Using Cellular IoT in Predictive Maintenance

Nordic Tech Webinar

Martin Lesund/ Technical Marketing

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Today's hosts

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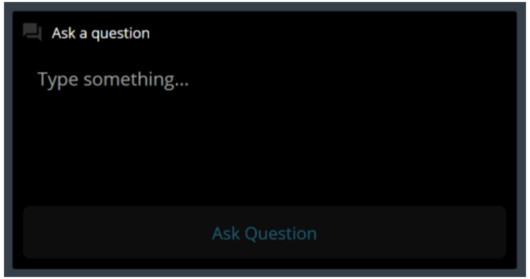
Technical Marketing Manager

Product Management

NORDIC SEMICONDUCTOR

Practicalities

- Duration: ~40 minutes + Q&A
- Questions are encouraged!
  - Please type questions at the top of the right sidebar
  - All questions are anonymous
  - Try to keep them relevant to the topic
  - We will answer them at the end
- The chat is not anonymous, and do not use 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



DevZone

Agenda

- Current LPWAN landscape
- Evolution of cellular IoT and 5G
- How cellular IoT enables predictive maintenance deployments
- How to benefit from using machine learning
- Q&A

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LPWAN Landscape

Understanding the LPWAN landscape

- Low Power Wide Area Network (LPWAN)
- Wireless network designed for long-range communication at a low bit rate
- Targets low power and low cost

Many flavors, different topologies, different use cases…

LTE-M

NB-IoT

sigfox

RPMA

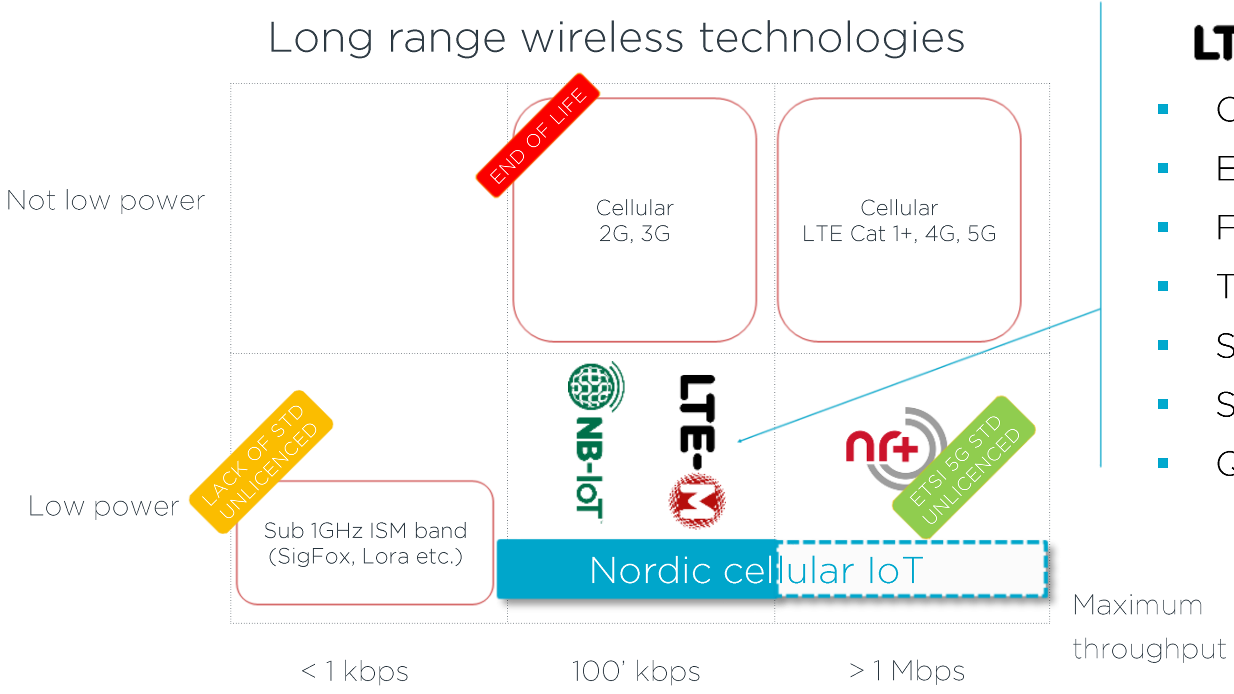
nwave

mioty

LoRaWAN®

There are even more…

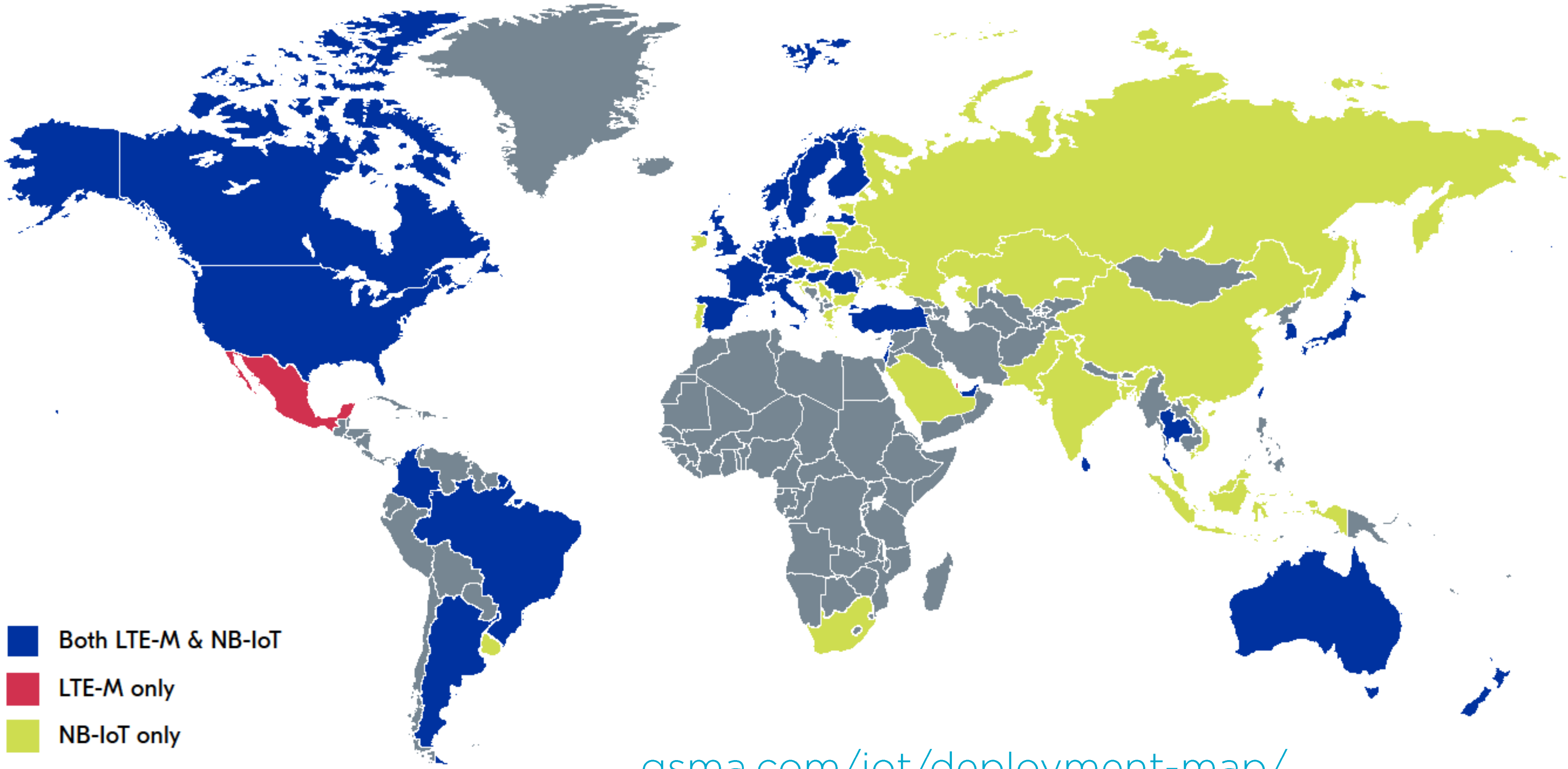
Low Power Wide Area Network Landscape



LTE-M NB-IoT

- Open standard (3GPP)
- Existing infrastructure
- Future proof (5G ready)
- Throughput
- Scalability
- Security and reliability
- Quality of Service

LTE-M and NB-IoT Landscape



gsma.com/iot/deployment-map/

LTE IoT technologies

LPWAN

	LTE CAT 1 bis	LTE-M	NB-IoT
Also known as	“LTE CAT 1” (3GPP Rel 8) “LTE CAT 1 bis” (3GPP Rel 13)	“eMTC”, “LTE CAT-M1” (3GPP Rel 13)	“LTE Cat-NB1” (3GPP Rel 13) "LTE Cat-NB2" (3GPP Rel 14)
Bandwidth	20 MHz	1.4 MHz	200 kHz
Max throughput (DL/UL)	10 Mbps/5Mbps	300/375 kbps	30/60 kbps (NB1) 127/169 kbps (NB2)
Typical range	2-6 km	<11 km	<15 km
Mobility	Yes	Yes	No
Roaming	Yes	Yes	Limited
Deep indoor coverage	no	no	Yes
Coverage	Global	mostly covered	mostly covered
Deployment density	~5000	Up to 50 000 per cell	Up to 50 000 per cell
Battery lifetime	1 year*	5 years*	

*predictive maintenance application

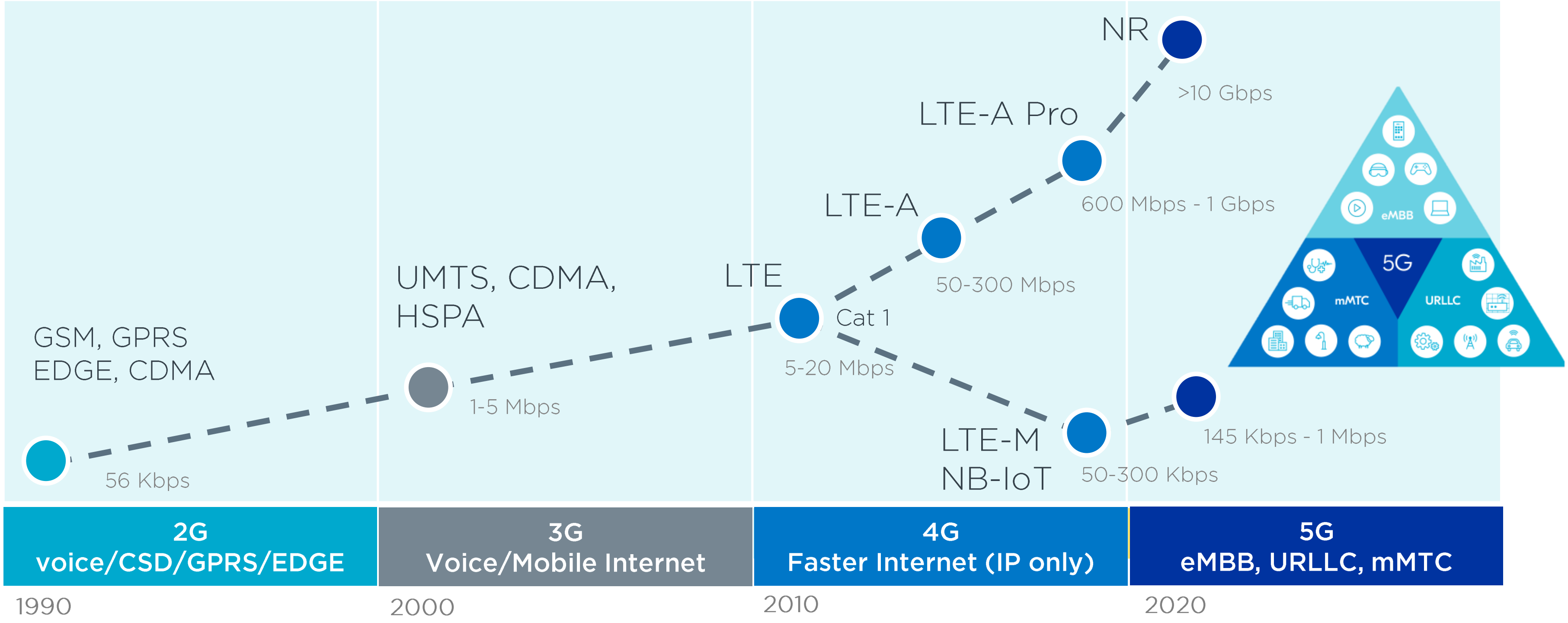
"Cat 1 bis" for massive IoT deployments?

- Global coverage on network side *(where you have 4G)*
  - Not so global on the module side
- Full duplex operation causes complexities
  - LTE-M/NB-IoT has much less complexity than CAT 1 bis
- High Bandwidth
- Power requirements (Not targeted small battery-operated devices)
  - Higher peak power consumption compared LTE-M/NB-IoT
- More Costs
  - Higher Module and design costs to be expected

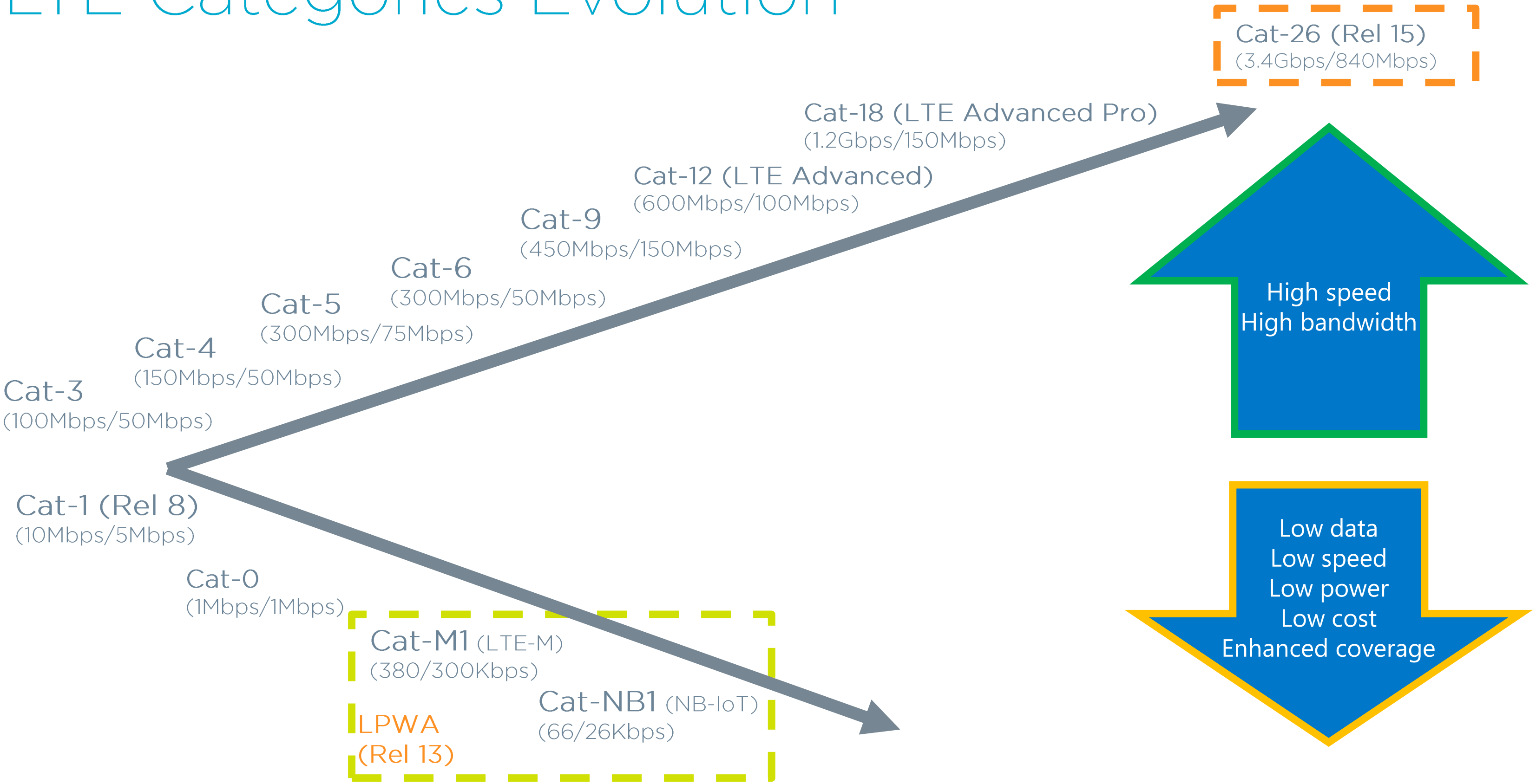
LTE-M/NB-IoT is designed for "massive IoT", while Cat 1 bis is "broadband IoT"

Cellular IoT evolution

Cellular evolution 2G to 5G



LTE Categories Evolution



What happens with 2G/3G/4G

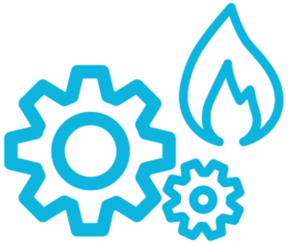
- Shutdown of old generation (2G and 3G) because spectrum is needed
- No need to refarming 4G frequency bands to deploy 5G
- Co-existence possible of 4G and 5G, both use same modulation in a compatible time and frequency grid

Co-Existence is a major 5G feature and extends 4G lifespan

Predictive maintenance

Different types of maintenance

Reactive maintenance



- Breakdown occurred
- Downtime
- Can be expensive
- Unplanned

Preventive maintenance

- Uses history of past failures
- Scheduled maintenance
- Limit potential downtime
- Cost saving vs. reactive

Condition-based maintenance

- Relies on sensor data
- Maintenance is only scheduled when performance has decreased
- Highly cost-effective

Predictive maintenance

- Data-driven
- Maintenance occurs when needed
- Utilizes condition-monitoring

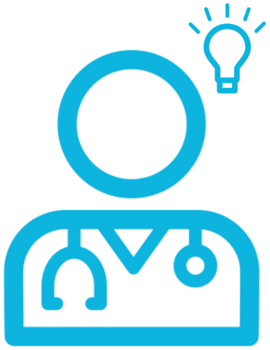
Predictive maintenance overview

- Maintenance strategy to predict when equipment is likely to fail
  - Allow for proactive actions to be made before failure occurs

McKinsey Global Institute reports that implementing PdM practices across manufacturing will have $240-$627 billion in cost savings across the industry

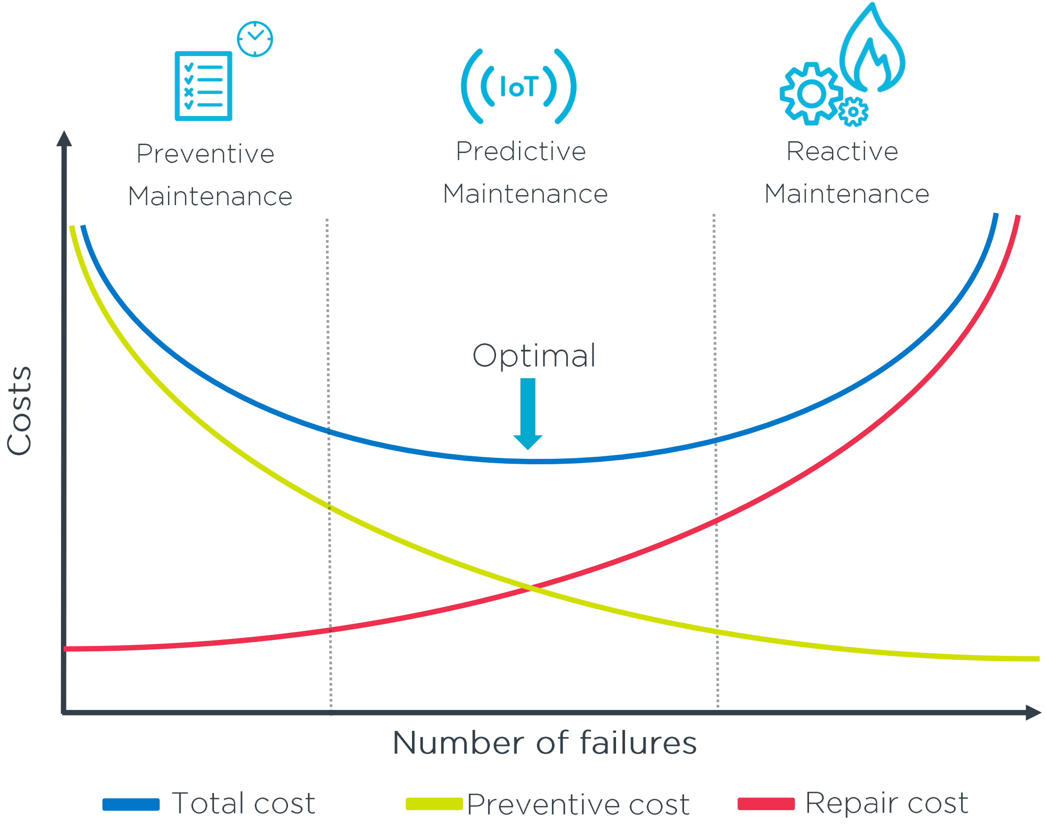
Benefits

- Reduce downtime
- Minimize maintenance costs
- Improve equipment performance and longevity



Where would it make sense to use it?

- Every machine/system is subject to wear and tear
- Cost decision
- How dependent are you on the device running?
- Factory line applications are depended on everything working



source

Why use cellular IoT in predictive maintenance

Reliable connectivity

Reliable and secure communication

Wide coverage

More coverage compared to other options

Scalability

Thousand to millions of devices in the same area

Why use cellular IoT in predictive maintenance

Real-time monitoring

Required to get alerts in real time if maintenance is needed

Reduced maintenance costs

Deploy and the device can run for years

Only run maintenance when needed

Machine Learning

Process the data on cloud or device side?

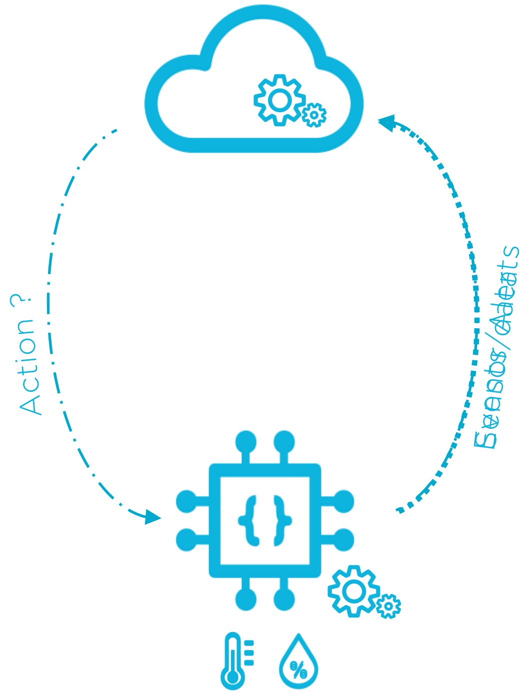
- You could process and train the ML models on the device or in the cloud

Using the cloud

- A lot of processing power available!
- Burn power consumption on the device
- Can be higher latency
- Higher costs (data processing and network traffic)
- Poor wireless connection will affect outcome

Using the device ("Edge computing")

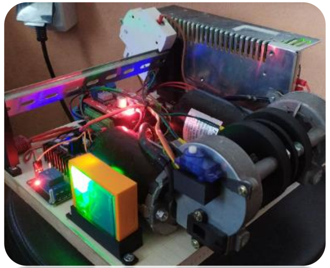
- Power efficient and not taking up network
- Processed in the same environment the data is captured
- Enhances privacy and data security



Make it smarter with machine learning (ML)

- Use historical data and live data to analyze failure patterns

1. Which sensors to use?
   1. What type of failures generally occurs?
   2. How does the failure process happen over time?
   3. Which parts/processes are related to the types of failures
   4. Data collection over time
2. What type of output should the ML model give?
   1. Historical data or static data
   2. Events recorded, labeled and logged



EDGE IMPULSE

Benefits of using ML in predictive maintenance

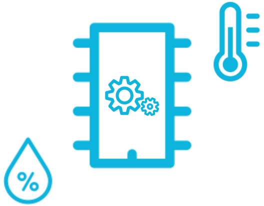
Improved accuracy

ML algorithms can analyze large amounts of data and make more accurate predictions than traditional methods

Early detection

Optimize the maintenance schedule based on ML predictions and detect failures before they occur

Scalability

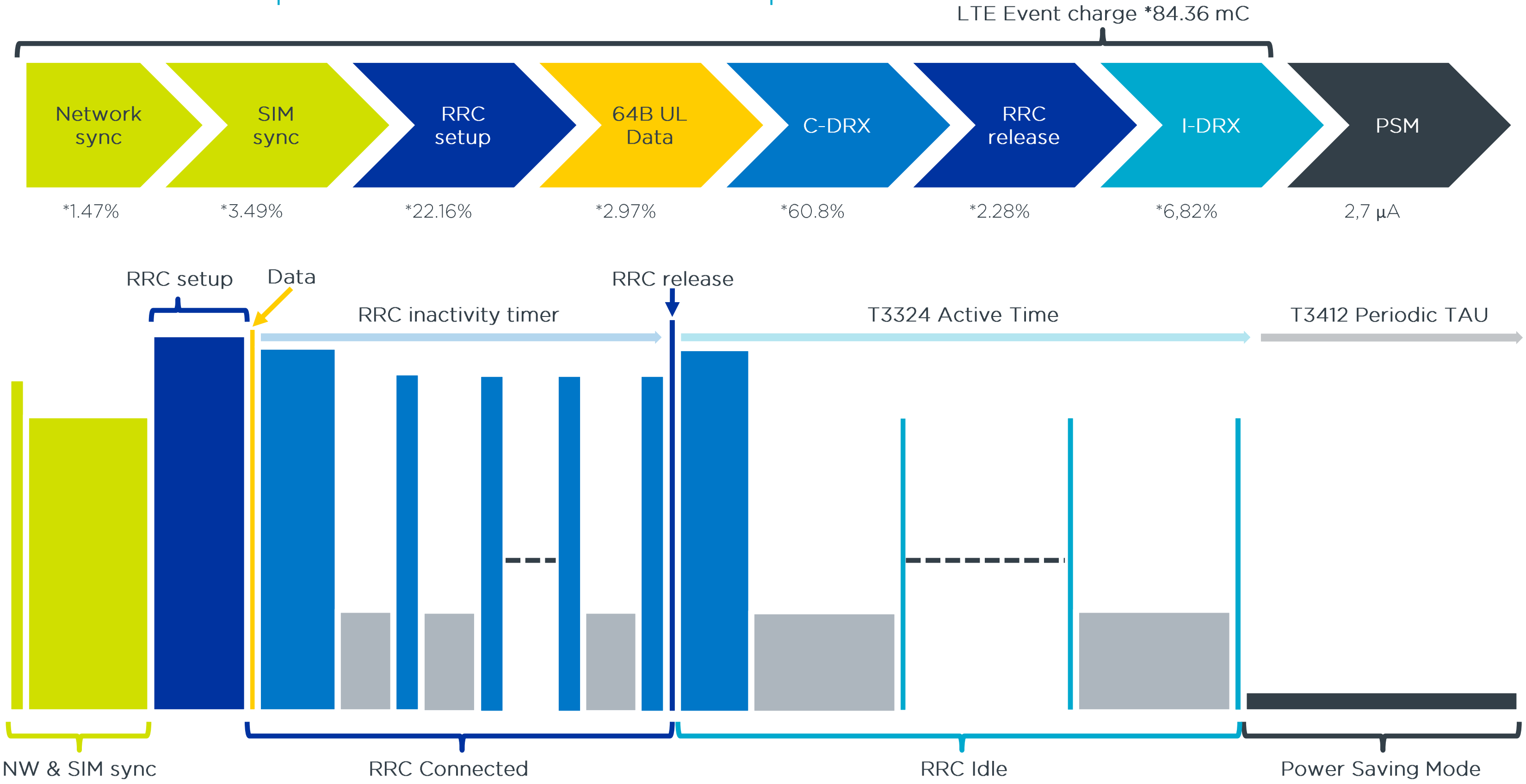


More data to train can improve the performance

Scale with more devices or sensors

* Numbers from nRF9160 SiP on Telenor network in Norway.

Cellular power consumption



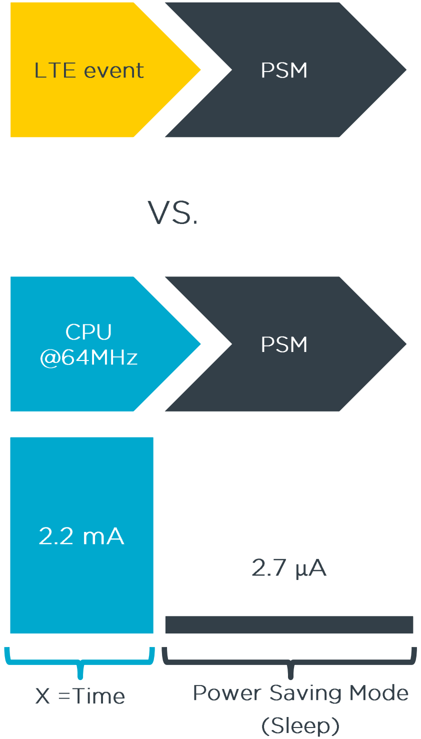
Break-even comparison - LTE vs. CPU

How much CPU run-time for the cost of the LTE event?

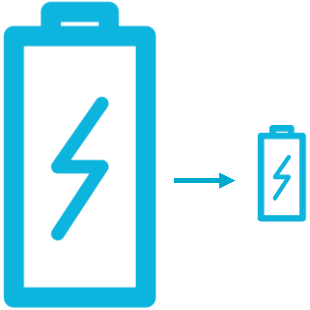
- 64B UL Data LTE event on Telenor Network
  - Consumes 84.36 mC *(where* $1\ Coulomb = 1\,[A] \cdot 1\,[s]$*)*
    - This gives the following equation:

$$t_{CPU}[s] = \frac{Charge_{LTE}[mA] \cdot 1[s]}{I_{CPU}\ [mA]}$$

UL data Charge	1 Byte 83.59 mC	64 Bytes 84.36 mC	1024 B 96.07 mC	2048 B 108.56 mC
Time	38.0 s	38.35 s	43.67 s	49.35 s



The advantages of nRF9160 SiP



Lowest power

Bottom-up design from scratch

Low leakage processes

Optimizing radio performance

Increase battery life

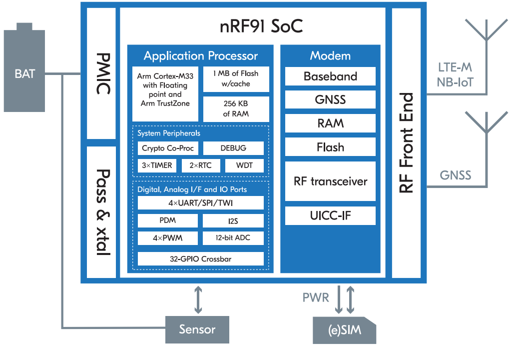
Ease of use

Complete software development kit

Complementary tools

Globally certified

Faster time to market



Smallest Integration

An unprecedented level of integration

Complete communication and application module with all relevant components in 10x16x1.04mm SiP

Smaller PCB and size costs

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Q&A

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