Empowering Embedded Devices for IoT Applications

Q&A with Benedetto Vigna, Executive Vice President, Analog and MEMS Group, STMicroelectronics

ST Bluemicrosystem Bluetooth Smart Sensor Node Empowers Real-World IoT Applications

ST Wireless Sensor Nodes Provide Access to Cloud
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CONTENTS

3 Q&A with Benedetto Vigna
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8 ST Bluemicrosystem Bluetooth Smart Sensor Node Empowers Real-World IoT Applications

12 ST Wireless Sensor Nodes Provide Access to Cloud
The Bluemicrosystem Bluetooth Smart sensor node comes with different options of sensors on board. Could you describe which the featured sensors are and how an IoT developer can take advantage of the platform?

The Bluemicrosystem (BM) Bluetooth Smart sensor node is a quick-start platform composed of an STM32 Nucleo microcontroller development board based on an STM32 MCU and various X-Nucleo expansion boards peripheral boards. The BM is available in three different flavors (BM1, BM2 and BM3) that address the main needs of many of the IoT application in the Smart Things and Wearables, Smart Home, Smart Industry, and Smart City segments. All the Bluemicrosystems platforms are equipped with Bluetooth Smart connectivity through Bluetooth Smart expansion boards.

Could you describe in more detail some of these Bluemicrosystem platforms and tell us which specific applications they target?

The Bluemicrosystem features sensors for motion (3-axis accelerometer, 3-axis gyro, and a 3-axis magnetometer) and environment (pressure, humidity, and temperature) that address a broad range of Smart Things, Fitness and Wearable applications to provide functions such as tap and double-tap detection, tilt and wake-up detection, and orientation, in addition to all of the capabilities in the Open.MEMS middleware libraries.

The Bluemicrosystem2 adds a microphone expansion board that can host (up to 4) microphones, in addition to the motion and environmental sensors from Bluemicrosystem1. In addition to sensor fusion, the microphones support the Bluemicrosystem2 suite of audio algorithms made available through the STM32 Open. Audio middleware libraries and a unique voice-over-BLE profile. With these supports, Bluemicrosystems2 is the perfect platform to address applications like home or office voice-assistant applications.

Could you elaborate the unique value proposition of the Open.MEMS and Open.Audio middleware libraries for IoT developers?

Open.MEMS and Open.Audio are two free and easy-to-use catalogs of software libraries for the development of best-in-class MEMS sensor and microphone applications that achieve the high level of accuracy required by portable and wearable devices and other IoT emerging applications.

All of the libraries allow IoT developers to reduce their development time; they were developed using the most advanced machine learning techniques. All of the libraries allow IoT developers to reduce their development time; they were developed using the most advanced machine learning techniques.

Open.MEMS is a catalog of several libraries that were developed and subsequently optimized for low power/battery-operated applications. All of these libraries can be downloaded from www.st.com just searching for Open.MEMS in the search engine.

i. Sensor data fusion with Gyroscope bias and magnetometer calibration routine

ii. Real-Time Activity recognition that provides real-time information on user activities (stationary, walking, fast walking, jogging, biking, and driving).

iii. Real-time Carrying position that provides real-time information regarding the position/location of the board (e.g. on a desk, in the hand, near the head, in a shirt pocket, a trouser pocket)

iv. Real-Time Pedometer software that provides real-time information on number of steps and cadence.

v. Real-Time Gesture recognition that provides real-time information on phone-related gestures such as wake up, glance, and pick up.

The Open.Audio catalog of software libraries simplifies the evaluation, design, and development of embedded audio applications enabled by ST’s MEMS microphones and STM32 microcontroller processing capabilities. All of the libraries can be downloaded from www.st.com by searching for Open.Audio in the search engine.

i. The osxBlueVoice profile library implements the transmission of Voice over Bluetooth Smart, an innovative function that leverages the advanced features of ST’s BlueNRG network transceiver. The associated BlueVoiceLink implementation example — available in the Open.Framework catalog — includes all the required drivers and middleware for Bluetooth Smart communication and code for real-time audio recording using ST’s digital MEMS microphones.

ii. The osxAcousticBF software implements a real-time adaptive beam-forming algorithm. Using the audio signals acquired from two digital MEMS microphones, it creates a virtual directional microphone pointing to a fixed location in space. The library supports a dynamic trade-off between complexity and acoustic performance.

iii. The osxAcousticEC software implements a real-time echo-cancellation routine based on the well-known SPEEX implementation of the Multi-Delay Filtering (MDF) algorithm. The function includes automatic gain control and preprocess options, as well.

iv. The osxAcousticSL software implements a real-time sound-source localization algorithm. Using 2 or 4 signals acquired from digital MEMS microphones, it calculates the Direction of Arrival of a real-time adaptive beam-forming algorithm. Using the audio signals acquired from two digital MEMS microphones, it creates a virtual directional microphone pointing to a fixed location in space. The library supports a dynamic trade-off between complexity and acoustic performance.

v. Real-Time Gesture recognition that provides real-time information on phone-related gestures such as wake up, glance, and pick up.
Are schematics, BOM and PCB/Gerber files available for the Bluemicrosystem?

Schematics, BoM and PCB/Gerber files are available for the Bluemicrosystem. Each Bluemicrosystem platform has a dedicated webpage that lists all the expansion boards needed and provides the schematics, BoM, Gerber files, application notes, and the software that a user needs to run the platform.

What’s the learning curve for using the Bluemicrosystem for someone who’d like to quick prototype an IoT application? Is it “plug-and -play”? Is example code available?

Each Bluemicrosystem platform comes with a “Quick-Start Guide” that explain to the developer how to easily assemble the X-Nucleo expansion boards, how to download the software, program the boards and run the sample application in a few minutes.

We want to give the user an out of the box experience, so we provide pre-compiled binary of the Bluemicrosystem. Since once connected to the laptop via USB the microcontroller board (the Nucleo board) will show up as a USB drive the developer will have to simply drag and drop the binary into the Nucleo board to program it.

Are there apps available for the developers?

Yes. The Bluemicrosystem is an end-to-end platform that provides developers with the main building blocks to build their IoT—or other—device: the HW components, the SW libraries, the algorithms, and of course, the apps.

The apps are available both for Android and iOS and can be downloaded from Google Play and iTunes.

The apps are also available as SDKs on github, so developers can jumpstart their development when they want to design a smart phone user interface that exploits all the functions of the ST sensors, along with, all the Open. MEMS and Open.Audio libraries.

Developers can also use the apps to acquire and log sensor data and to perform Over-The-Air (OTA) Firmware upgrades.

How does ST address the developers’ need for cloud-connected sensor nodes and what platforms does ST address?

In the cloud segment, ST provides end-to-end solutions that allow the developer to “securely” connect a sensor node to the most popular cloud services, including Microsoft Azure and IBM Watson. At ST we call these connectivity tools “STM32ODE function packs” and, as we do for Bluetooth Smart, we provide them as pre-packaged solutions that can be downloaded from www.st.com. Moreover, the “quick-start guides,” available for all the STM32ODE function packs, provide a step-by-step guide to the installation and evaluation process.

ST advertises “innovative semiconductor solutions for Smart Driving and the Internet of Things.” Does ST anticipate a part of its broad portfolio to be dedicated to these two relatively new industries, or is ST taking a more wait-and-see conservative approach?

ST’s focus is fully on Smart Driving and the Internet of Things, along with those applications that are growing the most in the next years —so we are fully looking forward.

For entrepreneurs whose time is limited and valuable, how much time, roughly speaking, is required (minutes, hours, days) for these solutions to be operational?

While every engineer and every design is different, it really takes just a few minutes to download and program the STM32 Nucleo development boards and STM32 X-Nucleo expansion boards using the binaries available in the software packages that can be downloaded from www.st.com. Moreover, the “quick-start guides,” available for all the STM32ODE function packs, provide a step-by-step guide to the installation and evaluation process.

Regarding the Internet of Things and the Maker movement, does ST support entrepreneurial and start-ups businesses in the same fashion, in customer service and technical support, as it does with large and established companies?

ST strongly supports all of our customers. In particular, in the Internet of Things, our customers run the full gamut of companies—from our largest customers to the tens of thousands of smaller and equally important customers who we serve through our distribution partners and mass-market initiatives. All of these customers are important to us. ■

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ST Intelligent Gateways are pre-integrated and pre-validated embedded hardware and software subsystems that bridge data flow between edge devices and the cloud. Designers can accelerate time to market and significantly reduce development cost by using the ST building blocks to enable secure wireless data flow in Machine-to-Machine (M2M) applications. The ST edge solution integrates a multi-sensor array to a variety of ready-to-go wireless interfaces, including a cellular modem, Wi-Fi and Bluetooth Low Energy solutions.

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The demos include a variety of example application GUIs that present the sensor data, including sophisticated dashboard designs.

The ST Intelligent Gateway includes a common set of API-based services to accelerate interface design, facilitate set-up, configuration and management. The gateway enables developers to immediately power-up, connect the system and input basic network and customer information. A simple virtual COM port based serial link achieves this. The demos include a variety of example application GUIs that present the sensor data, including sophisticated dashboard designs. The intelligent gateways do more than simplify design: intelligence and control functionality moved into the embedded edge enables seamless integration of cloud services for data, including filtering, proxy services and secure personality management. Engineers without embedded networking expertise can now integrate web-service-enabled intelligence into IoT products.

The Wi-Fi demonstration, based upon a three board stack, enables designers to test configuration of an IEEE 802.11 b/g/n Wi-Fi hotspot and to connect sensor data from the X-NUCLEO-IK50I0A1 motion MEMS and environmental sensor evaluation board system. The MEMS development system utilizes the LSM6DSO 3-axis accelerometer and 3-axis gyroscope, an LIS3MDI 3-axis magnetometer, an LPS25HB pressure sensor and an HTS221 humidity and temperature sensor. Use a serial link like Teraterrm to setup SSID and obtain the physical MAC address and sensor data is immediately available via IBM’s Watson IoT Platform webviewer. The Bluetooth Low Energy (BLE) demonstration is a three-stack system that utilizes the same MEMS sensor board in combination with an X-NUCLEO-IDBO40A1 BLE evaluation board. The BLE evaluation board is based around the BlueNRG, a low power network coprocessor compliant with BTLE 4.0 and BALF-NRG-01D3. Install the ST Intelligent Gateway Application from Android or Apple stores and configure the Bluetooth interface by pairing with a mobile phone. Sensory data now streams directly to the phone. A freeboard.io dashboard application is visually present for the sensor data in the demonstration.

The cellular network demonstration provides an example design for engineers that need to connect an embedded product over 2G, 3G and 4G LTE cellular modem varieties for CDMA and GSM networks with both North American and European SKUs support. The Nimbelt™ shield is compatible with all STM32 Nucleo boards, and allows incorporation of any Skywire modem module. The demonstration includes visual dashboard-style presentation of the outputs of the four sensors integrated on the Skywire mbed shield. As the mods are pre-approved for use on Verizon networks with specially optimized data packages immediately available, designers can get M2M solutions immediately up and running over mobile networks.

The cellular board also incorporates an adjustable potentiometer for manual level adjustment. Integrate further shields through stacking expansion headers enabling the addition of sensor, actuator and data logging peripherals. The processor sends collated data from sensors and board stack to the cloud via the selected wireless modem.

The ST Intelligent gateway demonstrations to accelerate your IoT project timetable. Using an integrated solution empowers engineers to focus on adding new features rather than reinventing the wheel. Pre-validated and pre-approved wireless modem technology avoids considerable cost and delay in the development process. The flexibility of the board-stacking paradigm and the comprehensive serial interface capability of the STM32F401 development kit enables the gateway to bridge data from legacy devices and connect them to the cloud. This provides a pathway to layer network connectivity on existing designs, maximizing reuse. Use the STM 32 open development environment to build up a hardware architecture with all the functionality required. Rapidly develop software with an integrated development environment that includes predesigned Hardware Abstraction Layer (HAL), advanced middleware and the STM32Cube expansion software. Open-X expansion software can be downloaded to obtain pre-integrated packages targeting specific applications. Turn your prototype into a product in one design step and commercialize designs with less development iterations. ■
ST Wireless

Sensor Nodes Provide Access to Cloud

The NimbeLink STMicroelectronics Nucleo mbed shield is an expansion board that provides cellular modem and multi-sensory capability compatible with the STM32F401 microcontroller development kit. The shield features a plug-in compact cellular modem module to enable rapid development of network connected IoT products. The module reduces cost, delays and design complexity caused through requiring obtaining FCC and carrier certifications. Any of NimbeLink’s Skywire™ end-device certified cellular modem modules can be installed on the shield. The Skywire™ socket supports 2G, 3G and 4G LTE cellular modem varieties for CDMA and GSM networks, along with both North American and European SKUs. The shield pin-out and physical connection footprint is compatible with all STM32 Nucleo boards.
Dynamic Efficiency™ range of 84MHz Cortex®-M4 devices. The integrated Arduino™ connection and ST Morpho header enable easy expansion of peripheral functionality with a wide choice of specialized compatible shields. This allows for the addition of capabilities like touch screens, GPS receivers, motor controllers and sensor boards. The Skywire mbed demo example enables designers to get a cloud-based sensor monitoring system up and running immediately. The freeboard™ dashboard application visually presents data streaming from the development kit to the PC using dweet.io from Buglabs.

Mbed is ARM’s powerful online development platform that simplifies and accelerates deployment of IoT devices through providing a compiler and simple embedded operating system. Easy device connection to the Internet while freeboard empowers designers to build beautiful dashboards and control panels to visualize sensor data. The combination of software, Skywire shield and Nucleo mbed dev kit enables rapid creation of stunningly beautiful monitoring applications. The Nucleo board integrates to the ST-LINK/V2-1 debugger/programmer for finer grained debug and development via an on-board SWD/JTAG connector with a wide choice of Integrated Development Environments (IDEs) including IAR®, Keil® and GCC eclipse-style tool suites.

The Skywire sensor shield is an excellent complement to the F401 dev kit, extending its capabilities substantially to empower IoT applications. The four sensors and cellular connect functionality add to the platform’s features. These include flexible power supply architecture enabling power through USB or an external source, user definable LEDs, virtual serial COM port, 16 channel 12 bit ADC, real time clock (RTC) and USB drive style drag and drop programming. The large non-volatile flash memory (512k bytes) and SRAM (96k bytes) provide sufficient capacity for complex applications. Designers can expand upon the Skywire reference design to get their applications connected to cellular networks and the internet as soon as possible. The Skywire modems have the additional benefit of certification with Verizon, enabling no-hassle cellular network connection. Verizon has flexible data service bundles and SMS plans specific to IoT and M2M applications that can be set up online with immediate activation. SIM cards are available from a number of sources. Developing Machine to Machine (M2M) data or SMS messaging (native voice interface is not supported) interface development to a remote webserver has never been easier.

NimbeLink’s technical support includes a comprehensive solution-based knowledge base and how-to guides on issues like provisioning services on Verizon, checking cellular signal strength, connectivity troubleshooting and even on starting PPP links on boot up. NimbeLink provides application notes for sending and receiving data to and from Windows, Linux and embedded devices. Consider using the Skywire mbed shield for your next remote monitoring application that requires a cellular RF connection. Simply connect a virtual COM port, follow a few basic steps and your cloud connection is ready to go!

Modem module installation is easy: simply attach the UMC connector for the integrated RF antenna connector and then insert the module onto a connector on the shield. The shield can then plug directly into the F401 dev kit (make sure to set its jumpers for external power supply). The board incorporates five additional sensors, including a three-axis accelerometer, temperature sensor, humidity sensor, ambient light sensor and an atmospheric pressure sensor. An adjustable potentiometer is also included to facilitate manual control calibration.

The shield includes Arduino™ expansion headers, enabling further shield placement on the board stack, enabling integration of additional sensor, actuator and data logging shield peripherals. Data, once collated from the sensors and stack by the processor can upload to the cloud via the cellular modem.

The low-cost, flexible STM32 Nucleo board is an open development platform that enables rapid implementation of prototypes with STM32 microcontrollers. The STM32F401 is a part of the STM32

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