



# 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



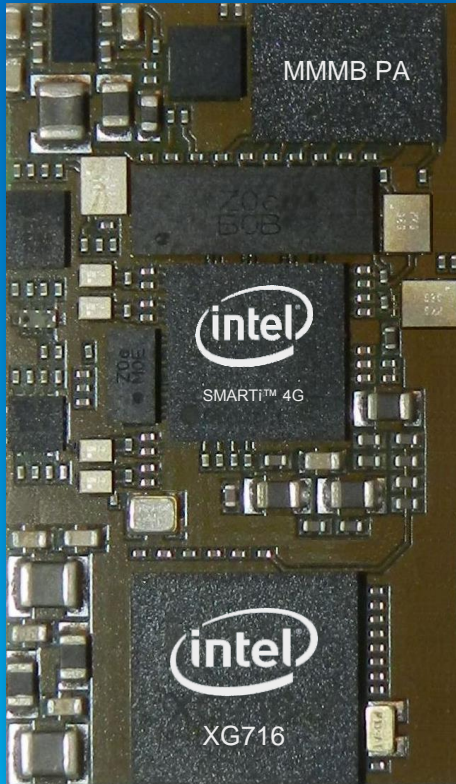
# LTE – Long Term Evolution (4th Gen. Cellular Radio)

- 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



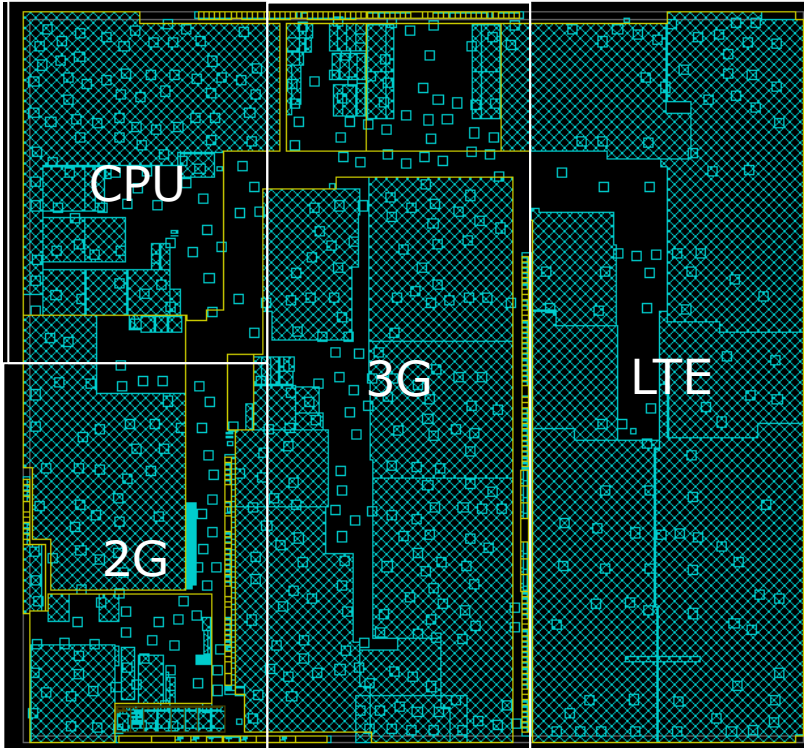
- ✓ Multi-mode multi-band 2G/3G/LTE slim modem
- ✓ Designed for smartphones, tablets, M2M and connected devices
- ✓ Powerful and flexible RF architecture to enable cost efficient band configurations as well as global roaming solutions for a world phone
- ✓ Reduced PCB sizes to enable attractive form 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 mm<sup>2</sup> 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

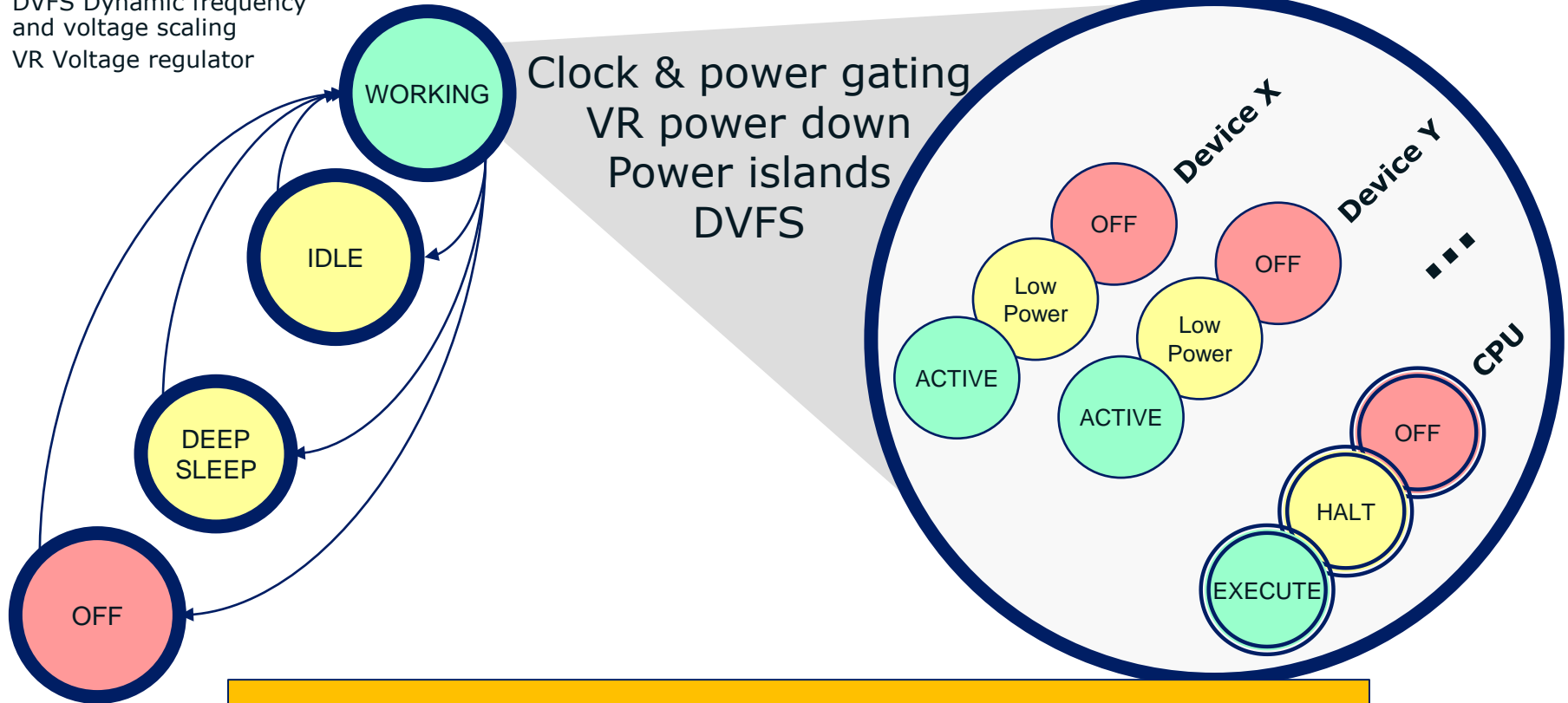
1. Turn off idle building blocks
  - Different idle times might require different definitions of “off”
2. Run active building blocks at lowest possible supply voltage
3. Thou shalt not be active without good reason
  - Waiting for something is not a good reason
  - Thou shalt not poll
  - Thou shalt 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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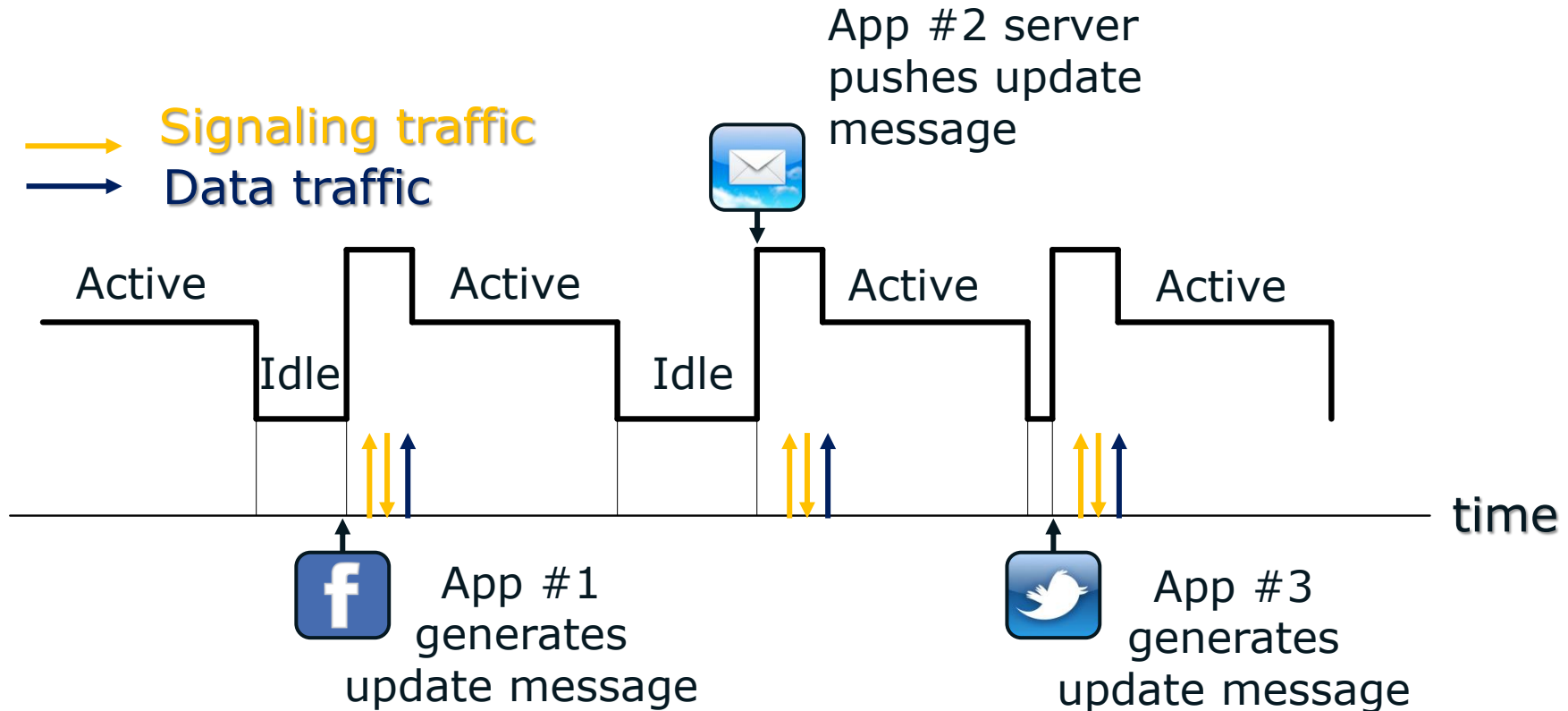
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# Challenges

- 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

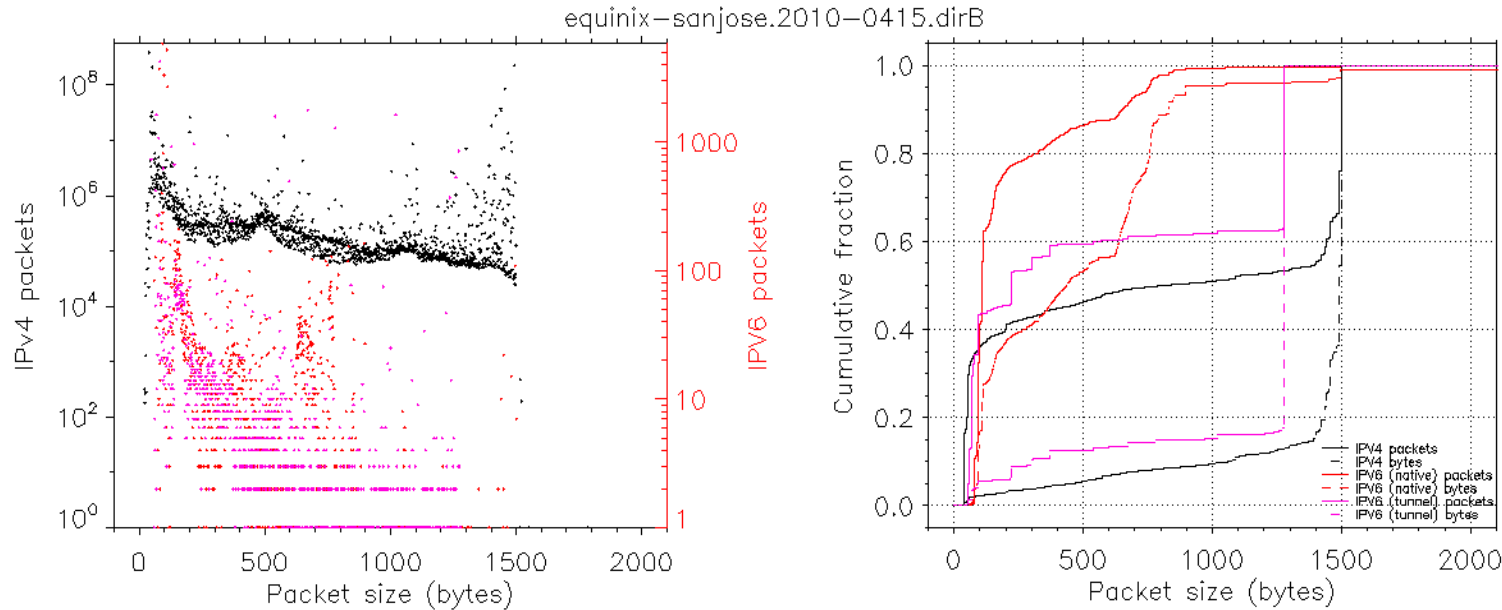
**These challenges must be addressed at system level – enabled by modem power management architecture**

# 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

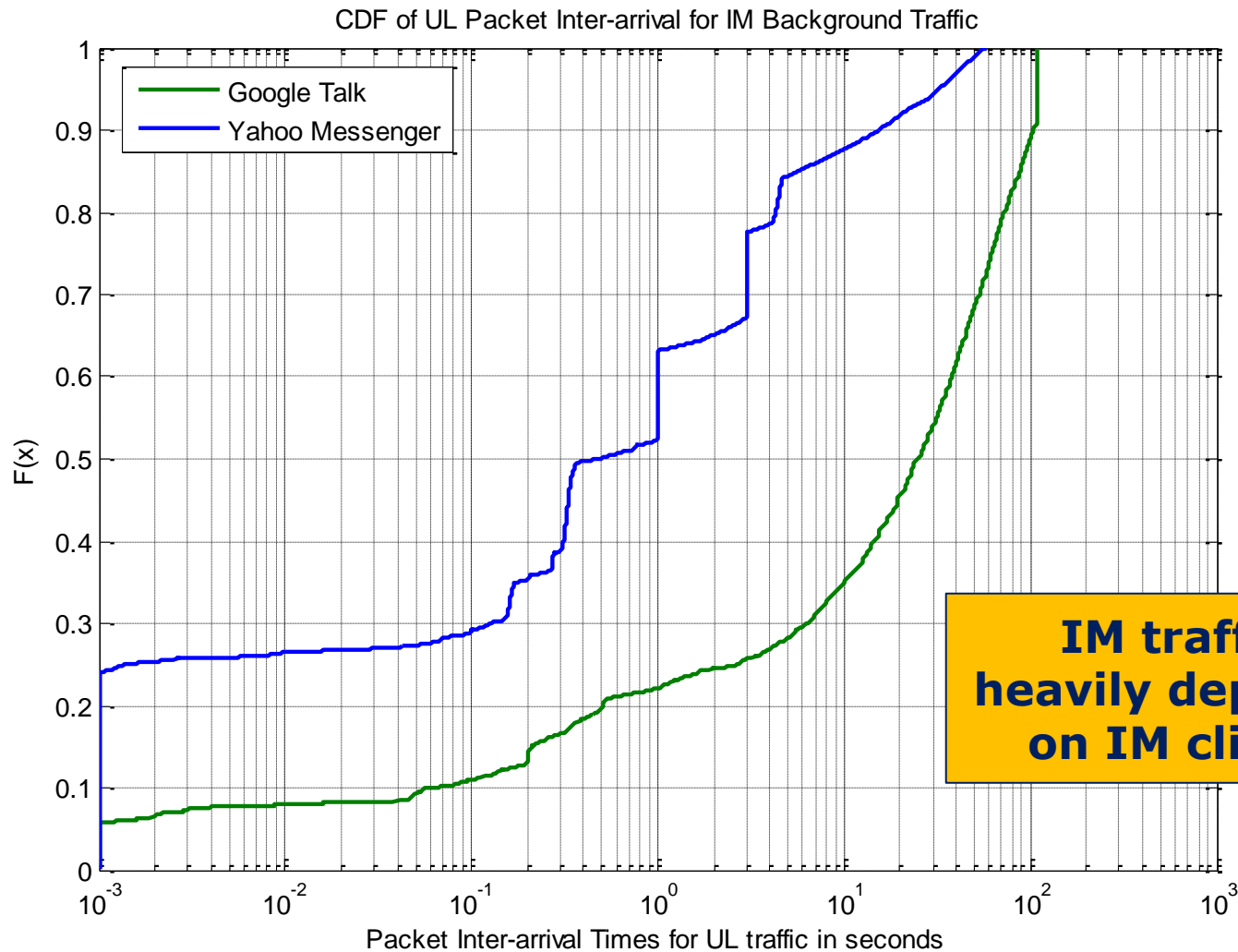
## Uplink Packets

- 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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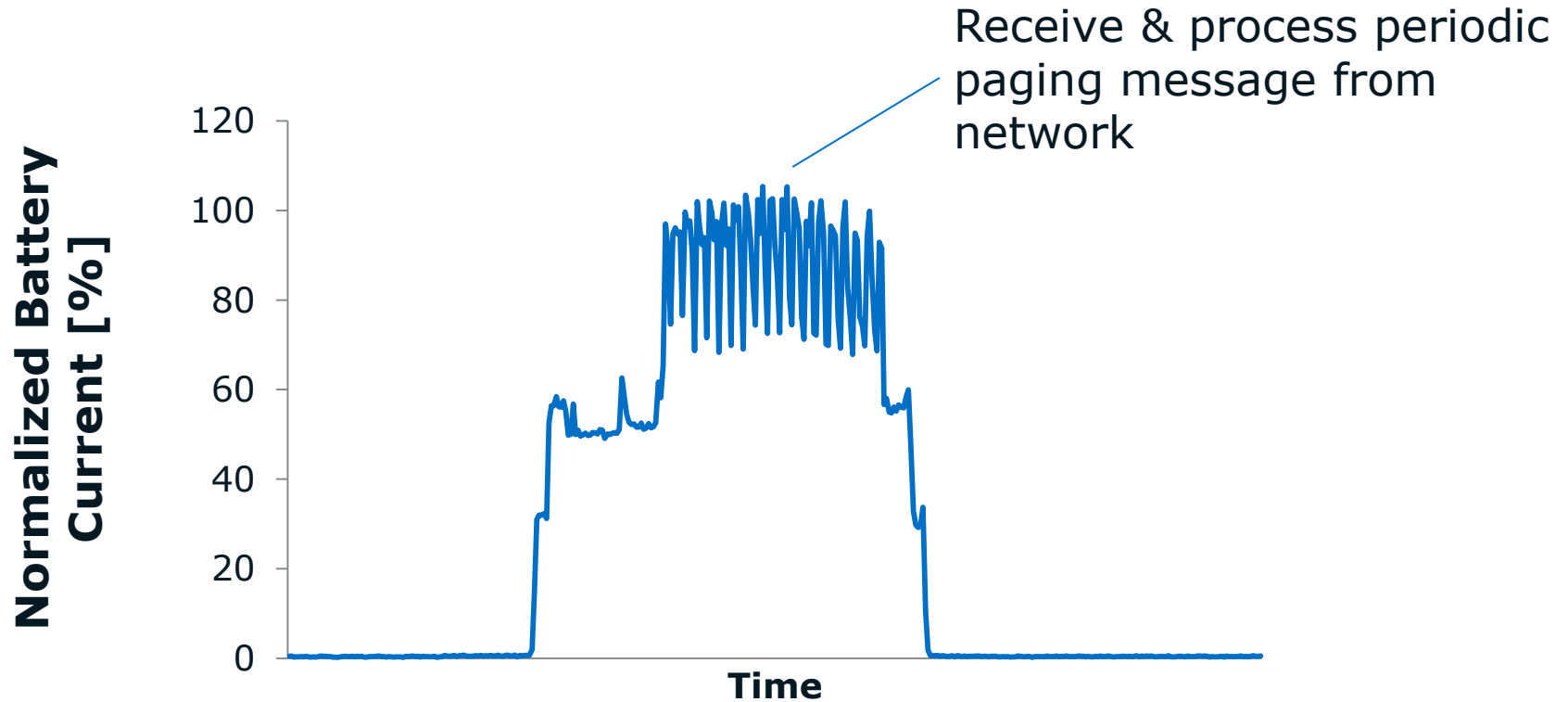
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# Power Optimization for Idle Modes

LTE idle mode

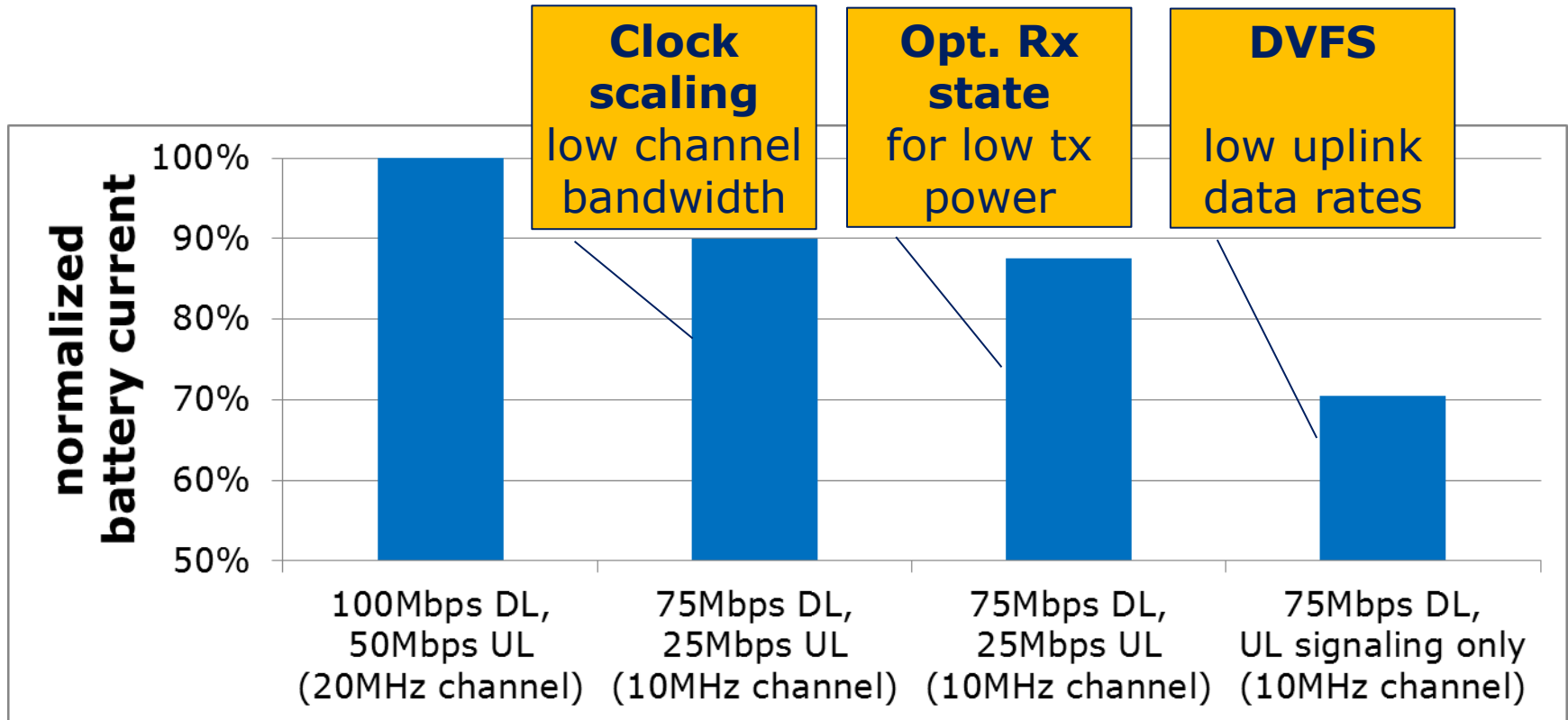


- Offloading main CPU tasks to power efficient HW accelerators
- Extensive use of DVFS
- All unused blocks are power gated

# 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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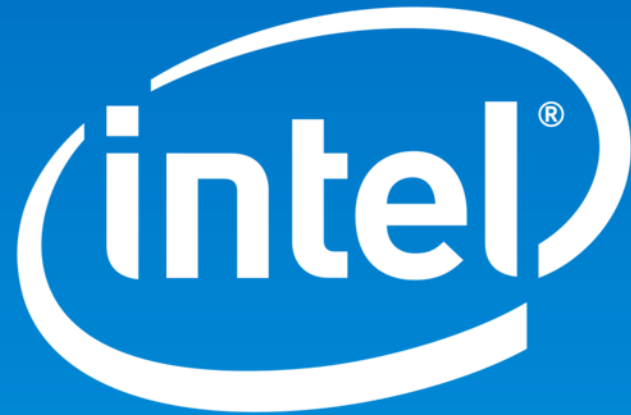
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# XMM™ 7160 Power Management Challenges Summary

- 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