EETOP物联网论坛：NB-IoT设计及测试技术研讨会（2017.7.4，北京）

NarrowBand-IoT:
A cellular technology connecting the Internet Of Things

Bai Ying
GCFO Wireless Segment
Marketing Manager

KEYSIGHT TECHNOLOGIES

Keysight History

1939–1998: HP

Start from electronic test and measurement

1999-2013: Agilent Technologies

Split from HP and became the world leading measurement company

Declared to split the electronic measurement business on Sep. 2013

2014: Keysight Technologies

Became an independent company on Nov. 2014

100% focus on electronic test and measurement

Agenda

Why NB-IoT

Test Challenges and Solutions

Summary

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Before we start… Cellular IoT gains momentum with NB-IoT

3. Keysight demonstrated a NarrowBand-IoT testbed based on an Intel XMM 7115 modem (left, zoomed in). (Source: ClariTek) (Click image to enlarge)

Vodafone reveals NB-IoT rollout plan

By Nick Wood, Total Telecom
Wednesday 19 October 2016

Dedicated IoT networks to go live in Germany, Ireland, Netherlands, Spain during first quarter of 2017.

Telefonica, Huawei, Kamstrup in first LatAm NB-IoT trial

Wednesday 15 February 2017 | 13:55 CET | News

Telefonica and Huawei have teamed up with smart metering products provider Kamstrup to launch what the partners describe as the first project using NarrowBand Internet of Things

Deutsche Telekom, Huawei activate NB-IoT network in Germany

NB-IoT demo planned for Bonn

AT&T and Ericsson To Deliver Technologies That Boosts The Internet of Things

INNOVATION / Barcelona, Spain, Feb 22, 2016

Share

Ericsson to Deploy Cat-M and NB-IoT Software for AT&T's 4G LTE Network to Lower Power Consumption, Cost and Complexity

AT&T* is working with Ericsson (NASDAQ:ERIC) to deploy CAT-M and NB-IoT 3GPP standards-based technologies. This new software will support a new generation of Internet of Things (IoT) apps and improve device performance on the AT&T 4G LTE network.

Vodafone Spain expands NB-IoT network to six cities

Monday 27 February 2017 | 09:36 CET | News

Vodafone has confirmed that its NB-IoT (narrowband Internet of Things) network is now available in a total of six major Spanish cities. The operator launched the network in Madrid

Huawei and Oviphone tout "world's first NB-IoT watch"

17 OCT 2016

6 18 24

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2016-5-27 15:43

China Unicom starts NB-IoT networking trials in China, plans to push NB-IoT deployment in 2017

KEYSIGHT TECHNOLOGIES

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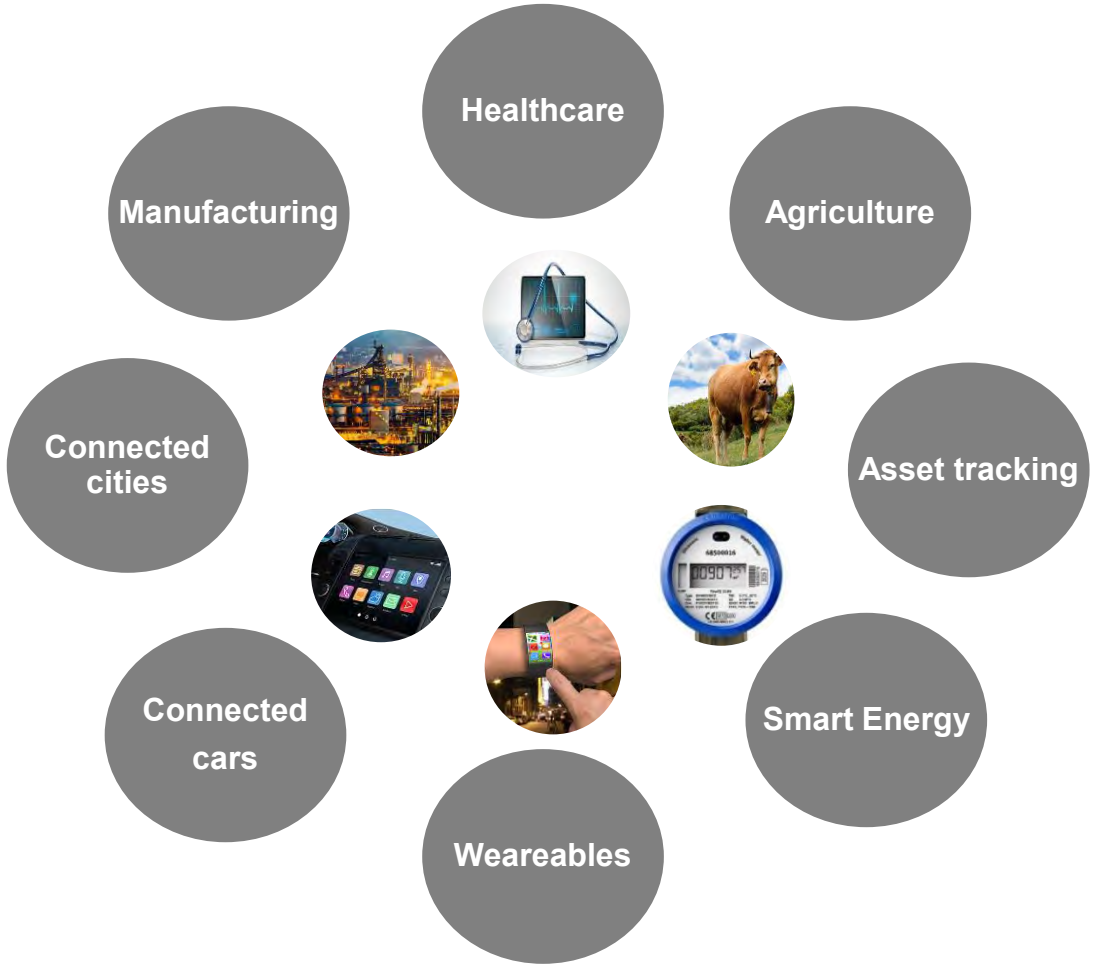
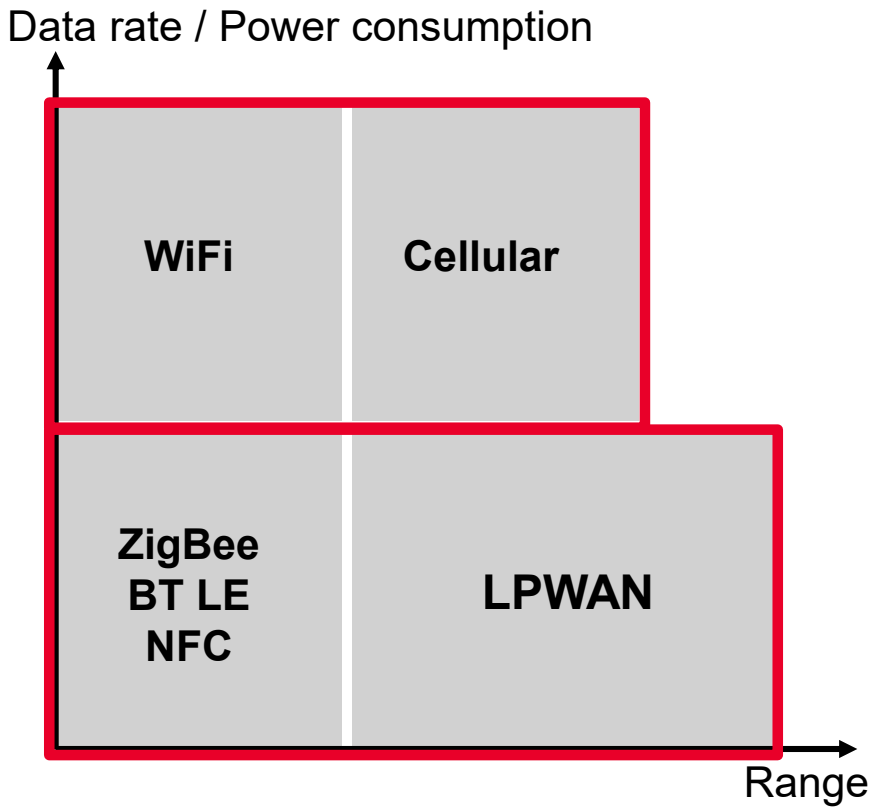
Test Challenges and Solutions

Summary

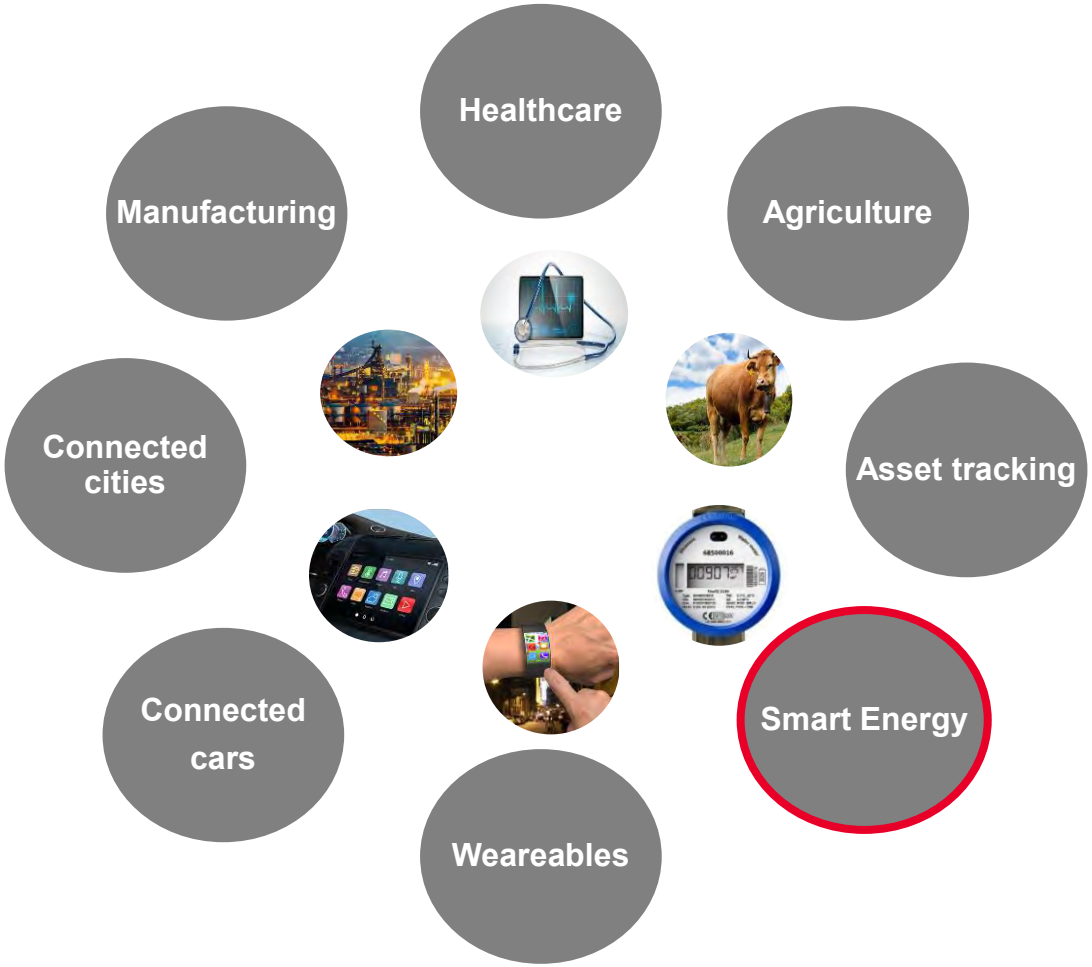
Diverse IoT Applications

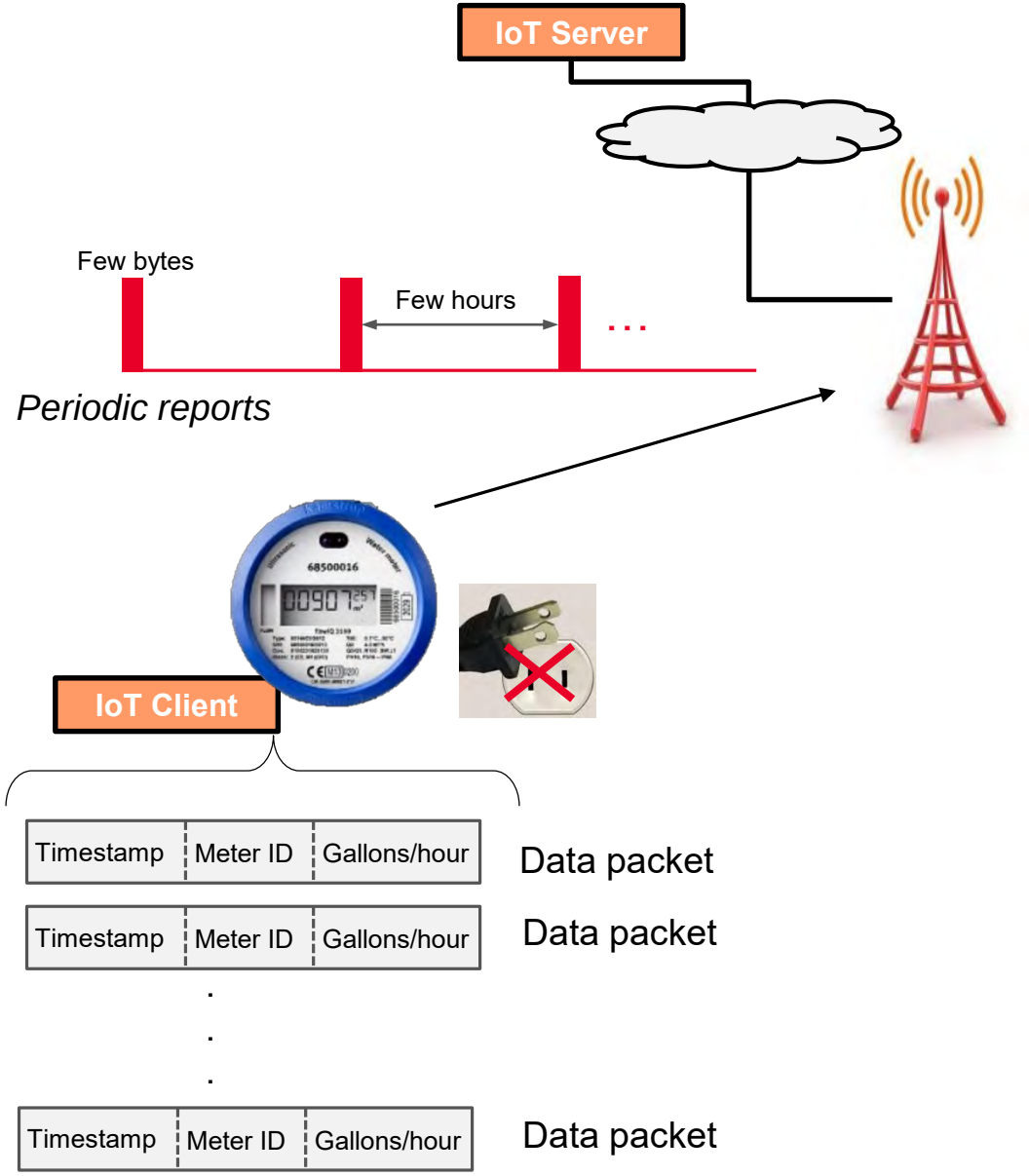


Diverse IoT Applications



LPWA Technology Challenges





The solution is in the Network Operators

Solutions Today

- Infrastructure investment
- Soft standardization
- Range limitations
- Limited battery life
- Cellular as backhaul

Cellular LPWA

- Reuse of Cellular infrastructure
- Strong standardization
- Improved coverage
- Mobility, Roaming
- Security, Authentication

The solution is in the Network Operators

Solutions Today	Cellular LPWA

Then…
What is holding back Operators??

Reasons are technical limitations in the Network:

It was designed for human communications

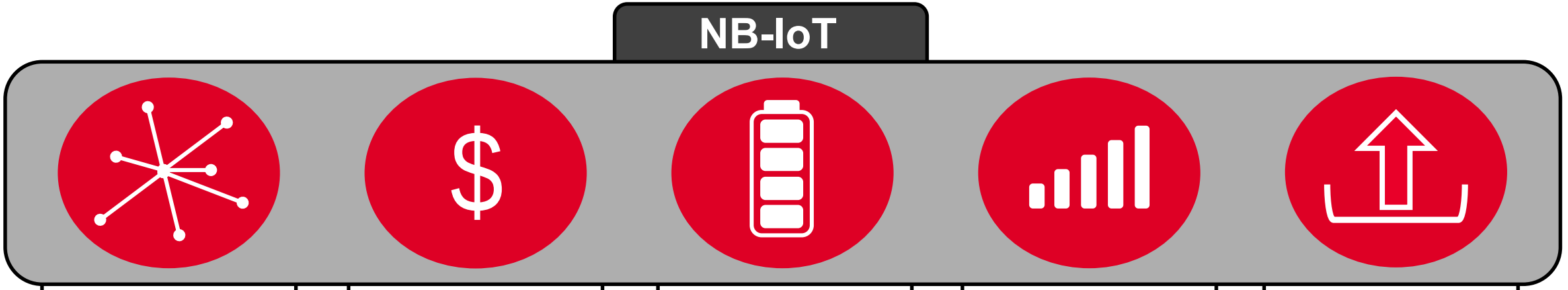
CONS

- Infra
- Soft
- Rang
- Limited battery life
- Cellular as backhaul

rastructure
on

- Mobility, Roaming
- Security, Authentication

3GPP Release 13 Narrowband IoT: Design Goals



High Density

- 10s k devices/cell
- Data rates of 10s of kbps
- Low frequency of connections

Low Cost

- Modules < $5
- No fancy features
- Reliable, stable

Superior Battery Life

- Up to 10+ years
- Enhanced sleep modes

Extreme Coverage

- +20 dB compared to GPRS
- Areas of difficult access or remote

Upgrade

- To existing RAN infrastructure
- Global technology standard (3GPP)

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The evolution of NB-IoT standardization

Low Cost

Low Power

Extreme Coverage

High Density

Higher data rates

Enhanced mobility

Positioning

Further power reduction

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NB-IoT Test Solutions Across the Lifecycle

Anite A9000 Protocol Conformance testing solution

Anite Propsim Channel Emulator

R&D | Verification | Acceptance | Manufacturing

System Vue

Design Simulate

Protocol L2/L3 Develop

L1/PHY Develop

RF Develop

Integrate

Protocol Verify

System & perf-ormance verify

RF Design Verify

Pre-cert

Certification

OTA test

Operator acceptance

Lab IOT

Field trials

GCF/PTCRB

CTIA/CE/FCC regs

Production

T4000S RF & RRM Conformance Testing Solution

UXM integrated test set

Low Power Analyzer

E6640A EXM Wireless Test Set

Speed, performance and results you can trust… Across the whole NB-IoT device lifecycle

KEYSIGHT TECHNOLOGIES

3GPP Release 13 Narrowband IoT: Design Goals

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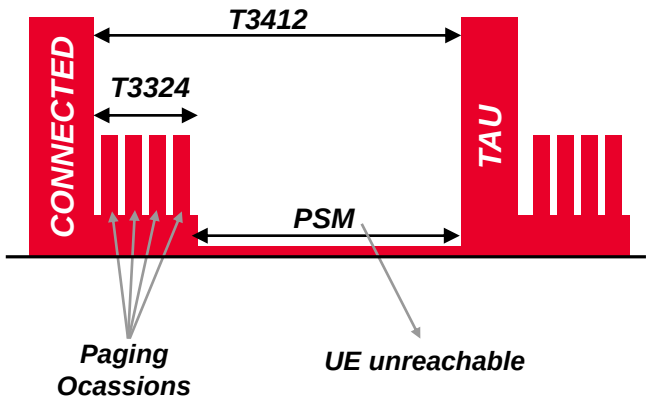
KEYSIGHT TECHNOLOGIES

NB-IoT Power Saving Mode and eDRX

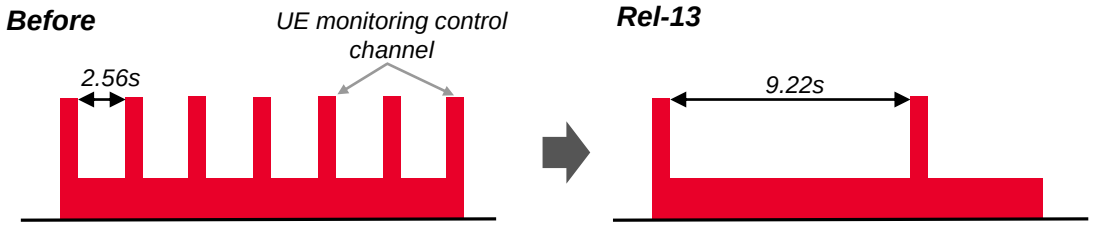
Rel-12 Power Saving Mode (PSM)



- T3324 determines for how long the UE will monitor paging beforing entering in PSM
- While in PSM, UE is not reachable by the Network and all circuitry is turned off
- UE exits PSM when T3412 expires (TAU) or with a Mobile Originated transfer

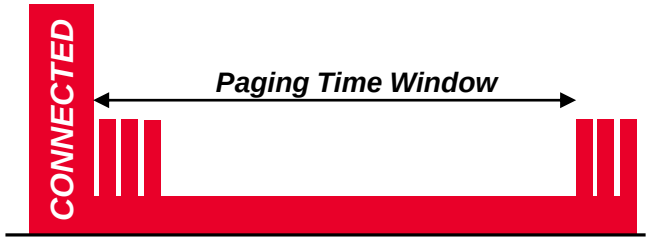
Rel-13 Enhanced DRX (eDRX)

CONNECTED eDRX



- DRX cycles extended from 2.56 seconds:
  - To 9.22 seconds in NB-IoT

IDLE eDRX



- New Paging Time Window which allows longer paging cycles:
  - 3 hours in NB-IoT

NB-IoT Design Challenge - Power Consumption & Efficiency

***Challenge #1*: Setting the device in different operating modes realistically**

- Different modes including IDLE, CONNECTED, PSM and eDRX
- Impact of very consuming activities like Repetitions, data transmissions or OTA updates

***Challenge #2*: Accurately measure sleep modes in presence of large spikes**

- Wide dynamic range: sub-µA to 100 mA
- Single view logging providing complete analysis

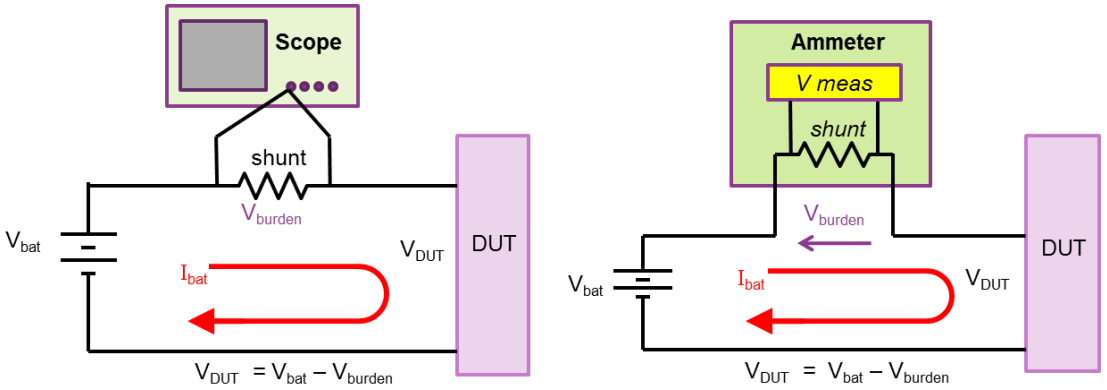
***Challenge #3*: Characterize battery run-down including aging effect**

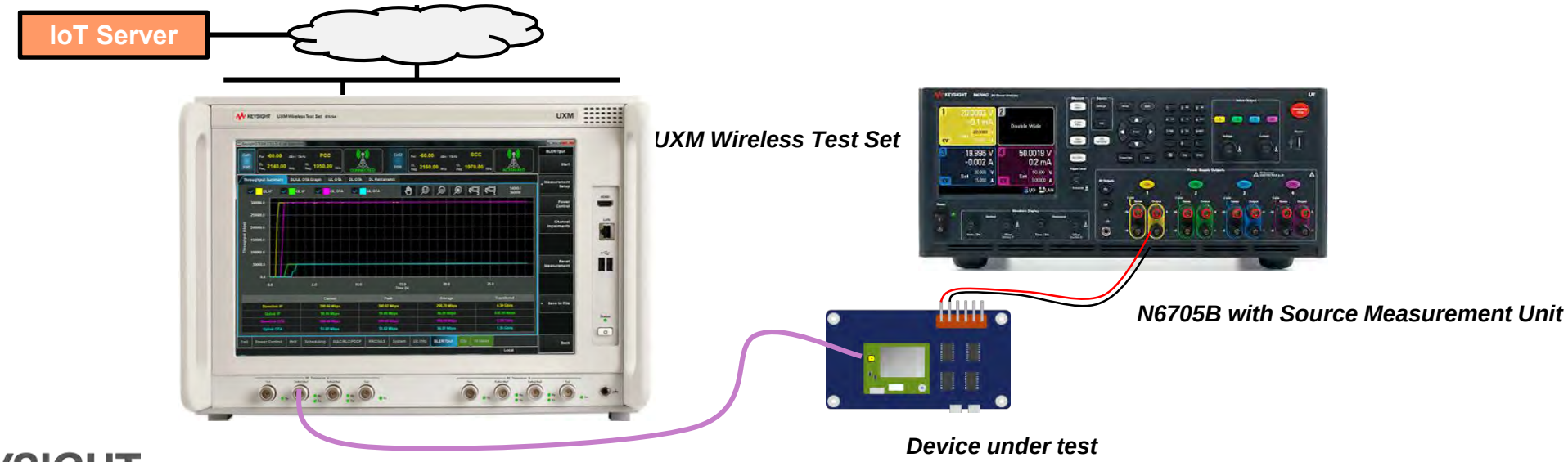
- Being able to measure current and voltage simulatenously with enough accuracy
- Emulation of series resistance of the power supply

NB-IoT Design Challenge - Power Consumption & Efficiency

Characterize critical scenarios before deploying:

- Efficiency of power saving modes (PSM, eDRX)
- Transitions between states (connected, idle, sleep)
- Data transfer (uplink, downlink, bi-directional)
- Repetitions performance for different Coverage levels
- Negative testing (IoT server down, no coverage, etc…)
- Software updates when in the field





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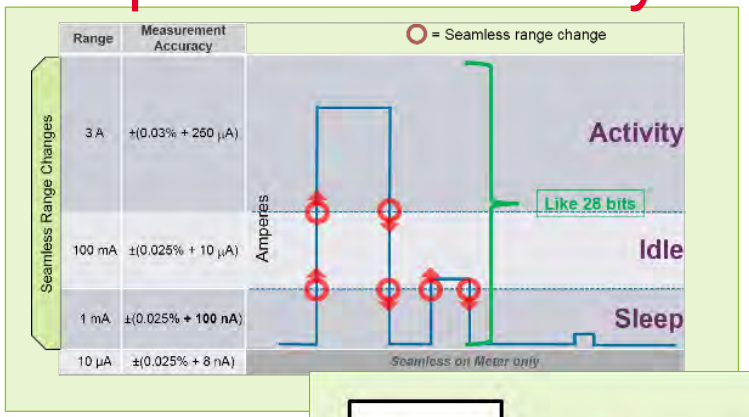
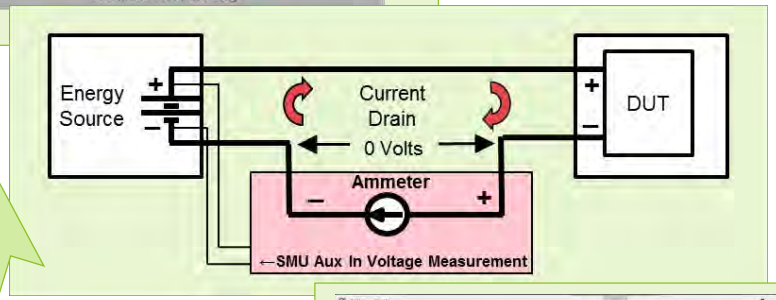
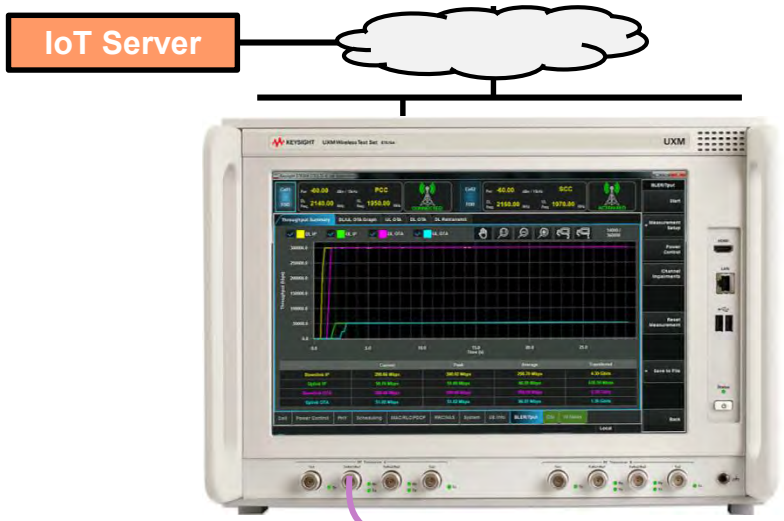
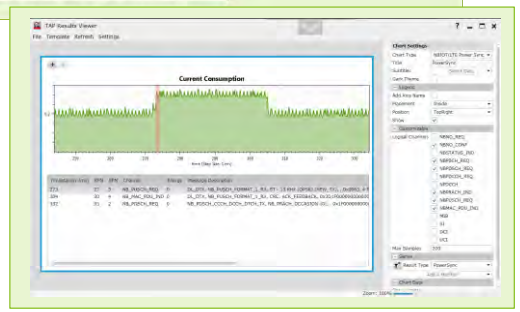


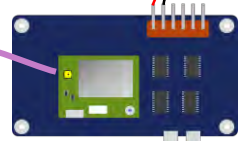




UXM Wireless Test Set



N6705B with Source Measurement Unit



Device under test

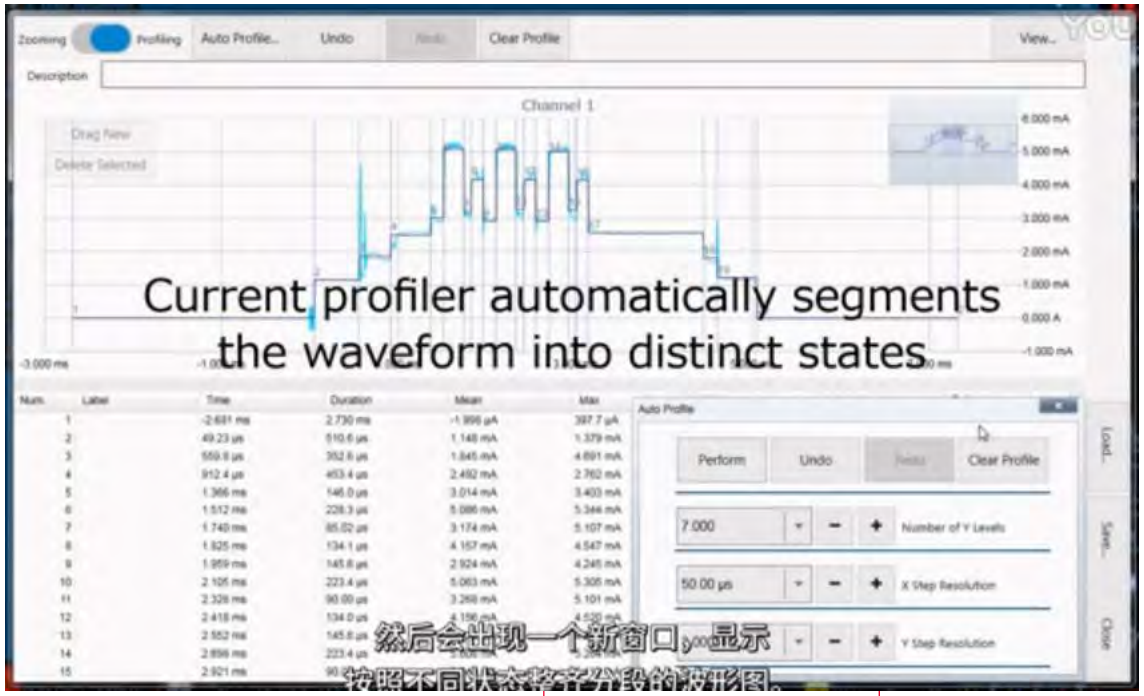
CX3300 Current Waveform Analyzer

CX3322A (2 Channel)

CX3324A (4 Channel)

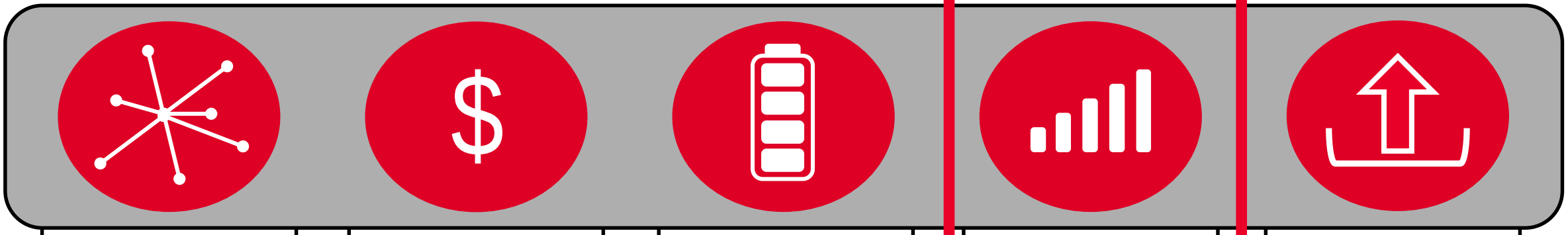
- Test the small current signal you never see(pA level)
- WXGA 14.1 multi-touch display and familiar measurement function save the start-up time for new users
- A wide variety of built-in analysis tools improve debugging efficiency

Property	Range
Current Range	100 pA ~ 10 A
Max. Bandwidth	200 MHz
Max. Sample Rate	1 GSa/s
Dynamic Range	14-bit or 16-bit
Store Depth	256 Mpts/ch
Channels	2 or 4



KEYSIGHT TECHNOLOGIES

3GPP Release 13 Narrowband IoT: Design Goals



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- Areas of difficult access or remote

Upgrade

- To existing RAN infrastructure
- Global technology standard (3GPP)

KEYSIGHT TECHNOLOGIES

NB-IoT: Extreme Coverage

Remote location

Basements and sewerages

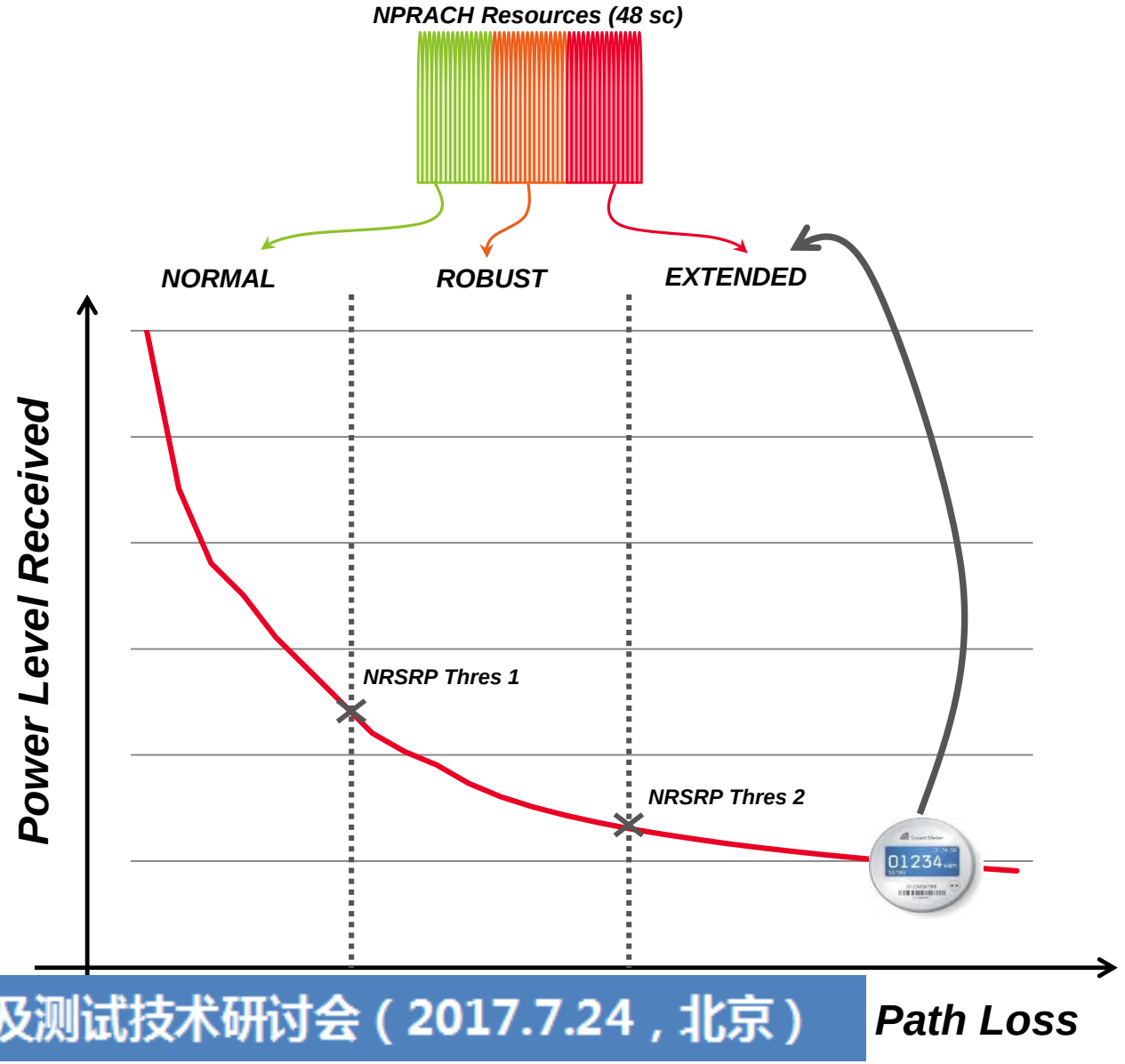
Hidden Installation

Industrial Environments

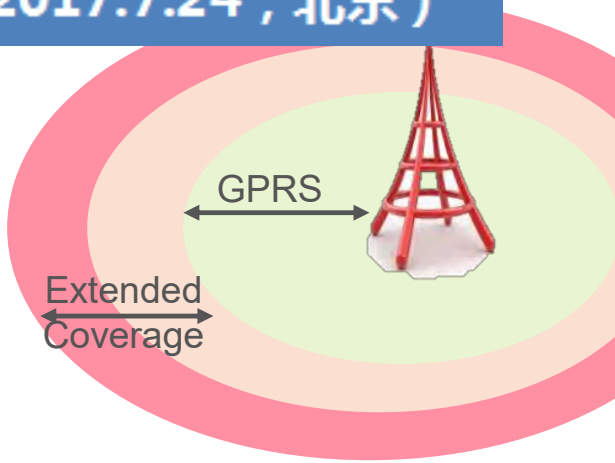
Characaterization	Performance	OTA
- Extreme Sensitivity - Sync under low SNR - Transmitted Signal - Blocking and Intermodulation	- Propagation conditions - Slow fading profiles - Different operation modes and antenna configurations	- Wall, metallic structures - 3rd party enclosure and antenna effects

NB-IoT: Coverage Levels

- Up to 3 different Coverage Levels signaled via SIB2-NB (Normal, Robust, Extreme)
- The coverage level selected determines the NPRACH resources to use:
  - Subset of subcarriers, PRACH Repetitions, Max number of attempts, etc…
- UE derives the Coverage Level based on NRSRP measured
  - NPRACH resources to be used are determined by the Coverage Level

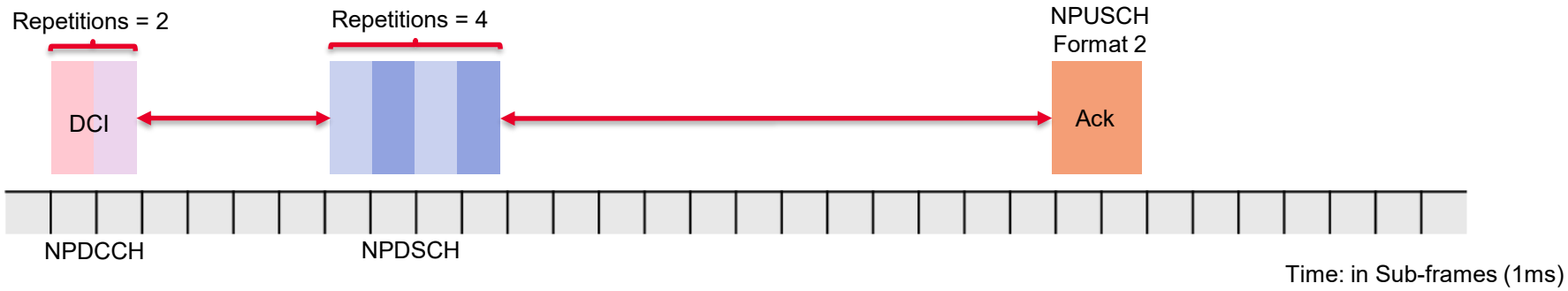


NB-IoT: Repetitions



– Technique consisting on repeating the same transmission several times:
  - Achieve extra coverage (up to 20 dB compared to GPRS)
  - Each Repetition is self-decodable
  - Scrambling code is changed for each transmission to help combination
  - Repetitions are ACK-ed just once

– For NB-IoT all channels can use Repetitions to extend coverage



Example: *Repetitions used in NB-IoT in NPDCCH and NPDSCH channels*

NB-IoT: Extreme Coverage – Test Challenges

***Challenge #1*: Receiver Sensitivity without and with Repetitions**

- Below -120 dBm requires very accurate signal generation
- Soft-combination delivers expected gain in the receiver
- NRSRP and NRSRQ properly measured and reported to higher layers

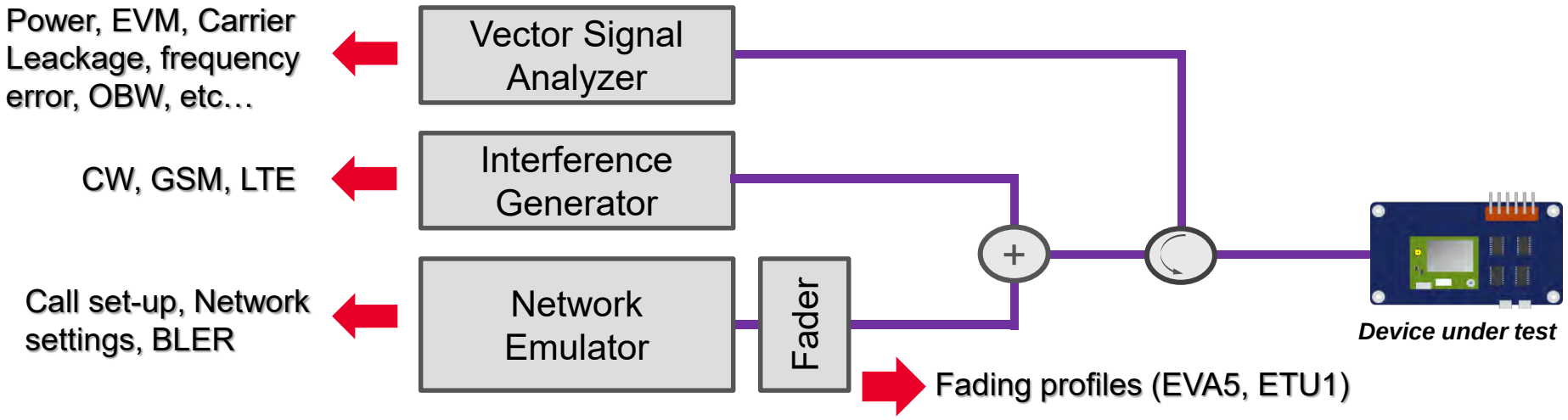
***Challenge #2*: Performance characterization using low cost components**

- Synchronization when poor Signal to Noise Ratio due to low cost crystal oscillator
- Impact of the transmitted signal due to removal of PAPR reduction circuitry

***Challenge #3*: Nomadic devices with slow mobility**

- SISO and Transmit Diversity
- Complex test set-ups including multiple antennas, AWGN and Fading

NB-IoT: Extreme Coverage



Characaterization	Performance	OTA
- Extreme Sensitivity - Sync under low SNR - Transmitted Signal - Blocking and Intermodulation	- Propagation conditions - Slow fading profiles - Different operation modes and antenna configurations	- Wall, metallic structures - 3rd party enclosure and antenna effects

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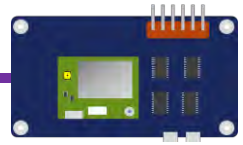
NB-IoT: Extreme Coverage

Power, EVM, Carrier Leackage, frequency error, OBW, etc…

CW, GSM, LTE

Call set-up, Network settings, BLER



Device under test

Fading profiles (EVA5, ETU1)

Characaterization

- Extreme Sensitivity
- Sync under low SNR
- Transmitted Signal
- Blocking and Intermodulation

Performance

- Propagation conditions
- Slow fading profiles
- Different operation modes and antenna configurations

OTA

- Wall, metallic structures
- 3rd party enclosure and antenna effects

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Test Challenges

Summary

Summary

❖ **NB-IoT addresses LPWA use cases re-using existing cellular infrastructure**

- A completely new technology that will continue developing in further 3GPP Releases
- Narrowband technologies will continue to serve the MTC use case with 5G NR

❖ **NB-IoT networks are becoming a reality…**

- Multiple Operators trials now in EU and Asia; planning to deploy services during 2H 2017
- Strong interest from other Operators worldwide

❖ **Covering new use cases means facing new challenges**

- Extended coverage, low power consumption, stability, etc…
- Operators' Acceptance including 3GPP conformance test and certification

Certification and Operators Acceptance

Validated Platform in GCF (TP195)

- Integration of **E7515A UXM Wireless Test Set**
- Confidently runs **RF & RRM Conformance 3GPP Test** cases on a validated GCF/PTCRB Test Platform: TP-195
- Designed like a pre-conformance and **Design Verification** (DV) tool
- Extensive test coverage for major US operators acceptance test plans: AT&T, Verizon, T-Mobile and Sprint
- **Scalable & Compact solution** based on a common hardware set
- Create **Custom Test Campaigns** with flexibility, use powerful debug tools for results analysis
- Free-up engineering resource by adopting **test automation**

KEYSIGHT TECHNOLOGIES

Keysight Technologies

Modelling tools

Network Analyzers

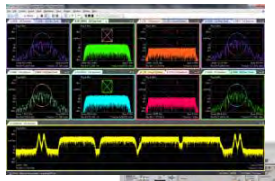
Protocol conformance test

Propsim channel emulator

i3070 test systems

FieldFox

R&D	Design validation	Compliance	Manufacturing	Deployment
Modelling	RF performance	OTA	IC	Spectrum clearance
PHY/RF	Throughput	Lab IOT	Module	Installation
L2/L3	Battery Drain	Operator	Product	Optimization
Apps	Stress	GCF/PTCRB	Sample	Repair
Integration	Regression	Regulations	Debug	Operations



VSA/VSG

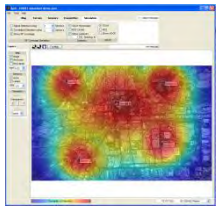
Thermal test

UXM Wireless Test Set

Power measurement units

RF & RRM conformance

EXM Wireless Test Set



Oscilloscopes

NarrowBand-IoT:
A cellular technology connecting the Internet Of Things

The Key to Success in Technology

We deliver what's next. First.

THANK YOU!

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HARDWARE + SOFTWARE + PEOPLE = INSIGHTS

KEYSIGHT TECHNOLOGIES