

How nRF9160 enables cellular IoT asset tracking

Nordic Tech Webinar

*Kristian Sæther / Product Manager - Cellular IoT
October 2020*

1

© Nordic Semiconductor

Today's host

Kristian Sæther



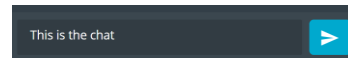
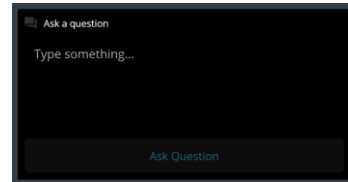
Product Manager, Cellular IoT
Product Management



2

Practicalities

- Duration: 50-60 mins
- Questions are encouraged!
 - Please type questions in the top of the right sidebar
 - All questions are anonymous
 - Try to keep them relevant to the topic
 - We will answer them towards the end
- The chat is not anonymous, and should not be used for questions
- Go to DevZone if you have more questions
- A recording of the webinar will be available together with the presentation at webinars.nordicsemi.com



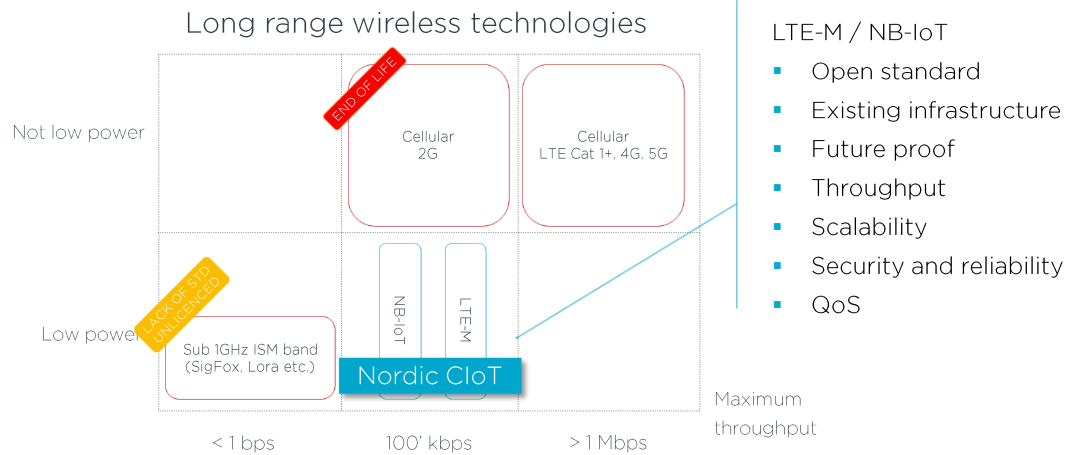
3

Agenda

- Asset Tracking Overview
- nRF9160 for Asset Tracking
- GPS and cellular positioning
- Low Power
- Development tools
- Summary

4

Low Power Wide Area Network Landscape



5

Some Examples

Shipping/Packets



Location / Route
Theft / lost package
Environmental data
Product health
Physical Handling
Fleet mngt.

Consumer/retail



Theft
Fleet mngt.
Geo-Fence
Location on-demand
Usage

Health



Location
Geo-fence
Health/movement
Fall detection

Livestock/Pets



Location
Geo-fence
Animal health

Machinery



Geo-Fence
Theft
Usage

6

... so why is not everything tracked then

Get hold of everything

A lot of bits and pieces
Hardware and software
Connectivity and cloud

Make it run for years – without wires

Cellular is not low power
The network are in control
Modem and MCU interactions
Must be small too ?

Get it to work

Stitching everything together
Get support
Deploy and certify
Global coverage ?

7

The nRF9160 Advantage in Asset Tracking

Integration



Integrate and use
advanced packaging
techniques to reduce
solution size

Strong connectivity
partners

Low Power



Build everything from
scratch for low power
Integrate memories
and use low-leakage
process features

Ease of Use



Enable self-service
for the diverse set of
asset tracking
applications

8

The nRF9160 Advantage in Asset Tracking

Integration



Integrate and use advanced packaging techniques to reduce solution size

Strong connectivity partners

Low Power



Build everything from scratch for low power
Integrate memories and use low-leakage process features

Ease of Use

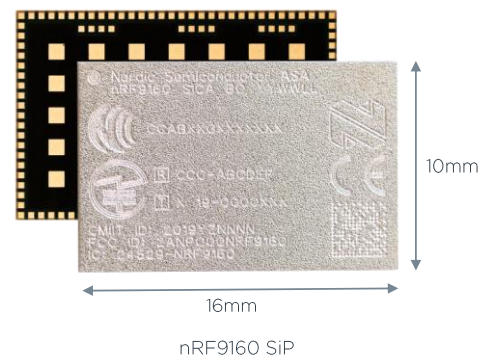


Enable self-service for the diverse set of asset tracking applications

9

nRF9160 – voids cellular modules

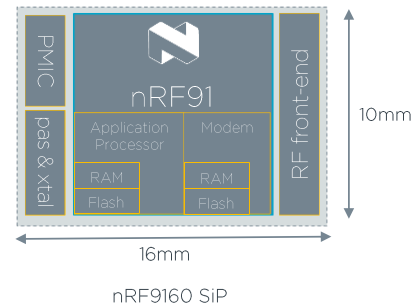
- Based on Nordic Dual Core SoC:
 - multiband LTE-M/NB-IoT modem with GPS
 - Arm® Cortex® M33 MCU for the application
- Small form factor (includes PMIC, RF FEM, passives and crystals)
- Ultra Low Power – 18uA @ 81.92s eDRX
- Multiband support for global coverage
- Pre-certified System-in-Package (SiP)



10

nRF9160 – voids cellular modules

- Based on **Nordic Dual Core SoC**:
 - multiband **LTE-M/NB-IoT** modem with **GPS**
 - Arm Cortex M33** MCU for the application
- Small form factor** (includes PMIC, RF FEM, passives and crystals)
- Ultra Low Power** – 18uA @ 81.92s eDRX
- Multiband support for global coverage
- Pre-certified System-in-Package (SiP)**



11

Best in class FEM and Packaging

Optimized Front End



23dBm Max Tx Power

Very Stable Tx (coupler at antenna for feedback loop)

Temperature range -40 to 85 °C (3GPP)

Advanced Packaging



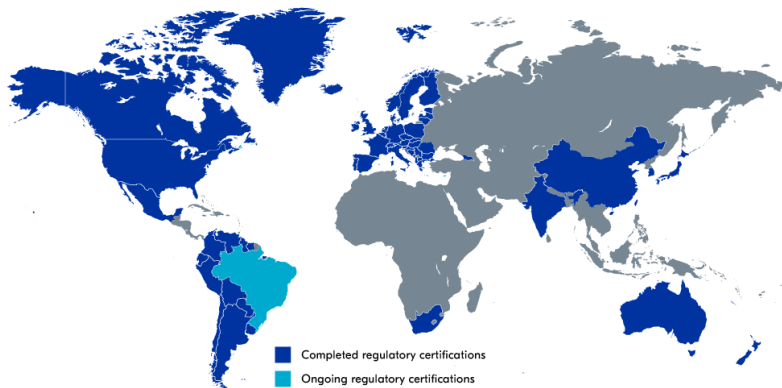
SiP shield is composed of plated metal (Cu+Ni)

All Internal components covered by molding compound

SiP can be molded by all commonly used materials

12

Leading worldwide coverage with single SKU



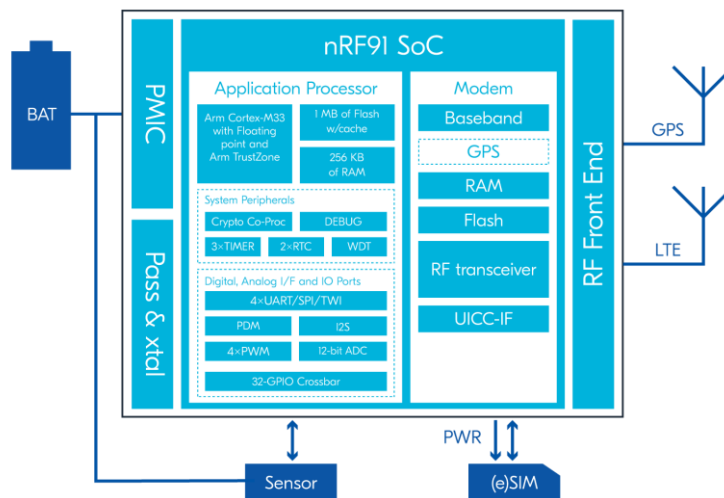
- Supported LTE Bands:
- LTE-M:
1,2,3,4,5,8,12,13,14,17,18,19,
20,25,26,28,66
- NB-IOT:
1,2,3,4,5,8,12,13,17,19,20,2
5,26,28,66

PTCRB



13

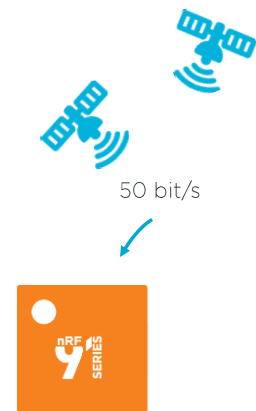
nRF9160 Application Circuit



14

GPS Overview

- Standard GPS devices download position data from satellites
 - Almanac: Valid for many days
 - Ephemeris: Valid for 2-4 hours
- Slow downloads impacts Time To First Fix (TTFF)
 - Particularly painful for sleeping devices

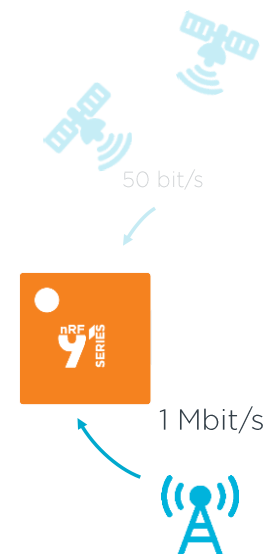


Typical Device Condition	Condition	Typical TTFF
Off/sleeping for many days	Cold start	1 - 12 minutes
Sleep cycles of a few hours	Warm start	30-60 seconds
Always-on, or short sleep cycles	Hot start	< 10 seconds

15

Assisted GPS Overview

- Assisted GPS improves Time To First Fix
 - Ephemeris and Almanac downloaded over fast LTE-M link
- Ideal for low power sleeping devices



Typical Device Condition	Condition	Typical TTFF
Off/sleeping for many days	Cold start	< 10 seconds 1 - 15 minutes
Sleep cycles of a few hours	Warm start	< 10 seconds 30-60 seconds
Always-on, or short sleep cycles	Hot start	< 10 seconds

16

Why does fast TTFF Matter ?

- Est. GPS power usage for first fix

Typical Device Condition	Condition	Typical TTFF	GPS current	Est. current usage
Off/sleeping for many days	Cold start	1-12 minutes	40mA	up to 8 mAh
Sleep cycles of a few hours	Warm start	30-60 seconds	40mA	0.4 mAh
Always-on, or short sleep cycles	Hot start	< 10 seconds	40mA	0.06 mAh

17

Assisted GPS save power

- ~3KB assistance data download from nRF Cloud

LTE-M1 data download	Condition	Typical time	Current	Est. current usage
Data reception	LTE-M1	< 500ms	50 mA	0.007 mAh

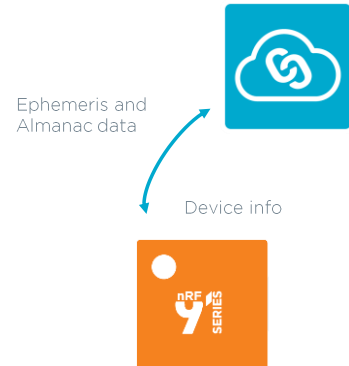
- In total ~0.06 mAh for first fix vs ~ 8 - 0.06 mAh spread

Typical Device Condition	Condition	Typical TTFF	Est. current usage
Off/sleeping for many days	Cold start	< 10 seconds	<0.06 mAh up to 8 mAh
Sleep cycles of a few hours	Warm start	< 10 seconds	<0.06 mAh 0.4 mAh
Always-on, or short sleep cycles	Hot start	< 10 seconds	<0.06 mAh

18

nRF Cloud Assisted Location

- Device fetches data from nRF Cloud
 - Packed and formatted to fit embedded device
- nRF Cloud
 - Sends optimized and packed data to device
- nRF9160
 - Connect to cloud and subscribe to A-GPS data
 - Complete with source code and example in nRF Connect SDK

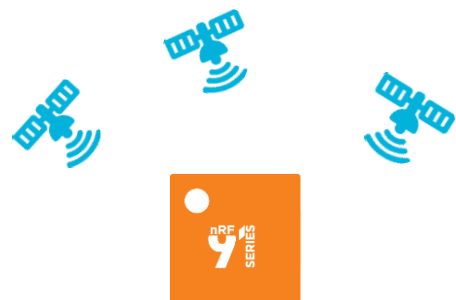


19

NEW nRF9160 GPS Enhancements

Modem firmware v1.2.2 released Oct 22

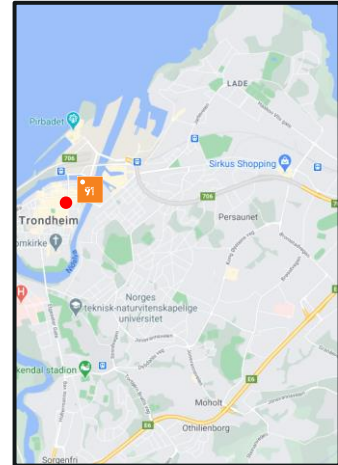
- Low resolution and 2D positioning mode
 - Fix with only 3 satellites in view
 - Urban canyons, hilly landscape, etc.
 - Positioning without altitude
- 2D Position is without altitude
 - High accuracy close to sea level
 - Inaccuracy increases with altitude



20

Trondheim example – Nordic HQ

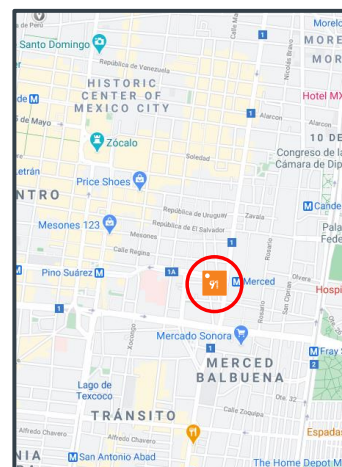
- ~at ocean level
- 2D fix will be accurate
- Most big cities in the world are at ocean level



21

Mexico City example

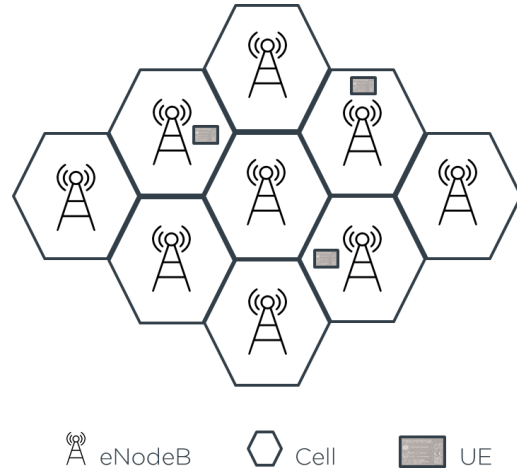
- ~ 2200 m above sea level
- 2D fix inaccuracy of ~50 – 100 meter
- Application can inject the altitude to the GPS
 - Removes the error



22

What is an LTE Cell?

- eNodeB - Evolved Node B
 - The hardware that wirelessly connects the cellular devices to the network.
- UE - User equipment
 - The cellular devices and products made with nRF9160 SiP.
- Cell - Area of range for an eNodeB
 - The physical region where a device is connected to a particular eNodeB.

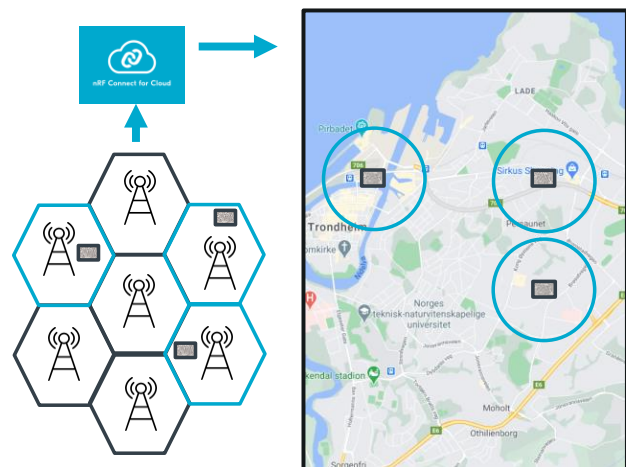


23

LTE single cell location

Optimized for constrained and embedded devices

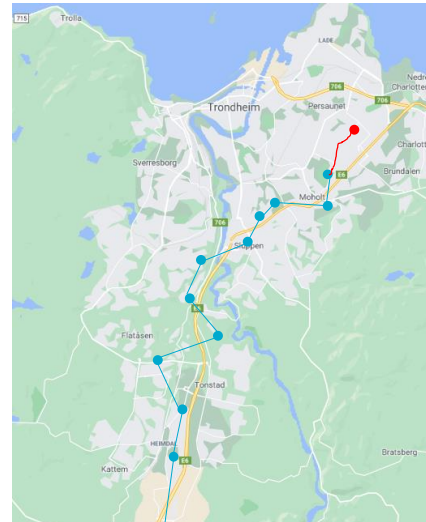
- Simple lookup in database
- Data available once connected
 - Zero time-to-first-fix
- Location accuracy
 - Kilometer range
 - What part of the city
- No added power consumption
- Both indoor and outdoor usage
- Useful to decide if a more accurate tracking must be started



24

GPS and Cellular Location Combined

- Cellular Location
 - No wasted power on accuracy unless needed
 - Not loosing track on things as they go indoor
 - GPS support – 2D altitude inject
 - Course tracking
 - Geo-fence
- GPS
 - When high accuracy is needed
 - When there is no LTE coverage



25

The nRF9160 Advantage in Asset Tracking

Integration



Integrate and use advanced packaging techniques to reduce solution size

Strong connectivity partners

Low Power



Build everything from scratch for low power
Integrate memories and use low-leakage process features

Ease of Use

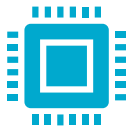


Enable self-service for the diverse set of asset tracking applications

26

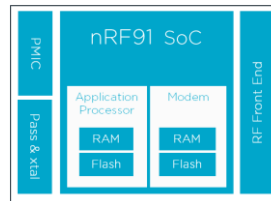
Saving power

Optimized HW and SW



Bottom up design from scratch
Low leakage processes
Optimizing radio performance
Continues improvements

Smart application



Taking advantage of dual core,
optimizing the application:
when and what to send

Testing



Nordic help customers with
power measurement in different
scenario

27

Ultra Low Power

Improved nRF9160 revision 2 – available NOW

Sleep Current Consumption

System Disabled	0.15uA		Device's internal power regulator disabled (entire device down). Reset when powered on.
PSM Floor	2.9uA	- 27%	LTE modem: RAM fully retained; M33 MCU: in idle with full RAM Retained; RTC on;

RCC mode – LTE-M1

eDRX average current, 81.92 s eDRX, one PO per PTW, PTW = 2.56 s	18uA	-14%	cycle average current, no repetitions. DRX set by network – in this case DRX 2.56s No calibration required during eDRX Floor eDRX < 6uA
Idle eDRX average current, 655 s, one PO per PTW, PTW = 2.56 s	6uA	-18%	
Uplink 180 kbit/s, Pout 23 dBm,	115mA	-15%	RMC settings as per 3GPP TS 36.521-1 Annex A.2

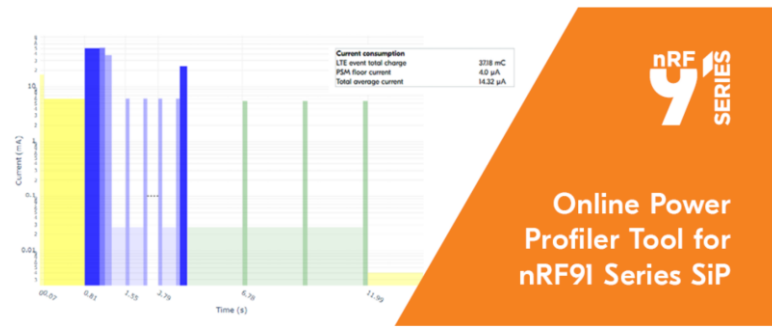
Similar improvements for NB-IoT

3.7 V, Typical values, Non including SIM

28

Try it yourself: Online Power Profiler

the first step towards a predictable low power solution

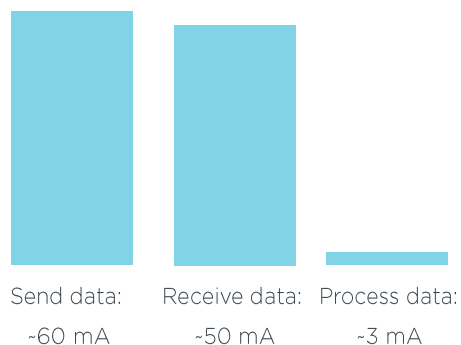


Online power profiler	https://devzone.nordicsemi.com/nordic/power/w/opp/3/online-power-profiler-for-lte
Online power profiler – User Guide	https://devzone.nordicsemi.com/nordic/power/w/opp/4/user-guide-lte

3.7 V, Typical values, not including SIM

29

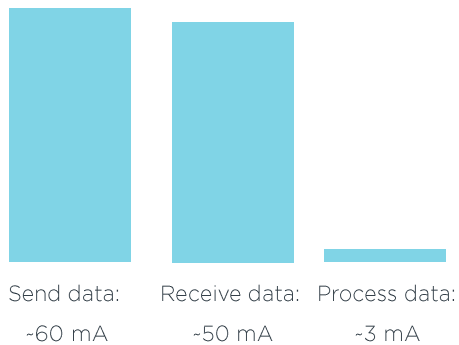
Utilize nRF9160 for Edge Computing



- Data transfers costs energy and subscription fee
- Processing data is ~20 times less energy
- To achieve 50% less data transfer time you can spend 10x that time on data processing
- Spend 5s of data processing to reduce 500ms data transfer time to 250 ms

30

Utilize nRF9160 for Edge Computing



1. Send information – not data

- Data: Accelerometer data, continues 3x16-bit values
- Information: The thing fell over sideways and is now laying flat
– 1 byte of information at the event

2. When something interesting happens

- send data anyway

31

The nRF9160 Advantage in Asset Tracking

Integration



Integrate and use advanced packaging techniques to reduce solution size

Strong connectivity partners

Low Power



Build everything from scratch for low power
Integrate memories and use low-leakage process features

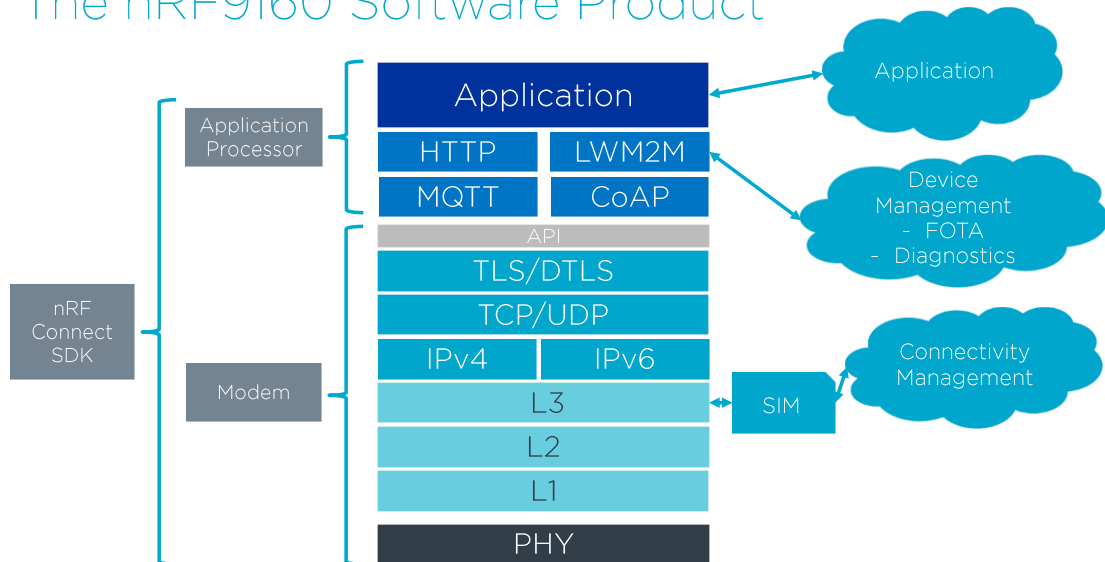
Ease of Use



Enable self-service for the diverse set of asset tracking applications

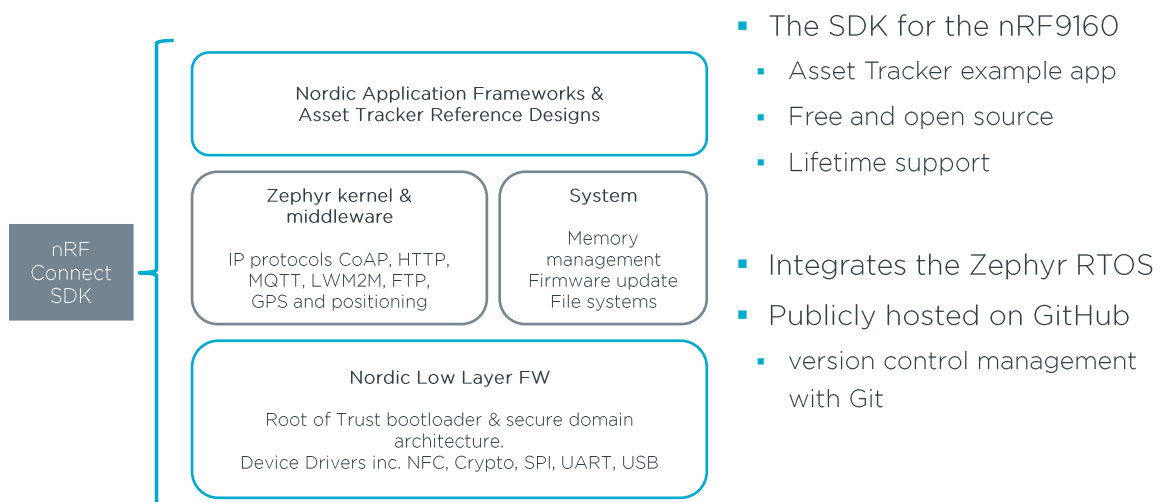
32

The nRF9160 Software Product



33

The nRF Connect SDK

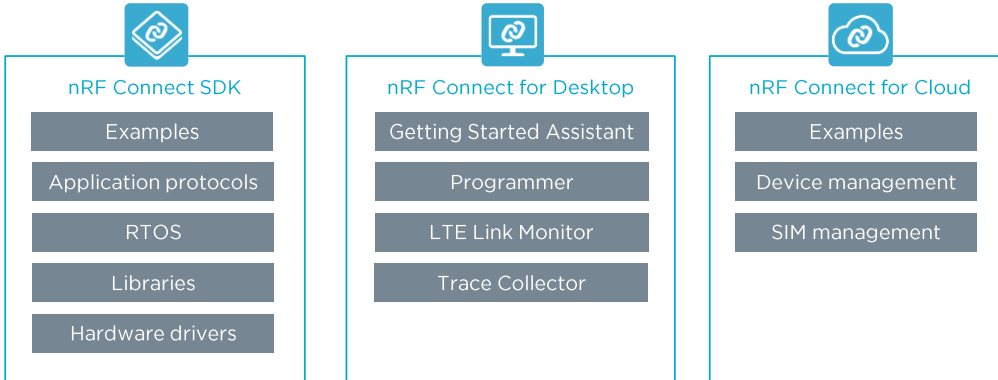


- The SDK for the nRF9160
 - Asset Tracker example app
 - Free and open source
 - Lifetime support
- Integrates the Zephyr RTOS
- Publicly hosted on GitHub
 - version control management with Git

34

nRF Connect family

- Development tools and support

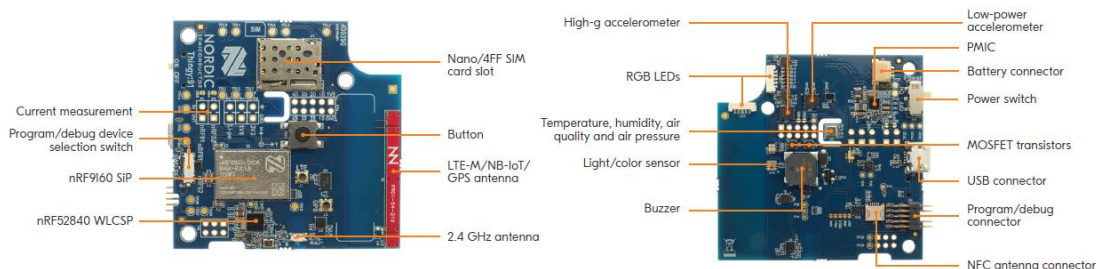


35

Nordic Thingy:91 Overview

Low barrier cellular IoT asset tracking proof-of-concepts

- Fully available hardware design and open source software
- Simple starting point for your own designs
- Work with your antenna manufacturer on antenna design that fits your application !



36

nRF9160 & cellular IoT Asset Tracking

The takeaways

- #1 The 4G network is already in place, 90% of world's population have coverage. Cellular IoT adds low power to that
- #2 nRF9160 is certified for world-wide operation in a single SKU
- #3 nRF9160 is a game-changer: connectivity, positioning and application CPU, all in a very small device: Open documentation and open source SDK and tools
- #4 nRF9160 has absolute 'best-in-class' power consumption: 50-90% lower than existing modems: Use the online power profiles to test your design
- #5 We built the hardware & software, a device that is tuned for high performance and energy-efficient operation

37

Register for upcoming
Nordic Tech Webinars

www.nordicsemi.com/webinars

38

Q&A