Contiki 6LoWPAN Quick Guide

Contiki on STM32 Nucleo plugged with Sub-1 GHz RF expansion board (X-NUCLEO-IDS01A4, X-NUCLEO-IDS01A5)

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Version 1.2 (Nov. 25, 2015)

Introduction

- Contiki (*) is an open source operating system (OS) for the Internet of Things (IoT)
- ST has developed a Contiki 3.x port for the STM32 Nucleo board (NUCLEO) plugged with the supported expansion boards (X-NUCLEO)
- The guide explains how to quickly get started with this platform

(*) Information on Contiki OS are available at www.contiki-os.org

ST port overview

- The ST port allows running the Contiki OS, 6LoWPAN protocol stack and related applications on an STM32 Nucleo board plugged with one sub-1 GHz RF expansion board and, optionally, one motion MEMS and environmental sensors expansion board

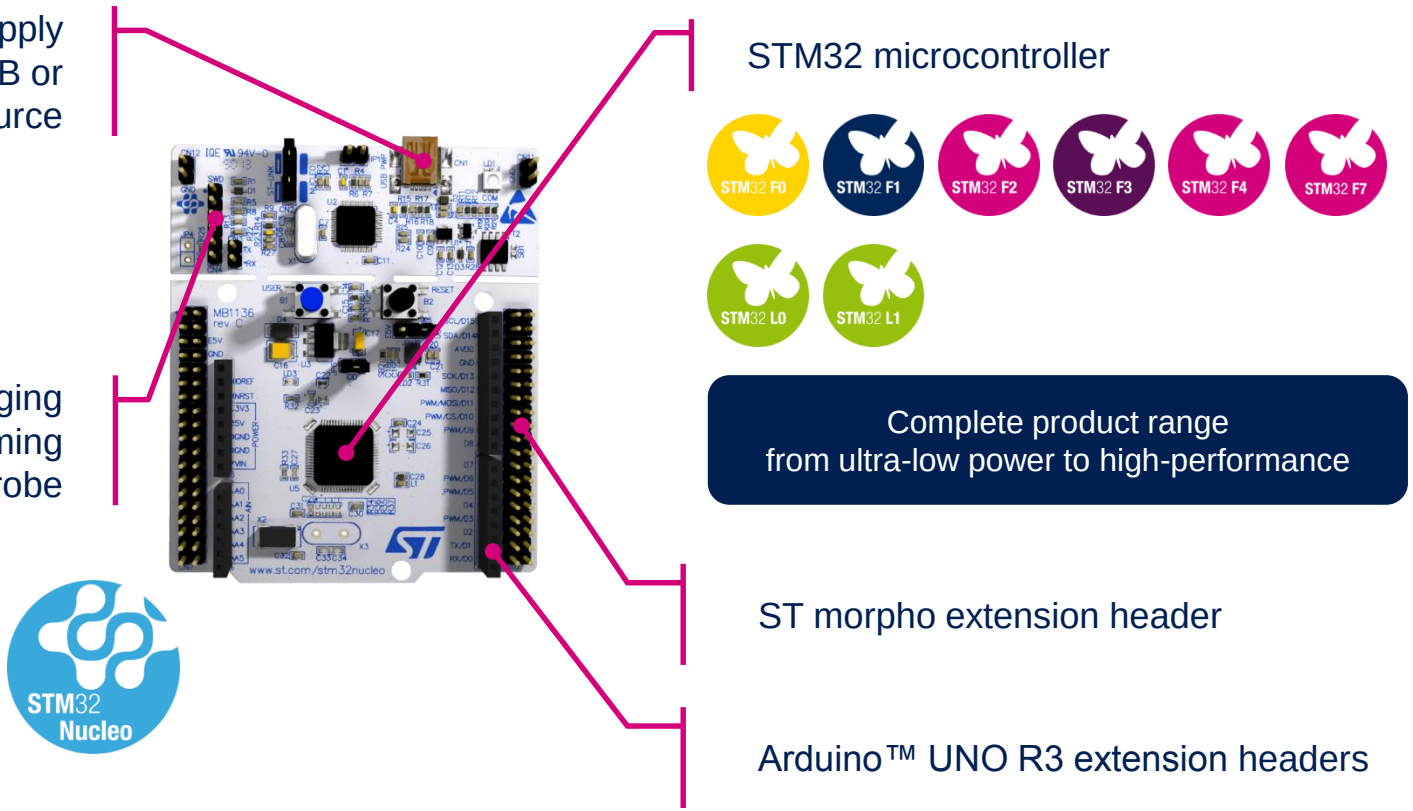
- Software available for download from Contiki GitHub repository: https://github.com/contiki-os/contiki

- Boards supported:
  - NUCLEO-L152RE based on the STM32L152RET6 ultra-low power microcontroller
  - X-NUCLEO-IDS01A4 based on sub-1 GHz SPSGRF-868 SPIRIT1 module (operating at 868 MHz)
  - X-NUCLEO-IDS01A5 based on sub-1 GHz SPSGRF-915 SPIRIT1 module (operating at 915 MHz)
  - X-NUCLEO-IKS01A1 based on motion MEMS and environmental sensors (optional)

- License: BSD-3 (same as the Contiki distribution license)

Development Boards (NUCLEO)

- A comprehensive range of affordable development boards for the entire STM32 microcontroller series, with unlimited unified expansion capabilities and integrated debugger/programmer functionality.



Description

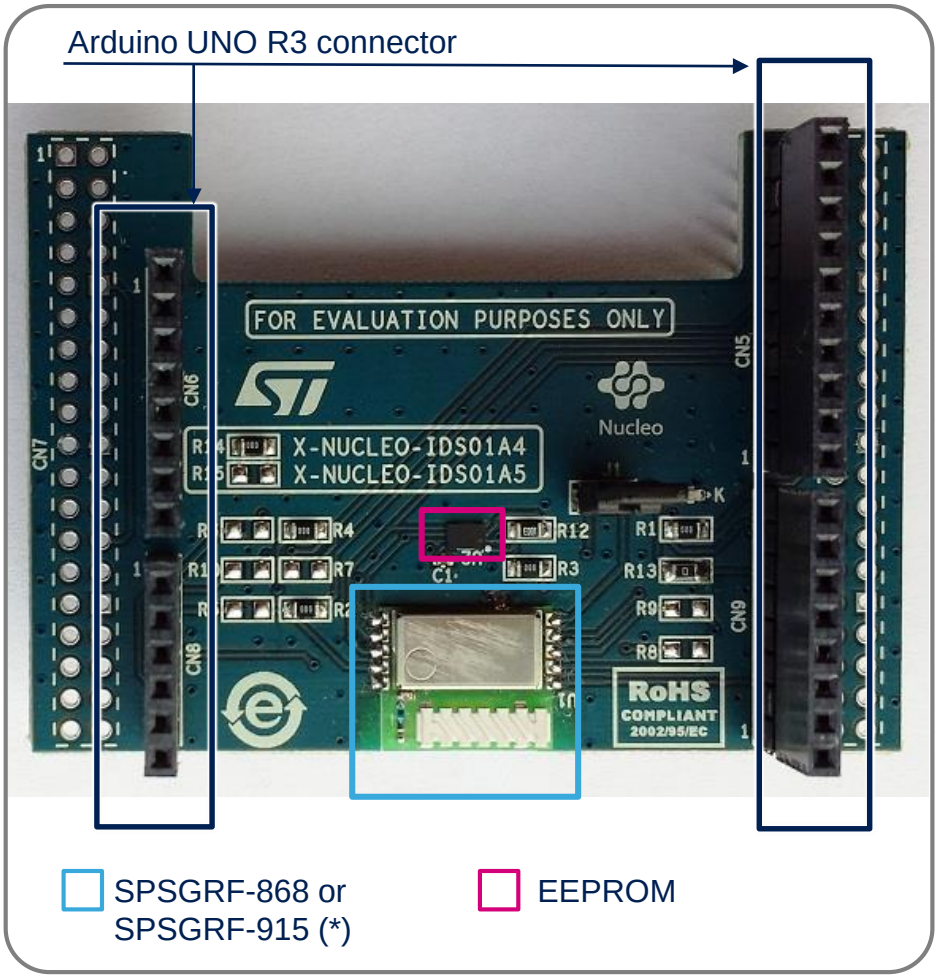
- The X-NUCLEO-IDS01A4, X-NUCLEO-IDS01A5 are evaluation boards based on the SPIRIT1 RF modules SPSGRF-868 and SPSGRF-915
- The SPIRIT1 module communicates with the STM32 Nucleo board host microcontroller through an SPI link available on the Arduino UNO R3 connector.

Key products on board

SPSGRF
SPIRIT1 (Low data-rate, low-power sub-1GHz transceiver) module

M95640-RMC6TG
64-Kbit serial SPI bus EEPROM

Latest info available at
X-NUCLEO-IDS01A4
X-NUCLEO-IDS01A5



Order code: **X-NUCLEO-IDS01A4, X-NUCLEO-IDS01A5**

(*) Identification of the operating frequency of the X-NUCLEO-IDS01Ax (x=4 or 5) is performed through two resistors (R14 and R15).

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Motion MEMS and environmental sensor expansion board

Overview

Description

- The X-NUCLEO-IKS01A1 is a motion MEMS and environmental sensor evaluation board.
- It is compatible with the Arduino UNO R3 connector layout, and is designed around ST's sensors.

Key products on board

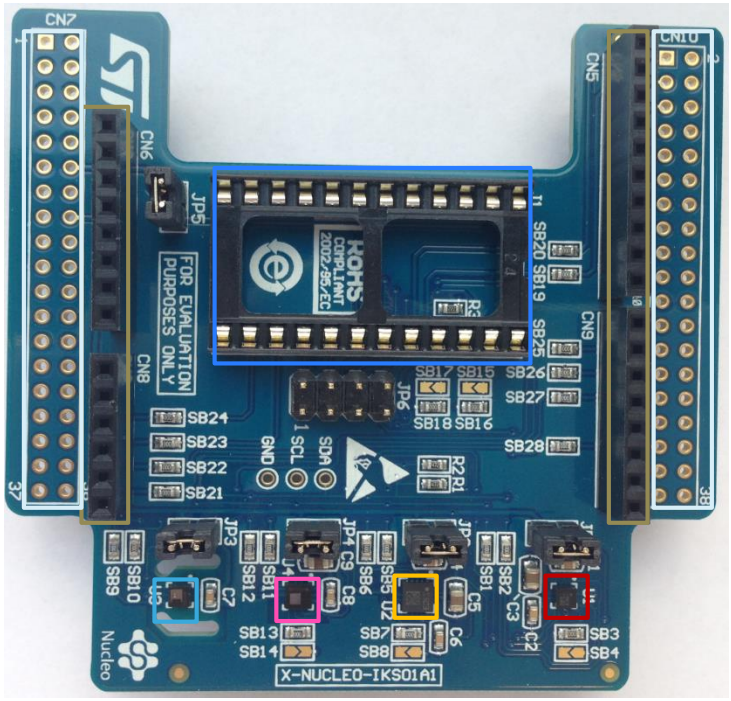
LSM6DS0: MEMS 3D accelerometer (±2/±4/±8 g) + 3D gyroscope (±245/±500/±2000 dps)

LIS3MDL: MEMS 3D magnetometer (±4/ ±8/ ±12/ 16 gauss)

LPS25HB: MEMS pressure sensor, 260-1260 hPa absolute digital output barometer

HTS221: Capacitive digital relative humidity and temperature

DIL 24-pin: Socket available for additional MEMS adapters and other sensors (UV index)



HTS221 LSM6DS0 ST morpho connector**

LPS25HB LIS3MDL Arduino UNO R3 connector

DIL 24-pin

Latest info available at
X-NUCLEO-IKS01A1

Order code: X-NUCLEO-IKS01A1

** Connector for the STM32 Nucleo Board

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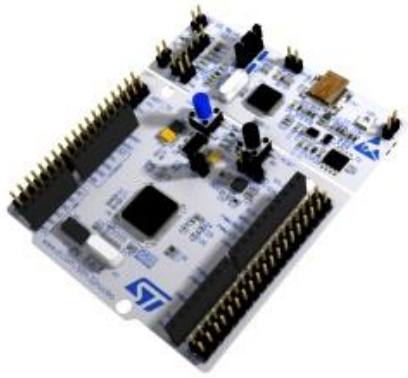
Hardware prerequisites

- 1 x NUCLEO-L152RE (STM32 Nucleo board)
- 1 x X-NUCLEO-IDS01A4 (Sub-1 GHz RF expansion board based on the SPSGRF-868 module) or 1 x X-NUCLEO-IDS01A5 (Sub-1 GHz RF expansion board based on the SPSGRF-915 module)
- (OPTIONAL) 1 x X-NUCLEO-IKS01A1 (Motion MEMS and environmental sensor expansion board)
- Laptop/PC with Windows 8/7 or Linux Ubuntu 15.4
- 1 x USB type A to Mini-B USB cable



NUCLEO-L152RE

X-NUCLEO-IDS01A4 or
X-NUCLEO-IDS01A5

Mini USB

X-NUCLEO-IKS01A1
(OPTIONAL)

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Software prerequisites (1/2)

- The ST port is installed automatically when the Contiki and sub-module repositories are cloned
- The cloning can be done using the following command:

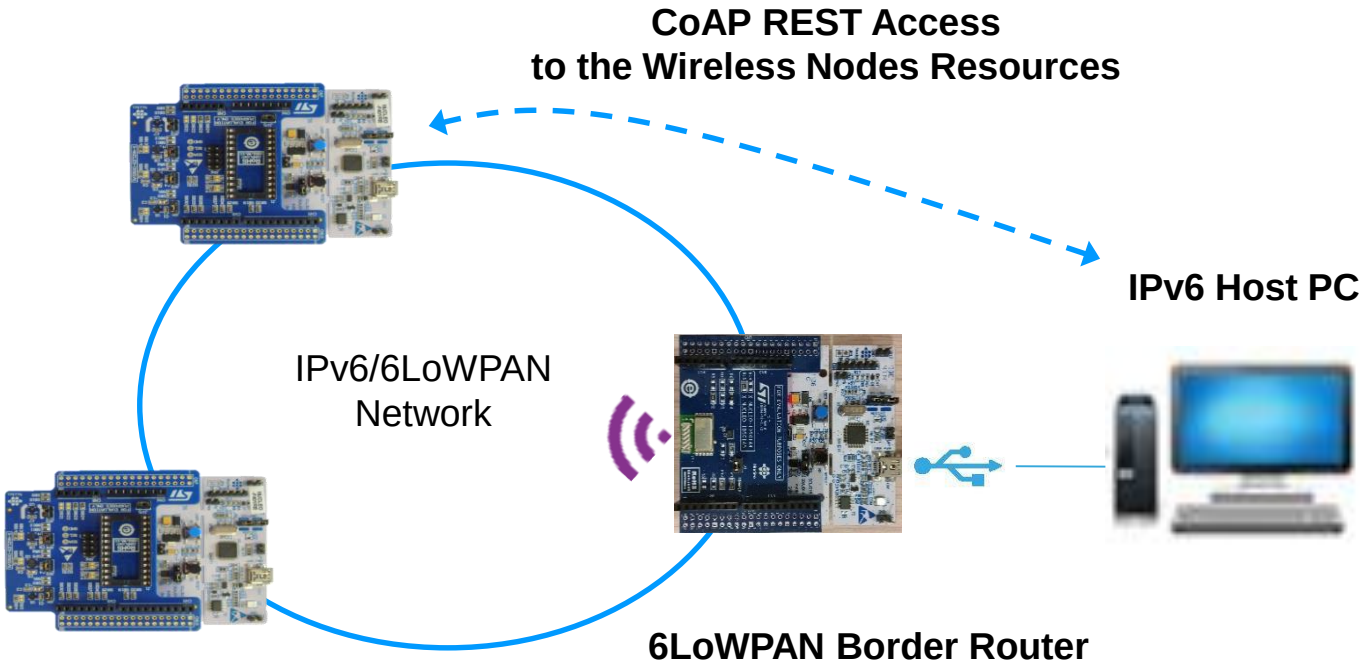
  git clone --recursive https://github.com/contiki-os/contiki.git

- Contiki Platform name for ST port: stm32nucleo-spirit1

Software prerequisites (2/2)

- PC software
  - Windows PC:
    - Linux environment on Windows using Cygwin (Link)
    - GCC is provided in the System Workbench for STM32 (SW4STM32) (Link)
    - Git package for Cygwin or Git for Windows (Link)
    - WinPcaP (for demo purpose) (Link)
  - Linux PC:
    - GNU Tools for ARM Embedded Processors (Link)
- Firefox web browser (Link)
- Firefox Copper plug-in (only for CoAP demo purpose) (Link)

Demo Overview



Contiki on STM32 Nucleo in a few steps (1/2)

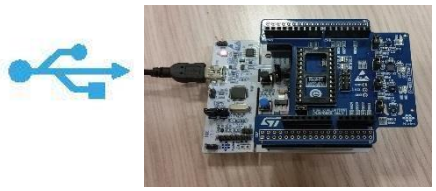
1 Clone the online repository

```
git clone --recursive https://github.com/contiki-os/contiki.git
cd contiki/
```

2 Compile the FW for a wireless node: REST example (using the standard Contiki provided “er-rest-example”)

```
cd examples/er-rest-example
make TARGET=stm32nucleo-spirit1 BOARD=ids01a5
arm-none-eabi-objcopy -O binary er-example-server.stm32nucleo-spirit1 er-example-server.bin
```

3 Connect the wireless sensor board to a PC USB slot and program the device



Copy the “er-example-server.bin” file (e.g. drag & drop) to the USB mass storage corresponding to the STM32 Nucleo board

Contiki on STM32 Nucleo in a few steps (2/2)

4

Compile the FW for the Border Router node

```
cd examples/ipv6/rpl-border-router
make TARGET=stm32nucleo-spirit1 BOARD=ids01a5
arm-none-eabi-objcopy -O binary border-router.stm32nucleo-spirit1 br.bin
```

5

Connect the board to USB and program the device

copy the “br.bin” file
(e.g. drag & drop) to the USB mass storage corresponding to the STM32 Nucleo board

Contiki on STM32 Nucleo in a few steps

6 Setup the IPv6 Host PC for IP traffic bridging between host and 6LowPAN border Router

Windows PC setup (Win 7/8)
using "**wpcapslip6**" utility

OR

Linux PC setup (Ubuntu)
using "**tunslip6**" utility

1. wpcapslip6 needs a working network adapter:
The Microsoft loopback adapter can be installed via "Add legacy hardware" in the Windows Device Manager (reboot is needed after installation of the loopback adapter)
2. Copy "cygwin1.dll" from "contiki/tools/cygwin" to wcapslip6 folder
3. Install WinPcaP
4. run Cygwin as administrator

cd ./tools

cc tunslip6.c –o tunslip6

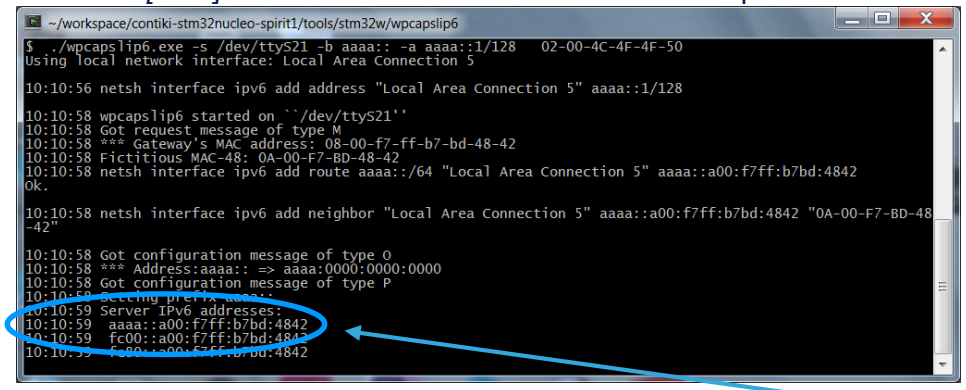
sudo ./tunslip6 –s /dev/ttyACM0 aaaa::1/64

wpcapslip6 utility can then be used with the rpl-border-router example

cd ./tools/stm32w/wpcapslip6

./wpcapslip6 –s /dev/ttyS21 –b aaaa:: -a aaaa::1/128 [addr]

Where *[addr]* is the MAC address of the local net adapter



wpcapslip6 terminal window output

```
********SLIP started on ``/dev/ttyACM0''
opened tun device ``/dev/tun0''
ifconfig tun0 inet `hostname` up
ifconfig tun0 add aaaa::1/64
ifconfig tun0 inet 172.16.0.1 pointopoint 172.16.0.2
ifconfig tun0 add fe80::0:0:0:1/64
ifconfig tun0

tun0      Link encap:UNSPEC  HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
          inet addr:172.16.0.1  P-t-P:172.16.0.2  Mask:255.255.255.255
          inet6 addr: fe80::1/64 Scope:Link
          inet6 addr: aaaa::1/64 Scope:Global
          UP POINTOPOINT RUNNING NOARP MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:500
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

*** Address:aaaa::1 => aaaa:0000:0000:0000
Got configuration message of type P
Setting prefix aaaa::
Server IPv6 addresses:
 aaaa::800:f5ff:eb3a:14c5
 fe80::800:f5ff:eb3a:14c5
```

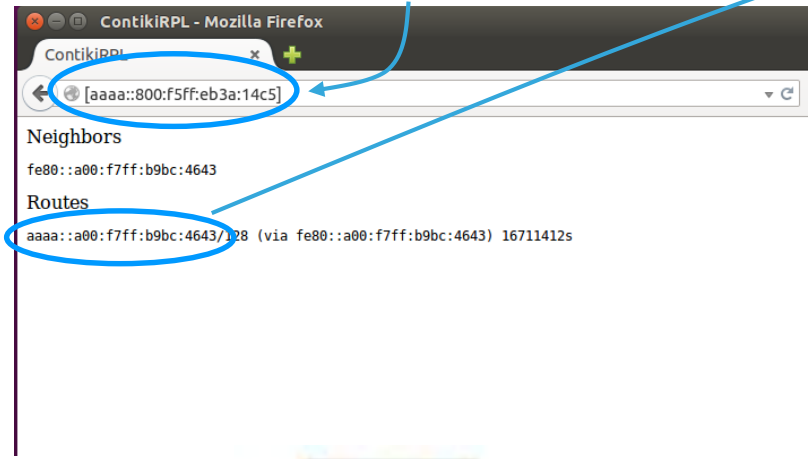
Tunslip6 terminal window output

Contiki server address (used in the next step)

Contiki on STM32 Nucleo in a few steps

7 Open a Web browser (Firefox) to access the Contiki server providing the RPL neighbors and routes information.

Contiki server address (see previous step) between brackets, e.g. [aaaa::800:f5ff:eb3a:14c5]



ping6 aaaa::a00:f7ff:b9bc:4643

8 Ping the wireless Node to test the 6LoWPAN connectivity

```
PING aaaa::a00:f7ff:b9bc:4643(aaaa::a00:f7ff:b9bc:4643) 56 data bytes
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=1 ttl=63 time=70.0 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=2 ttl=63 time=70.7 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=3 ttl=63 time=76.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=4 ttl=63 time=65.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=5 ttl=63 time=72.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=6 ttl=63 time=67.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=7 ttl=63 time=74.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=8 ttl=63 time=68.9 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=9 ttl=63 time=75.9 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=10 ttl=63 time=64.9 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=11 ttl=63 time=65.9 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=12 ttl=63 time=72.9 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=13 ttl=63 time=67.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=14 ttl=63 time=74.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=15 ttl=63 time=69.8 ms
64 bytes from aaaa::a00:f7ff:b9bc:4643: icmp_seq=16 ttl=63 time=70.8 ms
^C
--- aaaa::a00:f7ff:b9bc:4643 ping statistics ---
16 packets transmitted, 16 received, 0% packet loss, time 15017ms
rtt min/avg/max/mdev = 64.936/70.685/76.827/3.620 ms
fabien@marco-linux-HP:~$
```

9 Install the “Copper” CoAP plugin for Firefox
https://addons.mozilla.org/en-US/firefox/addon/copper-270430

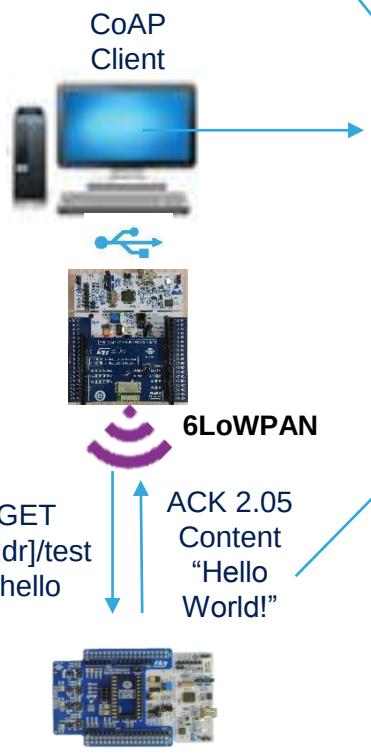
Then access the CoAP Server on the wireless node by typing the URL with the node IP address

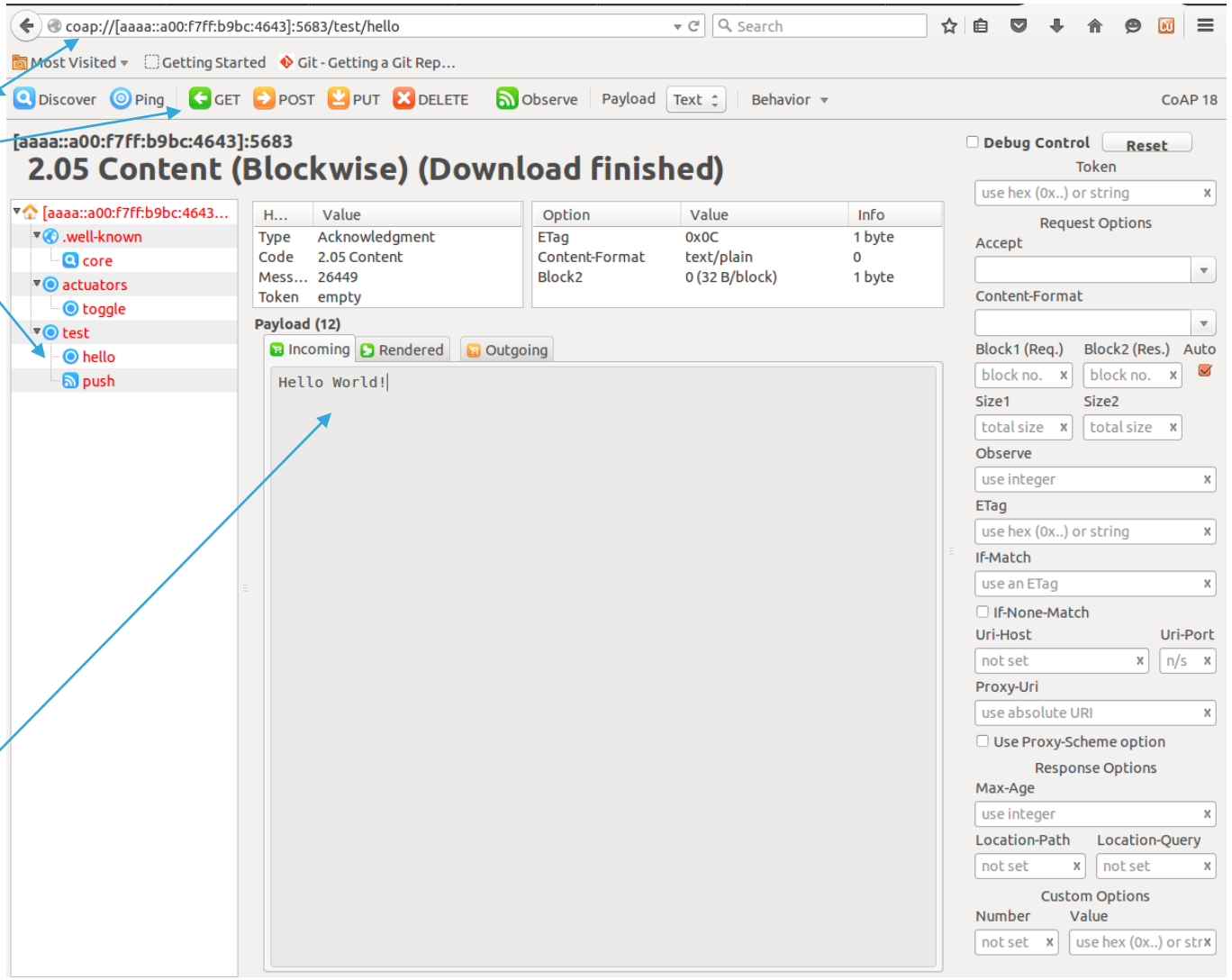
coap://[aaaa::a00:f7ff:b9bc:4643]:5683/

Example: “Hello World!” Resource Access using CoAP

(1) CoAP Resource Discovery

(2) CoAP GET Access to the “test/hello” resource





Firefox Browser window on Linux PC with “Copper” plugin (CoAP client)

Sensors Access using CoAP Demo

- This demo requires an X-NUCLEO-IKS01A1 expansion board for STM32 Nucleo to be mounted on a wireless node
  - The X-NUCLEO-IKS01A1 should be plugged on top of X-NUCLEO-IDS01A4/5 and NUCLEO-L152RE
- To get the demo running, a modified version of the standard Contiki “er-rest-example” application needs to be used
  - The modification is needed to update the names of the sensors used in the “er-rest-example” application and match the names of the X-NUCLEO-IKS01A1 sensors
  - The modified application is available for download from the following GitHub repository: https://github.com/STclab/stm32nucleo-spirit1-examples
  - The step-by-step setup is identical to the one described in the previous “Hello World” demo, except for “step 2” in which the modified “sensor-er-rest-example” is used
- The next slide shows the result of a CoAP GET access to the “temperature” resource hosted by the CoAP server on the wireless node

Sensors Resource Access using CoAP

Example of temperature sensor reading

CoAP GET Access to the resource: “sensors/temperature”

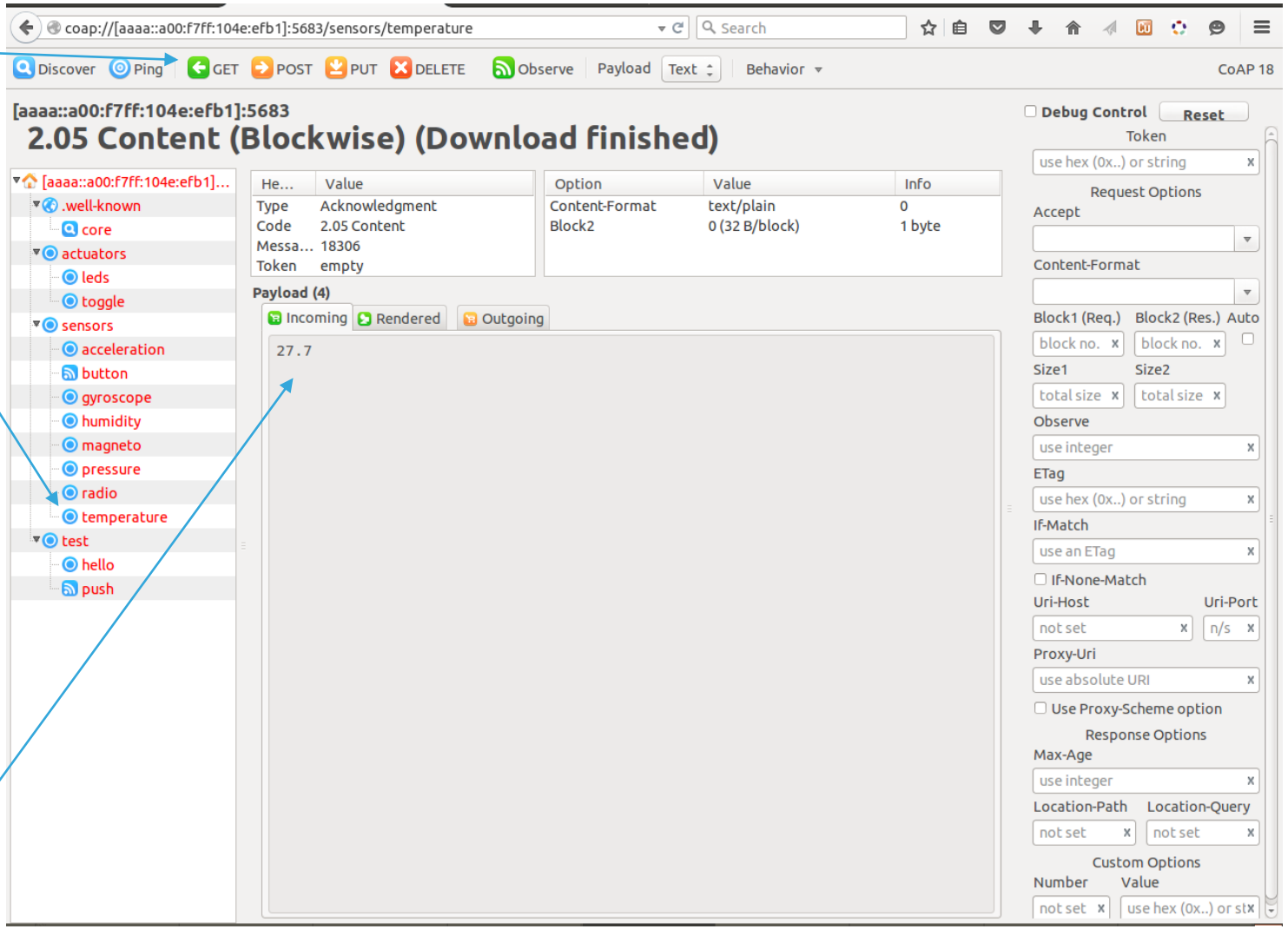
CoAP Client

6LoWPAN

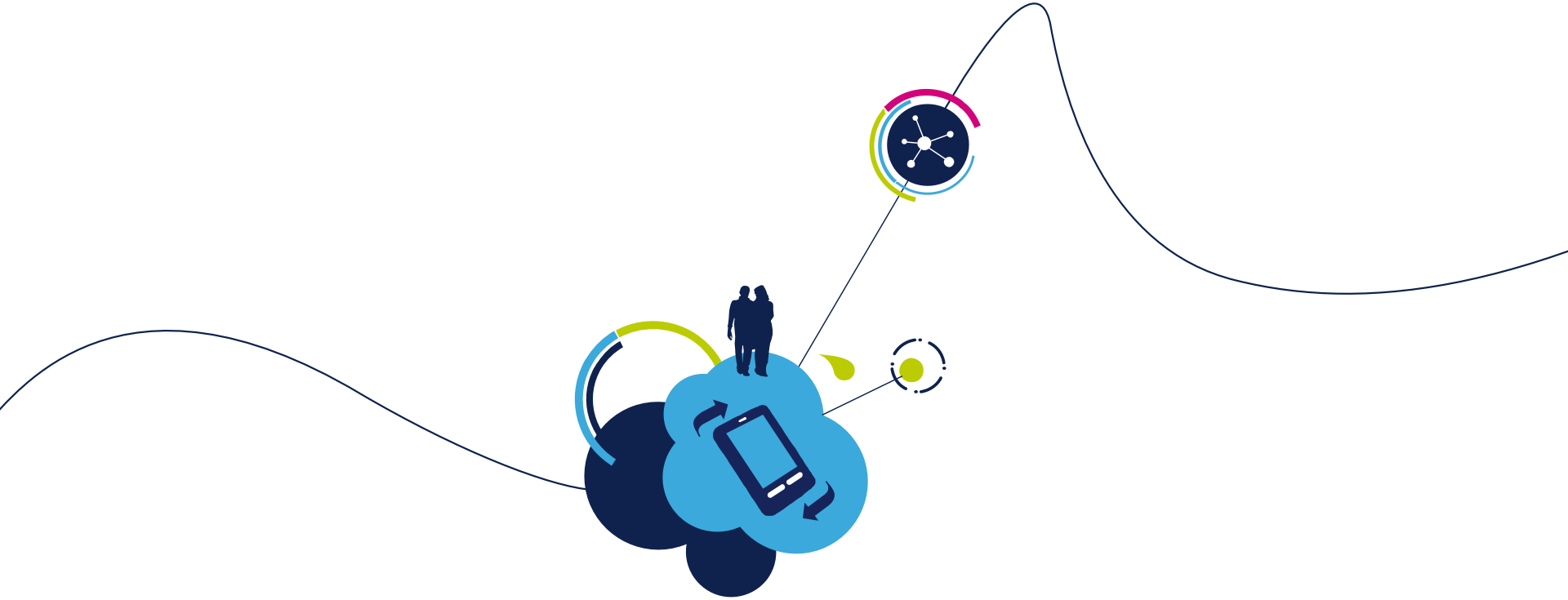
GET [addr]/ sensors/ temperature

ACK 2.05 Content “27.7”

CoAP Server



(*) Use of the X-NUCLEO-IKS01A1 sensors expansion board is required for this demo



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