June 2023 – Davide Giannubilo 10775105 & Salvatore G. Karra 10867052

PROJECT 1 – LIGHTWEIGHT PUBLISH-SUBSCRIBE APPLICATION PROTOCOL

INDEX

ASSUMPTIONS

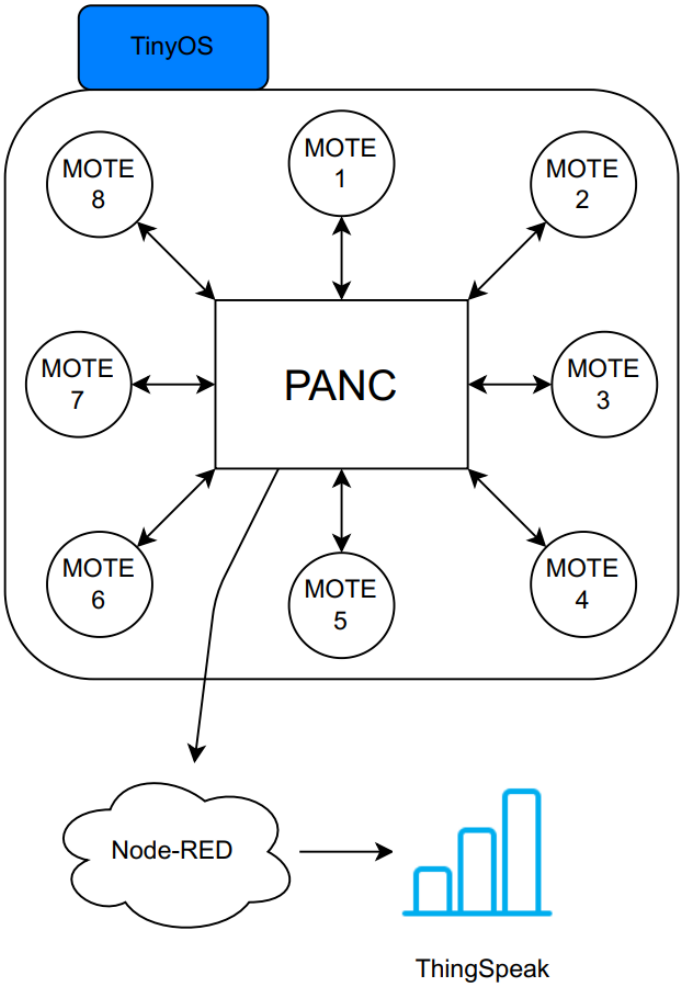
1. The node indicated as 1, in the file topology.txt, is the PAN Coordinator.
2. Since there is not an exit condition explained in the pdf, you must force the exit on the terminal.
3. If a CONN or CONNACK message is lost, the node will resend a CONN message just be sure that everything will work in the right way.
4. If a SUB or SUBACK message is lost, the node will resend a SUB message just to be sure that everything will work in the right way.
5. To handle the retransmission we used some arrays that help us to keep track of which nodes received any messages.
6. We left some lines commented to help you in understanding what is going on between nodes and PAN. (e.g. line 129 – 130 – 131 – Project1.nc | you can see step-by-step which nodes have received CONNACK, SUBACK and what topi they have chosen)
7. The choice of the topic for the SUB messages is fixed. It is equal to reminder of the division between the node ID and 3 since we have 3 different topics.
8. We put a sleep of 16 seconds in the code (line n. 248 – Project1C.nc) because of a limitation of ThingSpeak. In this way we have emulated a periodic sending to Node-RED and it can correctly manage the messages.
9. We used a TCP connection between TinyOS and Node-RED.
10. The number of events in the Python file (line 149 – RunSimulationScript.py) has been modified. We put 25000 just to be sure to have a correct simulation.

TOPOLOGY.TXT

The node 1 is the PAN Coordinator, instead, the nodes from 2 to 9 are the nodes connected to it. (In the picture below, the nodes are mote 1 to mote 8)

```
1 2 -60.0
2 1 -60.0
1 3 -60.0
3 1 -60.0
1 4 -60.0
4 1 -60.0
1 5 -60.0
5 1 -60.0
1 6 -60.0
6 1 -60.0
1 7 -60.0
7 1 -60.0
1 8 -60.0
8 1 -60.0
1 9 -60.0
9 1 -60.0
```

This is a picture of the whole infrastructure:



PROJECT1.H

Here is defined the structure of messages that the PANC and the nodes can exchange each other. As mentioned in the “Assumptions” part, there those arrays used for keeping track of messages received or sent to and by nodes.

```
#ifndef PROJECT1_H
#define PROJECT1_H

#define MESSAGE_BUFFER 5

typedef nx_struct Msg
{
	nx_uint8_t type;
	/*
	* type = 0 -> CONN
	* type = 1 -> CONNACK
	* type = 2 -> SUB
	* type = 3 -> SUBACK
	* type = 4 -> PUB
	*/
	nx_uint8_t sender;
	nx_uint8_t dest;
	nx_uint8_t data; // Field containing the value to send to Node-RED
	nx_uint8_t topic;
	/*
	* topic = 0 -> TEMPERATURE
	* topic = 1 -> HUMIDITY
	* topic = 2 -> LUMINOSITY
	*/
}msg_t;

uint16_t indexConnReceived[8] = {0}; // Contains which node has received a CONN message
uint16_t indexConnAckReceived[8] = {0}; // Contains which node has received a CONNACK message
uint16_t indexSubReceived[8] = {0}; // Contains which node has received a SUB message
uint16_t indexSubAckReceived[8] = {0}; // Contains which node has received a SUBACK message
// Contains the subscribed topic of each node. Filled with 3 because we cannot have a topic that has "3" as integer
uint16_t indexSubbedTopic[8] = {3, 3, 3, 3, 3, 3, 3, 3};
// Contains PUB messages
// 5x5 because we have 5 variables in our msg struct and 5 rows because it's enough to contain messages. It's like a queue.
uint16_t buffer[MESSAGE_BUFFER][5] = {{0, 0, 0, 0, 0},
                                      {0, 0, 0, 0, 0},
```

```
                                        {0, 0, 0, 0, 0},
                                        {0, 0, 0, 0, 0},
                                        {0, 0, 0, 0, 0}};

enum
{
        AM_RADIO_COUNT_MSG = 6,
};

#endif
```

PROJECT1APPC.NC

Here you can find all the components we used to develop the project.

```
#include "Project1.h"

configuration Project1AppC {}

implementation
{
	components MainC, Project1C as App;
	components new AMSenderC(AM_RADIO_COUNT_MSG);
	components new AMReceiverC(AM_RADIO_COUNT_MSG);
	components new TimerMilliC() as MilliTimer;
	components ActiveMessageC;
	components RandomC;

	App.Boot -> MainC.Boot;
	App.Receive -> AMReceiverC;
	App.AMSend -> AMSenderC;
	App.AMControl -> ActiveMessageC;
	App.MilliTimer -> MilliTimer;
	App.Packet -> AMSenderC;
	App.Random -> RandomC;
}
```

PROJECT1C.NC

In this file we implemented all the functionalities requested.

Definition of components for connecting to Node-RED

We used two additional libraries, and we defined two global variables in order to set the server address and the service port.

```
#include <arpa/inet.h>
#include <sys/socket.h>

#define SERVER_IP "127.0.0.1"  // Localhost IP address
#define SERVER_PORT 1234       // Port number for the server
```

Event: Boot.booted()

It starts the system through the AMControl interface.

Event: AMControl.startDone(error_t err)

If there is no error, it prints on the simulation output and calls a Timer to start the execution.

Event: AMControl.stopDone(error_t err)

If called, it prints a message on the simulation output.

Event: MilliTimer.fired()

When called from the "AMControl.startDone" event, every node create a CONN message and send it to the PANC.

Event: Receive.receive(message_t* bufPtr, void* payload, uint8_t len)

This is the core event where all the messages are handled depending on which receive them.

This event is made of two main parts:

1. the PANC receives
    a. If it receives a CONN message, it writes the node that sent the message in the array called "indexConnReceived" and, after this, it sends a CONNACK message to that node.
    b. If it receives a SUB message, it writes the node that sent the message in the array called "indexSubReceived" and, after this, it sends a SUBACK message to that node.
    c. If it receives a PUB message, it starts looking for an empty row in the matrix "buffer" because we want to save the message inside it. Then, it sends the PUB to all nodes that have subscribed to the same message topic, so it opens the connection to Node-RED and sends the message.

2. The nodes receive
    a. If a node receives a CONNACK message and the relative position in the array “indexConnAckReceived” is zero (e.g. node 3 – position 2 in the array == 0), the same position will be marked with the node ID in order to remember which nodes have already received it. Then, it creates a SUB message and sends it to the PANC. (the choice of the topic is explained in the assumption section above)
    b. If a node receives a SUBACK message and the relative position in the array “indexSubAckReceived” is zero (e.g. node 3 – position 2 in the array == 0), the same position will be marked with the node ID in order to remember which nodes have already received it.
    Once this is done, there is a check to be sure that the node is effectively connected and subscribed. After this check, it can create a PUB message (using QoS = 0) with a random payload as requested and send it to the PANC.

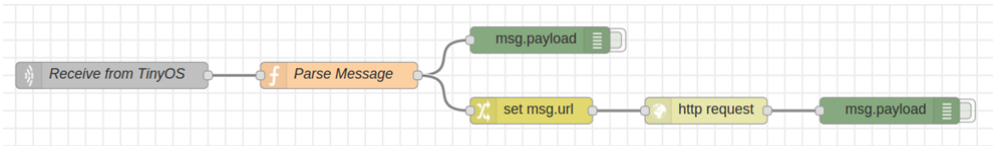
Event: AMSend.sendDone(message_t* bufPtr, error_t error)

It checks that messages are sent successfully, and it handles the retransmissions of messages if they get lost.

There are two checks:

1. if the respective node position in array “indexConnReceived” is zero or if the respective node position in array “indexConnAckReceived” is zero, this means that the message gets lost, so the node will resend a CONN message to the PAN.
2. if the respective node position in array “indexSubReceived” is zero or if the respective node position in array “indexSubAckReceived” is zero and, if the respective node position in array “indexConnAckReceived” is NOT zero, this means that the node has received a CONNACK but not a SUBACK or the PAN has not received a SUB from the node, so the node will resend a SUB message to the PAN.

NODE-RED FLOW



Receive from TinyOS

It is the component that use TCP protocol and listens to the port “1234” that is the one set for Node-RED.

Parse message

It parses messages to extract the topic and the payload and creates the URL for the http request to our ThingSpeak public channel.

THINGSPEAK

[Link to our public channel]

In the charts below, we set the max number of the chart points as 10, just for a better visualization.