# Modular Architecture for Wireless Sensor Network Nodes

J. Portilla, A. de Castro, E. de la Torre, T. Riesgo
Universidad Politécnica de Madrid
E.T.S.I. Industriales. División de Ingeniería Electrónica
e-mail: jportilla@etsii.upm.es

This work presents a modular node for wireless sensor networks. This node is composed of four layers, each one fulfilling a specific functionality of the node. These four layers are communication, processing, power supply and sensing/actuation (Fig. 1).

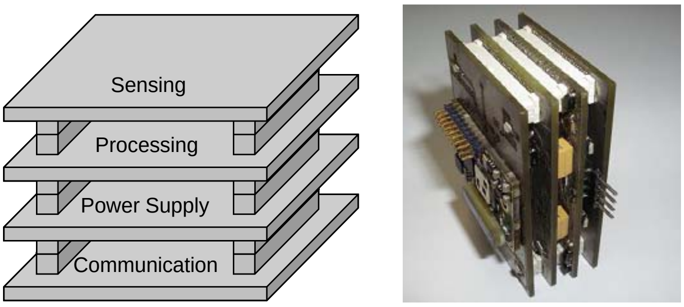

Fig. 1 Architecture and aspect of a node

The benefits of modularity are a low redesign effort and the possibility of interchanging between different layers depending on the requirements of the application. This makes the node very versatile and adaptable. Modularity reduces redesign, as each module is not started from scratch, and cost when the work environment changes. The concept is to have different implementations of each layer to be stacked together in order to create a node adapted to the requirements of the application (Fig. 2).

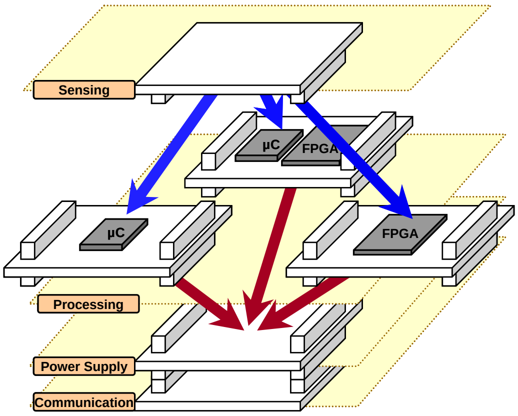

Fig. 2 Modularity of the node

A physical node has been constructed to test the modularity concept. The heart of the node is the processing layer. In this first prototype, a mixed design composed of an ADuC831 μC from Analog Devices and a XC3S200 Spartan III FPGA from Xilinx has been chosen, in order to give as much flexibility as possible to the node. In simple applications only one of the devices (the μC or the FPGA) could be used (Fig. 2). The μC deals with communication control and signals coming from analog sensors (the μC has a 227 kSPS ADC integrated) or simple digital sensors. In the other hand, the FPGA processes signals coming from the rest of digital sensors, releasing the μC from complex processing. Moreover, the FPGA gives much flexibility to the node, allowing testing several different approaches in the data process.

The communication layer allows the node to send and receive data to other nodes or to a base station, and to be part of a sensor network. Bluetooth technology was chosen in a first prototype of the node, due to its suitable data rate and its low power consumption. The communication layer includes an OEMSPA13i

Bluetooth module from ConnectBlue, which allows the creation of piconets with a master and up to 3 slaves. The Bluetooth module is controlled through its UART port. The µC sends AT commands in ASCII format to the module, controlling all the tasks related to node communication with the network. Creation of scatternets is not trivial using Bluetooth, and Zigbee technology is being implemented in a new communication layer, so two different technologies will be available for the communication, allowing choosing between both without redesign the node.

The power supply layer distributes different voltages to the node (3.3 V, 2.5 V and 1.2 V). This layer includes of linear regulators and capacitors. The power consumption of this layer must be optimized and a switching converter may be a possible solution.

Finally, the sensor layer is the connection with the physical world. Almost every physical parameter can be measured and processed in the node, and communicated to the network. The first prototype presents two different sensor layers, as a first demonstration of modularity, and it is possible to interchange them. The first one includes three temperature sensors to test different interfaces in the processing layer. The second one includes humidity, temperature, acceleration and light sensors. The sensor layer can be adapted to the application due to the versatile processing the node has.

The layers are stacked through vertical connectors, which fulfil both electrical and mechanical connections. This architecture allows interchanging between different layers in a very easy way (Fig. 2). The result is a very robust node, with cubic aspect.

Signals are distributed in a standardised way, in order to make the design of the layers independent one from the others. In this way, analog signals from the sensors and some digital signals go to the connector 1 (the closest to the µC) and digital signals go to the connector 2 (Fig. 3). Several general I/O from the FPGA are available in the connector 2 for processing, as well as I/O ports from the µC. Power supply is distributed through every layer.

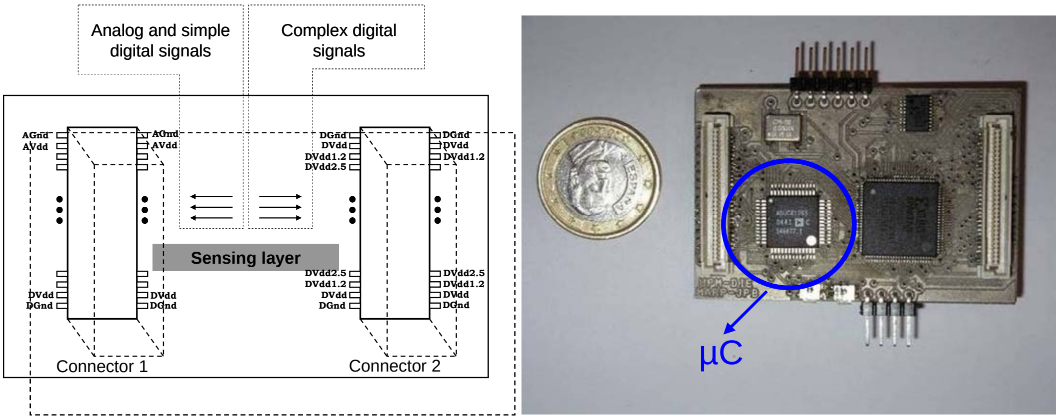

Fig. 3 Signal distribution in the connectors and processing layer

This platform was designed in order to test different concepts related to the sensor networks discipline like processing, power consumption, communication, etc. It can be adapted to very different situations changing one or more layers with a minimum effort. The size of one full node is 40 x 60 x 20 mm.

A first application for this modular platform is sensing different physical parameters in refrigerated trucks. Perishable goods like fruits and vegetables may lose quality level and market price due to sudden ambient changes and unsuitable manipulation. Monitoring of several parameters like acceleration, temperature, humidity, etc, helps to improve the way this merchandise is transported. Different tests will be carried out in the next months.