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**DEPARTAMENTO DE ELECTRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA**  
**MESTRADO EM ENG. DE COMPUTADORES E TELEMÁTICA**  
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# **REDES E SISTEMAS AUTÓNOMOS**

## **AUTONOMOUS NETWORKS AND SYSTEMS**

### **PRACTICAL GUIDE 2 – B.A.T.M.A.N.**

#### **Objectives**

- Set up B.A.T.M.A.N. ad-hoc network
- Validate the multi-hop ad-hoc network with simple tests
- Observe the status of the network
- Try new topologies of the ad-hoc network to force different paths
- Analyse metrics of the network

#### **Duration**

2 weeks

## 1st week

### Introduction

The Better Approach to Mobile Ad-hoc Networking (B.A.T.M.A.N.) is a protocol for multi-hop mobile ad hoc networks. The official documentation is available [here](#).

In this practical guide, we will learn how to deploy a Wi-Fi ad-hoc network with support for multi-hop. Supporting more than one hop means the network will behave like a mesh network, where the nodes can reach other nodes that are directly or indirectly connected, if they are part of the same batman group and Wi-Fi channel.

### Environment

The setup we will be mounting for the experience uses [Nvidia Jetson Nano 2GB Dev Kits](#), and there is one available for each group of 2 students:



Nvidia Jetson Nano 2GB Dev Kit

Each Jetson is identified with a sticker, example “UW 306”. For this example, the **id** of the device is 6.

Every Jetson is already flashed with the official Nvidia image (Ubuntu-based) and it has already some pre-configuration (the batman binary is installed).

In terms of networking and authentication, the board is configured with the following:

- Hostname: jetson-**id**
- Ethernet interface: 192.168.3.**id** (it also accepts DHCP)
- SSH login
  - Username: jetson
  - Password: rsa2023

An USB Wi-Fi Adapter, based on the Atheros AR9271 chipset, will be used extend Jetson with Wi-Fi capabilities. The important thing about this adapter is that the chipset allows the configuration of the Wi-Fi interface in IBSS mode which is required for the configuration of ad-hoc networks.



USB Wi-Fi Adapter with Atheros AR9271 chipset

## 1. Connecting your PC to the Jetson board

1.1. Configure your PC with an IP in the same LAN of the Jetson Ethernet interface (192.168.3.0/24) and connect an Ethernet cable between your PC and Jetson.

Example: 192.168.3.1/24 (no gateway needed)

1.2. Use ssh to connect to the Jetson board, using the IP and authentication described in the previous page. In Windows use Putty or ssh through WSL. In Linux use ssh directly.

## 2. Configure the Wi-Fi interface in preparation for the batman network.

2.1. Change the Wi-Fi interface mode to IBSS

(check the Wi-Fi interface name (`ip a`), and use it to replace with the right name in the following commands)

```
$ sudo ip link set wlanX down
```

```
$ sudo iw wlanX set type ibss
```

```
# sudo ifconfig wlanX mtu 1500
```

- 2.2. Select the right Wi-Fi channel. The 4 groups in the front of the room use channel **1**, and the 4 groups at the back use channel **11**:

```
$ sudo iwconfig wlanX channel Y
```

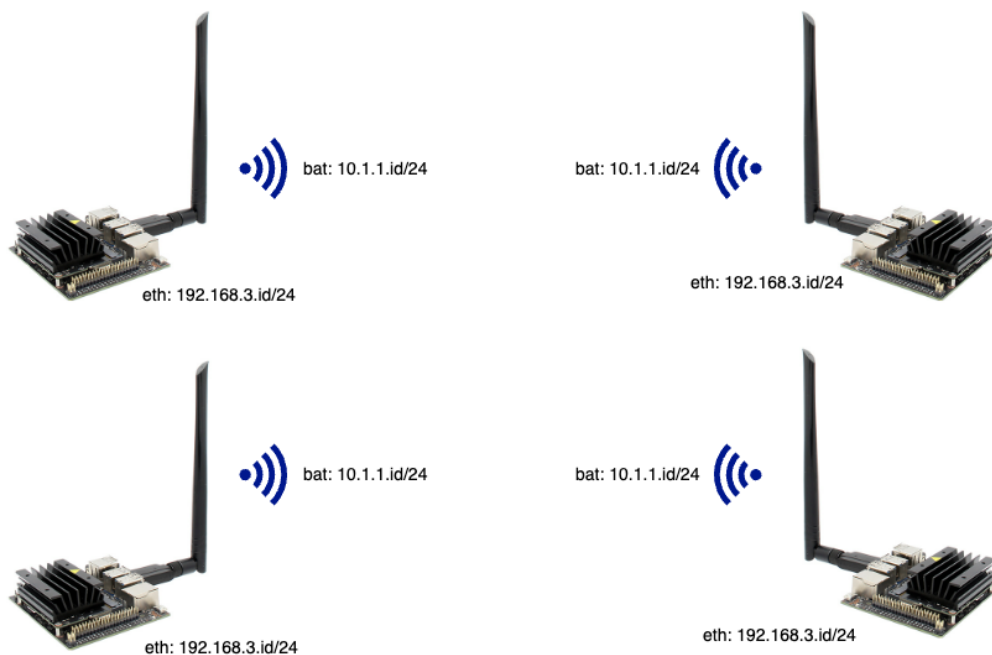
```
$ sudo ip link set wlanX up
```

- 2.3. Confirm if the Wi-Fi interface is in the correct mode, with the following command:

```
$ sudo iw dev
```

### 3. First batman network configuration

- 3.1. In the classroom, we will form 2 networks, each with 4 groups together. Each batman network will look like the following scheme:



- 3.2. Find out (**search online**) what is the frequency ( $f_0$ ) in MHz for the Wi-Fi channel selected in the configuration of exercise **2.2**.
- 3.3. Then, choose a name for your batman network (together with the other 3 groups).

- 3.4. On your Jetson, run the following command, according to the frequency and the chosen ad-hoc network name:

```
$ sudo iw wlanX ibss join network_name f0
```

- 3.5. Finalize the batman configuration with the following:

```
$ sudo modprobe batman-adv
```

```
$ sudo batctl if add wlanX
```

```
$ sudo ip link set up dev wlanX
```

```
$ sudo ip link set up dev bat0
```

```
$ sudo ifconfig bat0 10.1.1.id/24
```

(Configure the IP for the batman LAN, according to the **id** of your board)

#### 4. Testing the batman network for the first time

- 4.1. Together with the colleagues from the other groups, test the wireless connection to their Jetsons, using the ping command. Validate that you can reach every node of the ad-hoc network.

```
$ batctl ping 10.1.1.id
```

**Important note:** For every time you boot the Jetson board, you need to setup batman again. However, there are ways to put the configuration automatic at the boot.

## 2nd week

### 5. Tweaks for the Jetson board:

5.1. Edit the following:

```
$ sudo vi /etc/default/networking
```

And change:

```
#CONFIGURE_INTERFACES=yes
```

to

```
CONFIGURE_INTERFACES=no
```

5.2. Then edit:

```
$ sudo vi /etc/network/interfaces
```

And change the content of the file to:

```
# interfaces(5) file used by ifup(8) and ifdown(8)
# Include files from /etc/network/interfaces.d:
source-directory /etc/network/interfaces.d
```

```
auto eth0
iface eth0 inet static
    address 192.168.3.id
    netmask 255.255.255.0
```

5.3. Apply also the following tweak, which will change the power mode to just 5W (from the default 10W):

```
$ sudo nvpmode1 -m 1
```

5.4. Reboot the board.

## 6. Automatic configuration of batman

6.1. To allow an easier configuration of batman from now on, modify the following script (with vim for example) with the same settings used before in exercises **2.** and **3.**:

Go to `~/batman_installation` and run the following to edit the script:

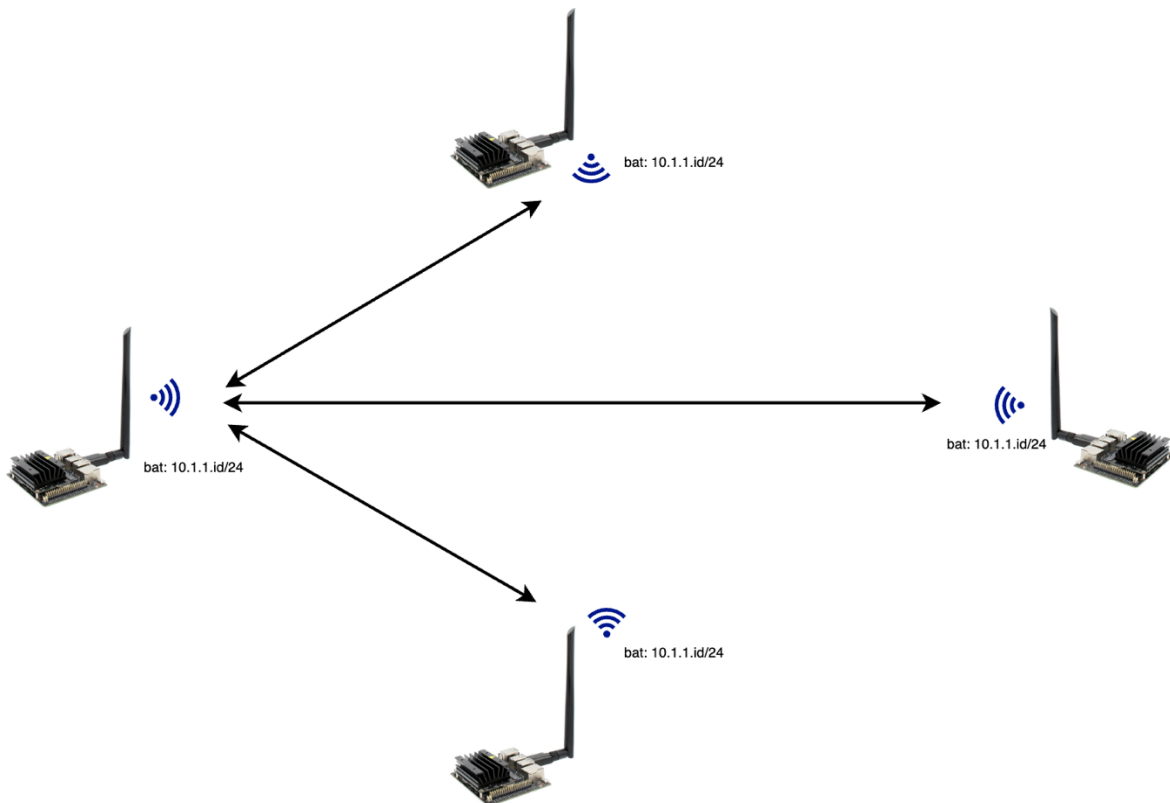
```
$ vi create_batman_interface.sh
```

6.2. After booting of the board, now you only need to run the script to configure batman:

```
$ ./batman_installation/create_batman_interface.sh
```

## 7. Analysis of the batman mesh topology and conditions

When the boards are placed together and close enough, each board connects to the other in a direct way, as seen in the following figure from the perspective of one of the Jetsons:



7.1. Confirm this behavior, analyzing the batman status with the following

7.2. Use the following to check the neighbors table. The command `watch` is to keep observing in real time:

```
$ watch -n 0.1 batctl n
```

Example of output:

```
Every 0.1s: batctl n jetson-14: Thu Mar 16
19:52:03 2023[B.A.T.M.A.N. adv 2021.3...
IF Neighbor last-seen
wlan0 24:ec:99:b4:0f:a6 0.444s
wlan0 24:ec:99:8b:e7:08 0.128s
```

7.3. Utilizing the ssh connection to each Jetson, save the MAC address of the wireless interface and map it with the id of the board, so you can identify the devices in `batctl`.

7.4. Confirm in the neighbors table that the boards of your mesh are the ones appearing there.

7.5. Now run the command to check the originators table. This command lists all other nodes in the network and remembers in which direction to send the packets. More importantly identify which row is marked with `*` and who is the nexthop. In the current topology, all should be direct.

```
$ watch -n 0.1 batctl o
```

Example of output:

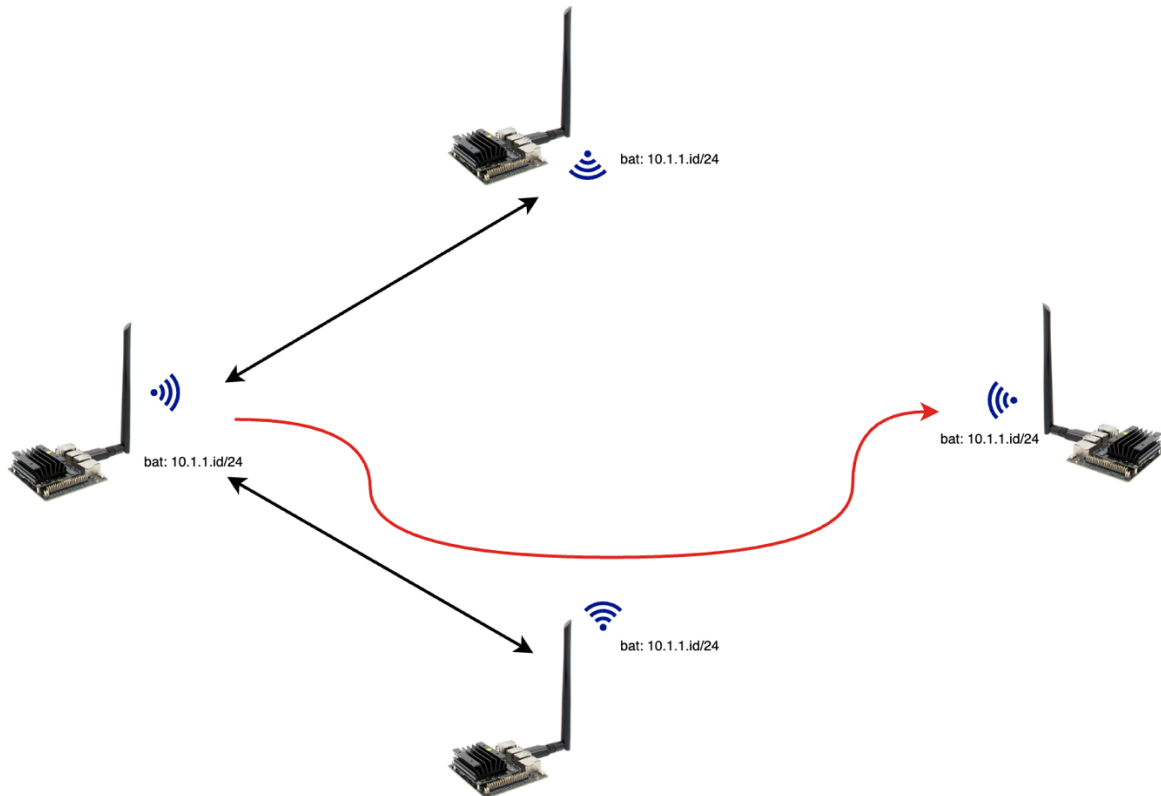
```
Every 0.1s: batctl o jetson-14: Thu Mar 16 19:53:05
2023[B.A.T.M.A.N. adv 2021.3...
Originator last-seen (#/255) Nexthop [outgoingIF]
24:ec:99:8b:e7:08 0.696s ( 12) 24:ec:99:b4:0f:a6 [ wlan0]
* 24:ec:99:8b:e7:08 0.696s ( 43) 24:ec:99:8b:e7:08 [ wlan0]
24:ec:99:b4:0f:a6 0.756s ( 10) 24:ec:99:8b:e7:08 [ wlan0]
* 24:ec:99:b4:0f:a6 0.756s ( 78) 24:ec:99:b4:0f:a6 [ wlan0]
```

The column `#/255` is the sequence number.



## 8. Change the physical topology, forcing at least one indirect connection

8.1. Use the space of the classroom beyond the table, and also the powerbank for at least one Jetson so you can carry it far away. The idea is to change the topology to have at least one indirect connection as seen in the following figure:



8.2. Use the commands in 7.2. and 7.5. to confirm if you see a change in the topology. Keep observing while you move the boards.

8.3. To help forcing the topology, you may also remove the external antenna of the USB adapter (in the SMA connector).

8.4. Test the network with

```
$ batctl ping 10.1.1.id
```

More info and more commands to analyse batman:

<https://www.open-mesh.org/projects/batman-adv/wiki/Understand-your-batman-adv-network>