EZMAC®PRO OVERVIEW

1. Introduction

This application note gives a general overview of wireless networks and network protocols. It introduces EZMacPRO (EZHop), describes how the protocol stack fits into the wireless network, and addresses some of the standard questions raised when implementing a protocol stack, such as:

- What is a wireless sensor network?
- What are the EZMacPRO and EZHop software modules?

2. Wireless Networks

A wireless sensor network is a collection of inexpensive computational nodes that can measure local conditions or environmental parameters and send that information wirelessly to a central location for the appropriate manipulation by the main application node. Typically, wireless sensor nodes sense variables, such as the environment, or perform basic data processing and then transmit the result or data to a central data collection node. Sensor networks are common with many applications in many different markets, including:

- Health Applications
  - Remote monitoring of physiological data
  - Tracking and monitoring doctors and patients inside a hospital
  - Drug administration
  - Elderly assistance
- Home Applications
  - Home automation
  - Instrumented environments
  - Automated meter reading
- Commercial Applications
  - Environmental control in industrial and office buildings
  - Inventory control
  - Vehicle tracking and detection
  - Traffic flow surveillance
- Military Applications
  - Monitoring friendly forces
  - Battlefield surveillance
  - Targeting
  - Nuclear, biological, and chemical attack detection
- Environmental Applications
  - Forest fire detection
  - Flood detection

3. Network Protocols

The network communication protocol is a well structured software stack designed to ensure that the appropriate data reaches its destination with minimal lost data packets. Most communication protocols are structured as suggested by the Open Systems Interconnection (OSI) reference model. The OSI model divides the communication system into layers, with each layer serving a specific purpose.

The OSI defines the purpose and working architecture of each layer and then makes recommendations for the interactions between layers. The layer structure consists of seven individual layers as shown in Figure 1.

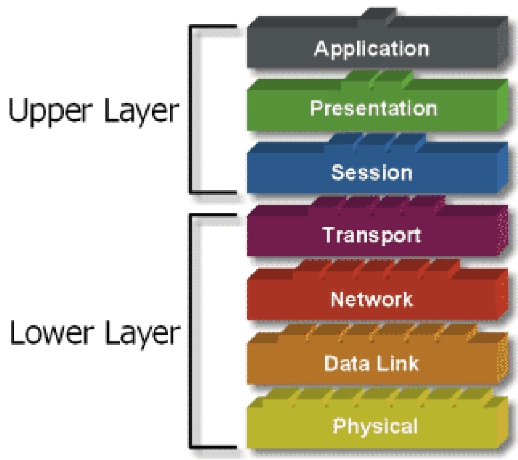

Figure 1. OSI Model

- Physical Layer
  - Delimits and encodes the bits onto the physical medium
  - Defines electrical, mechanical, and procedural formats
- Data Link Layer
  - Transfers data units from one network node to another over the transmission circuit
  - Ensures data integrity between nodes
- Network Layer
  - Routes and relays data units across a network of nodes
  - Manage flow control and call establishment procedures
- Transport Layer
  - Ensures end-to-end data transfer and integrity across the network
  - Assembles (and breaks into smaller portions) packets for routing by Layer 3
- Session Layer
  - Coordinates connection and interaction between applications
  - Establishes dialogue; manages and synchronizes direction of data flow
- Presentation Layer
  - Negotiates syntactic representation and performs data transformation, compression, and code conversation
- Application Layer
  - Applications and application interfaces for OSI networks
  - Provides access to lower layer functions and services

Not all layers of the OSI reference model need to be implemented since, in certain implementations, layers may be combined or omitted depending on the complexity of the application. Such simplifications of the OSI model are essential in small embedded wireless sensor networks where system resources in the embedded MCU are limited or the cost of wireless nodes is critical. A classic example of this consideration can be seen when comparing proprietary type networks to standards-based networks. For example, standards-based ZigBee stacks can reach memory requirements of 128k whereas proprietary based stacks, such as those based upon EZMac, may only reach 10k.

4. The EZMacPRO and EZHop Software Modules Position in the OSI Model

EZMacPRO and EZHOP software modules are designed to only contain the low-level functions according to the OSI model, and their implementation provides the two lowest layers: the Physical and the Data Link layer. This design allows EZMac to satisfy the needs of most network designers.

This implementation allows Silicon Laboratories to provide the common layers as a starting place upon which customers can write higher layers where the design can be best optimized for their application. EZMacPRO/EZHop use a common, well-defined API enabling designers to easily add these higher level layers.

As designers learn about network implementation, they often decide that simpler, smaller networks do not require these additional layers, and the network structure can be represented by the model demonstrated in Figure 2. In this case, the two lower layers are implemented using EZMac and EZHOP and the Application Layer is similar to that used in wired or infra-red implementations.

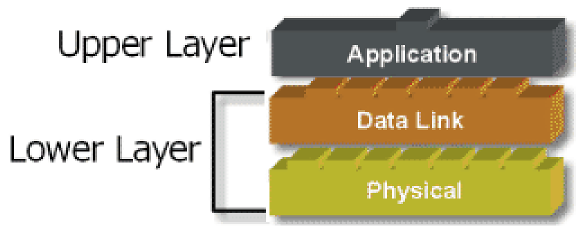

Figure 2. Protocol Scheme with EZMac and EZHOP

Designers wanting to see an example of a simple star network implementation (where network forming and network management are implemented in the application layer) may wish to review the EZMac Programming Guide for further details.

5. EZMacPRO and EZHop Software Modules

EZMacPRO and EZHop solutions are wireless communication software modules for embedded systems using the EZRadioPRO-based radio. Both EZMacPRO and EZHop are implemented as a single-source code. They have the same programming interface (API) serving the same OSI layers; however, they are designed for very different and specific applications.

The EZHop module is a frequency-hopping module designed to provide up to 50 individual channels for communication. It is primarily designed for applications that must meet FCC Part 15 Section 247 in order to transmit at high powers (above –1.2 dBm).

According to the FCC requirement for frequency hopping systems operating in the 902–928 MHz band, if the +20 dB bandwidth of the hopping channel is less than 250 kHz, the system must use at least 50 hopping frequencies. The maximum allowed +20 dB bandwidth of the hopping channel is 500 kHz.

In systems where high output power can be used without the need for compliance to FCC regulations, such as in applications aimed at meeting the ETSI regulations in Europe, the standard implementation of the EZMacPRO stack without the EZHop routines is a good choice.

The standard implementation of EZMacPRO supports frequency hopping of up to four channels to increase the robustness of communication. Robustness is increased because the likelihood of all channels being blocked by other transmitters is vastly reduced. The reduction of channels makes the system more power efficient because the transmitted packets contain fewer preamble bytes. In addition, the use of fewer channels makes it possible to implement additional features without adding timing complexity to the stack. This makes feature implementation easier and more robust (e.g., auto transmit on all channels, antenna diversity, etc.).

EZMacPRO and EZHop solutions transmit and receive data in short packets via an RF link in the ISM band. These routines run as background tasks (two interrupt service routines) on the main application microcontroller. No part of the MAC engine is run in the foreground loop; so, it can be used exclusively for the embedded application.

The EZMacPRO module supports a wide range of addressing modes, packet filtering modes, collision, and error-detection schemes. Additionally, the EZMacPRO module provides a built-in acknowledgement and packet forwarding feature. The EZMacPRO module is also compatible with earlier versions of EZMac, which were designed to support the EZRadio family of devices.

EZHop additionally supports a wide range of addressing modes, packet filtering modes, and collision detection with the built-in acknowledgement and packet-forwarding feature while implementing an advanced frequency search mechanism used to find valid packets during the receive process.

By design, EZMacPRO and EZHop are intended for small networks and are used to easily build peer-to-peer or star networks. The node count is 255 per subset with a maximum subset count of 255. The EZMacPRO and EZHop routines are designed to be used in low-node-count wireless networks to specifically avoid the need for a network management feature, thus, again, avoiding the cost overhead of processing, memory, and power requirements. If larger networks are required, users can add this layer above the standard EZMac layers.

Both EZMacPRO and EZHop solutions can theoretically support mesh networking; however, this network topology is not coded into the current implementation of the EZMac stack. The current stack provides no network organization or self-healing feature since the large majority of applications do not require them, and minimal processing, power, and memory requirements are key.

EZMacPRO and EZHop support transmitter, receiver, and transceiver devices from the EZRadioPRO family. To optimize code size for a given application, some features can be disabled before the compilation of source code.

NOTES:

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