ET016A Laboratory Exercise 3:
Wireless Networking with Contiki-NG

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1 Background and Goals

This lab extends our communication capabilities to higher communication layers. Instead of communicating only point-to-point between nodes, we add IPv6 networking and route packets using the RPL routing protocol. We will run networking applications on the Firefly nodes, and analyze them in the Cooja simulator.

After this exercise you should be able to:

- Configure applications to utilize IP communication
- Ping nodes in the network
- Communicate in a multi-hop network with and without border router
- Evaluate communication patterns in Cooja

1.1 Preparation

Read the following documentation pages. You can use the quiz on Moodle for some guidance what to focus on.

- Configuration
- RPL

1.2 Required Equipment

- a minimum of two Zolertia Firefly nodes
- a computer with the Contiki-NG development environment

1.3 Evaluation

This lab is evaluated through the demonstration of functional implementations.

Task 1: Pinging nodes in an IPv6 network

In the previous lab we communicated between nodes using just the lower two layers (i.e., physical and MAC layer), implemented with the IEEE 802.15.4 protocol. In this lab, we will add a networking layer implementing IPv6 communication. This is actually the default for Contiki applications and previously we actively had to tell the compiler not to include IP networking.

We can test connectivity between two nodes in a simple manner using the `ping` command. To do so, we need a node with enable shell. You can create a copy of the hello-world example and then follow the NG sheel tutorial here to enable the shell.

Using our newly created application, you can follow the IPv6 ping tutorial to find out about your nodes IPv6 addresses and test their communication. If you haven't changed anything, you should be able to see even nodes from other groups in the neighbor table of your own device. If you want to have your own network, which is recommended for the next tasks, you can use an individual PAN ID and frequency channel, as we learned in the previous lab.

Task 2: RPL networking without border router

Now that we know we have IP communication between our nodes, we will have a closer look at one important aspect of the networking layer, which is routing. Contiki-NG, by default, uses `RPL` as its routing protocol. RPL forms tree-like network topologies with routes directed towards a common root.

In order to have a first look at RPL, you should follow the RPL basics tutorial. For this tutorial, you will be able to use the same program as you have used in Task 1. Follow the tutorial using the Firefly nodes.

Task 3: RPL networking with border routers

In task 2, our network was standalone without any connection to the outside world. A great benefit of using IPv6 in our sensor network is that we can seamlessly communicate with the Internet (using the same kind of protocol). To establish the link to the outside world, while considering the limitations of our low-power devices, we can utilize what we call a `border router`.

In order to make your root node a border router and explore its capabilities, you can follow the RPL with border router tutorial.

Task 4: RPL networks in Cooja

As we only have a limited number of Firefly nodes, and routing only shows its real potential in multi-hop scenarios, this is a great opportunity for utilizing the Cooja simulator.

Task 4.1: RPL in Cooja

To test RPL in Cooja you can follow this tutorial. Adding multiple nodes and arranging them in a suitable manner should demonstrate RPLs routing capabilities to you.

If you view the 'Radio messages' window in the simulator, you can dig further down, observing all packets being transmitted. Here you can try to find the RPL packets (DIS, DIO, DAO) that we talked about in the lectures.

Task 4.2: RPL with border router in Cooja (optional)

You can also simulate networks with border routers in Cooja, tunneling data to your host PC. In order to explore this, you can follow the respective tutorial here.