Hello, and welcome to this presentation of the STM32CubeMonitor-RF Tool. Part of the comprehensive STM32Cube software development toolkit, this tool is designed to help developers test and optimize code used to manage the wireless communication features of STM32WB microcontrollers.
Using the STM32cubeMonitor-RF tool, developers can test the STM32WB’s Bluetooth Low Energy, OpenThread and 802.15.4 radio frequency functions. The target can be an STM32 Nucleo board, a USB dongle from ST, or any customer device. The tool is connected to the target device via a serial connection: a virtual COM port over USB or a physical UART interface.
When the tool is launched, the user must first select the mode to be used:

- 802.15.4 RF: Select this mode to test functions and applications based on the IEEE 802.15.4 wireless protocol.
- BLE: Select this mode for any function related to Bluetooth Low Energy (BLE) network protocol.
- OpenThread: Select this mode to send commands using OpenThread software based on the low-power Thread mesh network protocol.

If the option "remember my choice" is checked, the tool automatically starts in the previously selected mode.
This slide presents the features used for testing the BLE stack application command interface (ACI). When BLE mode is selected, users can perform various tests. First, it is possible to send ACI commands. ACI commands are standardized commands used to communicate with the BLE stack. The tool displays the list of commands supported by the STM32WB device, and, for each command, a list of its parameters and their description.

Another important feature is that it can be used to test RF communications. The tool can be used to send or receive tones or packets. It is also possible to use 2 devices to evaluate the quality of the BLE communication link.

The STM32CubeMonitor-RF tool can also flash software on a device without a wired connection. Using the Over-the-Air programming (OTA) feature, firmware or data can be loaded on a device wirelessly. The tool can also create beacons. In a few seconds, the device can be configured as a BLE Beacon.
It is also possible to configure the board in Advertising mode to check the power consumption and explore the services available on remote devices.
Here, the tool is connected to the device via a serial port. The device must have the "transparent mode" firmware. This firmware configures the UART communication and forwards the ACI commands to the BLE stack.

To connect the device:
- Connect the device to your PC running the STM32CubeMonitor-RF tool via its USB or UART port.
- Wait for the device to be detected. If VCP or USB/serial converters are used, additional drivers may be required.
- Select the virtual COM port from the drop-down list.
- Click “Open” to start communication with the target device.

If the connection is successful, the device information is displayed on the right side. If communication is not possible, an error message is displayed.
The ACI command panel is used to prepare ACI commands that will be sent to the target. The user interface is separated into 2 main areas:

• The Command part on the left side includes the list of commands and the parameters for each command.
• The Log area on the right side displays the details of each selected element.

It is possible to use the search feature to query the command list and to filter commands by category.
There are three steps to send a command:

- Select the command from the list. The filters and search parameters can be used to quickly find commands.
- Enter the correct command parameters.
- Click "Send command".

The log is updated with the sent command and the result returned by the device.
Click the Log area to displays packet details. More details are available using the “+” button.
The RF test pane in organized in 2 areas: the configuration part on the top and the results part at the bottom. It is possible to perform various tests:

- Packet transmission
- Packet reception
- Start/Stop a tone signal
- Perform BLE Packet Error Rate (PER) measurement

The RF test pane in organized in 2 areas: the configuration part on the top and the results part at the bottom. It is possible to perform various tests:

- Packet transmission
- Packet reception
- Tone transmission
- Packet Error Rate (PER) computation. The test is performed with 2 devices: the first one sends the packets, while the second one counts the received packets. The PER is computed based on the number of packets sent versus the number of packets received.
To perform an RF test, first select the required RF test. You can select the Transmitter test to put the device in Emission mode, the Receiver test to put the device in Receive mode or the Packet Error Rate test to measure performance. When one option is selected, click “SELECT TEST MODE”. The Selection panel is replaced by the test panel. The current panel selection is indicated in the blue bar at the top. It is useful to see which panel is displayed, and to navigate to other panels.
The tone test can be used with measurement equipment to verify the transmission level of the device or to verify the frequency accuracy.

To start a Tone test:

- Set the tone parameters: transmission power (PA level) and frequency.
- Click “START TONE”. The board is configured to transmit a continuous tone. The button changes to “STOP TONE”.

To stop the test, click “STOP TONE”.

![Start/Stop the tone test](image)
The Transmitter test is used to send packets. The transmission power level and frequency, the length and content of the data and the physical modulation can be selected.

After pressing “START TX”, packets are sent indefinitely until “STOP TX” is pressed.

After the end of the transmission, the number of transmitted packets is displayed.
The Receiver test is used to receive packets from another device. The frequency and modulation can be selected. The reception starts when “START RX” is pressed. The number of valid packets received is counted until “STOP RX” is pressed.
The packet error test involves two devices. When no specific test equipment is available, it is possible to use two STM32WB devices to test the Bluetooth Low Energy link. One device is used to send packets, and the second one receives the packets. It is possible to compute the packet error rate from the number of transmitted and received packets. The STM32CubeMonitor-RF tool automatically counts the number of sent and received packets. It can also perform multi-channel measurements.
Select the PER test mode.
There are 4 steps to launch the test.
Step 1: Connect the tester device. The device under test (DUT) is expected to be already connected.
For the tester, select the COM port of the second device, and press “CONNECT”. If the connection is successful, the Tester information is displayed.
Click “CONFIGURE TESTER” to go to the next step.
Step 2: Configure the tester. The transmission parameters of the tester can be configured in this screen. The parameters are the same as those of the TX tests. Select the parameters and press "CONFIGURE DUT".
Step 3: Configure the receiver (DUT).
The parameters for the receiver are the same as those of the RX test. Set the parameters and then press "CONFIGURE PARAM".
This is the last step: Configure the test procedure.
- To perform this test on multiple channels, select "PER tests on multiple channels". When the box is ticked, the tool measures the PER of each channel. The tester and the DUT are tuned on the same frequency, and the test is started for the duration indicated in the "measurement period" box.
- It is possible to read the Received Signal Strength Indication (RSSI) that displays the reception level. When "Get RSSI" is selected, the tool performs RSS measurement at regular intervals.
- The measurement results can be saved in a file. This is convenient for storing tests results.

When the options are selected, click "START TEST". The test starts and begins measuring. When "PER tests on multiple channels" is selected, the test stops when all channels have been scanned. Click “STOP TEST” to get the results.
It is possible to display the results in a graph or in a large text format. Use the blue icon at the top right corner of the result area to select the display mode. The graph view gives an overview of the measurements in real time. The large text format can be visible far from the computer, when it is useful to test over long distances.
A script can be used to simplify the sending of repetitive
tasks via ACI commands.
A sequence of ACI commands is stored in a text file, and are
played back by the tool.
To start the script:
• Select the file to play.
• Click “START SCRIPT”. The script is displayed on the
  main window, and the current line is highlighted in green.
• Press “START/STOP” to stop or restart the script.
The script syntax is simple:

- Lines starting with a hash (#) are comments.
- The Send() instruction is used to send an ACI command. The tool encodes the command and the parameters and sends it to the device.
- The wait() instruction is used to insert a pause.
- There are more commands available to display user messages and create loops. Please refer to the User Manual for a detailed description of available commands.
Now let’s go through OpenThread mode. Thread is an IoT protocol created for building and home automation. While BLE is very efficient for wearables, Thread is the best fit for static objects inside a building. Thread protocol uses IEEE 802.15.4 links to create a mesh network, and devices communicate with each other using the IPv6 network protocol. The Thread connectivity offered by the STM32WB devices is based on the OpenThread stack. The RF tool uses the Thread Command Line API (CLI) to communicate with the OpenThread stack.
Connecting to a Thread device is similar to that of a BLE device. First, the device must be loaded with the OpenThread firmware. The firmware is provided in the STM32Cube package examples. The name is Thread_Cli_Cmd. Note: If the Cortex M4 firmware is changed (i.e. from BLE), you may have to update the Cortex M0 firmware to ensure that it is compatible with the OpenThread stack. The virtual COM port (VCP) driver must be installed if a VCP is used. Connect your PC to the device, wait for the COM port enumeration, select the correct port from the drop-down list, and press "CONNECT". 
The OpenThread screen is divided into two parts:

- Command area: used to search, enter and send commands
- Terminal area: Displays the commands and answers.

The OpenThread screen is divided into 2 areas:

- The top part is the Command area. This part provides a list of commands, with additional information about each command and the parameters to fill in. It is very useful for commands that are not frequently used, and avoiding having to check the documentation to get the parameter descriptions.
- The bottom part is the Terminal area. The commands and responses are logged in this area. It is also possible to directly type a command in the line at the bottom.
To send a command, select the command from the command list. The commands are grouped in a tree view: the commands with a triangle on the left have sub-commands. It is possible to search (commands and sub-commands) using the search box at the top. When a command is selected, the information about the command and the list of the related parameters are displayed on the right. Enter the parameter values then click "SEND COMMAND" to send the command to the device. The list of sent commands is displayed in the terminal window. The tool stores the parameter values used for the sent command. When the command is selected again, the parameters are already set to its previously used values.
Some commands can be used to retrieve or set parameter data. When these commands are selected, the "SEND COMMAND" button is converted in two buttons.

• "READ PARAM" to read the parameter
• "SET PARAM" to update with the parameter provided in the box.

• Some OT commands can be used to retrieve or send information:
  • "channel": Retrieve the RF channel used
  • "channel 14": Set the RF channel to channel 14.
The terminal area displays the communication with the device. It is possible to use the bottom line to directly enter an OpenThread command. Put the cursor in the bottom area and type the command. Place “Enter” to send the command. Use the up and down keys to select a previous command from the list to send it again. It is possible to clear the windows or the history list using the icons at the top right corner.
IEEE 802.15.4 RF mode is used to test RF devices that operate using the OpenThread or Zigbee communication protocol. The RF mode user interface is similar to the BLE RF test panel.
The PER test can be used to perform continuous measurements on a single channel or a sequence of single measurements on multiple RF channels.

The values measured are:
- RSSI: Received Signal Strength Indication.
- LQI: Link Quality Indicator.
- PER: Packet Error Rate

The PER test can be used to perform continuous measurements on a single channel or a sequence of single multi-channel measurements on multiple RF channels.
For more information related to this STM32CubeMonitor-RF tool, please refer to the documents and videos listed in this slide.