



Power Management Challenges in Wireless WAN SoCs

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Agenda Overview

1. Intel XMM™ 7160 Cellular Modem Platform Overview

2. Cellular Modem Power Management Basics

3. Modem Power Management Challenges

4. Modem Power Management Solutions

5. Conclusion and Outlook

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Cellular Modems in Tablet and Smartphone Context



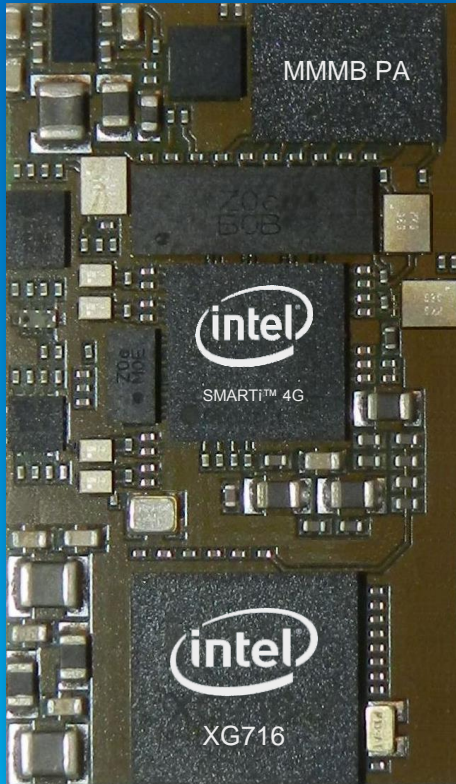
LTE – Long Term Evolution (4th Gen. Cellular Radio)

- User experience 2013: Mobile broadband
 - 100Mbps (up from 42Mbps with 3G)
 - 50% latency reduction versus 3G
- Operator experience: \$\$\$
 - All IP core network
 - More efficient utilization of spectrum
- Outlook 2014: 300Mbps, carrier-aggregation, WiFi-offloading

Intel® XMM™ 7160

LTE slim modem

Product Highlight



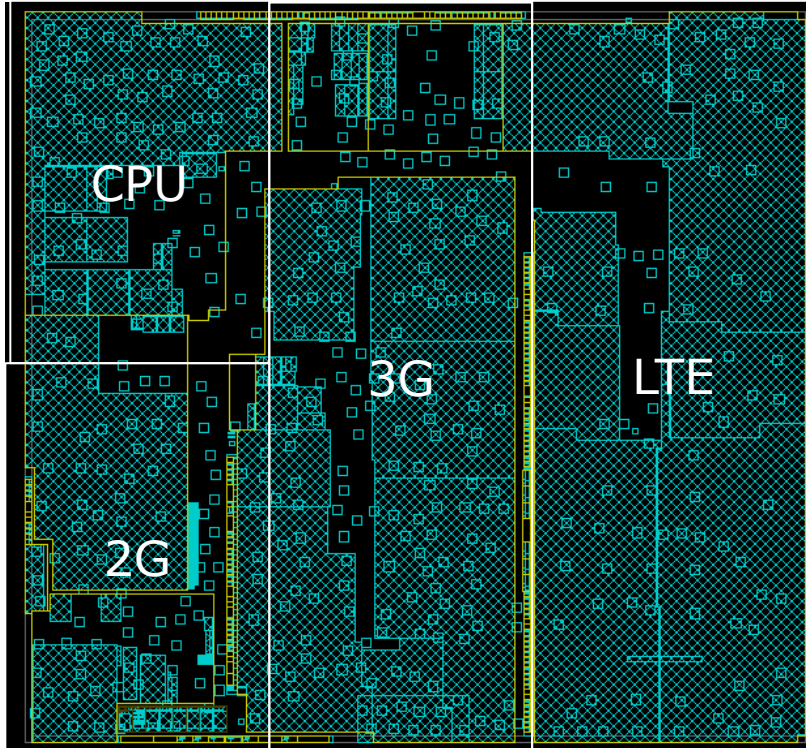
- ✓ Multi-mode multi-band 2G/3G/LTE slim modem
- ✓ Designed for smartphones, tablets, M2M and connected devices
- ✓ Powerful and flexible RF architecture to enable cost efficient band configurations as well as global roaming solutions for a world phone
- ✓ Reduced PCB sizes to enable attractive form factors
- ✓ Very low power consumption for longer active and standby times
- ✓ Support for LTE cat3 (DL 100 Mbps, UL 50 Mbps)
- ✓ Support for DC-HSPA+ 42 Mbps and HSUPA 5.7 Mbps

DL Downlink; UL Uplink

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X-GOLD™ 716

2G/3G/LTE Communication Processor



- 40 nm CMOS
- 9.5 x 7.5 mm² x 1.0 mm VF2BGA
- SoC architecture
 - CPU
 - On-die memory
 - External memory subsystem
 - HW accelerators for radio signal processing



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The 5 Power Save Commandments and Their Amendments

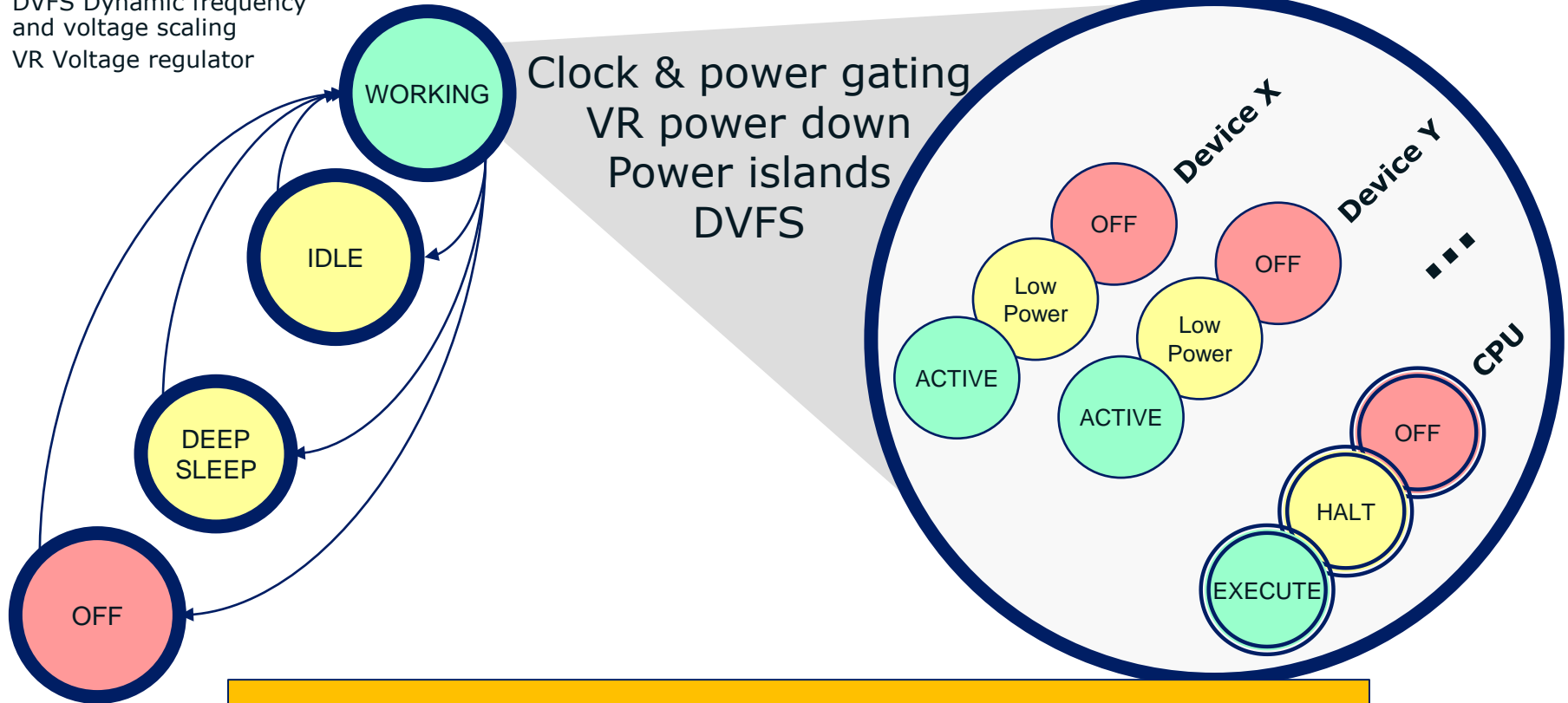
1. Turn off idle building blocks
 - Different idle times might require different definitions of “off”
2. Run active building blocks at lowest possible supply voltage
3. Thou shalt not be active without good reason
 - Waiting for something is not a good reason
 - Thou shalt not poll
 - Thou shalt not wake up the system for uncritical tasks
Schedule them when the system is awake for critical tasks
4. Use on-chip memory whenever possible
5. Supply power hungry blocks from DCDC converters

LTE Modem Low Power States – Overview

- System Power State
- Processor Power State
- Device Power State

DVFS Dynamic frequency and voltage scaling
VR Voltage regulator

SoC power saving toolbox



Optimized system power states tailored to critical modem scenarios

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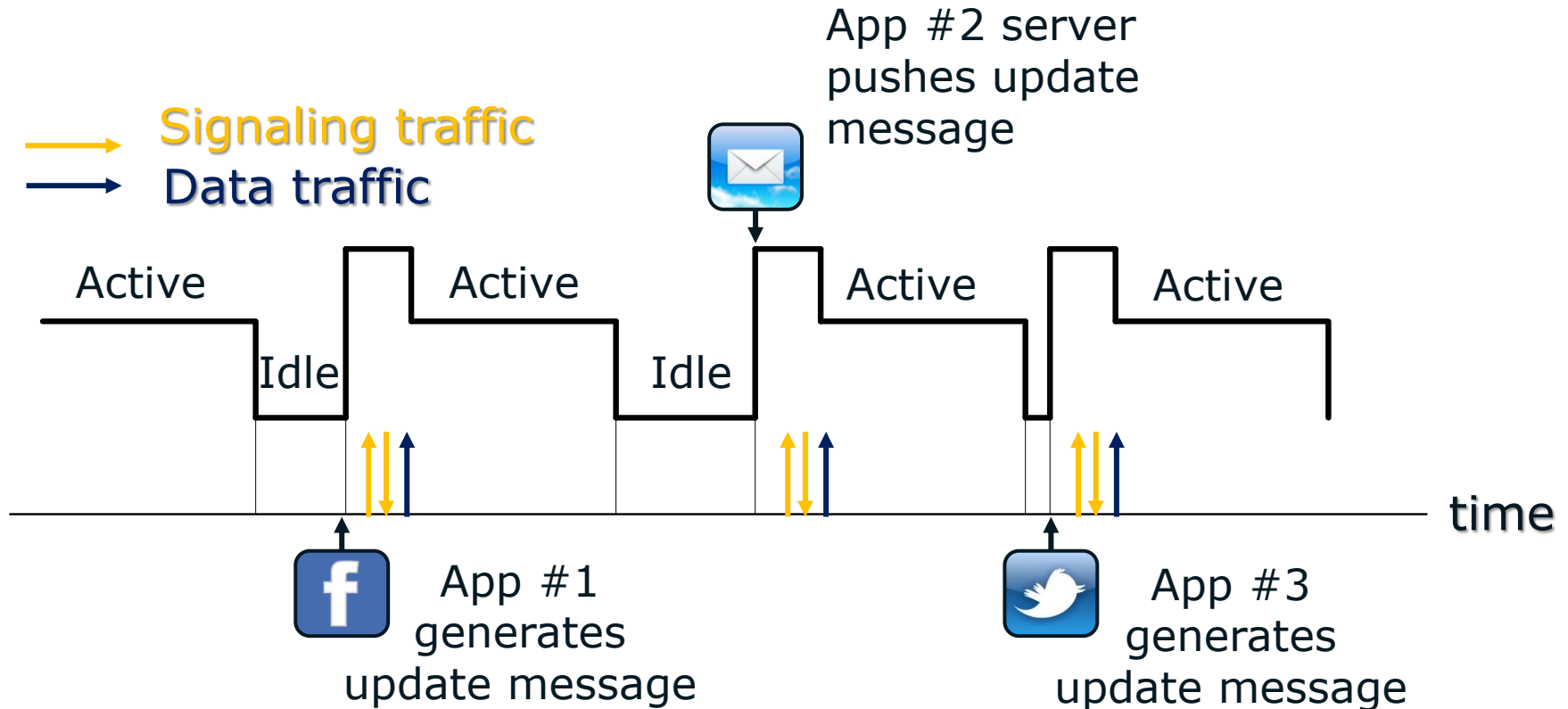
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Challenges

- Concurrent operations of multi radio access technology protocol stack SW under tight real-time constraints imposed by cellular network timing
- Shared hardware resources to meet the requirements of cost-sensitive consumer segments
- Low power consumption constraints of battery powered mobile devices
- Unpredictable nature of future applications traffic

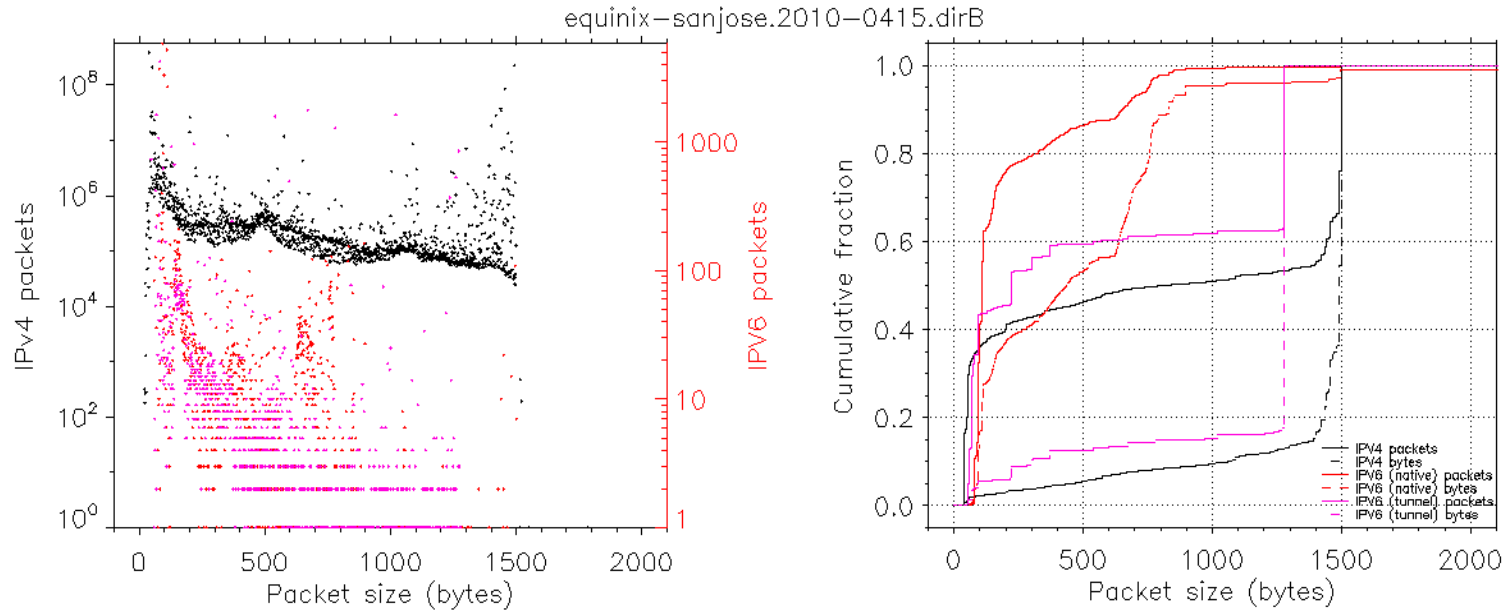
These challenges must be addressed at system level – enabled by modem power management architecture

Concurrent Operation of Foreground or Background Apps



Power consumption challenges due to frequent modem activity subject to network timers and configuration

Small data packets



IPv4	2371005620 packets	1880380592682 bytes
IPv6 (native)	39572 packets ($1.7 \times 10^{-3} \%$)	8691831 bytes ($4.6 \times 10^{-4} \%$)
IPv6 (tunnel)	293344 packets ($1.2 \times 10^{-2} \%$)	168938348 bytes ($9.0 \times 10^{-3} \%$)

- 40% of IPv4 packets (aka payload) are less than 50B in size: TCP ACKs, keep alives, IMs, status updates, VOIP silence suppression packets, etc.
- Data applications (Twitter, Facebook, etc) keep the device always in connected state with very low data traffic

Background Traffic Inter-Arrival Times (IAT)

Source: Intel 2011, 3GPP RAN2 R2-115386

Downlink Packets

- 4-8% are bundled
- 20% have IAT of 30ms
- 10% have IAT of 60ms
- 10% have IAT of 90ms
- 30% have IAT 100-300ms

85% are <100 bytes

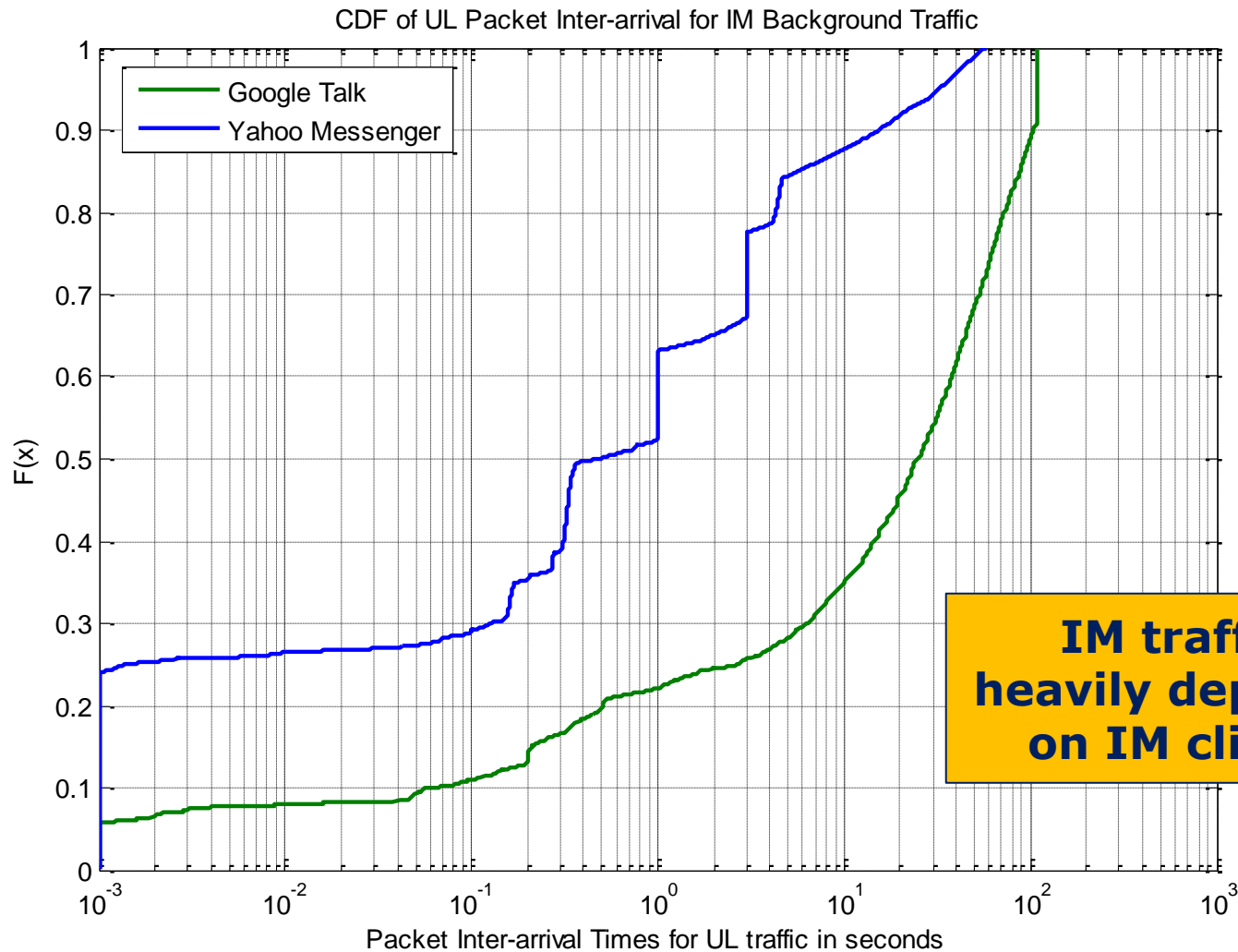
Uplink Packets

- 20-40% are bundled
- 20% have IAT 100-500ms
- The rest have IAT 1-500s

65% are <100 bytes
20% are 150-200 bytes

Instant Messaging (IM) Traces

Source: Intel 2011, 3GPP RAN2 R2-115386



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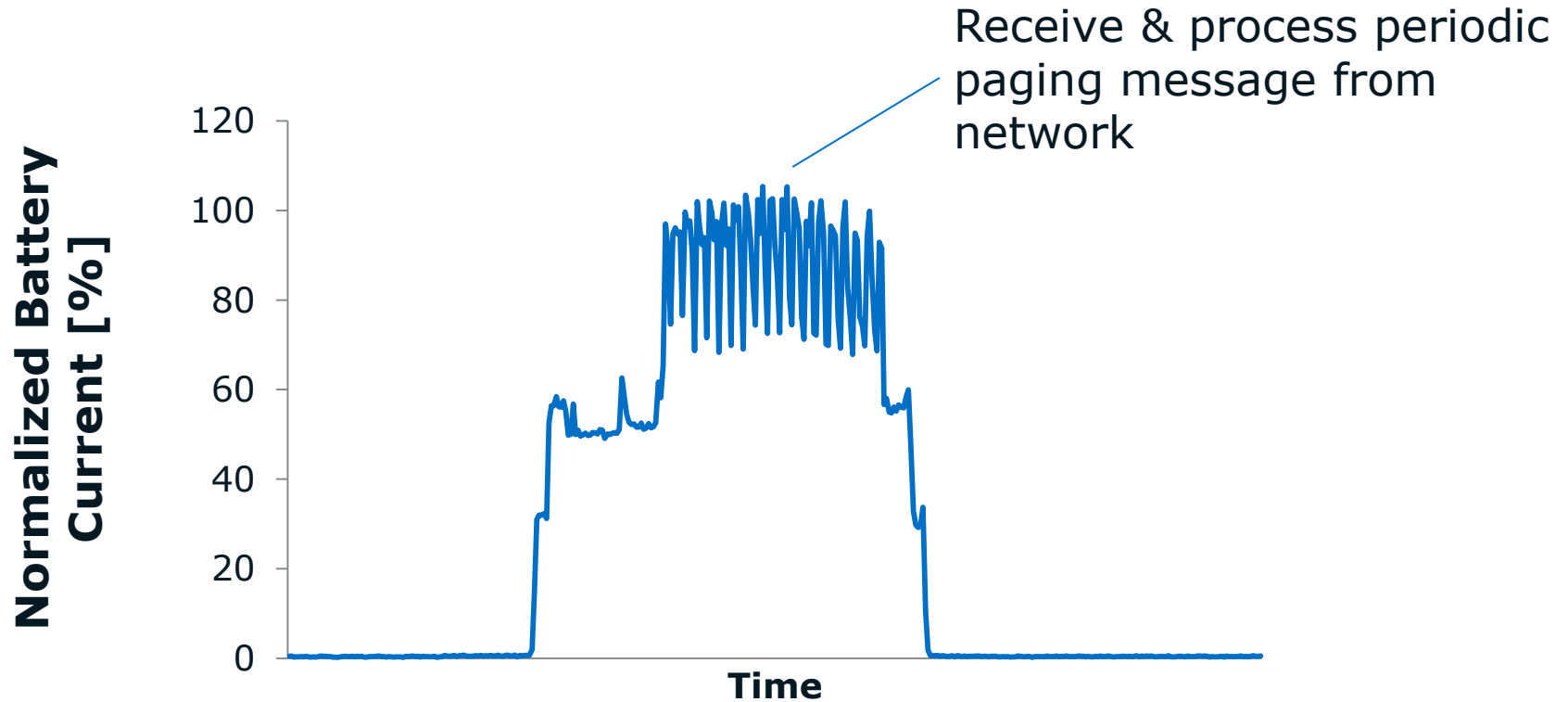
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Power Optimization for Idle Modes

LTE idle mode

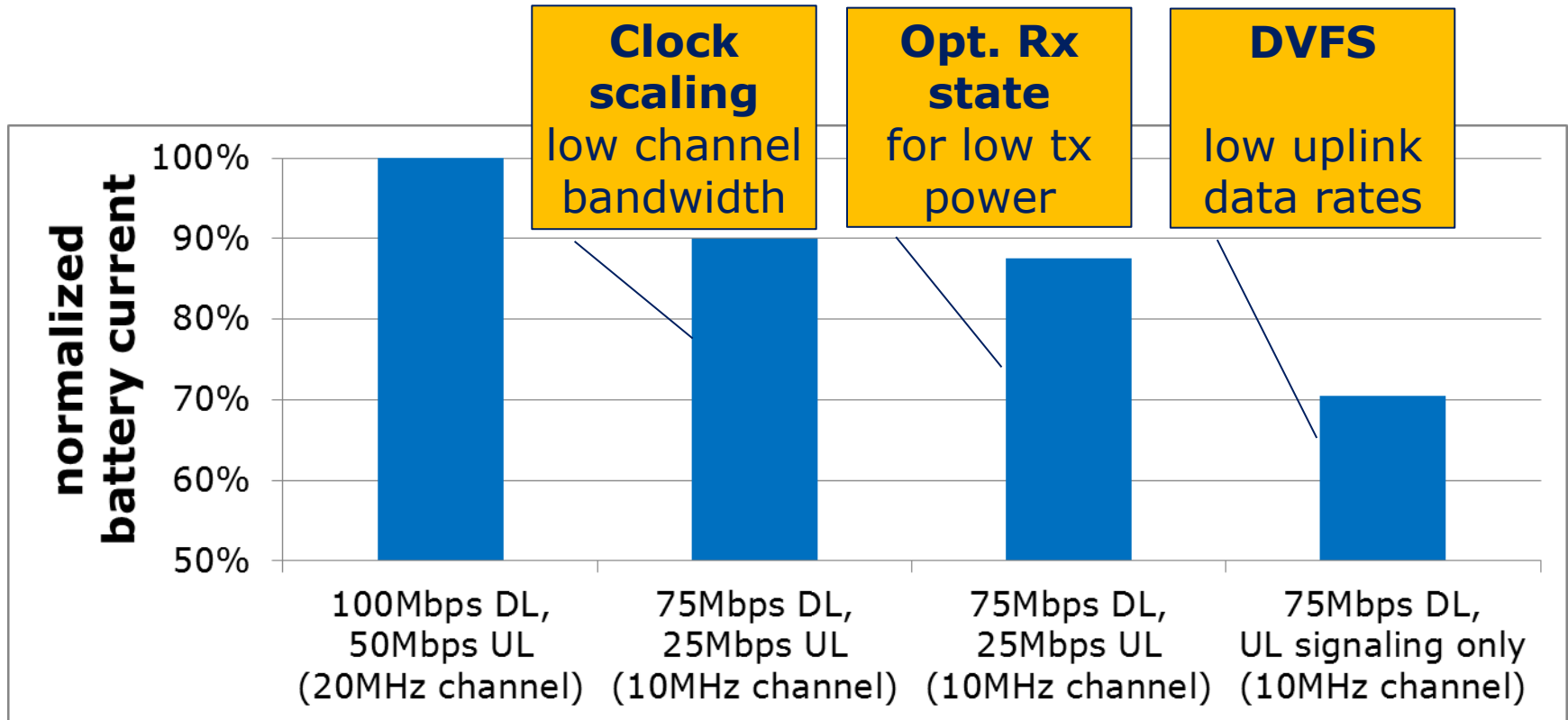


- Offloading main CPU tasks to power efficient HW accelerators
- Extensive use of DVFS
- All unused blocks are power gated

Power Optimization for Data Calls

LTE cat3, tx @ 0dBm, band 3

DL Downlink; UL Uplink



Modem Components Transition to Lowest Possible Power State under Given Network & Application Conditions

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Power Distribution Cost/Power Consumption Trade-Offs

Feature Segment



Area/cost optimized solution using single switched mode voltage regulator and no DVFS

Performance Segment



Power consumption optimized solution with several switched mode voltage regulators and DVFS

Power Optimization of Terminal / Base Station Interactions

RRC – Radio resource control
DRX – Discontinuous reception

- In LTE, there are 2 states
 - RRC Connected - always connected, data transmission, full control signaling
 - RRC Idle - no connection, limited control signaling (paging)
- Diverse data applications
 - Small and frequent packets – too many Idle to Connected mode transitions
 - One set of DRX parameters for all network – increase power consumption
- RAN enhancements for diverse data applications (eDDA)
 - Keep the user in RRC Connected
 - Efficiently move the user to RRC Idle

Power consumption optimization of mobile data devices goes beyond device boundaries

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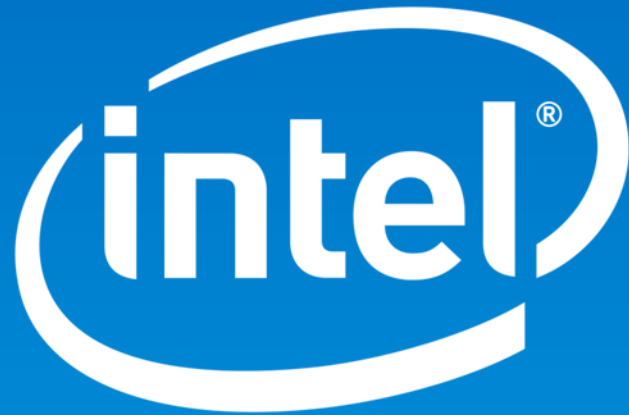
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XMM™ 7160 Power Management Challenges Summary

- XMM™ 7160 power management scheme provides outstanding power consumption while meeting tight system cost and time-to-market requirements
- LTE modem power states tailored to critical network & mobile data application scenarios
 - Active and standby modes
 - All possible LTE network configurations
 - Frequent small data transmission
- State-of-the-art fine granular SoC power saving techniques allow to operate all LTE modem sub-components always in the lowest possible power state



Mobile and Communications Group