

# nRF Cellular Monitor

## v1.0.4

User Guide

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# Revision history

Date	Description
2023-09-01	First release

# 1 Introduction

nRF Connect for Desktop Cellular Monitor is a cross-platform tool for Nordic Semiconductor nRF91 Series devices. It is used for capturing and analyzing modem traces to evaluate communication and view network parameters.

A cellular connection involves the interoperation of diverse components and scenarios. Sometimes not everything goes according to plan, and we need information about the environment. The modem of the nRF91 Series *System in Package (SiP)* collects data about the connection in a modem trace. With Cellular Monitor, you can access the trace data and use it to visualize and optimize the connection.

Cellular Monitor features include:

- Get started quickly by programming precompiled sample apps and modem firmware to the device
- Modem trace capture - live or playback modes
- *Wireshark* and serial terminal emulator interfaces
- Visualization of cellular connection status
- Packet event viewer
- Extensive modem connection status dashboard with mouse-over access to detailed information
- Auto-selection of trace database
- Play back trace files from Trace Collector, nRF Util Trace, *Memfault*, and *Real Time Transfer (RTT)*
- Modem credential management

Cellular Monitor replaces the deprecated nRF Connect for Desktop apps Trace Collector and LTE Link Monitor.

Cellular Monitor is installed and updated using [nRF Connect for Desktop](#).

## 2 Installing Cellular Monitor app

Cellular Monitor is installed as an app for nRF Connect for Desktop.

Before you can install the app, you must download and install [nRF Connect for Desktop](#) (version 4.1 or later).

To install the app:

1. Open nRF Connect for Desktop.
2. Find the Cellular Monitor app in the list and click **Install**.

Once the app is installed, you can launch it by clicking **Open**.

For easy access, you can create a desktop shortcut by clicking the **arrow down** button and selecting **Create shortcut**.

If a new version of the app becomes available, an **Update** button is displayed next to the **Open** button. Click this button to install the latest version.

To uninstall the app, click the **arrow down** button and select **Uninstall**.

# 3

## Minimum requirements and limitations

Cellular Monitor supports Nordic Semiconductor *Development Kit (DK)*s and prototyping platforms. Your application or sample must enable modem trace and *AT commands*.

### Minimum requirements

- nRF91 Series DK with a USB cable, a Nordic Thingy:91™, or a custom board with an nRF91 Series *SiP*

Either **Program** one of the built-in sample apps and/or required modem firmware, or both, or enable the following on your device:

- The modem firmware must be at least version 1.3.3.
- The application firmware must use nRF Connect SDK version v2.0.1 or higher. The latest version is recommended.
- The application must enable modem trace over *Universal Asynchronous Receiver/Transmitter (UART)* using snippets. See [nRF Connect SDK nRF91 modem tracing with UART backend using snippets](#) for more information.
- Your application must also include Modem Shell, the [AT Host](#) library, or AT Shell. See the following for more information.
  - Enable the [AT Host](#) library using the Kconfig option `CONFIG_AT_HOST_LIBRARY` in the `prj.conf` file of your application. The library exposes the AT commands interface to the application and enables you to communicate with the modem using AT commands.
  - Information on Modem Shell and AT Shell can be found in [nRF Connect SDK documentation](#)

### Limitations

Some limitations apply for applications that do not use AT commands extensively.

In the first release of Cellular Monitor, the information in the **Dashboard** tab and the **Connection Status** is based on the AT commands in the modem trace. This limits trace data for applications that do not extensively use AT. It is recommended to use the option **Open in Wireshark** where you can find all available traffic.

# 4 Overview and user interface

After starting the Cellular Monitor, the context sensitive application window is displayed. If a supported device is selected, you can capture traces, otherwise traces can be played back.

Before a device is selected, the side bar contains the following elements:

## Select Device

Dropdown to list the devices attached to the computer. When you select a supported device, the app attempts to connect to two different serial ports. One of the ports is for communication and logging, the other is for modem trace.

## Buy development kit...

Opens a dialog with localized links to partner web sites to purchase the supported devices.

## Load trace file...

Opens file explorer and allows you to select a trace file. Traces captured using Cellular Monitor have the file extension `.mtrace`. You can also open files from `nrfutil trace` and legacy Trace Collector `.bin` files.

## Open trace file in Wireshark...

Opens file explorer and allows you to select an `.mtrace` or `.bin` file. The selected file is converted to *Packet Capture Next Generation (PcapNG)* format and displayed in *Wireshark*.

When a device is selected, Cellular Monitor tries to discover its capabilities. The side panel options are updated depending on the results.

## Start

Starts tracing.

## Refresh dashboard

Extensively populates the dashboard fields by sending a set of recommended AT commands to your device. This button is available only if Cellular Monitor has identified either Modem Shell or [AT Host](#) on the device, and if you are tracing.

## Open Serial Terminal

Opens the Serial Terminal application in a new window. You can view the modem dialog and logging information from your application and the RTOS here. See [nRF Connect for Desktop Serial Terminal User Guide](#) for more information on the application.

## Connection Status

Displays the trace status. If you have enabled Modem Shell or [AT Host](#) and click **Refresh Dashboard**, the **Connection Status** is updated automatically. See [Capturing a Modem trace](#) on page 10 for more information.

## Trace database

The trace database is used to decode the raw modem trace. Each modem firmware version has a separate trace database. The trace database version must match the modem firmware version of the selected device.

If [AT Host](#) is enabled, choose **Autoselect** and Cellular Monitor automatically selects the trace databased version. If not, select the database whose version matches your modem firmware from the dropdown list of databases.

**Serial port trace capture**

The serial port used to send the modem trace. It is the last port in the dropdown list if your application firmware uses default settings.

**Reset device**

Resets the device before starting a new trace.

**Open in Wireshark**

Opens and displays trace data live in Wireshark when the trace is started.

**Program device**

Select and program precompiled sample applications and modem firmware to your device. The samples enable the trace and AT Host prerequisites for Cellular Monitor. Modem firmware supporting trace is available with all samples, and you can choose to program the modem or application firmware, or both. The modem firmware needs only to be programmed once.

**Terminal Serial Port**

The serial port used to send AT commands to your device if Modem Shell or [AT Host](#) is enabled. This is the port used by Serial Terminal. It is the first port in the dropdown list if your application firmware uses default settings.

**Dashboard tab and Packet Event Viewer**

See [Viewing a Modem trace in Cellular Monitor](#) on page 11.

**Certificate Manager tab**

See [Managing modem credentials](#) on page 16.

**Log**

The Log panel allows you to view the most important log events, tagged with a timestamp. Each time you open the app, a new session log file is created. You can find the Log panel and its controls, below the main application Window.

- When troubleshooting, to view more detailed information than shown in the Log panel, use **Open log file** to open the current log file in a text editor.
- To clear the information currently displayed in the Log panel, use **Clear Log**. The contents of the log file are not affected.
- To hide or display the Log panel in the user interface, use **Show Log**.
- To freeze Log panel scrolling, use **Autoscroll Log**.

**About tab**

You can view application information, restore defaults, access source code, and documentation. You also can find information on the selected device, access support tools, and enable verbose logging.



# 5 Preparing the device for modem trace

A device can optionally be programmed with modem trace prerequisites making it easy to get started.

1. Connect the device to your computer's USB port.
2. Click **Select Device** on the left-side panel.  
You can view the name and serial number of Nordic Semiconductor devices connected to your computer.

3. Select the device you want to use.

The options in the left-side panel are updated. See [Overview and user interface](#) on page 7.

You can also view information on the device's connection settings and status in the Cellular Monitor **LOG** view.

4. If your application does not support Cellular Monitor minimum requirements, **Program** the prerequisites as follows.

Select and program precompiled sample applications and modem firmware to your device. The samples enable the trace and AT Host prerequisites for Cellular Monitor. Modem firmware supporting trace is available with all samples, and you can choose to program the modem or application firmware, or both. The modem firmware needs only to be programmed once.

# 6 Capturing a Modem trace

Cellular Monitor generates a broad set of cellular environment data which is displayed in the dashboard panels. Optionally, you can also view the modem trace in *Wireshark* and view application logging and the modem dialog in Serial Terminal.

See [Minimum requirements and limitations](#) on page 6 and [Preparing the device for modem trace](#) on page 9.

Complete the following steps to trace data.

1. Set the trace options in the Cellular Monitor side panel.
  - To store a copy of the trace for future use, enable **Save Trace file to disk**.
  - To supplement the information in the Cellular Monitor dashboard, choose from the following options:
    - To reset your application for trace capture, click **Reset device on start**.
    - To view the device modem dialog, application log, and depending on the application running, send custom AT commands, click **Open Serial Terminal**.
    - To view the live trace in Wireshark, click **Open in Wireshark**.
2. Click **Start** to trace.
3. Generate additional trace data.
  - Click **Refresh Dashboard** to send a set of AT commands to the device to feed the trace with information on the environment.
  - Send AT commands using the Serial Terminal and from the dashboard fields.
4. Follow the progress in the **Connection Status** panel.

On success, the stage's status indicator turns green with a checkmark.

If a stage fails, a red X is displayed along with a reason for the failure. You can check the corresponding dashboard field for troubleshooting information.

- If the minimum requirements for trace have been met, the **Trace** checkmark should be green. See [Minimum requirements and limitations](#) on page 6 and [Preparing the device for modem trace](#) on page 9.
- **SIM** shows the *Subscriber Identity Module (SIM)* card status. For example, if you remove your SIM card from the device, the **SIM** turns red.
- **Long-Term Evolution (LTE) Connection** depends on conditions in the local cellular network to which you are subscribed.
- **Packet Data Network (PDN)** turns green when the device has successfully connected to the connection endpoint.

For more information on trace data visualization see [Viewing a Modem trace in Cellular Monitor](#) on page 11 .

# 7

## Viewing a Modem trace in Cellular Monitor

To play back and focus on a part of the trace, you can drag and scroll the **Packet Event Viewer**. Cellular Monitor's **Connection Status** and **Dashboard** update and replay the selected events.

### Packet Event Viewer

The **Packet Event Viewer** visualizes communication at the *AT command*, *Radio Resource Control (RRC)*, *Non-access Stratum (NAS)*, and *Internet Protocol (IP)* levels.

By default, the events are equally spaced for readability. To view the timeline, switch to **Time** in **Packet Event Viewer** settings. You can also hide unwanted event layers here.

You can control the viewed trace data with the following options.

- To play back the trace, click on and drag the graph to the left.
- To extend or decrease the viewed trace events, scroll the graph.
- To view information on the AT commands and the event timestamp, hover over a specific event.
- To pause a live trace, click the live button.

### Cellular Monitor Dashboard

The **dashboard** contains detailed information about the connection and its components. During trace, dashboard fields are highlighted as they are populated. To view in slow motion, you can use the **Packet Event Viewer** to play back.

Hover over any of the fields to view a description of the field, including related AT commands and links to documentation. While capturing a trace, you can choose to run the AT commands from here.

The trace data is categorized into the following 6 dashboard panels:

- **LTE Network**
- **Device**
- **Power Saving Mode**
- **SIM**
- **Connectivity Statistics**
- **PDN** there can be more than one. A PDN panel is displayed for each network when a connection is established.

# 8 Using Wireshark

*Wireshark* can be used live while capturing a trace or to analyse saved trace files.

The following two alternatives are available.

## **Open in Wireshark**

Opens and displays trace data live in Wireshark when the trace is started.

The option is available only when a device is selected.

## **Open trace file in Wireshark...**

Opens file explorer and allows you to select an `.mtrace` or `.bin` file. The selected file is converted to *PcapNG* format and displayed in *Wireshark*.

Wireshark analyses layers and protocols in the trace, in addition to *AT commands*. It can color and filter traffic based on packet type. See [DevAcademy article on viewing modem traces in Wireshark](#) for more information.

# 9 Loading modem traces for play back

You can view previously collected traces in Cellular Monitor, including those captured in the Trace Collector app.

Open Cellular Monitor

1. Click **Load trace file...** in the side panel. File explorer opens.
2. Browse to the folder where you saved the trace. Select and double-click the file to open it. Cellular Monitor auto detects the modem firmware version from the trace file. You can also select the modem trace database version from the dropdown list.



Figure 1: The dashboard and UI are filled with the trace information.

See [Viewing a Modem trace in Cellular Monitor](#) on page 11 for more information.

# 10 Viewing RTT modem traces

Modem traces captured in J-link *RTT* logger can be played back in Cellular Monitor

In the first release of Cellular Monitor, RTT interface is not supported for traces capture. However, RTT modem traces captured outside of the tool can be viewed in Cellular Monitor with the following procedure.

1. Enable the RTT trace backend in your device's application using the Kconfig option `CONFIG_NRF_MODEM_LIB_TRACE_BACKEND_RTT` in the `prj.conf` file.
2. Ensure your device is running supported modem firmware, see [Minimum requirements and limitations](#) on page 6 and note the version for playback.
3. Use the J-link RTT logger to collect the trace or traces and save in binary (`.bin`) format.  
See [SEGGER Real Time Transfer \(RTT\)](#) for more information.
4. Load and playback the trace in Cellular Monitor.  
See [Loading modem traces for play back](#) on page 13 for more information.

# 11 Memfault and modem trace in production

In a production environment, you can configure the application to send modem traces to *Memfault*. The trace files can be downloaded from Memfault for playback and analysis in Cellular Monitor.

For information on nRF Connect SDK samples showing how to send modem traces to Memfault, see [NCS Memfault configuration](#).

See also [Memfault](#).

**Note:** The Memfault shell is enabled by default, using the UART interface. If [AT Host](#) library and the Memfault module are enabled simultaneously, neither behave as expected, as they both require the same UART interface. You can use Modem Shell or AT Shell as an alternative to [AT Host](#).

# 12 Managing modem credentials

You can store and update modem credentials, such as keys or certificates, manually by sending [Credential storage management %CMNG](#) commands to the modem. The certificate manager simplifies this process by offering a graphical user interface for updating credentials.

Before you can update the credentials stored by the modem, you must put the modem into the offline state by sending the **AT+CFUN=4** AT command.

Each set of keys and certificates that is stored in the modem is identified by a security tag. This means that all related credentials share the same security tag. Send the **AT%CMNG=1** command in the terminal view to display a list of all certificates that are stored on your device. If you have added your device in *nRF Cloud*, you should see a *Certificate Authority (CA)* certificate, a client certificate, and a private key with security tag 16842753 which is the security tag for nRF Connect for Cloud credentials.

The credentials can be managed in the following ways.

- To add or update credentials, enter a security tag and the new keys or certificates. Then click **Update certificates**.

Instead of entering the credentials manually, you can also import a JSON file. To do so, click **Load from JSON**.

- To delete a key or certificate, select the checkbox next to it. Then click **Update certificates**.

**Note:** Deleting the text from the text field does not cause the key or certificate to be unset.



# 13 Troubleshooting

These troubleshooting instructions can help you fix issues you might encounter in Cellular Monitor.

Check Cellular Monitor's [Minimum requirements and limitations](#) on page 6

## **Trace data is not displayed or the file size does not increase.**

- Check the trace serial port used, see [Identifying trace serial port](#)
- The default UART trace settings are 1 000 000 baud rate, with hardware flow control enabled.

## **Refresh Dashboard is greyed out.**

- **Refresh Dashboard** can be selected only after trace is started.
- Try to **Program** a provided sample application and modem firmware to your device.

## **Where can I find my trace files and what is the `.mtrace` file extension?**

Make sure that **Save trace file** to disk is enabled before starting trace if you want them to be saved. The easiest way to find your saved files is to click **Load trace file**.

Cellular Monitor `.mtrace` files are binary files, just like before. The `.mtrace` file extension is used to separate them from other binary files (extension `.bin`). If you want to open the file in a tool that requires a `.bin` extension, replace the `.mtrace` extension with a `.bin`. You are still be able to open it in Cellular Monitor.

## **Is it sufficient to update `prj.conf` to enable modem trace?**

- No, the latest UART trace backend requires changes to the device tree, as well as the configuration. It is recommended to use the new backend and snippets, see [nRF Connect SDK nRF91 modem tracing with UART backend using snippets](#) for more information.

# Glossary

## **AT command**

A command used to control the modem.

## **Certificate Authority (CA)**

A trusted third-party organization that acts to validate the identity of entities (such as IOT devices and websites) and bind them to cryptographic keys using electronic documents known as digital certificates.

## **Cat-NB1**

NB-IoT *User Equipment (UE)* category with 200 kHz UE bandwidth and a single RX antenna, specified in 3GPP Release 13.

## **Cat-NB2**

An upgraded version of *Cat-NB1*, specified in 3GPP Release 14.

## **Development Kit (DK)**

A hardware development platform used for application development.

## **Internet Protocol (IP)**

The network layer communications protocol in the Internet protocol suite for relaying datagrams across network boundaries. Its routing function enables internetworking, and essentially establishes the Internet.

## **Long-Term Evolution (LTE)**

A wireless broadband communication standard for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies.

## **LTE-M**

An open standard that is most suitable for medium throughput applications requiring low power, low latency, and/or mobility, like asset tracking, wearables, medical, POS, and home security applications. Also known as Cat-M1.

## **Memfault**

A cloud-based platform for connected device monitoring, debugging, and updating.

## **Non-access Stratum (NAS)**

In telecom protocol stacks, the highest stratum of the control plane between the core network and User Equipment (UE). The layer is used to manage the establishment of communication sessions and for maintaining communications with the UE as it moves.

## **Narrowband Internet of Things (NB-IoT)**

A narrowband technology standard with longer range, lower throughput, and better penetration in, for example, cellars and parking garages compared to LTE-M. NB-IoT is most suitable for static, low throughput applications like smart metering, smart agriculture, and smart city applications. Also known as *Cat-NB1* or *Cat-NB2*.

## **nRF Cloud**

Nordic Semiconductor's platform for connecting IoT devices to the cloud, viewing and analyzing device message data, prototyping ideas that use Nordic Semiconductor chips, and more. It includes a public REST API that can be used for building IoT solutions. See [nRF Cloud portal \(nrfcloud.com\)](https://nrfcloud.com).

#### **Packet Capture Next Generation (PcapNG)**

The default file format for Wireshark.

#### **Packet Data Network (PDN)**

A network that provides data services.

#### **Radio Resource Control (RRC)**

A protocol used in UMTS, LTE, and 5G on the radio interface. It is an OSI model network layer 3 protocol used between the User Equipment and Base Station.

#### **Real Time Transfer (RTT)**

A proprietary technology for bidirectional communication that supports J-Link devices and ARM-based microcontrollers, developed by SEGGER Microcontroller.

#### **System in Package (SiP)**

Several integrated circuits, often from different technologies, enclosed in a single module that performs as a system or subsystem.

#### **Subscriber Identity Module (SIM)**

A card used in *UE* containing data for subscriber identification.

#### **System on Chip (SoC)**

A microchip that integrates all the necessary electronic circuits and components of a computer or other electronic systems on a single integrated circuit.

#### **Universal Asynchronous Receiver/Transmitter (UART)**

A hardware device for asynchronous serial communication between devices.

#### **User Equipment (UE)**

Any device used by an end-user to communicate. The UE consists of the Mobile Equipment (ME) and the Universal Integrated Circuit Card (UICC).

#### **Universal Serial Bus (USB)**

An industry standard that establishes specifications for cables and connectors and protocols for connection, communication, and power supply between computers, peripheral devices, and other computers.

#### **Wireshark**

A free software tool that captures wireless traffic and reproduces it in a readable format. It is a cross-platform network protocol analyzer that can be used to view, analyze, and troubleshoot packets sent over a data network.

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