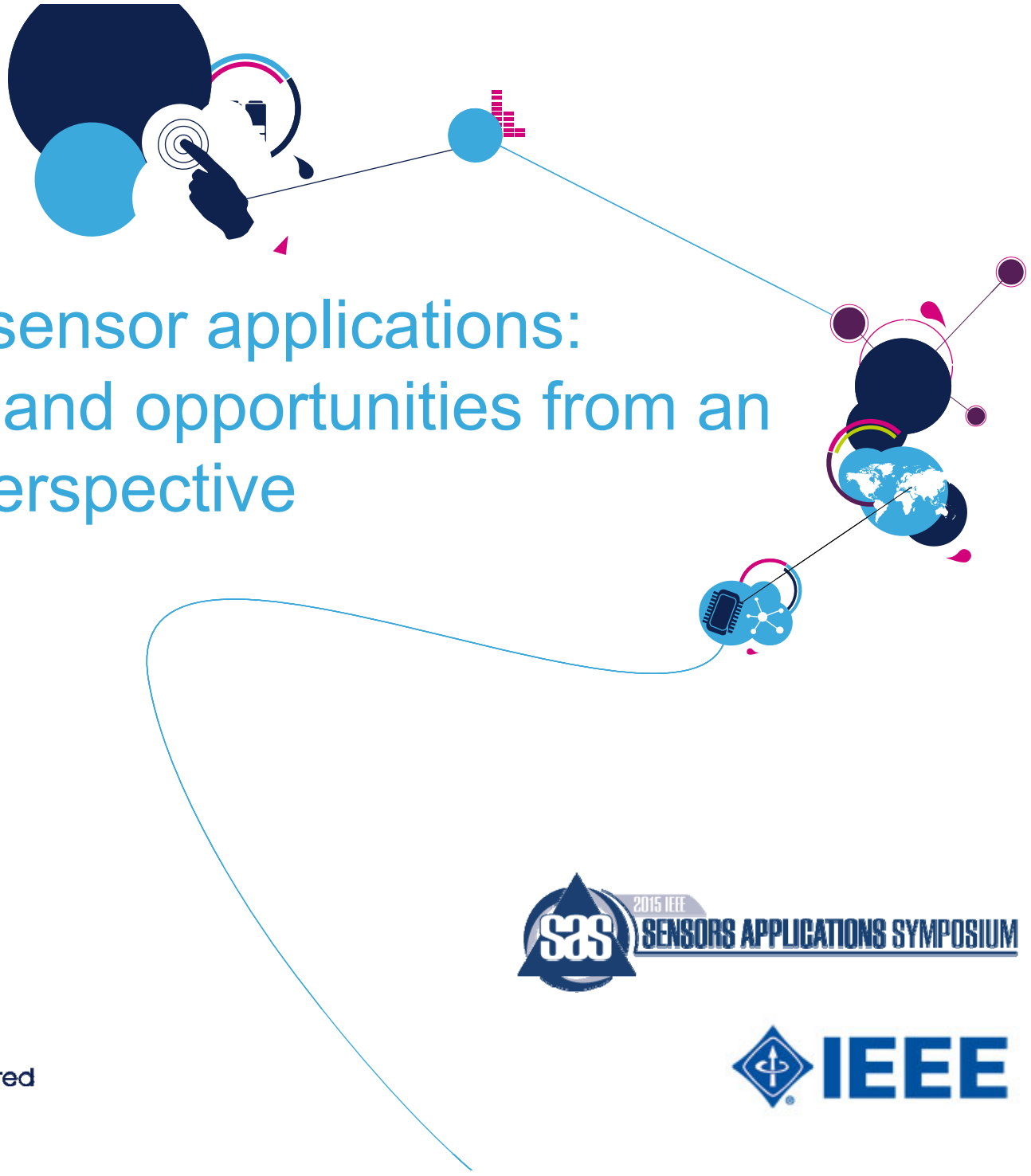

Integrated sensor applications: challenges and opportunities from an industrial perspective

Diego Melpignano,

STMicroelectronics

April 13th, 2015

2015 IEEE SENSORS APPLICATIONS SYMPOSIUM

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IEEE

Sensors Are Changing The World

Smart City

Reduce traffic congestion

Better use of resources

Improve security

Smart Me – Healthcare

Empower patients

Help physicians monitor and diagnose remotely

Smart Car

Reduce emissions

Increase safety

Save fuel

Smart Me – Wellness

Help to lead healthier lives

Optimize sports performance

Early warning of illness

Smart Home

Make entertainment more interactive and immersive

Increase comfort

Save energy

Smart Industrial & Smart Services

Productivity gains

Efficiency, agility

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Outline

- ST sensor technologies

- Distributed computing architecture for scalability
  - A Structural Health Monitoring example

- Improving time to market for sensor applications

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ST Sensors Brief Overview

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Complete Sensor and Actuator Portfolio

MOTION MEMS
Accelerometers
Compass
Gyroscopes

ACOUSTIC MEMS
Microphones

ENVIRONMENTAL SENSORS
Humidity / Chemical
Pressure / Temperature
Infrared / Gas Flow
Light / Proximity

Sensor Hub & Sensor Fusion

MICRO-ACTUATORS
Electrostatic: Mirrors for Portable Projector
Thermal / Piezoelectric: InkJet
Drug Dispensing

TOUCH SENSORS
Touch Screen
Active Pen

ANALOG
OpAmps, Comparators
Low-power electronics
Bluetooth Low Energy
Advanced Audio Solutions

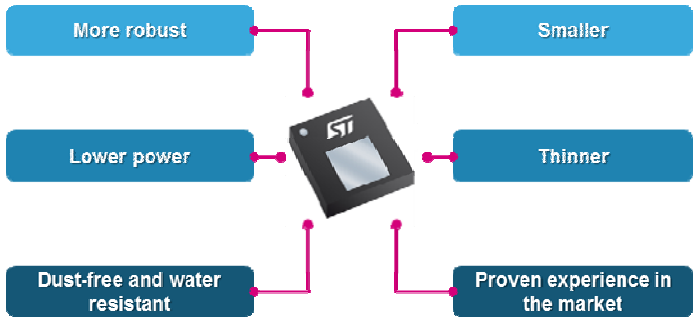
Few examples follow…

Environmental Sensors

- 260 to 1260 hPa absolute pressure range
- Embedded temperature compensation
- Programmable interrupt/data ready
- Low power consumption down to 4 µA
- Selectable ODR from 1 Hz to 25 Hz
- SPI and I²C interfaces
- Embedded FIFO
- Supply voltage: 1.7 to 3.6 V

Pressure Sensor

LPS25HB
high performances Pressure Sensor



HTS221 / HTS221E
Ultra-low Power Humidity Sensor

- 2x2x0.8mm package
- Low current consumption (2uA)
- Extended operative voltage (1.7 – 3.6V)

Humidity Sensor

- Humidity and temperature sensor
- 0 to 100% RH range
- Low Power Consumption: 1µA
- Humidity Accuracy - ±4%RH (20%RH to 80%RH)
- SPI and I²C interfaces
- -40 to 120 °C temperature range

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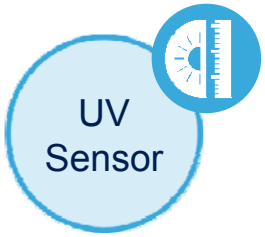
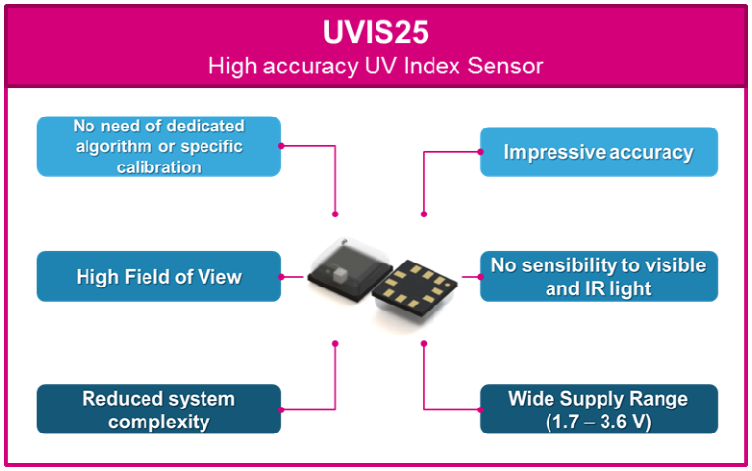
UV and Proximity Sensors

- 0 - 15 UV index output range
- Resolution: UVI / 16
- Selectable Read out :1 Hz ODR/ one shot
- SPI and I2C interfaces
- Supply voltage: 1.7 to 3.6 V
- 2.5x2.5x0.76 mm 10L





Proximity and Ambient Light Sensor

VL6180X

- 0 ÷ 10cm distance range, independent of target reflectance
- IR emitter 850nm
- HDR ambient light (calibrated lux output)
- Average 2mA power consumption
- I2C interface
- 2 programmable GPIOs (threshold interrupts)
- 4.8x2.8x1 mm

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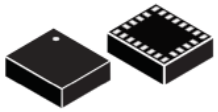
Sense

Motion Sensors: 2 Extremes



“Simplest”

LIS344ALH accelerometer

- 3 axis accelerometer (±2 ÷ ±6 g)
- Analog outputs
- Max BW = 1.8KHz
- 50 µg/sqrt(Hz) ← lowest noise density
- 4x4x1.5 mm

“Feature full”

LSM9DS1 inertial module

- 3 axis accelerometer (±2 ÷ ±16 g)
- 3 axis gyroscope (±245 ÷ ±2k dps)
- 3 axis magnetometer (±4 ÷ ±16 gauss)
- Embedded temperature sensor
- 16 bit digital out (I2C, SPI), variable output data rate
- ***Programmable interrupts***
- ***Position and motion detection***
- ***Click / double-click detection***
- ***Smart power saving***

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Sensor Systems: the Scalability Challenge

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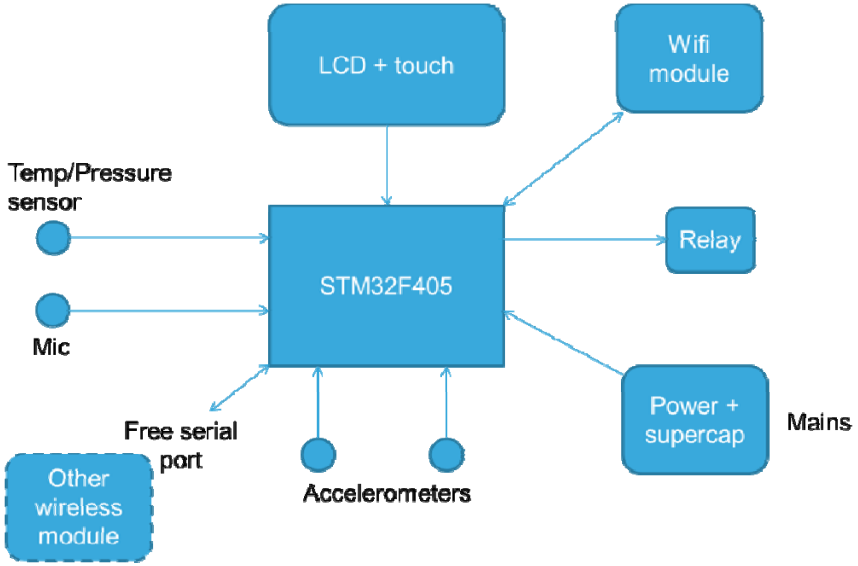
Example Application: Dynamic SHM

- Monitoring vibrations in buildings and other civil structures
- Modal identification (frequency / time domain), vibration patterns,…

When active, sensor nodes (SN) stream {x,y,z} accelerometer measurements, sampled @ 100 Hz ➔ ~16 kbps data flow

Sensor nodes with accelerometer, T/H, micro and Wi-Fi connectivity



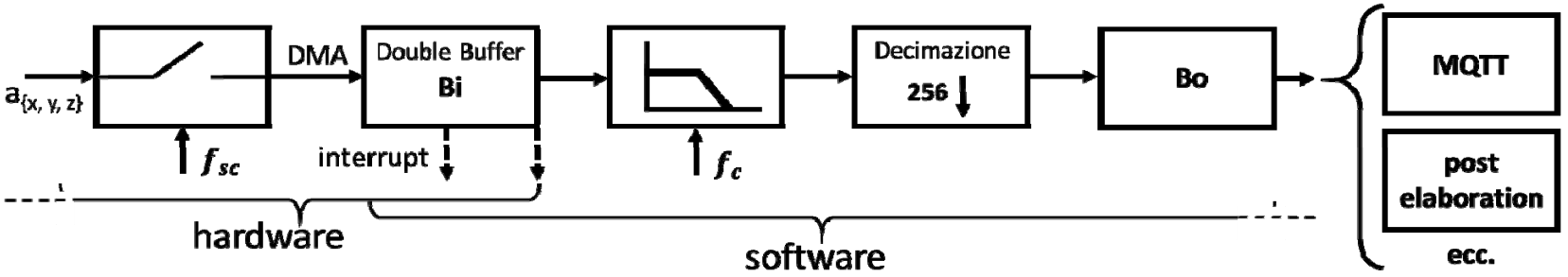
DSHM Experimental Field Trials

Highway bridge

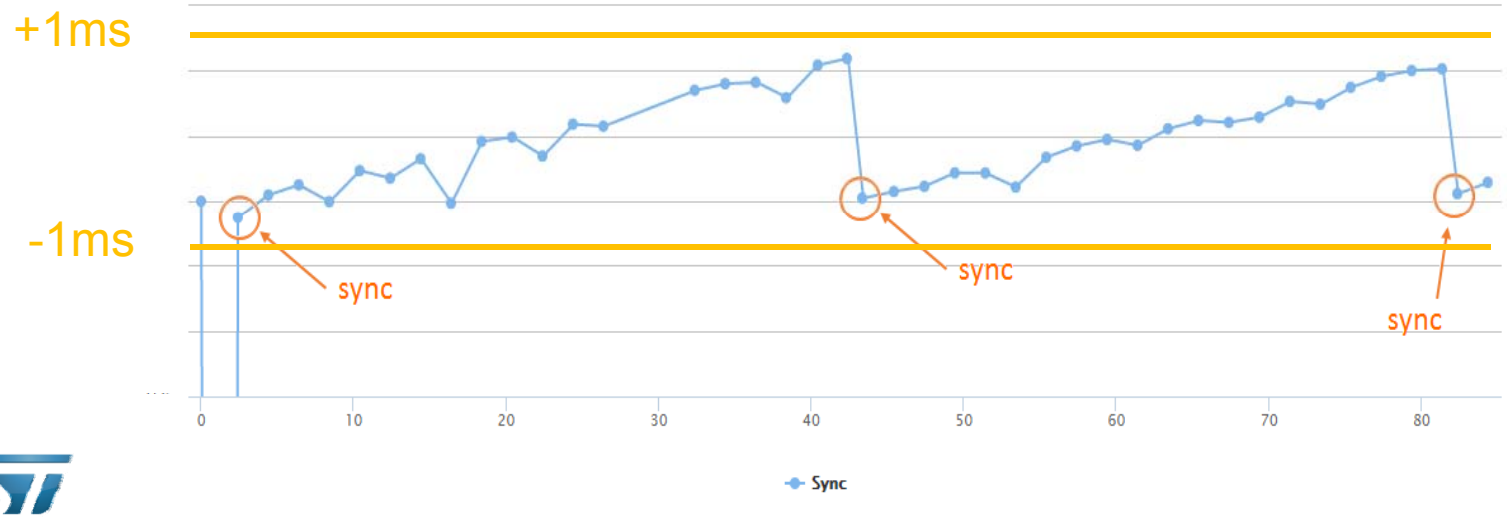
40 floor skyscraper

Sensor Node Processing Tasks

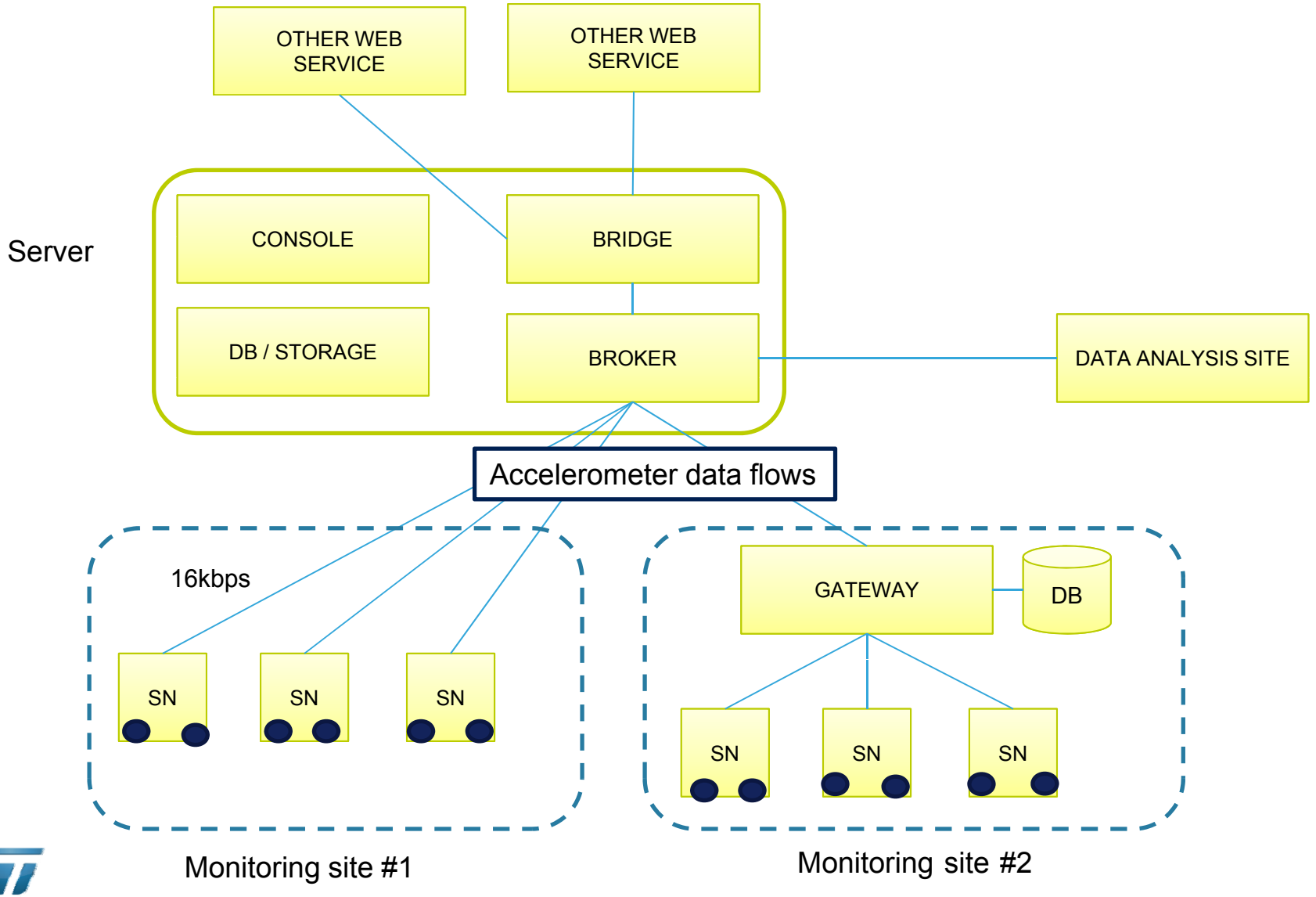
1) Signal conditioning



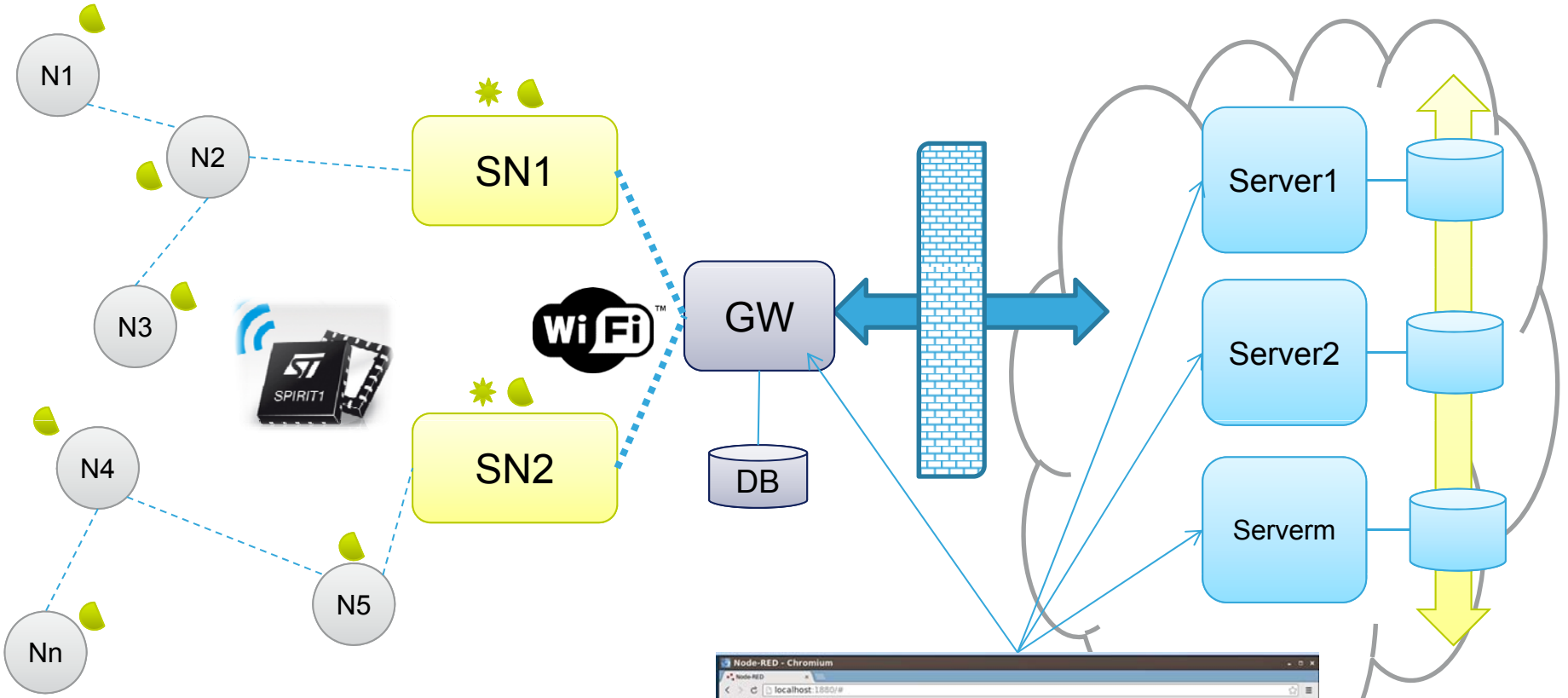
2) Time synchronization



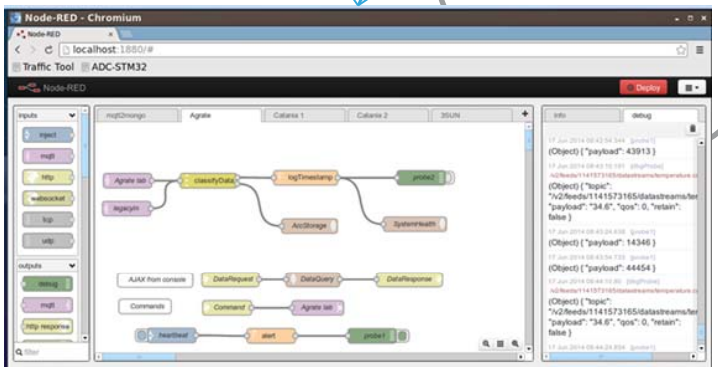
The Complete DSHM System



DSHM System: Closer View



Data flow processing environment



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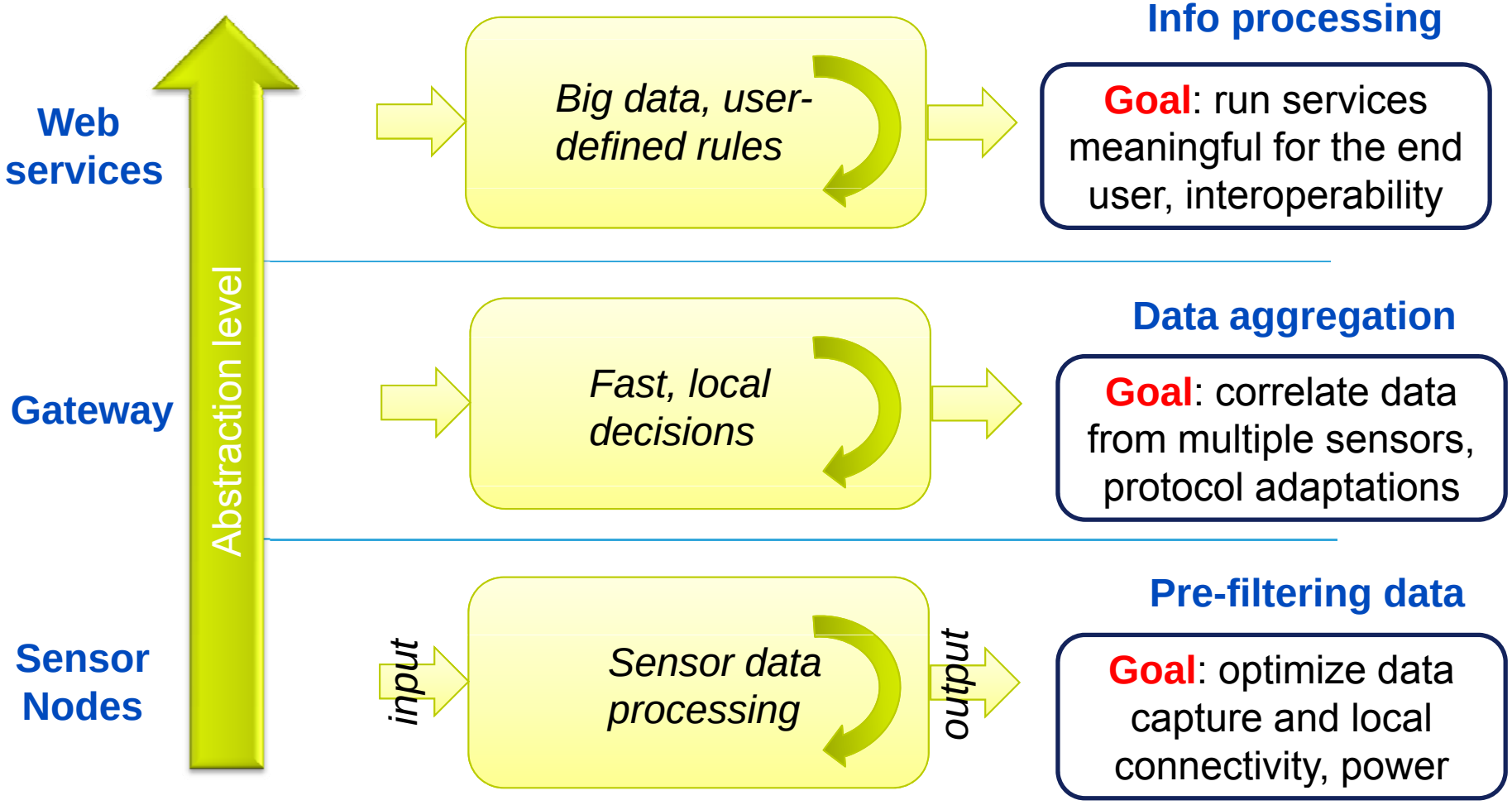
Fog Computing



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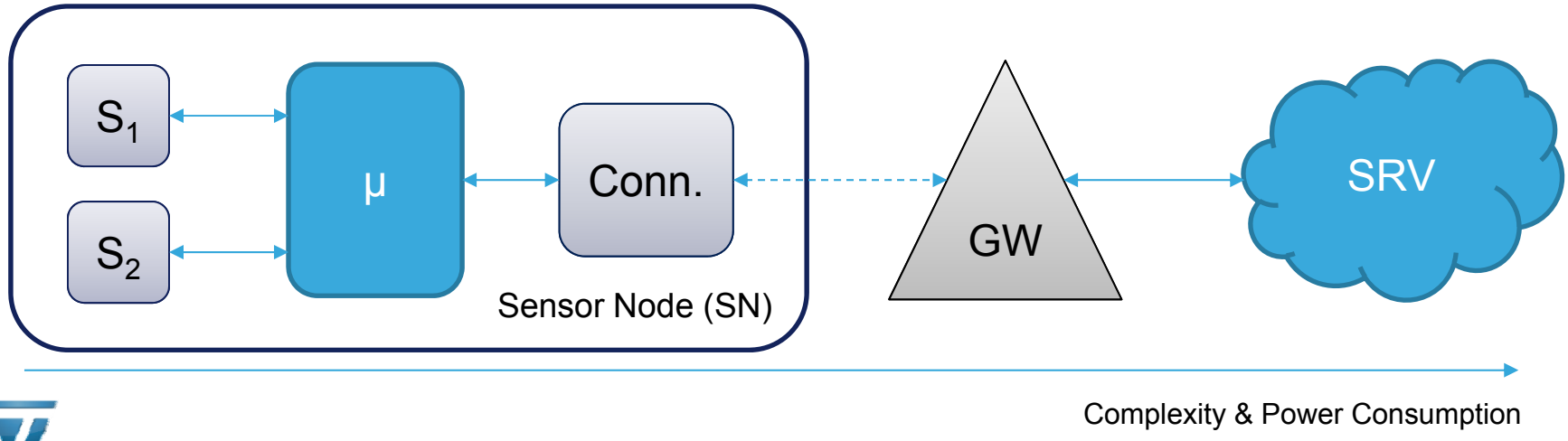
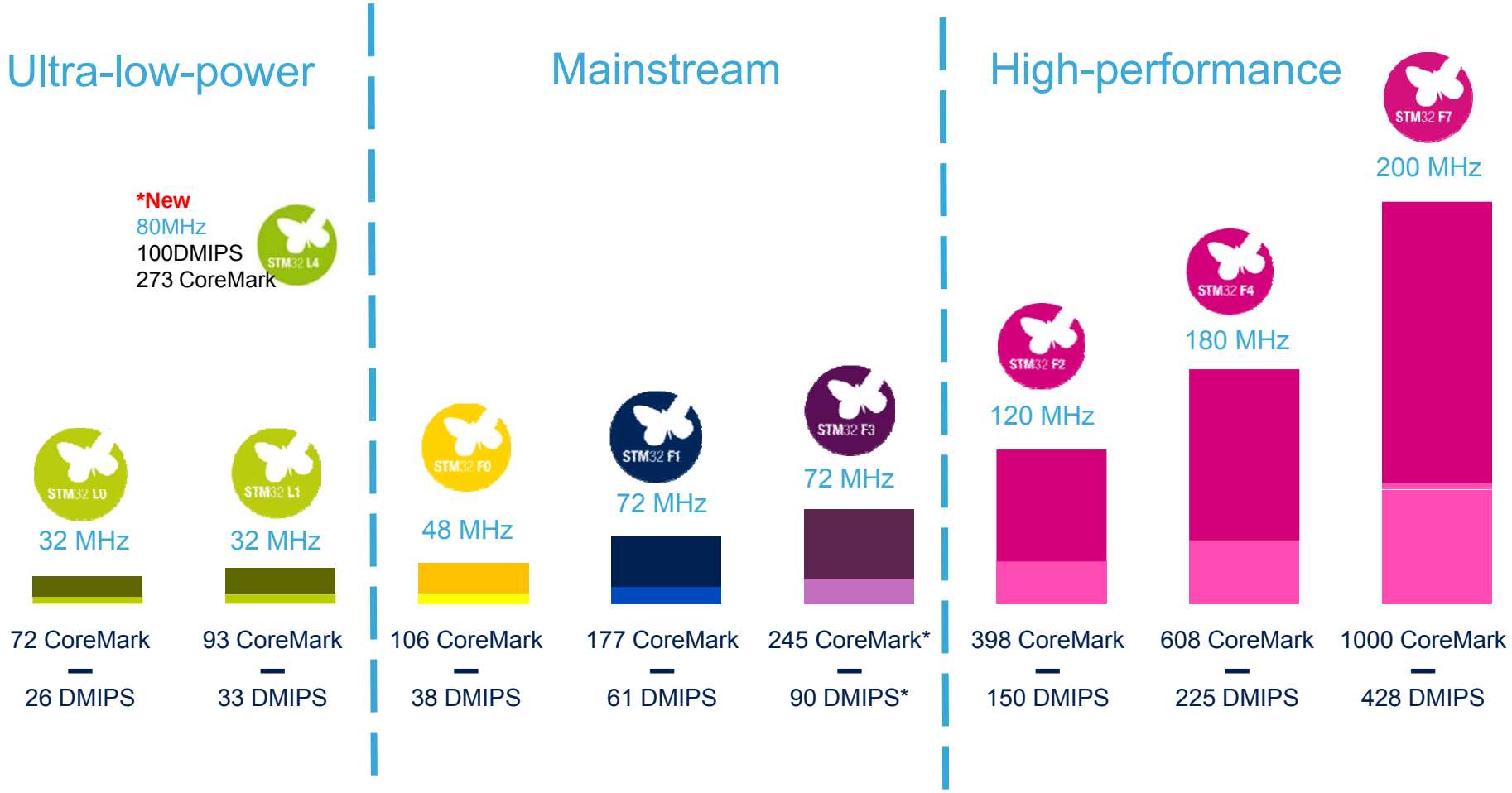
Trends…

- Sensors getting smarter and smarter ← programmability
- Low-power monitoring in the sensor: from simple thresholds to pattern recognition to …
  - Other components in the sensor node sleep to save power
- From centralized to distributed processing ← more powerful micros



STM32 Microcontrollers



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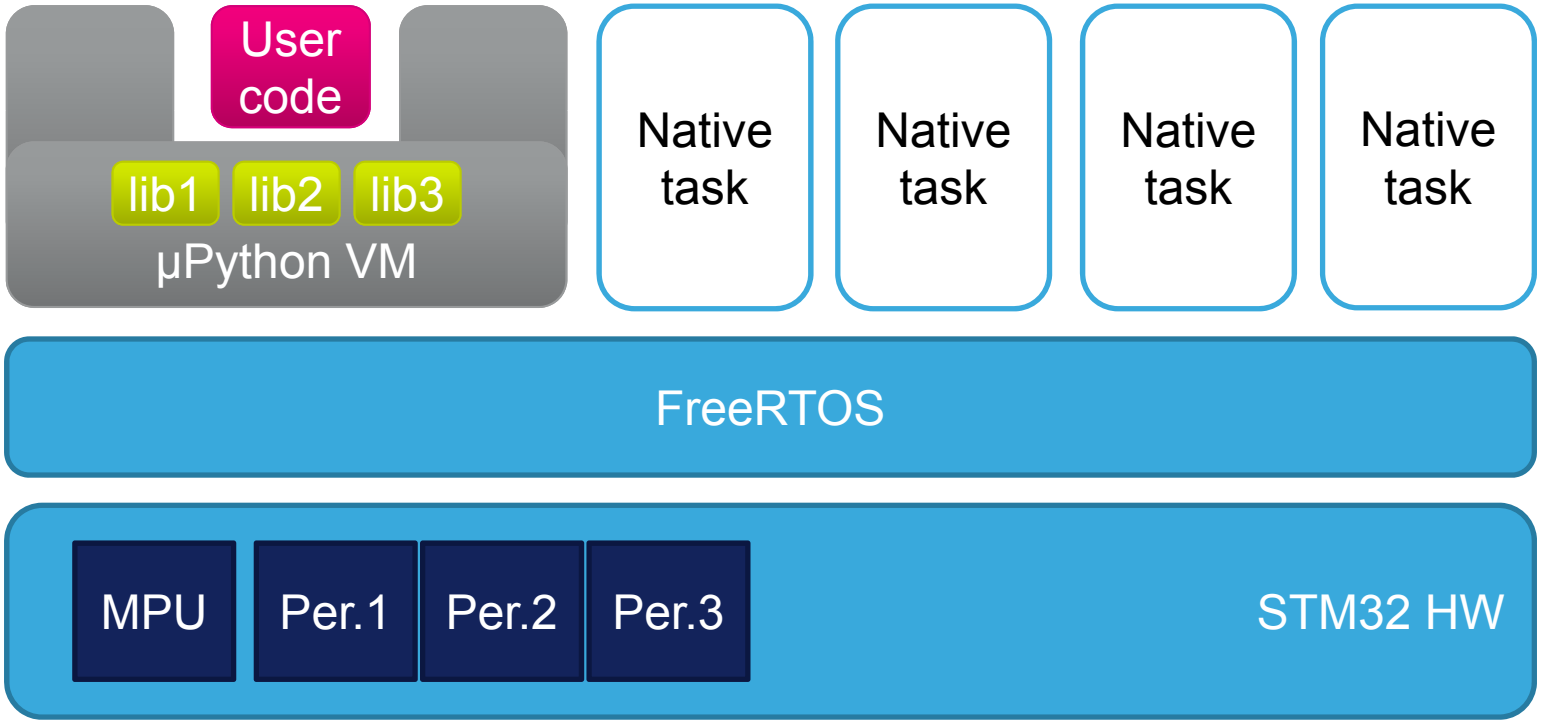
Programming Smarter Sensor Nodes

- Programmability challenge: embedded C is still difficult for many, even if it's getting simpler with environments like ARM mbed.org, Cube and the like

- Let's consider Python in a freeRTOS environment

Securely Running User Code



- microPython as freeRTOS task, user or privileged mode
- stack and heap allocation compatible with freeRTOS
- garbage collector optimizations
- MPU ensures native tasks are protected from wrong memory accesses by Python user code
- Selected HW peripherals exposed to Python with dedicated libraries/drivers

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ST Approach for Reducing Time to Market for Sensor Applications

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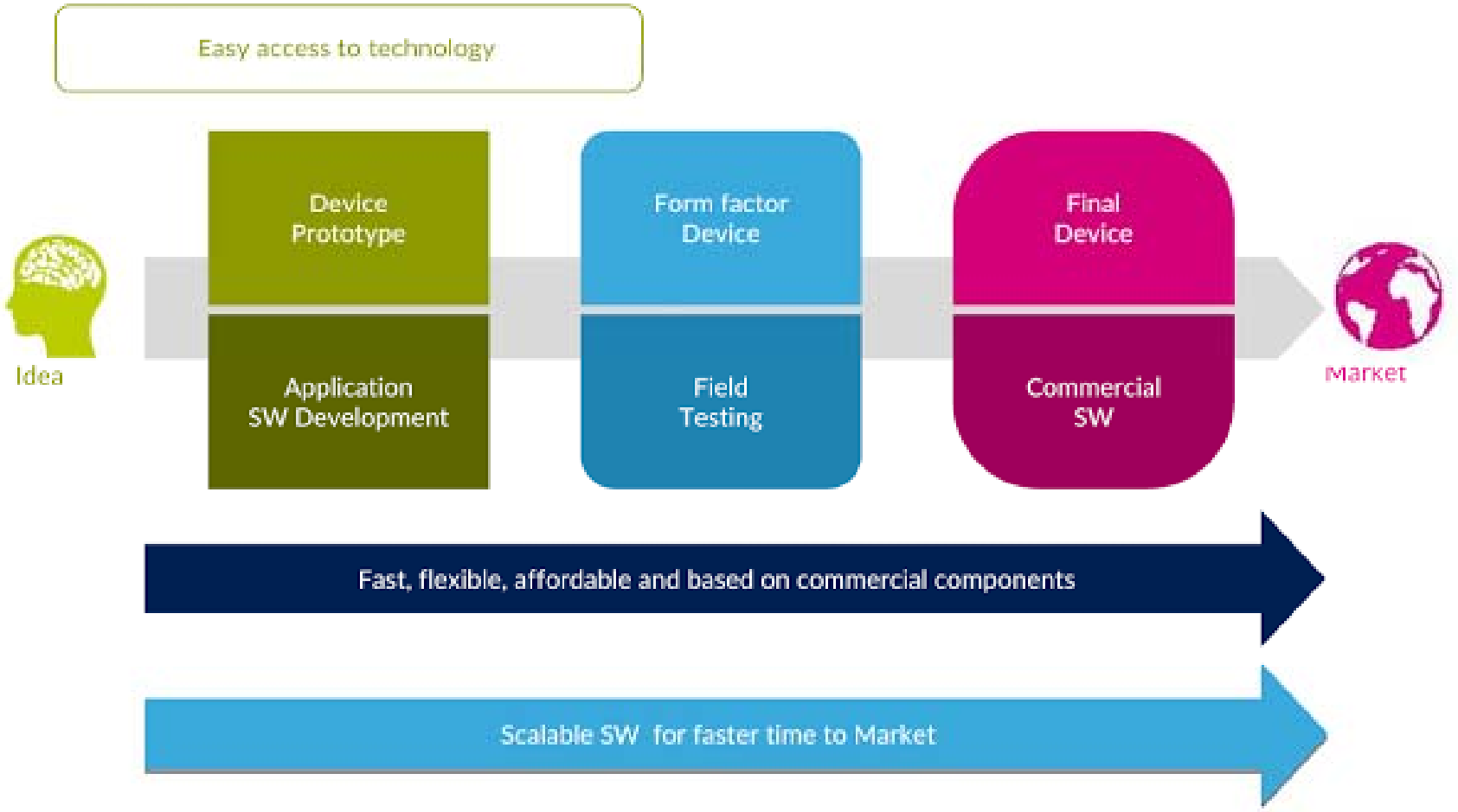
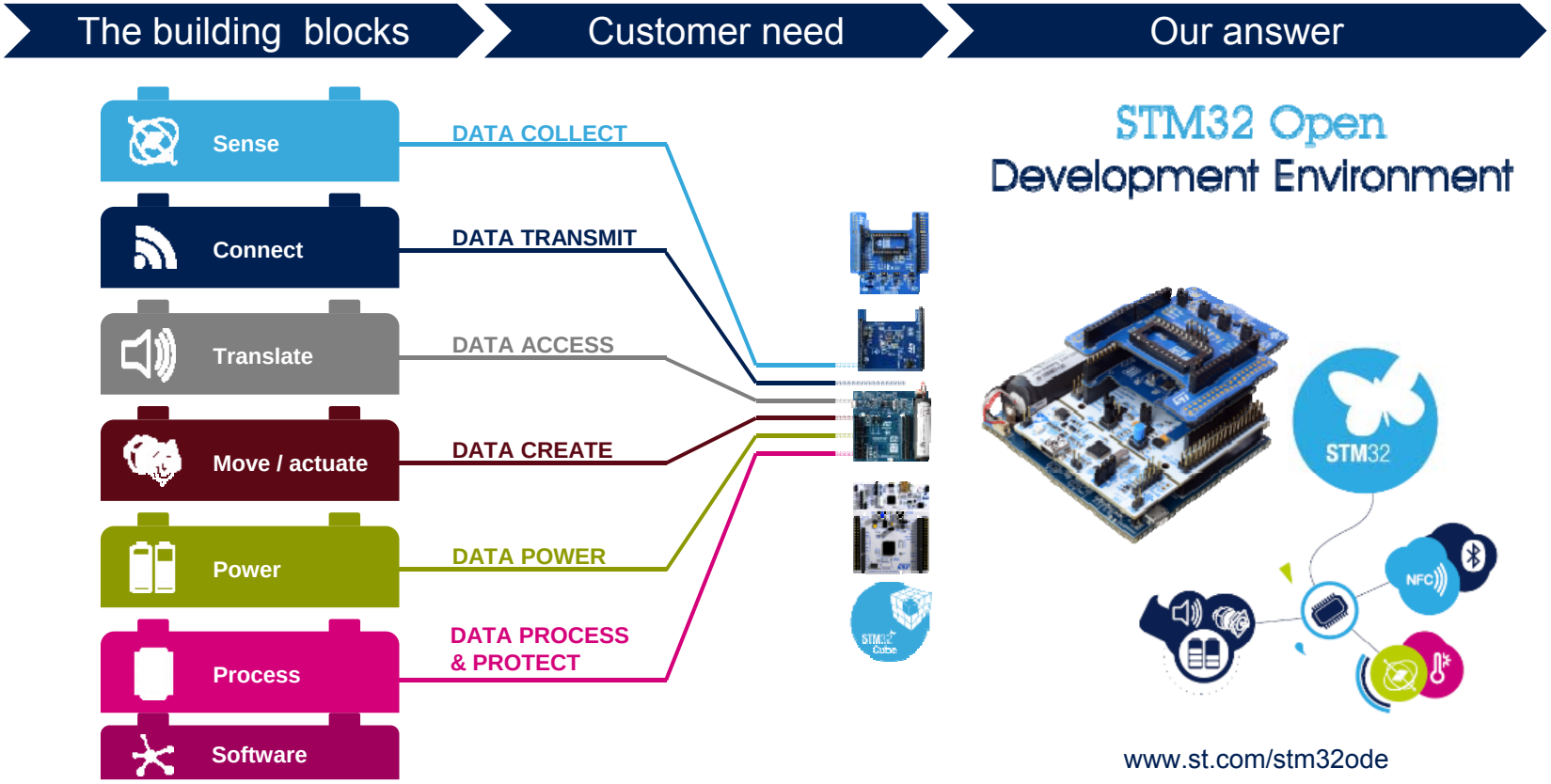
From Idea to Product



STM32 Open Development Environment

from low cost fast Prototyping to final Product



+ SW libraries + programming tools

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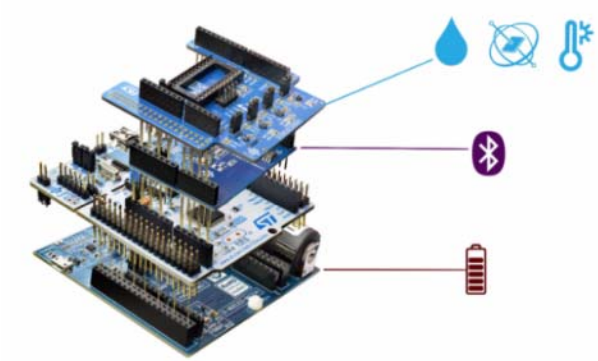
Optimized Solutions

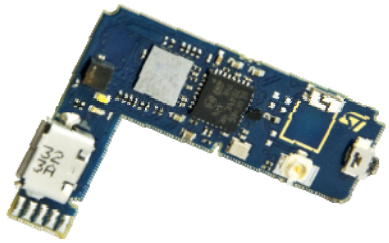
Example IoT Wearable → STEVAL-WESU01

STM32 ODE Verticals



- STM32 Nucleo Developer Board
- MEMS Inertial and Environmental Sensor Expansion Board
- Bluetooth Low Energy Expansion Board
- Battery Management Expansion Board
- BLUEMICROSYSTEM MIDDLEWARE

Optimized evaluation boards (STEVAL)



- Single & Compact Board (< 380 mm^2)
- BLUEMICROSYSTEM MIDDLEWARE

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Fast Prototyping

What do you want to do?	What you need	Board
Process	Ultra Low power	STM32 L0
	Ultra Low power	STM32 L1
	Mainstream	STM32 F1
	Mixed signal +DSP	STM32 F3
	High performance	STM32 F2
	High performance + DSP	STM32 F4
Sense motion, pressure, humidity, light, gas, location	Motion Sensors	Motion + Environmental
	Environmental Sensors	Motion + Environmental
	Proximity Sensors	FlightSense
	OpAmp	OpAmp
Connect wireless or wired	Bluetooth Low Energy	BlueNRG
	Wi-Fi	
	Sub-GHz radio	SPIRIT1
	NFC	M24SR
Translate Move/Activate Audio	Motor Driver	xSPIN (easySPIN, dSPIN,..)
	Audio amplifier	Audio-Out
	Microphone	Audio-in
Power	Energy management & Battery	Energy management
	(EnFILM)	

Motion & Environ. Sensors
X-NUCLEO-IKS01A1

Bluetooth Low Energy
X-NUCLEO-IDB04A1

NFC M24SR
X-NUCLEO-NFC01A1

Motor control
X-NUCLEO-IHM01A1

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STM32 Nucleo Expansion Boards

X-NUCLEO-IDB04A1

Bluetooth Low Energy Expansion Board based on BlueNRG

X-NUCLEO-NFC01A1

Dynamic NFC tag Expansion Board based on M24SR

X-NUCLEO-IHM01A1

Stepper motor driver expansion board based on easySPIN™ L6474

X-NUCLEO-IKS01A1

MEMS Inertial and Environmental Sensor expansion board

X-NUCLEO-IDS01A4/5

Sub-GHz expansion board based on SPGRF-868 and SPSGRF-915

X-NUCLEO-CCA02M1

Audio In Expansion Board based on MP34DT01

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Conclusions

- ST is a global leader in providing sensor solutions
  - Not only sensors but also connectivity and microcontrollers
- Scaling sensor systems calls for distributed processing
- Sensors themselves are poised to become smarter and smarter
- More and more processing power available in sensor nodes thanks to Moore's law at work in MCUs (STM32)
- STM32 Open Development Environment (ODE) enables fast prototyping with leading edge components that can be quickly transformed into final designs