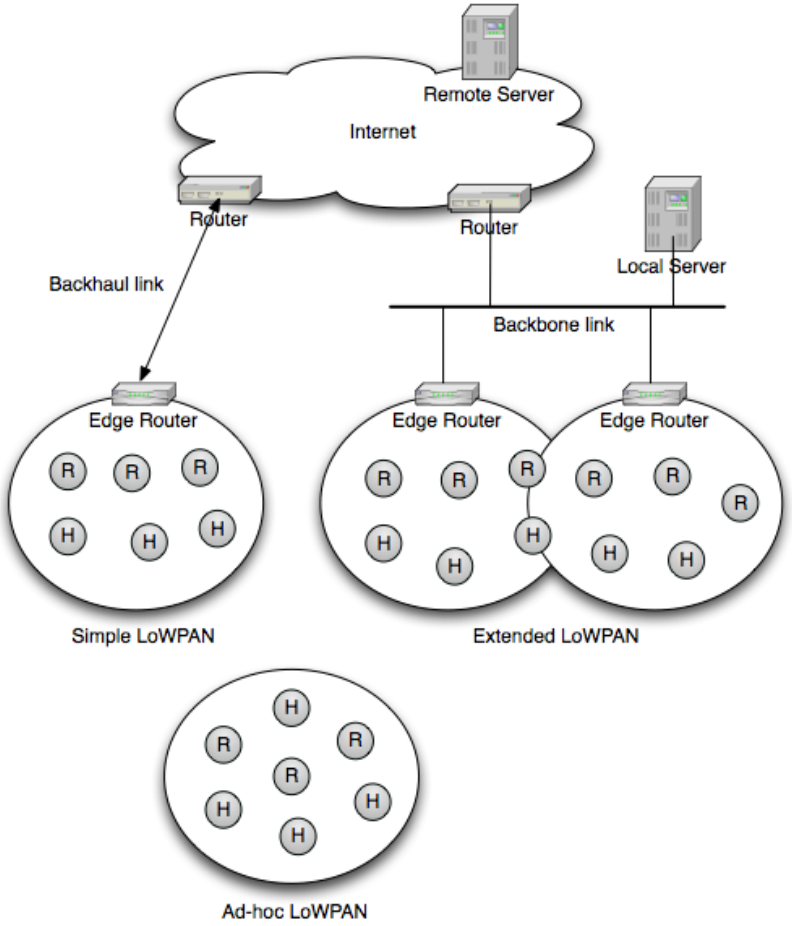
IEEE

	802.15.4	802.15.1	802.15.3	802.11	802.3
Class	**WPAN**	**WPAN**	**WPAN**	**WLAN**	**LAN**
Lifetime (days)	**100-1000+**	**1-7**	**Powered**	**0.1-5**	**Powered**
Net Size	**65535**	**7**	**243**	**30**	**1024**
BW (kbps)	**20-250**	**720**	**11,000+**	**11,000+**	**100,000+**
Range (m)	**1-75+**	**1-10+**	**10**	**1-100**	**185 (wired)**
Goals	**Low Power, Large Scale, Low Cost**	**Cable Replacement**	**Cable Replacement**	**Throughput**	**Throughput**

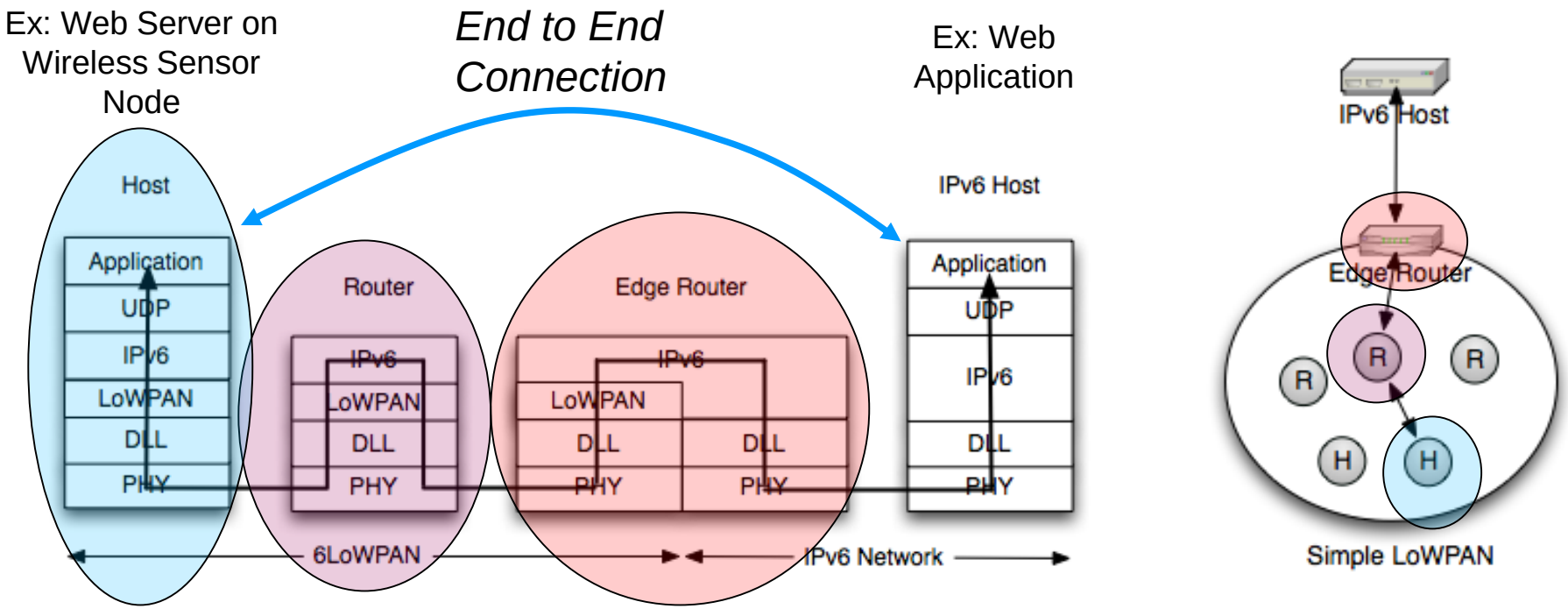


6LoWPAN Features

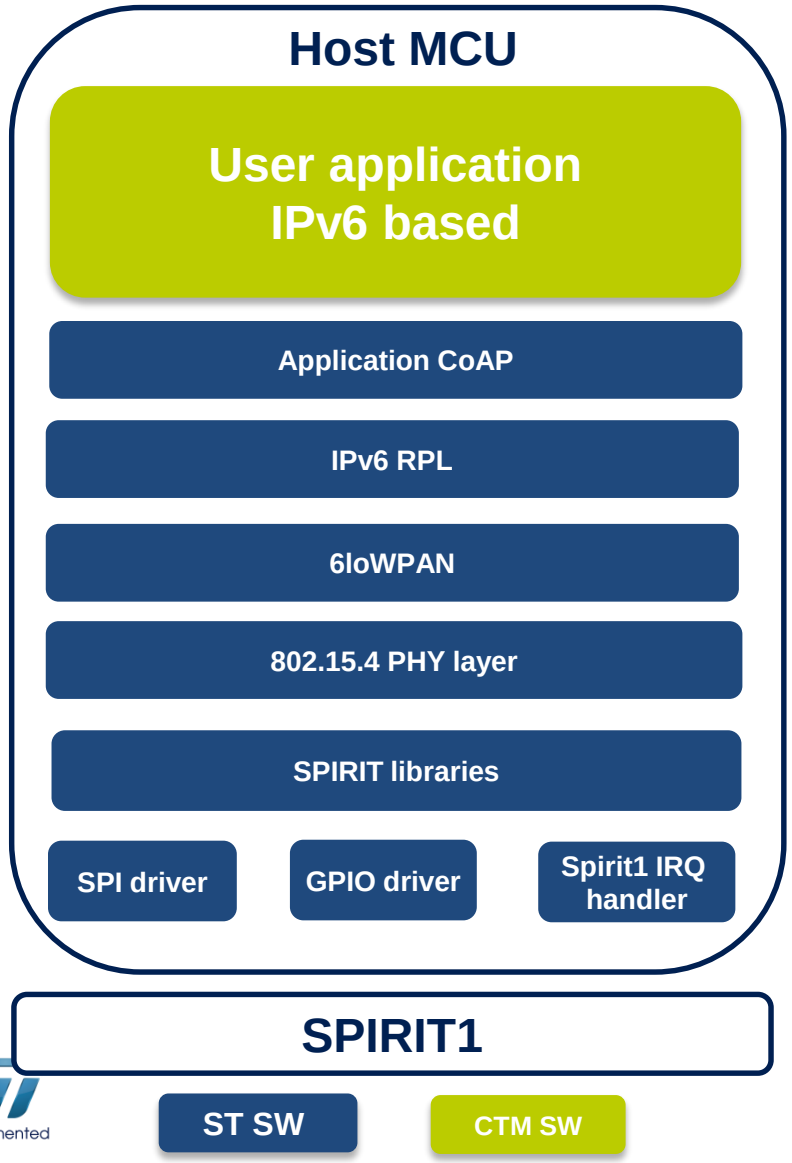
- Support for e.g. 64-bit and 16-bit 802.15.4 addressing
- Useful with low-power link layers such as IEEE 802.15.4, narrowband ISM and power-line communications
- Efficient header compression
- Network auto-configuration using neighbour discovery
- Unicast, multicast and broadcast support
- Fragmentation
- Support for IP routing (using the IETF RPL standards)



6LowPAN – Enabling End-to-end Connectivity

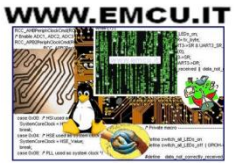


SPIRIT Libraries: 6LoWPAN Contiki OS

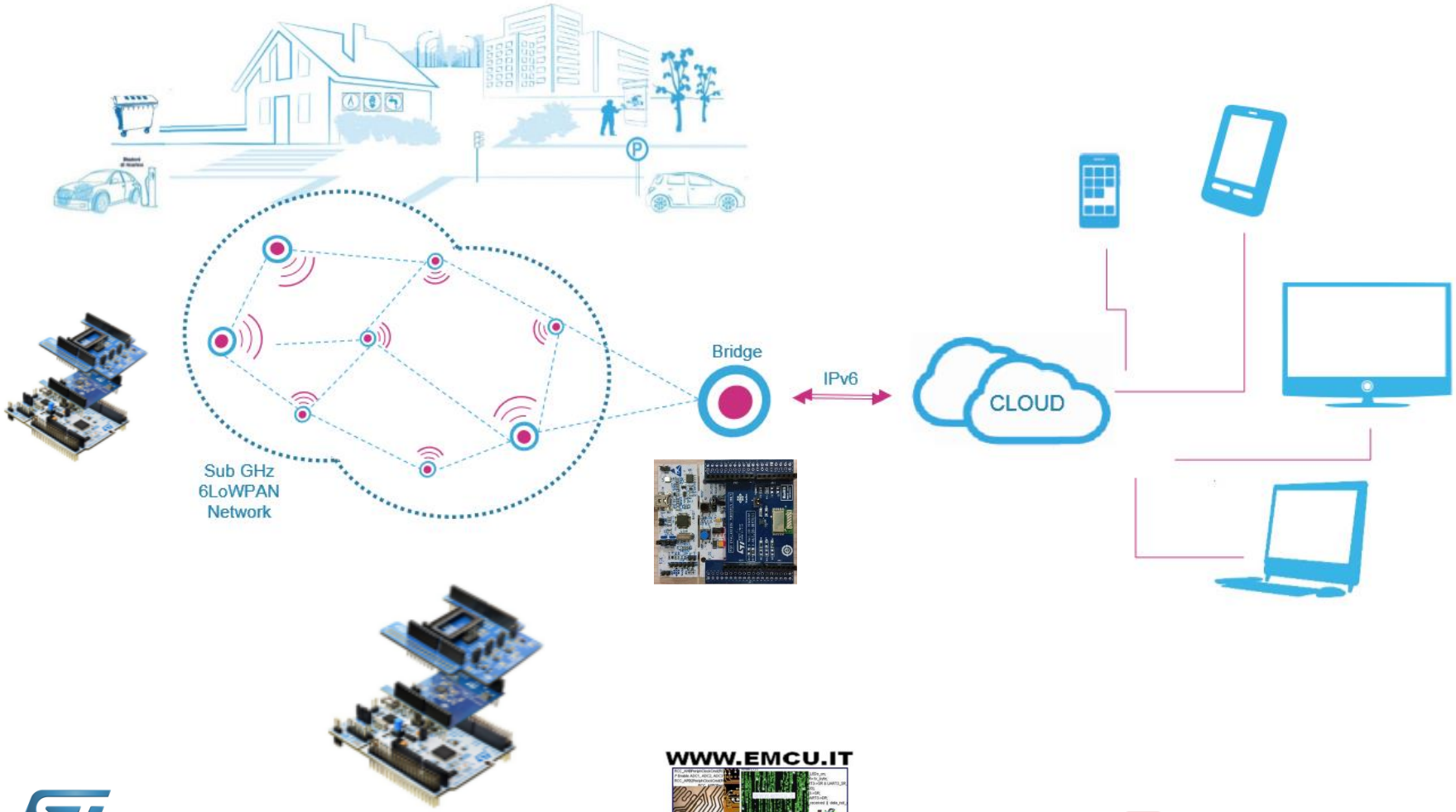


ST 6LoWPAN Package

- ST offering based on **Contiki 3.0 OS**
- ST package available with 2 configurations:
  - Sensor nodes
  - Border router
- Up to 20 supported nodes (RAM limitation on border router)
- X-NUCLEO-IKS01A1 used for sensor nodes

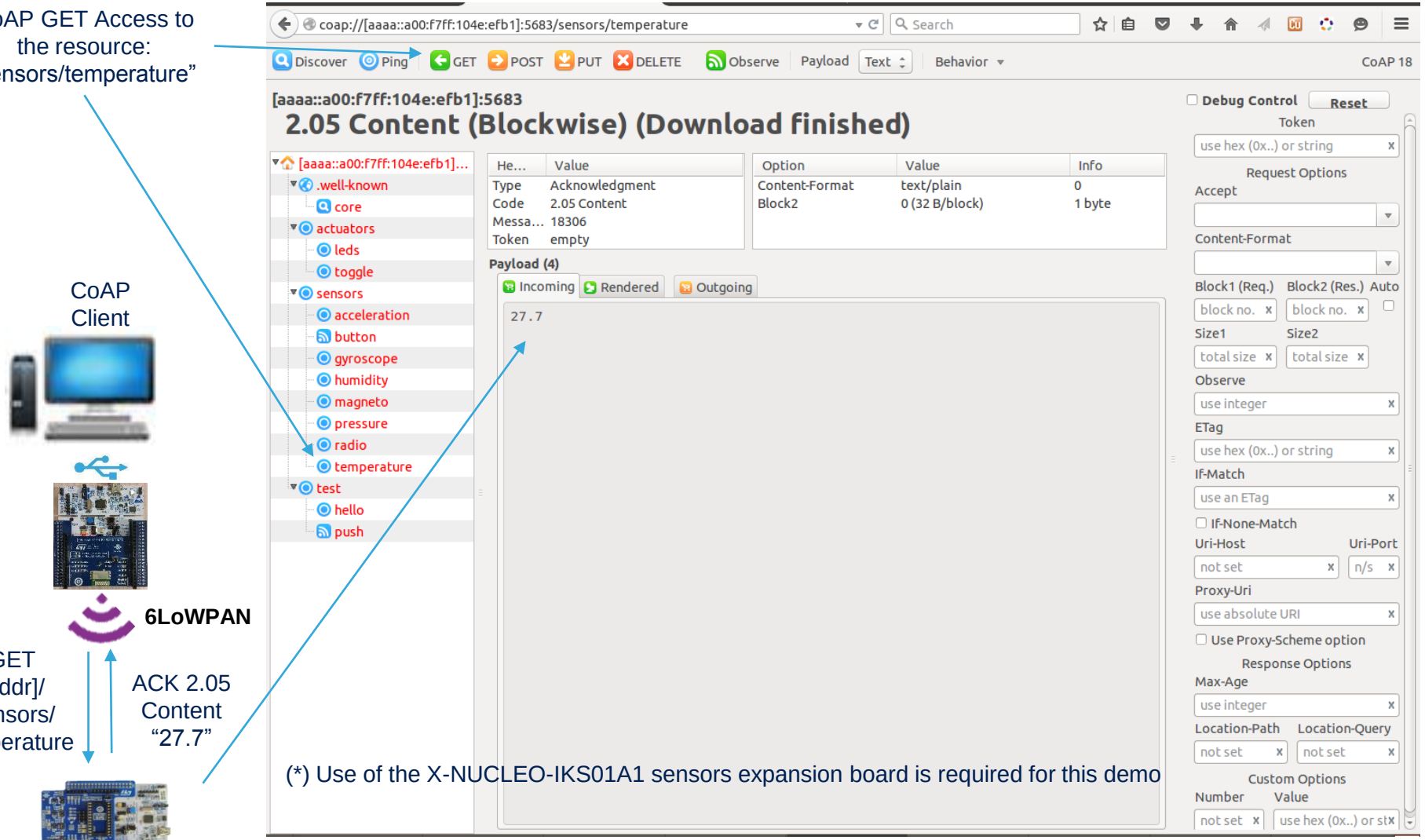


6LoWPAN Contiki
on STM32 Nucleo



Sensors Resource Access using CoAP
Example of temperature sensor reading

CoAP GET Access to the resource: “sensors/temperature”



CoAP Client

6LoWPAN

GET [addr]/ sensors/ temperature

ACK 2.05 Content “27.7”

CoAP Server

(*) Use of the X-NUCLEO-IKS01A1 sensors expansion board is required for this demo

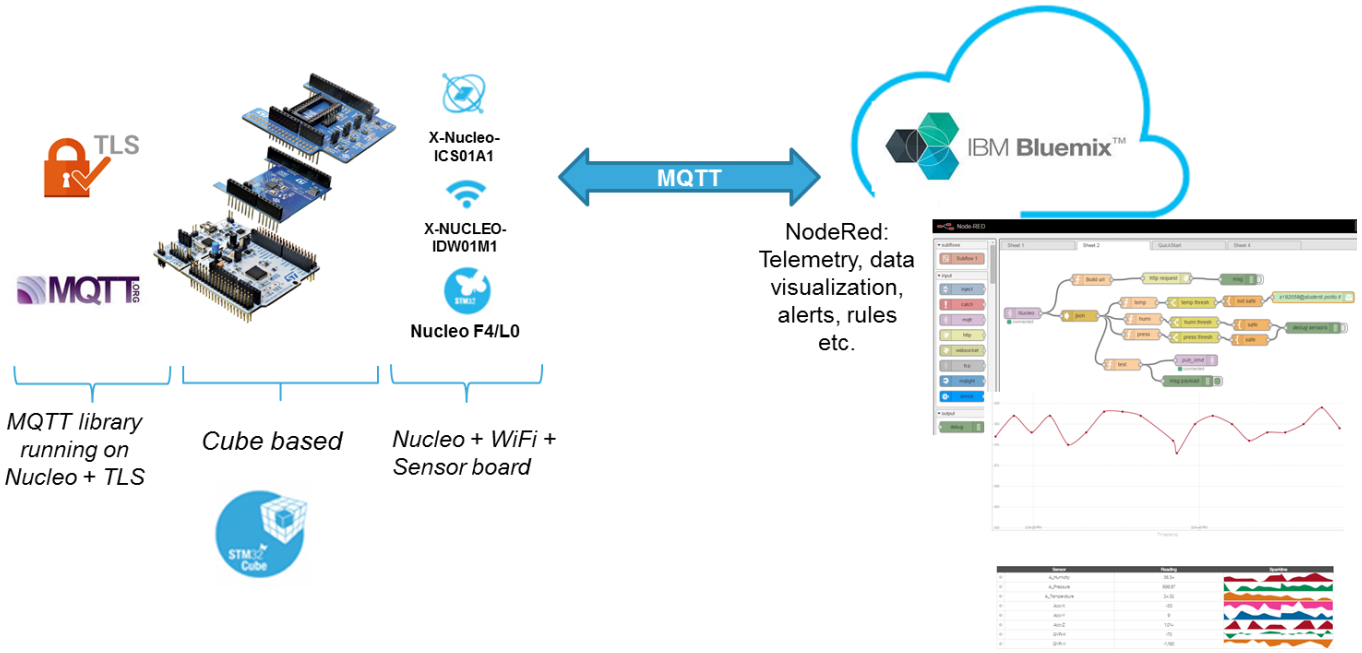
life.augmented

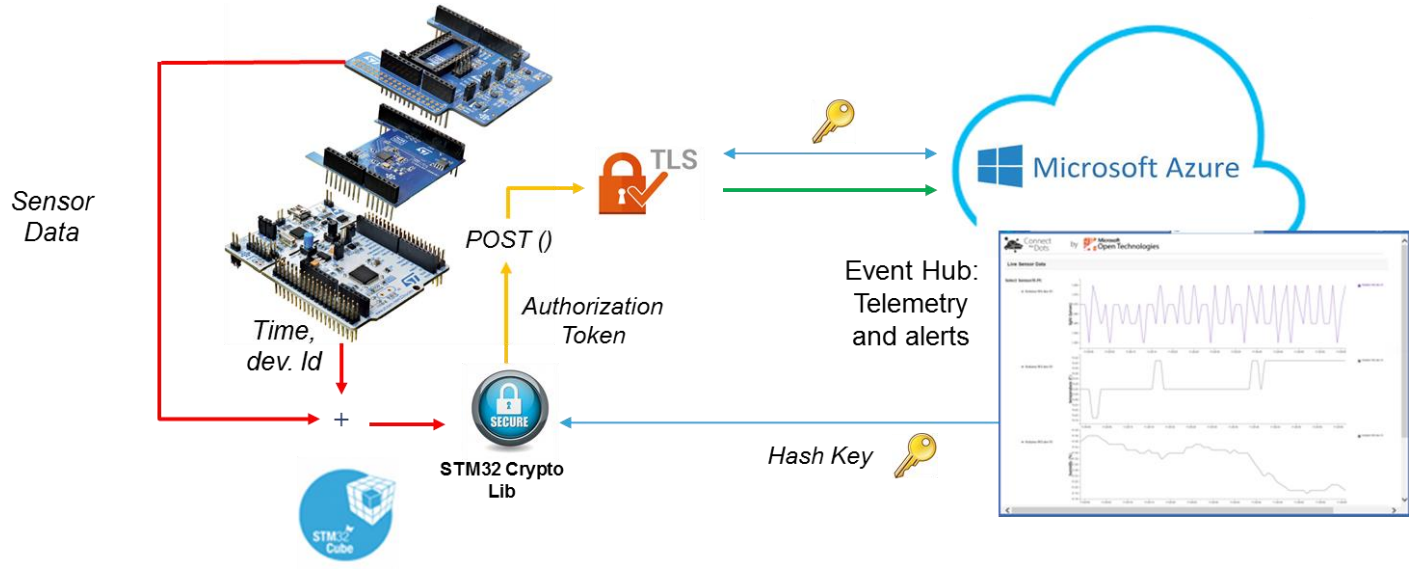
WWW.EMCU.IT

AVNET Memec

SILICA An Avnet Company

ST Cloud vertical. Overview

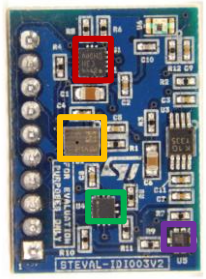




RF Multi-Sensor node

STEVAL Demo board

STEVAL-IDI003V2



LIS3DH

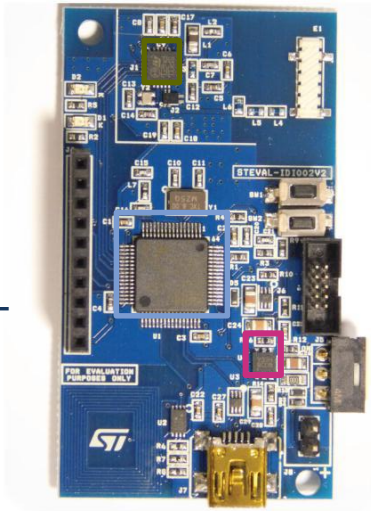
LPS25H

MP34DT01

HTS221

+

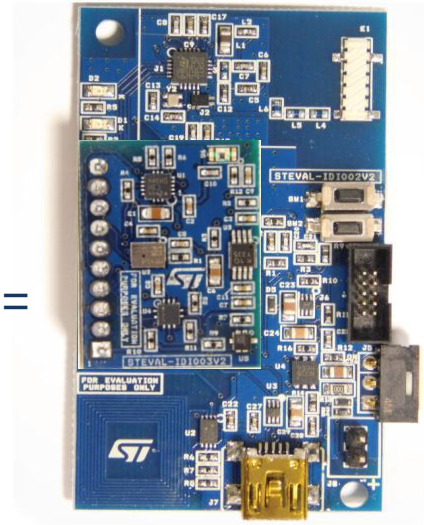
STEVAL-IDI002V2



SPIRIT1

STM32L151RB

=



+ STEVAL-IDI002V2

STM32L1RB
Ultra-low-power MCU

SPIRIT1
868 MHz, sub-1 GHz

M24LR64
Dual I²C RFID EEPROM

STEVAL-IDI003V2

LPS25H
MEMS pressure sensor

MP34DT01
MEMS microphone

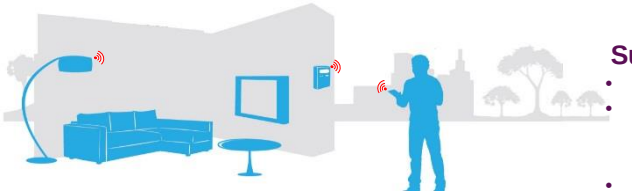
LIS3DH
MEMS 3-axis Acc.

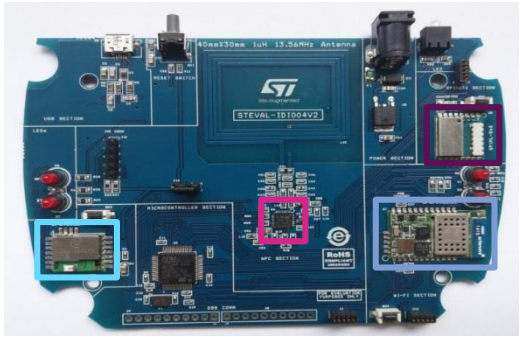
HTS221
Humidity and Temp.

Wireless Bridge

NFC reader IC: CR95HF

- 13.56-MHz multi-protocol contactless transceiver IC
- Reader/writer
- SPI and UART serial access
- Optimized power management





STEVAL-IDI004V2

- BT Classic module: SPBT2632
- NFC reader IC: CR95HF
- Wi-Fi module: SPWF01SA.11
- Sub-GHz RF module: SP1ML-868

Sub-GHz RF module: SP1ML-868

- 868 MHz ETSI-certified module
- Based on sub-GHz SPIRIT1 transceiver, STM32L1 ULP MCU and balun (BALF-SPI-01D3)
- Chip antenna
- Simple AT command

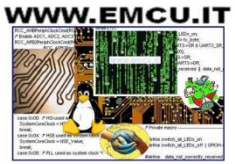
Sub-GHz

BT Classic module: SPBT2632

- Bluetooth® Classic 3.0 version
- Embedded firmware, including Bluetooth stack and profile, SPP and iAP profiles
- AT commands
- CE, FCC, IC, TELEC certified
- Low-power mode supported

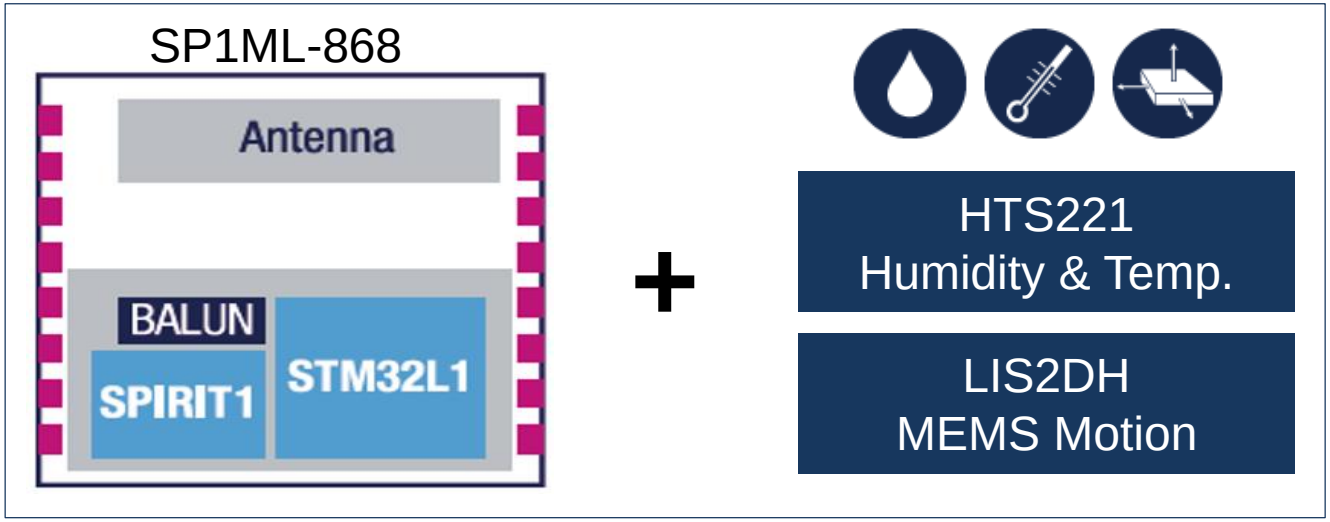
Wi-Fi module: SPWF01SA.11

- 2.4 GHz IEEE 802.11 b/g/n Wi-Fi
- Pre-certified RF module (FCC, IC, CE)
- Integrated **TCP/IP**
- AT commands
- TLS/SSL for end-to-end security
- Over-the-air firmware updates



- SP1ML 868 MHz wireless sensor board powered by a coin cell battery

- Key Features:
  - SP1ML-868, RF 868MHz certified module
  - HTS221: Humidity and Temp. Sensor
  - LIS2DH: MEMS Motion 3-axes Sensor
  - Serial wire debug interface (SWD)

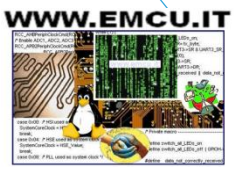


- Application Target:
  - Heat Cost Allocator, Alarm, Beacon

Sub-GHZ Mesh Routing

(ST/consultant partnership)

life.augmented

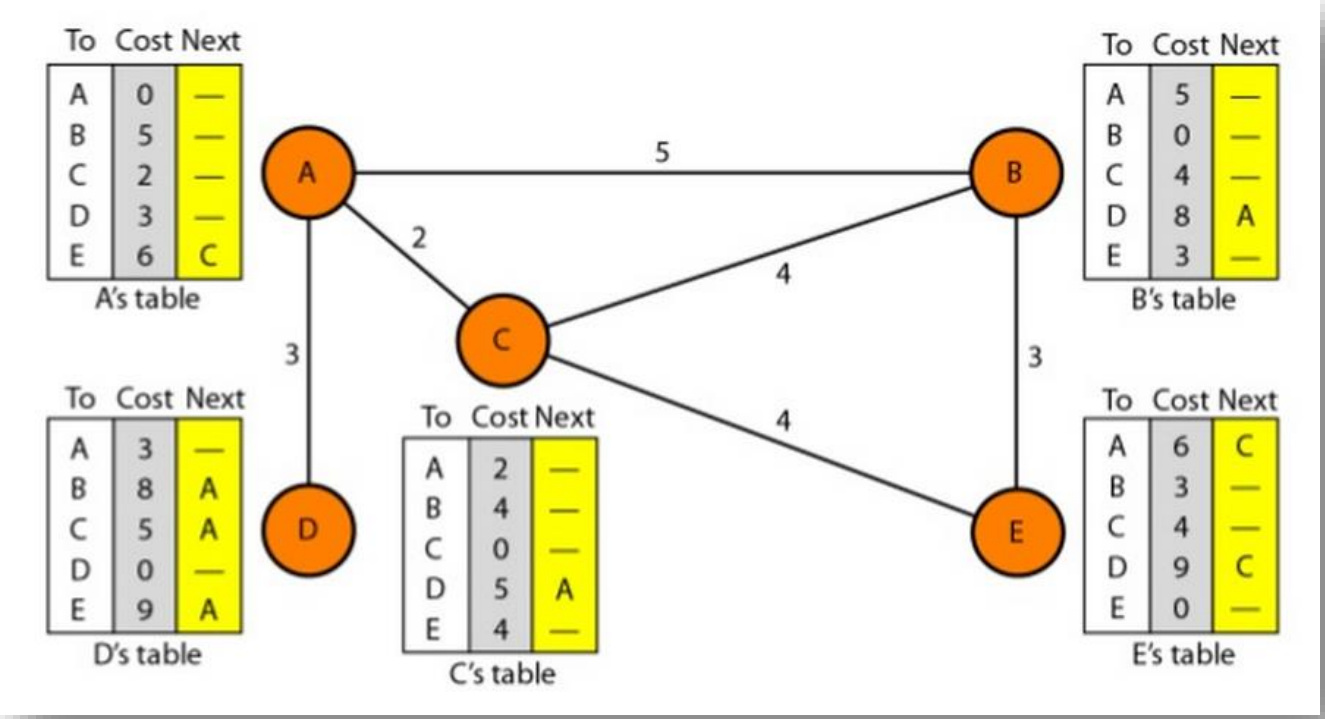


AVNET Memec

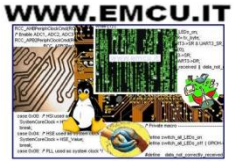
SILICA An Avnet Company

Mesh Routing Protocol

Distance Vector Protocol

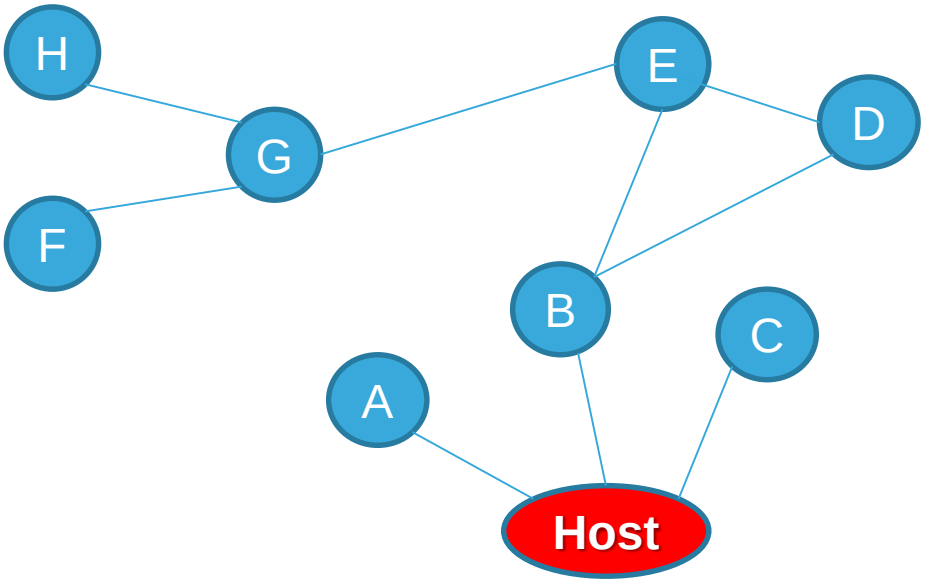


- Routers using distance-vector protocol do not have knowledge of the entire path to a destination. Instead they use two methods:
- Direction in which router or exit interface a packet should be forwarded.
- Distance from its destination



Mesh Routing Solution Proposed

Central Host Network Based



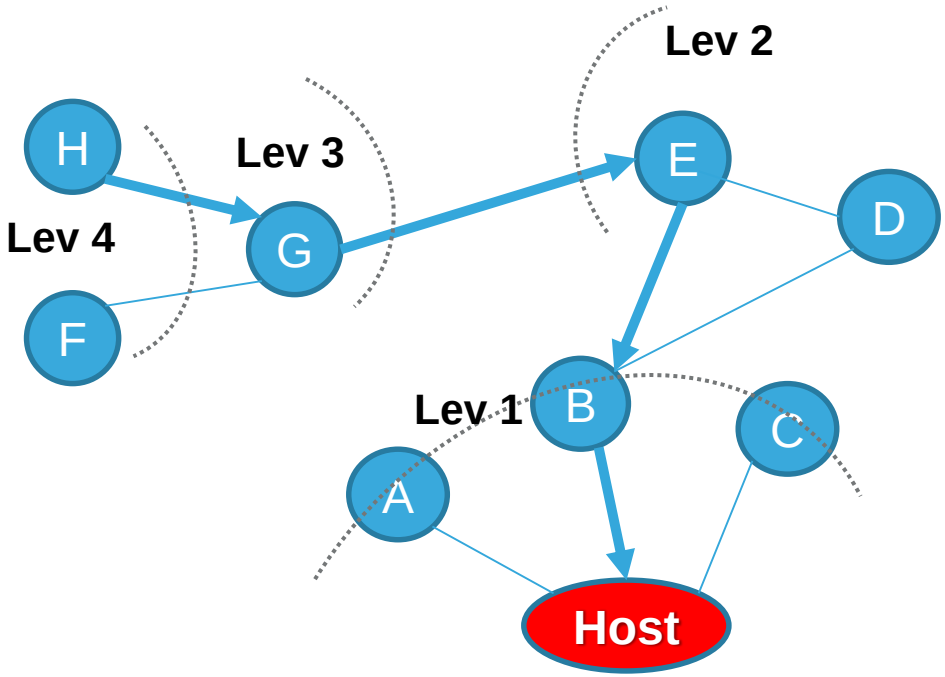
- Differentiation and optimization of the routing for:
  - node message vs host
  - host message vs node

-Optimized for a network which nodes are sent frequently information to Central Host

Mesh Routing Solution Proposed

Central Host Network Based: Messages vs Central Host

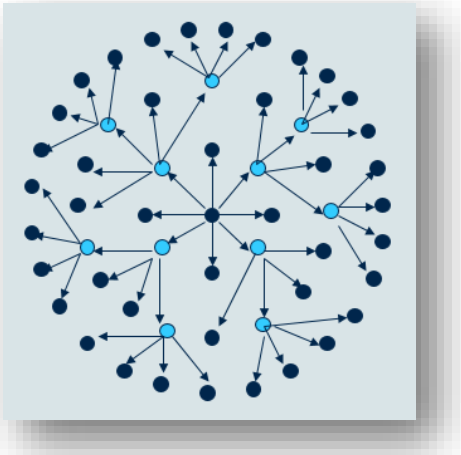
- Each nodes saves **only** information regarding which router or exit interface a packet should be
- Nodes are able only to reach Central Host
- **Light and Optimized version of a Distance Vector Protocol**

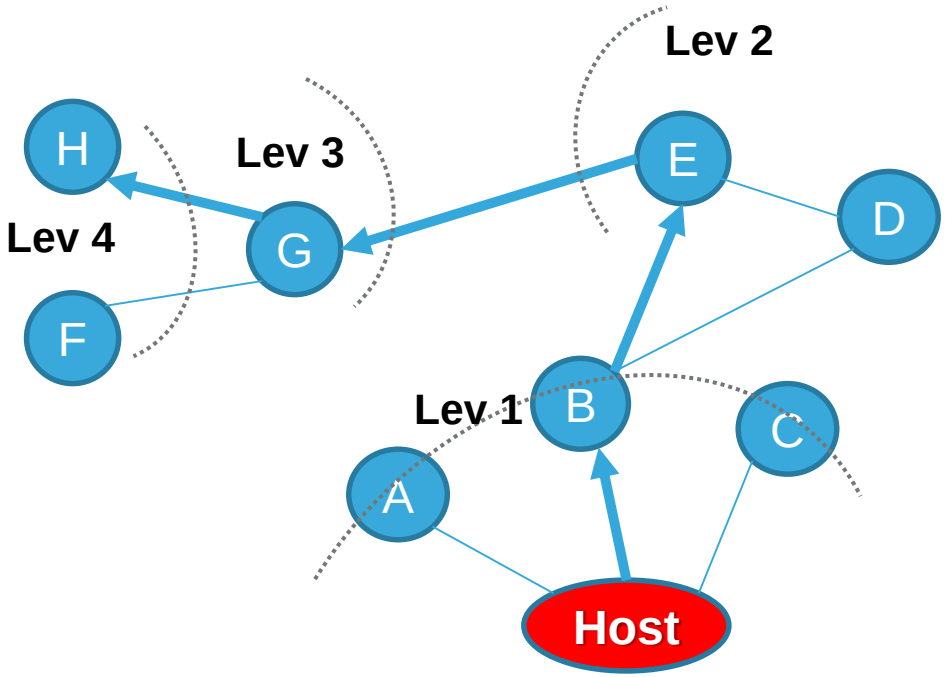


Mesh Routing Solution Proposed

Central Host Network Based: Messages vs Nodes

- Central Host calculates best routing starting from partials path of the nodes -> OLSR (Optimized Link State Routing) mechanism is implemented





…don’t forget the WIRES:

ST Power Line Communication

PLC

life.augmented

WWW.EMCU.IT

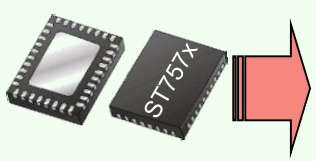
AVNET Memec

SILICA An Avnet Company

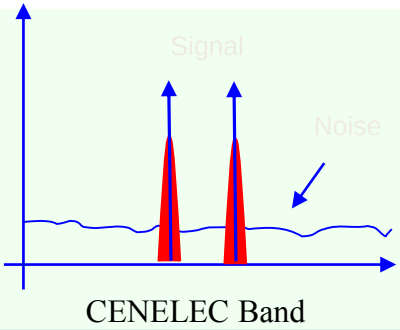
PLM Products

Basic Features

Scalability

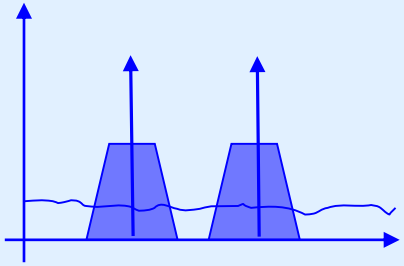


ST7570



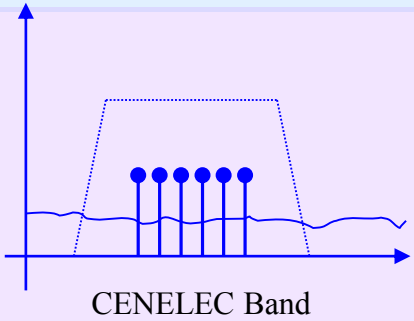
- S-FSK Modulation
- Narrowband single channel
- Speed : up to 2,4 kbps baud rate
- Compliant with IEC 61334-5-1 and LINKY specifications (ERDF)

ST7580



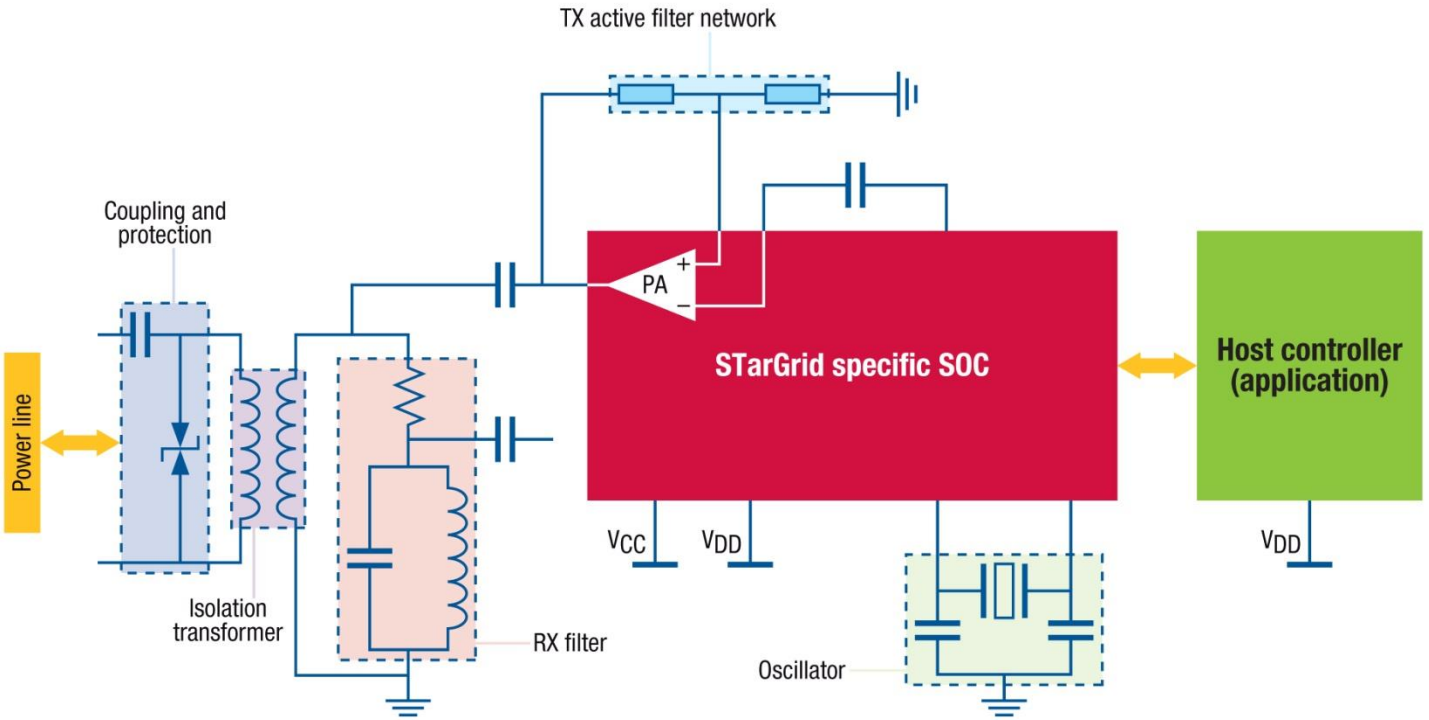
- FSK and n-PSK multiple modulations
- Narrowband dual channel
- Speed : up to 28.8kbps Baud Rate

ST7590



- OFDM modulation
- Narrowband Multicarrier
- Speed : up to 130kbps Baud Rate
- Compiant with PRIME specifications (IBERDROLA)

STarGRID-based PLC application diagram



Most compact, lowest BOM
PLC node on the market

Suggested ST PLM versus CENELEC PLC Frequency Bands & Use

ST7580 (meters&more),
ST7590 (PRIME)
ST7570 (IEC 61334-5-1)

ST7580

ST7540

Electricity Suppliers

Band A

Electricity Suppliers and their Licensees

Band B

Consumer Use

Band C

Consumer Use

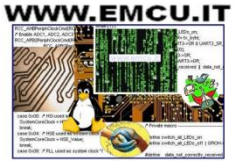
Access Protocol Mandatory

Consumer Use

D

3 9 95 125 140 148.6

f (kHz)

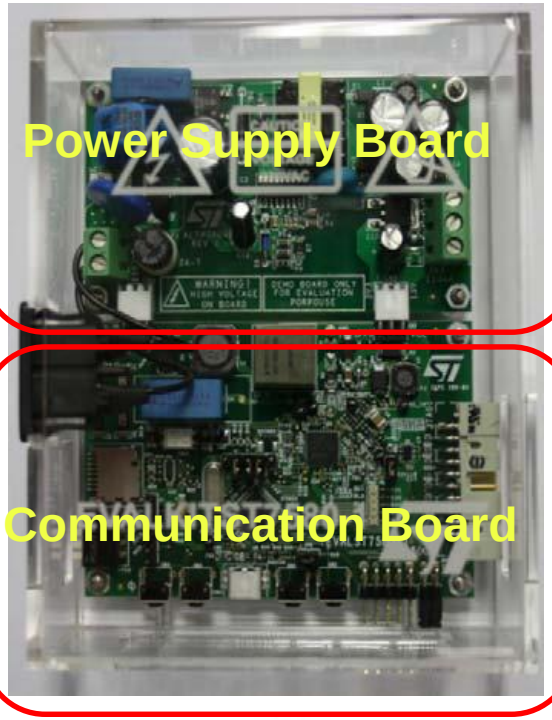


life.augmented

AVNET Memec

SILICA An Avnet Company

ST7580 Evaluation Boards



- **EVALKITST7580-1:** PLC Evaluation Node with Power Supply Board and embedded STM32 MCU for application prototyping

- **STEVAL-IHP007V1**

Power line communication street lighting (ST7580)