3GPP LPWA Standards
LTE-M, NB-IoT & EC-GSM
Eclipse Day Grenoble, March 9th 2017

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CTO Office, Sierra Wireless

The Internet of Things
#StartswithSierra
Sierra Wireless – The IoT Company

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

IoT Hardware
- AirPrime
- AirLink

IoT Connectivity

IoT Platform
- AirVantage IoT Platform

Connected Machines

Enterprise Services

R&D, Marketing, Operations
Manufacturing
Commercial offices

Locations:
- San Jose
- Paris
- Toulouse
- Munich
- Hong Kong
- Bangalore
- Beijing
- Tokyo
- Shanghai
- Melbourne
- Seoul
- Taipei
- Vancouver
- San Diego
- Shenzhen
- Nice
- Marietta
- London
Sierra Wireless – Open Source

www.mangoh.io

MangOH Green
- 120mm x 100mm
- ATmega32U4 MCU
- Arduino connector
- 2x CF3 cellular sockets
- MicroSD + 2xSIM
- Accelero, Gyro
- 2x USB, RJ45, 1 RS232
- 3x IoT Connectors

MangOH Red
- 69mm x 61mm
- ARM Cortex M4 MCU
- Raspberry Pi connector
- 1x CF3 cellular socket
- MicroSD + 1xSIM
- Accelero, Gyro, Altimeter
- 2x USB
- 1x IoT Connector

www.legato.io

- Yocto-built Linux distrib
- Application Framework
- Development Tools
- Multi-Language Support

Available now
Low Power Wide Area – A Revolution for the IoT

Low Consumption
- Smart Meter
- Wearables
- Street Lighting
- Home Automation

Extended Coverage
- Toll Collection
- Container Tracking
- Pipeline Management
- Smart Grid

Low Complexity
Low Power Wide Area – Technology Panorama

Ad-hoc Networks - Proprietary - Unlicensed Bands

Cellular Networks - Standardized - Licensed Bands

3GPP

2G
- GSM 200 kbps

LTE Cat. 1
- 10 Mbps

EC-GSM-IoT
- 200 kbps

Cat-M1
- 300/375 kbps
- 20/60 kbps

Cat-NB1
- LTE-M
- NB-IoT

Cat-M2
- LTE-M
- Cat-NB2
- 2.4/2.6 Mbps
- 60/120 kbps

2015
2016
2017
2018
2019

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Cellular LPWA – The Promise of the 3 C’s

Consumption
Coverage
Complexity
Low Consumption

Consumption

10-20 years lifetime
On AA batteries
(2500 mAh)

Coverage

Complexity
Low Consumption with PSM and eDRX

PSM - Power Saving Mode
Lets 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

eDRX – Extended Discontinuous Reception
Lets the device listen more infrequently to incoming messages

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Current (mA)</th>
<th>Time (s)</th>
<th>Energy (mAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Wake-up or Boot</td>
<td>80</td>
<td>0.185</td>
<td>14.60</td>
</tr>
<tr>
<td>1</td>
<td>Processing</td>
<td>45</td>
<td>0.430</td>
<td>19.35</td>
</tr>
<tr>
<td>2</td>
<td>Look up cells</td>
<td>190</td>
<td>0.915</td>
<td>173.85</td>
</tr>
<tr>
<td>3</td>
<td>Register onto network</td>
<td>320</td>
<td>1.6</td>
<td>512.00</td>
</tr>
<tr>
<td>4</td>
<td>Processing</td>
<td>45</td>
<td>4.09</td>
<td>184.05</td>
</tr>
<tr>
<td>5</td>
<td>Processing</td>
<td>80</td>
<td>2.13</td>
<td>170.40</td>
</tr>
<tr>
<td>6</td>
<td>Listen to network pages</td>
<td>8</td>
<td>16</td>
<td>128.00</td>
</tr>
<tr>
<td>7</td>
<td>Actual data transmission</td>
<td>320</td>
<td>1.6</td>
<td>512.00</td>
</tr>
<tr>
<td>8</td>
<td>Processing</td>
<td>45</td>
<td>3.1</td>
<td>139.50</td>
</tr>
<tr>
<td>9</td>
<td>Idle mode</td>
<td>300</td>
<td>7.07</td>
<td>2.12</td>
</tr>
<tr>
<td>10</td>
<td>Listen to network pages</td>
<td>8</td>
<td>16</td>
<td>128.00</td>
</tr>
<tr>
<td>11</td>
<td>TOTAL RED</td>
<td>969.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>TOTAL GREEN</td>
<td>594.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>TOTAL RED + GREEN</td>
<td>1564.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Consumption
10-20 years lifetime
On AA batteries
(2500 mAh)

Coverage
+18-22dB sensitivity
Open Range x 7
Basement Coverage

Complexity
## Extended Coverage through repetitions

<table>
<thead>
<tr>
<th>LTE-M Channel</th>
<th>Maximum Coupling Loss</th>
<th>Performance</th>
<th>Nb of Repeats</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSS/SSS</td>
<td>164dB</td>
<td>Acquisition Time=850 ms</td>
<td>-</td>
</tr>
<tr>
<td>PBCH</td>
<td>164dB</td>
<td>Acquisition Time=240 ms</td>
<td>5</td>
</tr>
<tr>
<td>MDPCCCH</td>
<td>164dB</td>
<td>99% detection using 128 repeats</td>
<td>256</td>
</tr>
<tr>
<td>PDSCH</td>
<td>164dB</td>
<td>1400 bps using 512 repeats</td>
<td>2048</td>
</tr>
<tr>
<td>PUSCH</td>
<td>164dB</td>
<td>250 bps using 1536 repeats</td>
<td>2048</td>
</tr>
<tr>
<td>PRACH</td>
<td>164dB</td>
<td>90% detection using 64-128 Repeats</td>
<td>128</td>
</tr>
<tr>
<td>PUCCH</td>
<td>164dB</td>
<td>90% detection using 16-32 Repeats</td>
<td>32</td>
</tr>
</tbody>
</table>

**HARQ: Hybrid Automatic Repeat Request**

Detailed coverage study available online
http://hub.sierrawireless.com/coverage_analysis_lte_m

PSS/SSS Primary/Secondary Synchronization Signals
PBCH Physical Broadcast Channel
MDPCCH MTC Physical Downlink Control Channel
PDSCH Physical Downlink Shared Channel
PUSCH Physical Uplink Shared Channel
PRACH Physical Random Access Channel
PUCCH Physical Uplink Control Channel
Low Complexity

Consumption

10-20 years lifetime
On AA batteries
(2500 mAh)

Coverage

+18-22dB sensitivity
Open Range x 7
Basement Coverage

Complexity

-75% (rel. Cat-1)
Target: 2G Price
Single WW Product
Low Complexity, Cost and Total Cost of Ownership

**Total Cost**
- Network Subscription
- Service connection
- Systems and platforms
- Distribution and installation
- Approvals
- Integration manufacturing
- Design
- Communication Hardware

**Summary**
- Design and Integration
- Comm. HW

**Total Cost Breakdown**
- Communication Hardware: 2-13%
- Network Subscription: 4-30%
- Design and Integration: 57-89%

Source: Analysis Mason, Nov. 2010
“The total cost of ownership for embedded mobile devices”
Cellular LPWA – Additional Benefits

Immediate Service

2016 – 2017 – 2018
447 Networks
143 Countries
Cellular LPWA – Additional Benefits

Immediate Service
2016 – 2017 – 2018
447 Networks
143 Countries

Durable Investment
Long-term availability
Global Standard
Scalable and Flexible
Cellular LPWA – Additional Benefits

Immediate Service
2016 – 2017 – 2018
447 Networks
143 Countries

Durable Investment
Long-term availability
Global Standard
Scalable and Flexible

Trusted Ecosystem
QoS & Security
Operator roaming
Embedded SIM - OTA
Mobile World Congress 2017 – On Air Demos

Live networks already on (US, Europe, Asia)
Mass deployments in 2017 and 2018
# Technology Comparison – Summary

<table>
<thead>
<tr>
<th>Attribute</th>
<th>LoRa</th>
<th>Sigfox</th>
<th>M1</th>
<th>NB1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spectrum</strong></td>
<td>Unlicensed ISM Bands: 433/868/915 MHz</td>
<td>LTE Bands</td>
<td>LTE &amp; 2G Bands</td>
<td></td>
</tr>
<tr>
<td><strong>Network:</strong></td>
<td></td>
<td></td>
<td>2017 and 2018 Global</td>
<td>SW upgrade</td>
</tr>
<tr>
<td>- Availability</td>
<td>In deployment</td>
<td>Parts of EU + US</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Lifetime 10 years+</td>
<td>Parts of EU + US</td>
<td>Uncertain Greenfield</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Roll out</td>
<td>Uncertain Greenfield</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Partial</td>
<td>Partial</td>
<td>Highest and Global Roaming</td>
<td></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>Mostly Uni-directional</td>
<td>Bi-directional</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Infrastructure Service Layer</strong></td>
<td>Messaging</td>
<td>IP and Messaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scalability</strong></td>
<td>Poor radio performance especially in ISM band</td>
<td>Limited Base Station density</td>
<td>Highest Base Station density</td>
<td></td>
</tr>
<tr>
<td><strong>SW upgrade</strong></td>
<td>Barely possible + severely impacts battery lifetime</td>
<td>Supported natively in the standard</td>
<td>Strong channel encryption (3GPP) + SW upgrade for security patches</td>
<td></td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Ad-Hoc, Not Strong</td>
<td>Very weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MNO Contract Lock-in</strong></td>
<td>Yes: if using an MNO</td>
<td>Yes</td>
<td>No: GMA eUICC SIM - Remote SIM provisioning enable/change MNO over the air</td>
<td></td>
</tr>
</tbody>
</table>
Thank You

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