

# Erika and Open-ZB: an implementation for real-time wireless networking

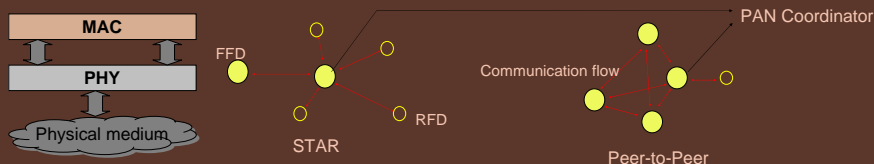


Paolo Pagano, Mangesh Chitnis, Antonio Romano, Giuseppe Lipari  
 ReTiS Lab. - Scuola Superiore S. Anna - Pisa (I)  
 Ricardo Severino, Mário Alves, Paulo G. Sousa, Eduardo Tovar  
 Polytechnic Institute of Porto - Porto (P)



Wireless Sensor Networks (WSNs) are emerging as enabling infrastructures for various types of large-scale distributed embedded applications. Some of those applications do not pose stringent timing requirements on data delivery. There are however a number of other applications in which timeliness is of great importance (industrial automation, process control, etc.). In addition to an increased robustness and fault tolerance, each node is expected to perform computations in real-time and to send large amounts of data with guaranteed Quality-of-Service (QoS).

The IEEE 802.15.4 protocol specifies the Medium Access Control (MAC) layer and the Physical Layer for Low-Rate Wireless Personal Area Networks (LR-WPANs). In IEEE 802.15.4 the star and the peer-to-peer topologies are supported as shown in the figure.

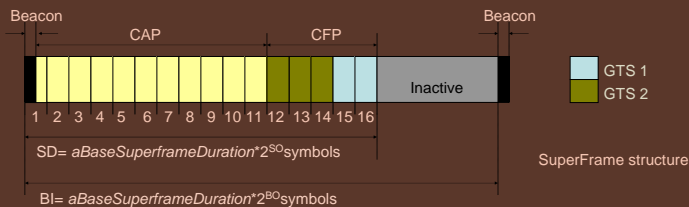


Two different device types can participate in an IEEE 802.15.4 network:

- full-function device (FFD)
- reduced-function device (RFD)

Data transfer mode:

- Beacon enabled (use of Superframe)
- Non-beacon enabled (unslotted CSMA/CA)

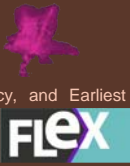


ERIKA Enterprise is a multi-processor real-time operating system for small microcontrollers:

- available in double licensing: GPL and commercial;
- implementing APIs similar to OSEK/VDX;
- having a very small RAM footprint (~3 Kbytes);
- supporting innovative scheduling algorithms (Fixed Priority, Stack Resource Policy, and Earliest Deadline First) suited for real-time applications.

ERIKA runs on several platforms (e.g. Microchip dsPic, Amel Atmega128, Altera NIOS II).

FLEX is the ERIKA Enterprise development board for MicroChip dsPic.



The Open-ZB toolset is available as open-source and aims at implementing, testing and evaluating the functionalities defined in the IEEE 802.15.4 standard as well as new add-ons.

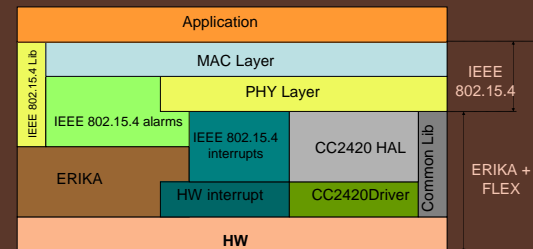
The IEEE 802.15.4 implementation in ERIKA supports the beacon-enabled mode, therefore includes functionalities such as the slotted version of the CSMA/CA algorithm, and the GTS mechanism.

Open-ZB is ported to TinyOS, Contiki, and ERIKA microkernels.

The implementation of the IEEE 802.15.4 (Open-ZB) protocols in ERIKA is organized in a layered architecture. In this design we implemented the MAC and PHY services making use of Operating System primitives, generic libraries and hardware-dependent features. The software architecture is depicted in the following figure.

The IEEE 802.15.4 layer (structured in IEEE 802.15.4 Lib, Alarms, and Interrupts) contains the code to initialize the hardware timers, as well as the communication between the CC2420 transceiver and the MCU, and to handle timer and transceiver interrupts.

The IEEE802.15.4 Lib implements the PHY and MAC layers of IEEE 802.15.4 standard.



The ERIKA layer is responsible for managing the system hardware resources providing the typical OS services such as Task management, resource access control (e.g. memory), interrupt and timer management (providing software abstractions).

We compare the performance (Throughput and Packet Delivery Ratio) of our system (ERIKA + Open-ZB on FLEX) with respect to other popular ones, namely: TinyOS 2.0 + BMAC on Telos-B ; TinyOS 2.0 + Open-ZB on Telos-B.

## TestBed

Measurement of Throughput and Packet Delivery Ratio in a star topology where Constant Bit Rate (CBR) traffic is directed to the PAN coordinator.

The metrics are evaluated against the traffic rate.

- Parameters:
- MAC payload = 104 bytes;
  - Number of packets = 1000.

