3GPP LPWA Standards: LTE-M, NB-IoT & EC-GSM

LPWA Roadshow
Melbourne, 14 September 2017

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OEM Business Unit - Sierra Wireless
Sierra Wireless – Introduction

- Founded in 1993
- 1,100 employees worldwide
- 2015 revenue: $608 million
- #1 IoT module supplier worldwide
- 25 years of steady innovation

- Connected Machines
- IoT Hardware
  - AirPrime
  - AirLink
- IoT Connectivity
- IoT Platform
  - AirVantage

- R&D, Marketing, Operations
- Manufacturing
- Commercial offices
Hold on. Let’s just take a step back......

What do you call a boomerang that doesn’t come back?

A Stick!

Ensure the right technology is used for your application!
LPWA Technologies and the IoT needs

**3 C’s**
- Low data rates
- Low data usage
- Long distances

**Use Cases**
- LPWA
  - Cat-M1/NB1

**Coverage**
- WWAN 10km
- WWAN 1km
- WLAN 100m
- WHAN 10m
- WPAN 1m

**Speed**
- 100 kbps
- 1Mbps
- 10Mbps
- 100Mbps
What makes LPWA a new category of cellular?

The 3C’s of LPWA

- **Coverage**
  - Extension
  - 5-10x greater than 4G LTE

- **Consumption**
  - Reduction
  - 100x lower power than 4G LTE
  - 10+ years battery life

- **Cost**
  - Optimization
  - 50% reduction from 4G LTE
  - Think 2G or Bluetooth
Low Power Wide Area

Proprietary - Unlicensed Bands
- RPMA – Ingenu
- UNB – Sigfox
- LoRa – Semtech

Standardized - Licensed Bands
- 1st 3GPP LTE-M contribution by Sierra Wireless*
- 3GPP

Cellular and Standard

* http://www.3gpp.org/ftp/tsg_s/TSG1_Serv/TSGS1_51_Seoul/Docs/S1-102151.zip
Three complementary cellular Standard LPWA technologies

- **LTE-M**
  - 4G - Cat-M1 & Cat-M2
  - High data rate - Mobile apps

- **NB-IoT**
  - 4G - Cat-NB1 & Cat-NB2
  - Low data rate - Stationary apps

- **EC-GSM-IoT**
  - 2G
  - Low data rate - 2G Evolution

- **164dB of link budget**
- **10+ years of battery life**
- **Super cost effective**

- **2015**
  - LTE Cat. 1
  - GSM

- **2016**
  - Cat-M1
  - Cat-NB1

- **2017**
  - Cat-M2
  - Cat-NB2

- **2018**
  - EC-GSM-IoT

- **2019**

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Super cost effective

10+ years of battery life

164dB of link budget

Cat-NB1 & Cat-NB2

Cat-M1 & Cat-M2

EC-GSM-IoT

GSM

LTE Cat. 1

Cat-M1

Cat-NB1

Cat-M2

Cat-NB2

2G Evolution

Mobile apps

Stationary apps

M2M Connectivity

SIERRA WIRELESS®
LTE-M, NB-IOT and EC-GSM – 3’Cs

The 3C’s of LPWA

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PLUS all the benefits of cellular

- Global Service
- Durable Investment
- Trusted Ecosystem

The 3C’s of LPWA

Global Service

Durable Investment

Trusted Ecosystem

SIERRA WIRELESS®
Coverage Enhancement Techniques

1. Repetition w/HARQ (hybrid automatic repeat request)
2. Frequency Hopping (LTE-M only)
3. Frequency Selective Scheduling (LTE-M only)
4. Downlink Power Spectral Density (PSD) Boosting
5. Improve time/frequency/channel estimation
   – Redundancy version cycling
   – Improved scrambling methods

Narrow band or Sub-PRB (used by NB-IOT and LTE-M in Rel15) is **NOT** a coverage technique
it mainly increases UL spectral efficiency
Expected Coverage Performance

• 3GPP Maximum Coupling loss (MCL) Targets:
  – MCL depends on Noise Figure (NF) and Power Amplifier (PA) power
  – EC-GSM/NB-IOT: Target 164dB assumed NF 3dB, PA 23dBm
  – LTE-M: Target 156dB assumed NF 5dB, PA 20dBm
  – LTE-M: Target 161dB assumed NF 3dB, PA 23dBm

• LTE-M Coverage Mode A and Mode B

KEY TAKEAWAY

• Similar MCL targets
• Targets were exceeded
• All provide 164dB MCL (or +20dB gain)

Detailed coverage study available online - http://hub.sierrawireless.com/coverage_analysis_lte_m
LTE-M Simulation on Coverage Enhancement

Data Rate (bps)

MCL (dB)

Downlink Data

Uplink Data

Normal Coverage

Extended Coverage Region

~Out of Coverage Region
LTE-M, NB-IOT and EC-GSM – 3’Cs

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The 3Cs represent the key advantages of LPWA (Low Power Wide Area) networks over 4G LTE, with a focus on low power consumption, wide coverage, and cost efficiency.
Power Saving Methods for LTE-M/NB-IOT/EC-GSM

Power consumption is reduced in devices via the use of 3 methods:

1. **PSM (Power Saving Mode)**
   - Technology used: PSM – Power Save Mode
   - What does it do? Reduces all core networking layer signaling overhead

2. **Radio Signalling Opt.**
   - Technology used: Control Plane Optimization, User Plane Optimization
   - What does it do? Reduces 50-75% of Radio Resource signaling overhead

3. **Flexible Sleep (eDRX)**
   - Technology used: I-eDRX/C-eDRX
   - What does it do? Application controlled Sleep between Paging Opportunity
**Offline Scenario**

Infrequent e.g. > 1 Hr device originated traffic
- Best power consumption
- Cannot receive data most of the time, except only during C-DRX Period

- **Modem Off**
- **Prototype:**
  - **C-DRX (2mA)**
  - **Modem Off**
  - Leakage Current ~1μA

**Power Consumption**

- **Boot**
- **System acquisition**
- **RRC connect**
- **Radio resource signalling**
- **Network signalling**
- **Registration**
- **De-registration**

The application data being sent.
Offline Scenario

Power Saving Techniques:

1. PSM (up to 413 days)
3. Flexible Sleep C-eDRX (up to 10 sec)
4. Faster Boot

Power Consumption:
- System acquisition
- RRC connect
- Radio resource signalling
- Network signalling
- Registration
- C-eDRX (2mA)
- C-eDRX (0.5mA)

PSM – Power Saving Mode

Leakage Current ~1μA
Offline Performance

- all three power saving techniques are used but PSM is the most important
- 87% of signalling overhead has been removed
- implementation matters!! especially boot time!
- 35X reduction in power
How PSM stacks up in practice

PSM - Power Saving Mode

Let's the device “hibernate” between data transmissions while remembering its network state (no need to re-register)

Power consumption in hibernation: 4 μA

Gain on battery lifetime: x2 (compared to shutting modem off)

Ex: Tx 670 bytes / Rx 350 bytes on 2500mAh AA battery

1 transmission every 1 hour => 1 year battery life
1 transmission every 6 hours => 5 years battery life
1 transmission every 24 hours => 19 years battery life

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Power consumption for 1 data transmission - With PSM

Power consumption for 1 data transmission - Without PSM (coming from “OFF” state)

<table>
<thead>
<tr>
<th>Description</th>
<th>Power Saving Mode on</th>
<th>Power Saving Mode off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake-up or Boot</td>
<td>80 mA</td>
<td>0.430 s</td>
</tr>
<tr>
<td>1. Processing</td>
<td>45 mA</td>
<td>0.430 s</td>
</tr>
<tr>
<td>2. Actual data transmission</td>
<td>520 mA</td>
<td>0.47 s</td>
</tr>
<tr>
<td>3. Listening to network pages</td>
<td>8 mA/s</td>
<td>124.96 s</td>
</tr>
<tr>
<td>TOTAL GREEN</td>
<td>893.62 mA</td>
<td>994.45 mA</td>
</tr>
</tbody>
</table>

TOTAL RED

TOTAL GREEN + RED

= 1984.07 mA
Use Case Power Comparison

Sending messages of 1000bits using a battery of 2.5AH with typical coverage of 0 dBm TX power

**Offline**

- Battery Life / years vs Messages per Day
  - Legacy (Cat-1)
  - New Arch (LTE-M/NB-IOT)

**Online**

- Battery Life / years vs Messages per Day
  - 81sec l-eDRX
  - HL76xx (Cat-1) obscured by WP77xx

- SIERRA WIRELESS®
- M2M connectivty
LTE-M, NB-IOT and EC-GSM – 3’Cs

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Think 2G or Bluetooth

Global Service

Durable Investment

Trusted Ecosystem
LTE-M / NB-IOT Cost Reduction

Reduce Complexity:
- Half Duplex
- Single receiver
- Lower Memory
- Lower bandwidth
- Simpler processing
- Lower PA

<table>
<thead>
<tr>
<th>RAM</th>
<th>CAT-3</th>
<th>CAT-M1</th>
<th>CAT-NB1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAT-3</td>
<td>4.30</td>
<td>0.25</td>
<td>0.21</td>
</tr>
<tr>
<td>CAT-M1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT-NB1</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RF Bandwidth</th>
<th>CAT-3</th>
<th>CAT-M1</th>
<th>CAT-NB1</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1.08</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>CAT-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT-M1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT-NB1</td>
<td></td>
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</tr>
</tbody>
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Legacy Cellular

Integration

LTE-M

NB-IOT

Flash
Baseband
RAM
Radio
PA
Power Management

Flash
BB/RF
XTAL
Network Operator Deployments – LTE-M (Current to 1H 2018)

Current cellular coverage
580+ networks
180+ countries
Network Operator Deployments – NB-IOT (Current to 1H 2018)

Current cellular coverage
580+ networks
180+ countries
Start with Sierra, scale with CF3™

One form factor is all you need
LPWA product spotlight: HL Series

- **One design** to deploy on 2G, 3G, 4G, LPWA
  - HL7718, Cat-M1
  - HL7748 / HL7749, Cat-M1

- Power performance improvement with total energy for 1KB TX per day (~143dB MCL)

<table>
<thead>
<tr>
<th>HL77 LPWA</th>
<th>HL7692 Cat-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>eDRX 5.5min</td>
<td>DRX 2.56s</td>
</tr>
<tr>
<td>Energy for 10 Years (Ah)</td>
<td>7</td>
</tr>
</tbody>
</table>

Sampling: Now
CA: Q3 2017
LPWA product spotlight WP Series

- **WP7700 & WP7702** (Cat-M1/Cat-NB1), World’s first **global & multi-mode LPWA**

- **WP77** are **SMART modules, Integrated core** and **application framework**

- Ideal for **Gateway and Transportation**, Ready for **sensors & companion chips**

WP77xx: M1/NB1 100% Compatible with WP76/X5 Series

Sampling: Q4 2017
CA: Q1 2018
Now planning next-gen LPWA products

**ECOSYSTEM EVOLUTION**

- new chipsets
- new customers
- new devices
- expanding LPWA coverage and features

- **Smaller** while maintaining CF3™ compatibility
- **Lower power** with 10x improvement in consumption
- **More flexibility** with integrated microcontroller running Legato with open source thin OS on WP Series
If you want to read more

• The Source (module specs, AT command guides, etc.) – [http://source.sierrawireless.com](http://source.sierrawireless.com)

• mangOH – [http://mangoh.io](http://mangoh.io)

• Legato – [http://legato.io](http://legato.io)

For more info on Standardized LPWA, you can have a look at the below white papers from Sierra:

- [NB-IoT and LTE-M Interoperability paths converge](http://source.sierrawireless.com)
- [LTE-M Coverage analysis](http://source.sierrawireless.com)
Thank you

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