Lab 1

Introduction to Xbee Zigbee

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GitHub Repository

Introduction

This lab focuses on introducing the group to the XBee Zigbee board. To better familiarize ourselves with how the board works, we focused on answering questions using the manuals. After working through the questions, we moved on to setting up a basic wireless network to send messages between three Zigbee boards.

Part 1: Set up your XBee Devices

a. Why should you make sure the development board is NOT powered when you plug in or remove the XBee module?
   - The development board should not be powered when you plug in or remove the XBee module, as it could cause voltage spikes that would damage the XBee module.

b. What is the difference between the XBee THT and XBee SMT Grove development boards?
   - The THT differs from the SMT Grove development board because it does not have spring sockets to push in the XBee module. Instead, it has a through-hole and surface mount design.

c. What is the loopback jumper and what does it do?
   - SMT: The loopback jumper is a three-pin jumper that connects the UART to the USB (normal mode) or makes a loopback connection between the Rx and Tx signals of the UART.
   - THT: Similarly, the loopback jumper is a three-pin jumper that connects the UART to the USB (normal mode) or makes a loopback connection between the Rx and Tx signals of the UART.

d. How can you power the XBee Grove Development Board?
   - You can power the XBee Grove Development Board from the 5-volt supply available on the USB. The board has a 3.3-volt regulator that generates a 500 mA supply.

e. What is the maximum voltage that can be applied to XBee GPIO pins?
   - 3.6 Volts

f. What is the indoor/urban range of the XBee?
   - 60 meters / 200 feet

g. What is the maximum RF transmit output power?
   - mW: 6.3 mW
   - Watts: 0.0063 W
   - dBm: +8 dBm
   - dBWatts: -22.01 dBW

h. What is the RF data rate?

- 250,000 bps

i. What is the receiver sensitivity?
   - -103 dBm

j. Why does understanding device specifications matter?
   - Understanding device specifications helps ensure proper network performance and prevents hardware damage. For example:
     - Scenario 1: Designing a sensor network where knowing the indoor range ensures all sensors remain within effective communication distance.
     - Scenario 2: Power management in battery-operated devices where knowing GPIO voltage limits prevents overvoltage damage.

Part 2: Download and Install XCTU

k. What operating systems are compatible with XCTU?
   - Windows Vista/7/8/10 (32-bit or 64-bit versions), Mac OS X v10.6 and higher (64-bit only), Linux with KDE or GNOME (32-bit or 64-bit versions)

l. What are the primary operating modes of XBee modules?
   - Transparent Mode (AT Mode): Acts as a direct serial line replacement, transmitting data exactly as received. Ideal for simple point-to-point communication.
   - API Mode: Uses structured packets (API frames) for advanced features like multi-device addressing, remote configuration, and delivery status tracking. Suitable for complex networks.

m. Sketch and label the fields in an Xbee API frame.
   - See Figure 1.

n. What is radio firmware?
   - Radio firmware is program code stored in a radio module's persistent memory that controls the device's operations.

Part 3: Configuring and Operating Modules

Part 3.1: Connect your XBee modules to XCTU

o. Take a screenshot to include in your lab report showcasing the Radio Modules section of the XCTU software and demonstrating the XCTU recognition of two of your group's Xbee radio modules.
   - See Figure 2.

Part 3.2: Configure All 3 XBee modules

We configured our three XBee modules using XCTU. One module was set as the coordinator, while the others were designated as a router and an end device. Once configured, we verified that all

nodes were in the same network using the "Discover radio nodes in the same network" function. See Figure 3, showing the successful configuration.

Part 3.3: Sending messages between 3 XBee Modules

p. Explain the steps involved in sending messages in Transparent (AT) Mode.
   - Transparent (AT) Mode
     1. Open XCTU and navigate to the Console tab.
     2. Connect to the router and end-device modules.
     3. Send the messages:
     4. "Hello from router (Router ID)"
     5. "Hello from end-device (End Device ID)"
     6. The coordinator receives and displays the messages.
   - See Figures 4 - 6.

q. Explain the steps involved in sending messages in API mode (without escapes).
   - API Mode (Without Escapes)
     1. Open XCTU and switch to API Mode.
     2. Construct and send structured API frames.
     3. The coordinator receives the data and displays the MAC address of the sending module.
   - See Figures 7 - 8.

r. Discuss the differences between the two processes.
   - Transparent Mode is simple and direct but lacks advanced control, while API Mode supports addressing, delivery confirmation, and remote configuration.

Conclusion

This lab introduced us to the XBee Zigbee module, XCTU software, and the process of configuring a wireless network. We successfully established a communication network between three XBee modules, sent messages using both AT and API modes, and explored the importance of understanding device specifications. These skills will be instrumental in future wireless communication projects.

Appendix

Figure 1: Fields in an Xbee API frame.

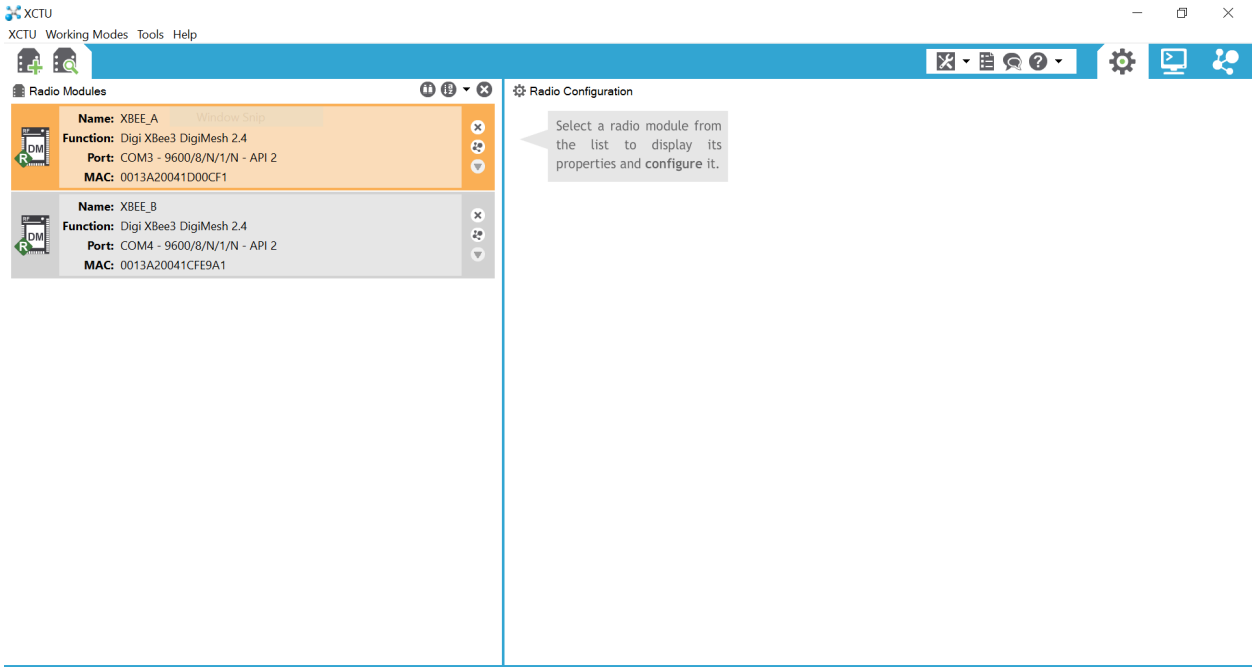

Figure 2: Screenshot showing two radio modules being recognized.

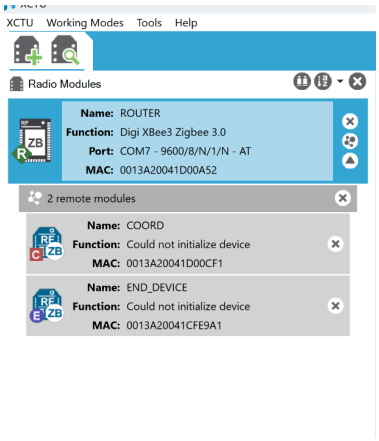

Figure 3: Screenshot showing one device detecting two additional radio modules.

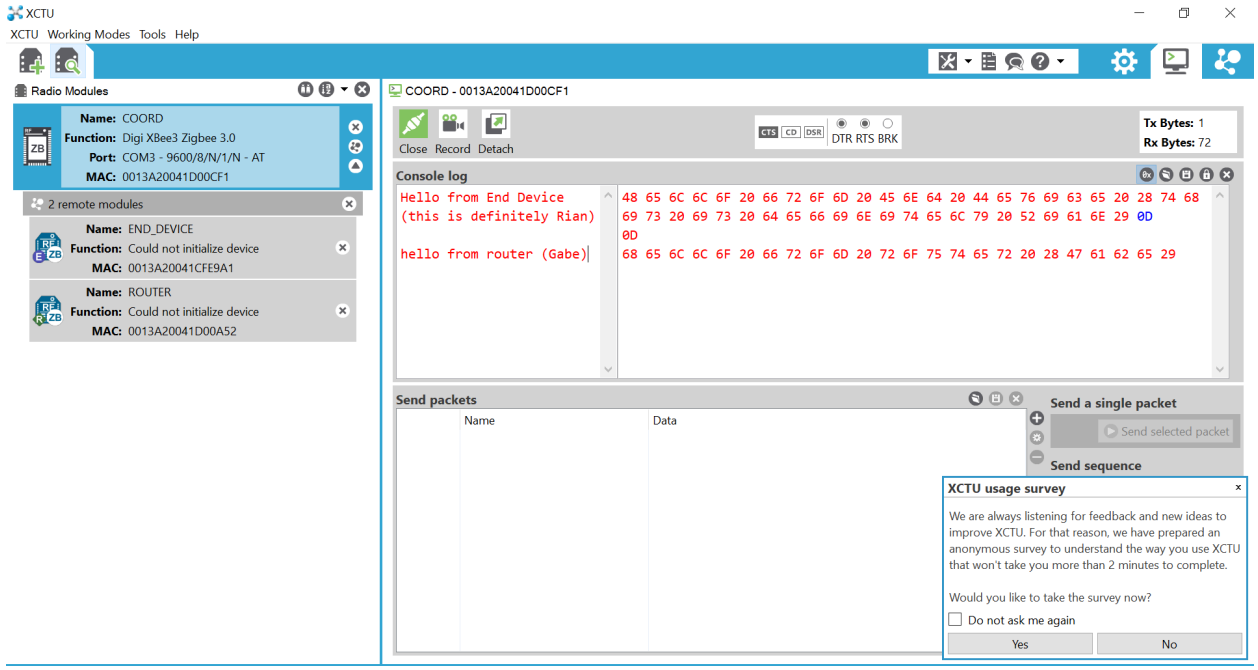

Figure 4: Screenshot showing the coordinator receiving messages from the end device and router in AT mode.

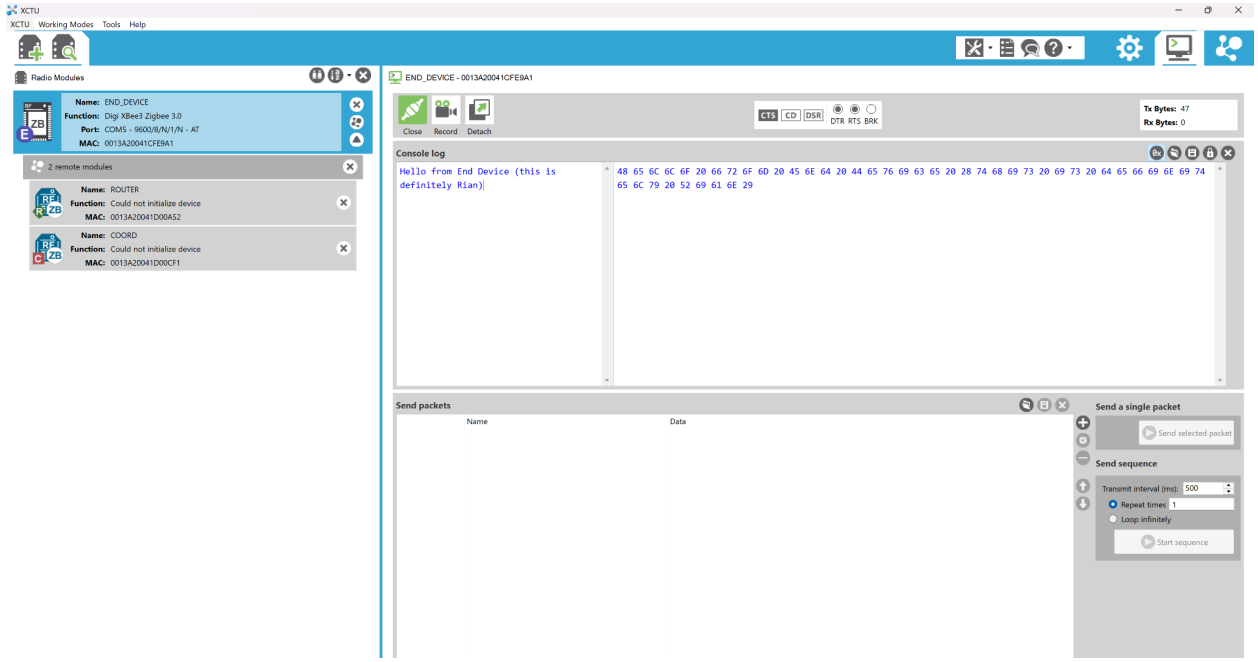

Figure 5: Screenshot showing the end device sending a message to the coordinator in AT mode.

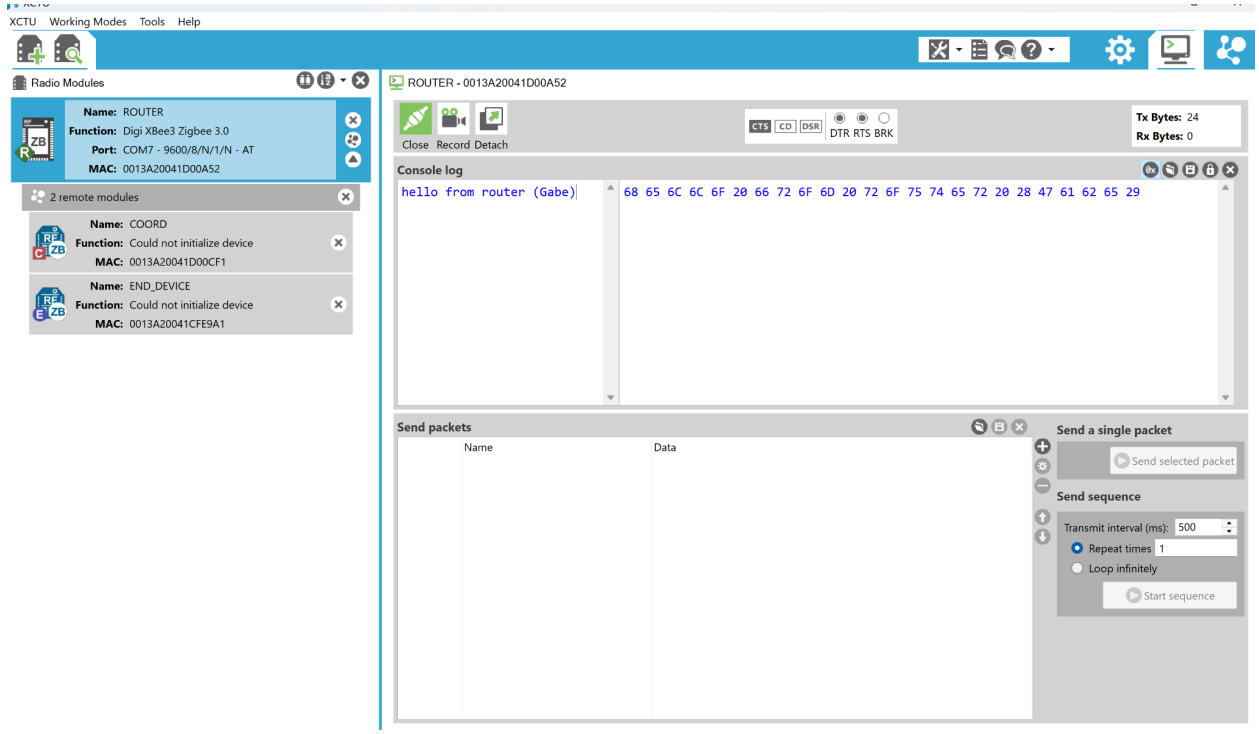

Figure 6: Screenshot showing the router sending a message to the coordinator in AT mode.

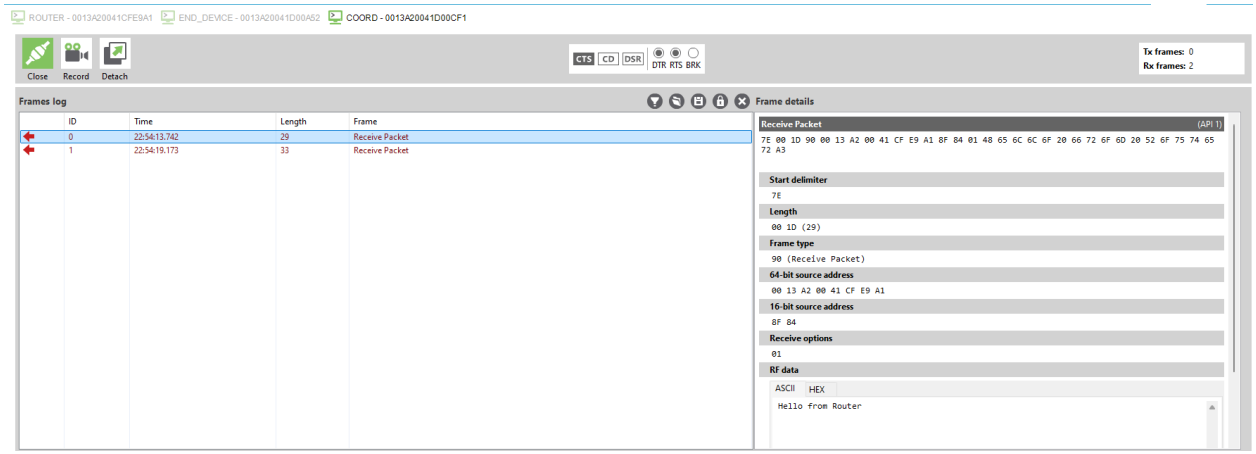

Figure 7: Message from router sent in a packet over API mode to the coordinator.

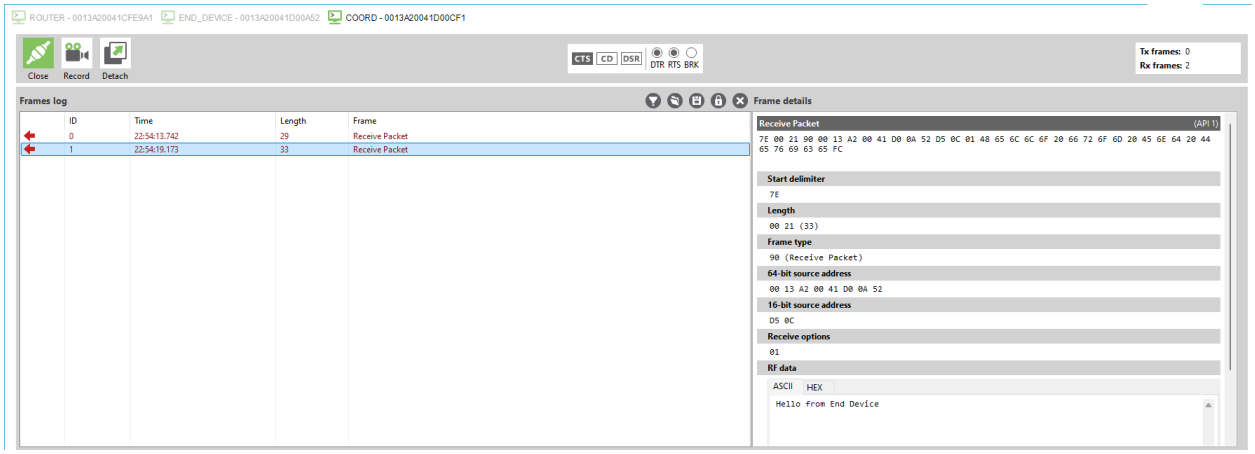

Figure 8: Message from end device sent in a packet over API mode to the coordinator.

References:

[1] Digi, “Get Started with Xbee Zigbee - Assemble the hardware,” Assemble the hardware, https://www.digi.com/resources/documentation/digidocs/90001942-13/concepts/c_assemble_hardware.htm?tocpath=Get+started+with+XBee+Zigbee%7CAssemble+the+hardware%7C_____0 (accessed Feb. 3, 2025).

[2] Digi, “XCTU Configuration and Test Utility Software User Guide,” XCTU User Guide, https://www.digi.com/resources/documentation/digidocs/90001458-13/default.htm#concept/c_90001458-13_start.htm?TocPath=_____1 (accessed Feb. 3, 2025).

[3] Digi, XBee Grove Development Board User Guide, https://www.digi.com/resources/documentation/digidocs/90001457-13/#common/t_pdf.htm?TocPath=_____2 (accessed Feb. 3, 2025).

[4] Digi, “Digi XBee 3 RF Module Hardware Reference Manual,” Digi XBee 3 Support Resources, https://hub.digi.com/support/products/digi-xbee/digi-xbee3/?path=%2Fsupport%2Fasset%2Fxbee3-hardware-reference-manual%2F (accessed Feb. 3, 2025).