Power Management Challenges in Wireless WAN SoCs

Gunnar Bublitz
Ralph Hasholzner, Christian Drewes
August 27, 2013

Legal Disclaimer

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

Agenda

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

Cellular Modems in Tablet and Smartphone Context

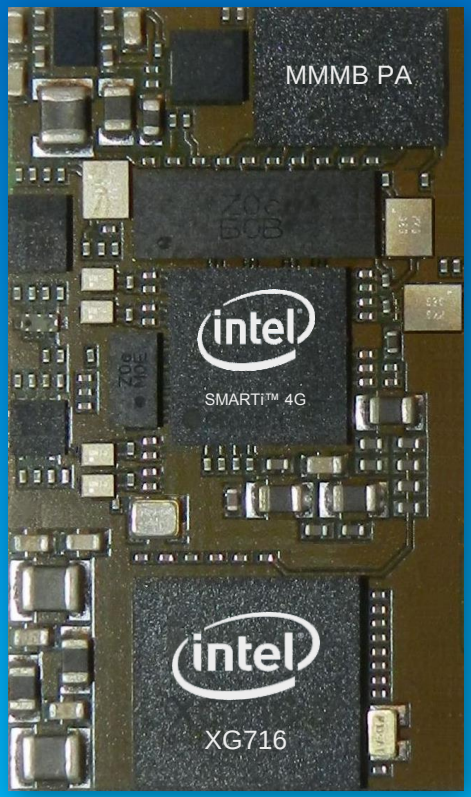
LTE – Long Term Evolution (4th Gen. Cellular Radio)

- 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

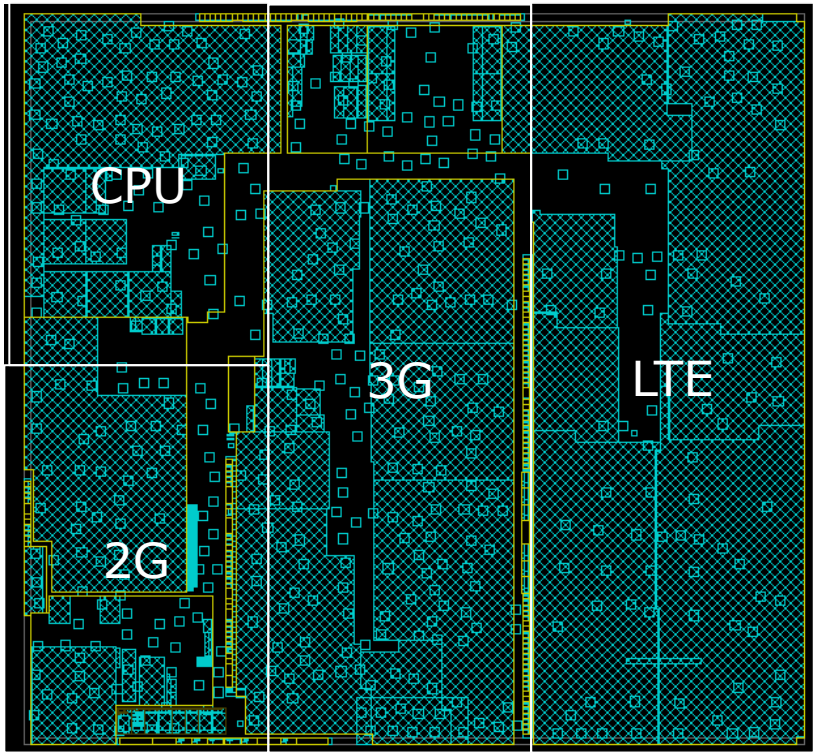
Product Highlight



- ✓ 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

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

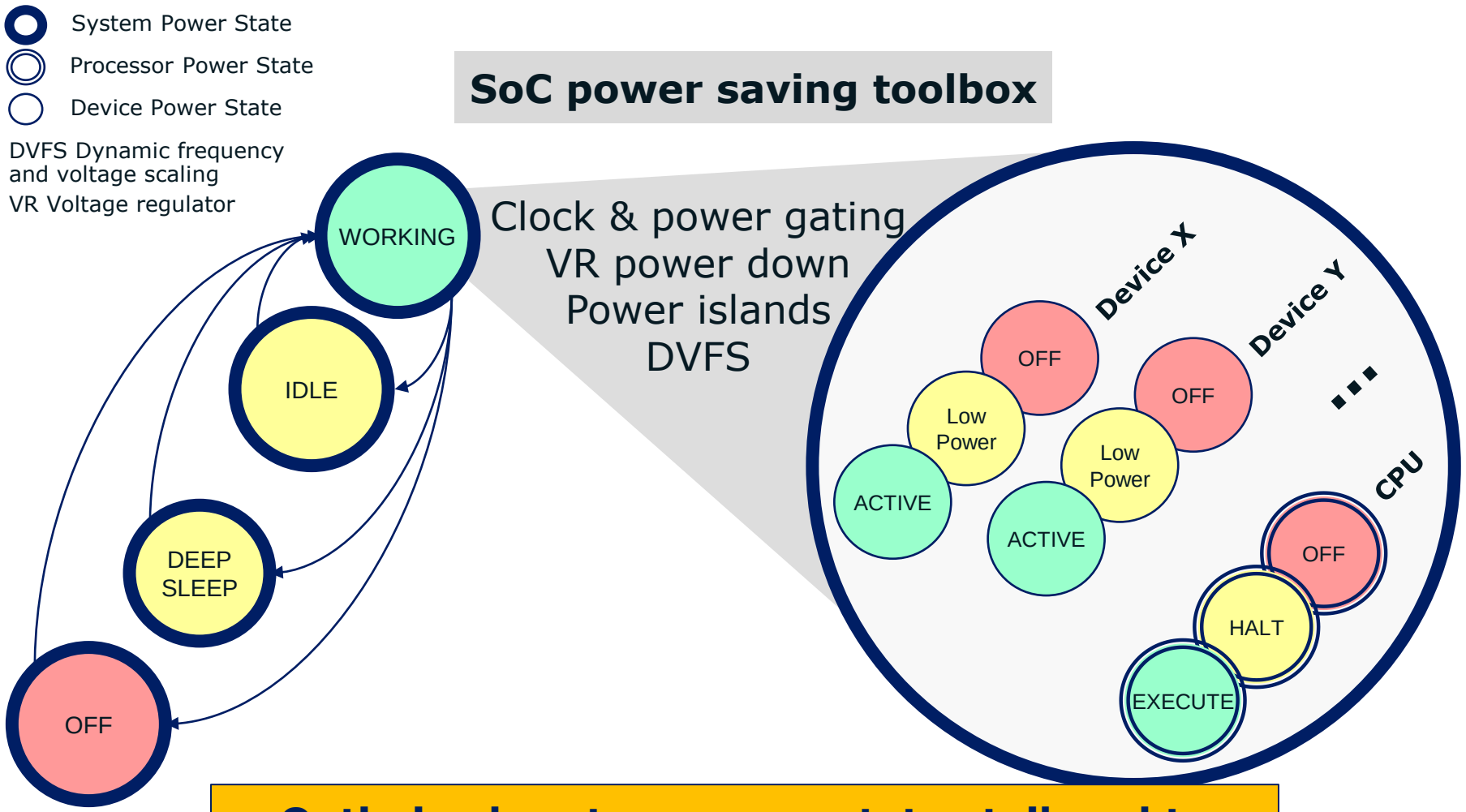
Agenda

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

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



Optimized system power states tailored to critical modem scenarios

Agenda

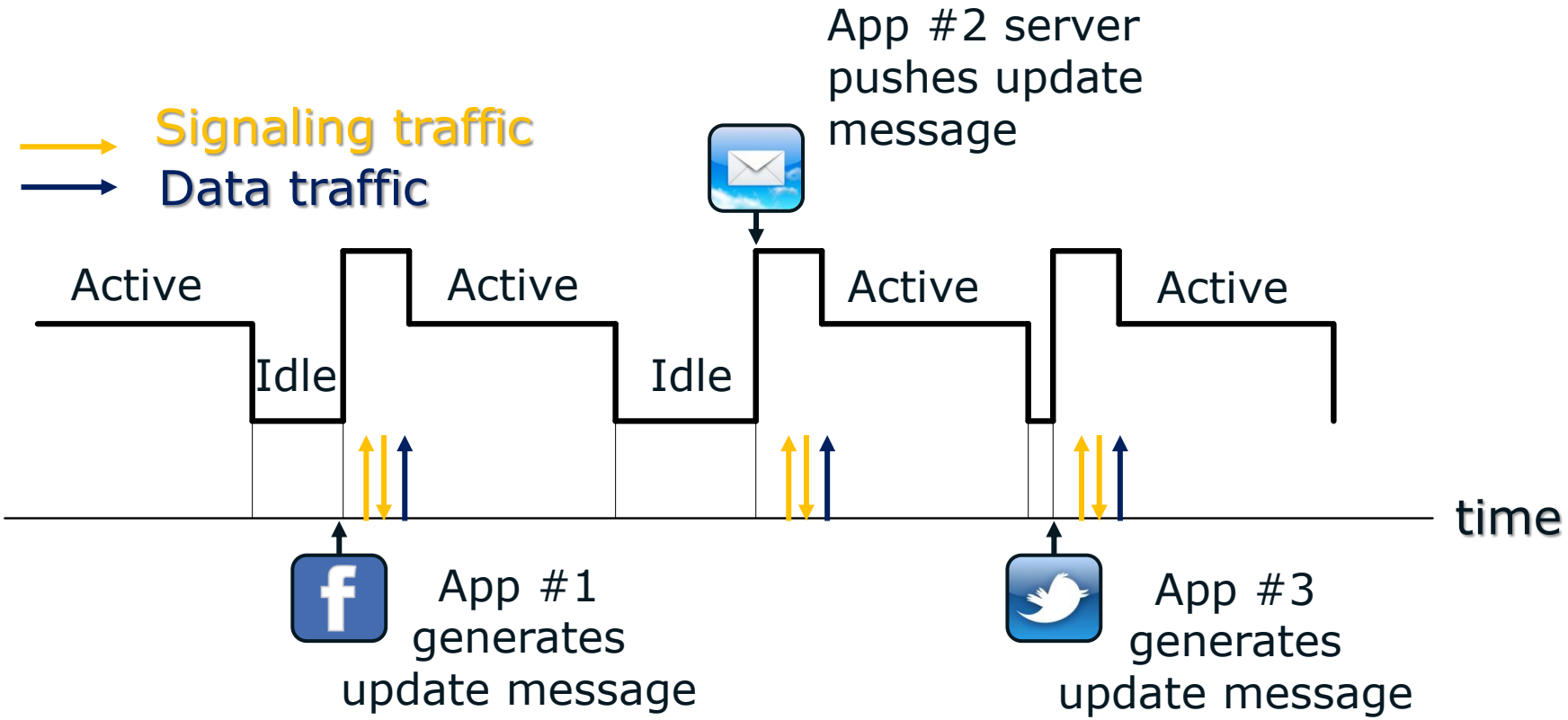
1. Intel XMM™ 7160 Cellular Modem Platform Overview
2. Cellular Modem Power Management Basics
3. **Modem Power Management Challenges**
4. Modem Power Management Solutions
5. Conclusion and Outlook

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

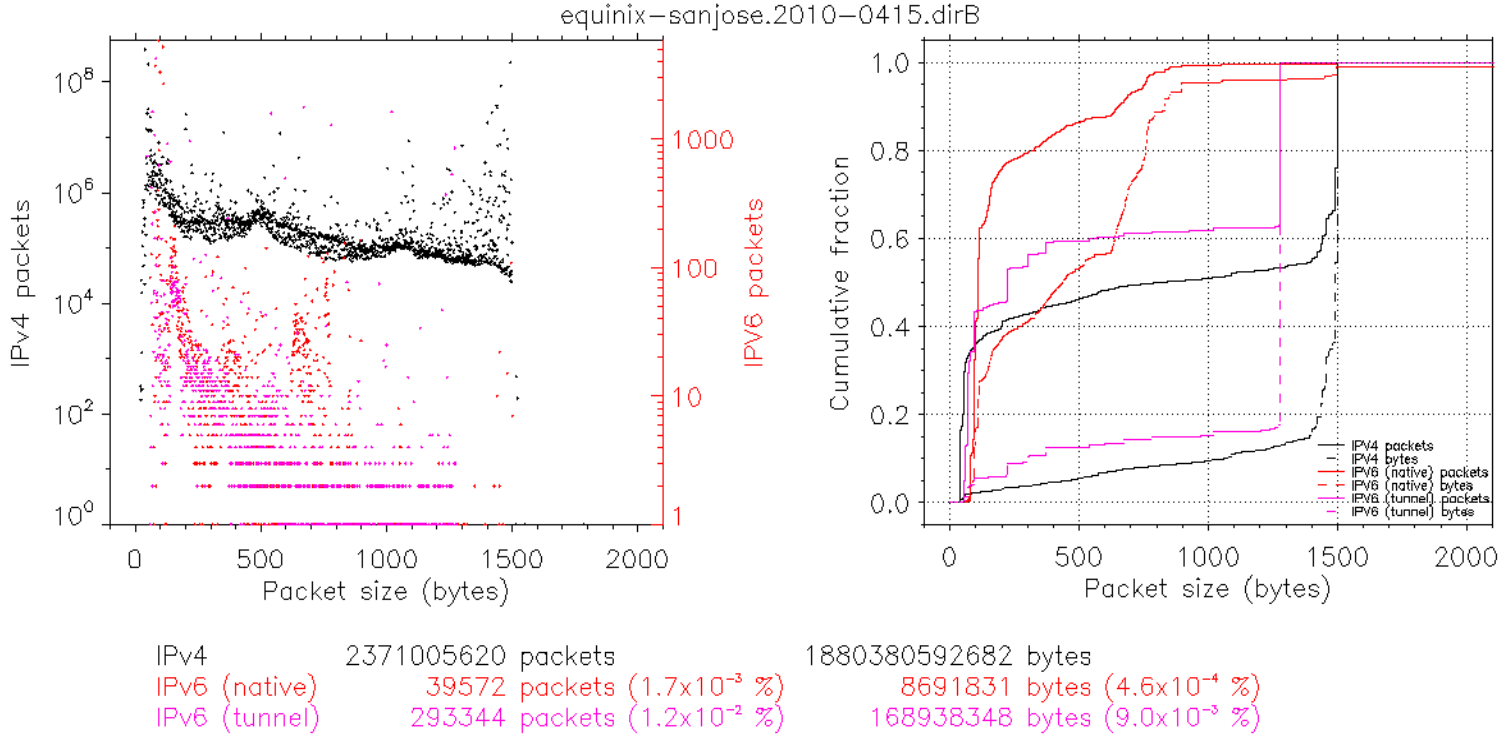
These challenges must be addressed at system level – enabled by modem power management architecture

Concurrent Operation of Foreground or Background Apps



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

Small data packets



- 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

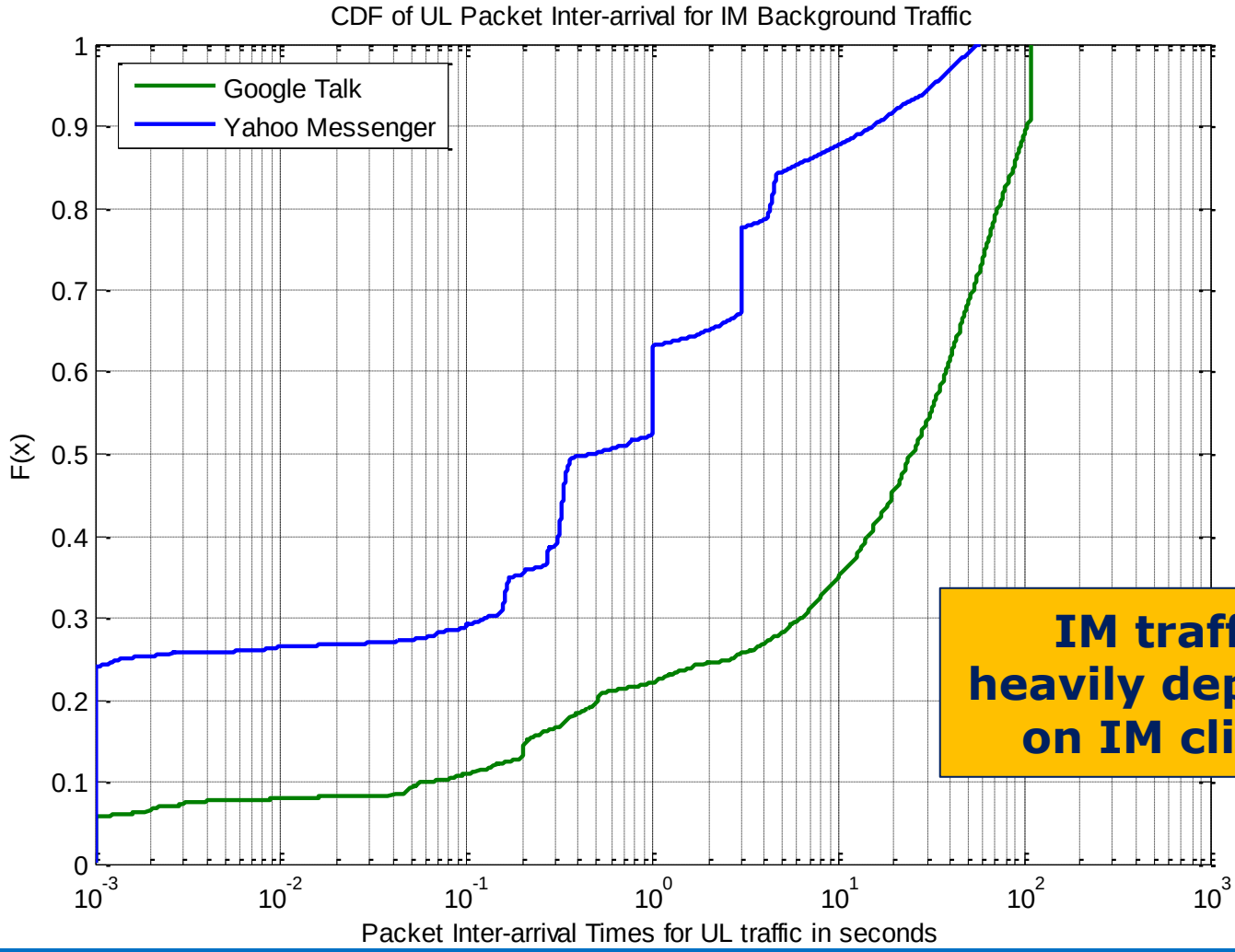
Background Traffic Inter-Arrival Times (IAT)

Source: Intel 2011, 3GPP RAN2 R2-115386

Downlink Packets	Uplink Packets
4-8% are bundled	20-40% are bundled
20% have IAT of 30ms	20% have IAT 100-500ms
10% have IAT of 60ms	The rest have IAT 1-500s
10% have IAT of 90ms	
30% have IAT 100-300ms	
85% are <100 bytes	65% are <100 bytes
	20% are 150-200 bytes

Instant Messaging (IM) Traces

Source: Intel 2011, 3GPP RAN2 R2-115386



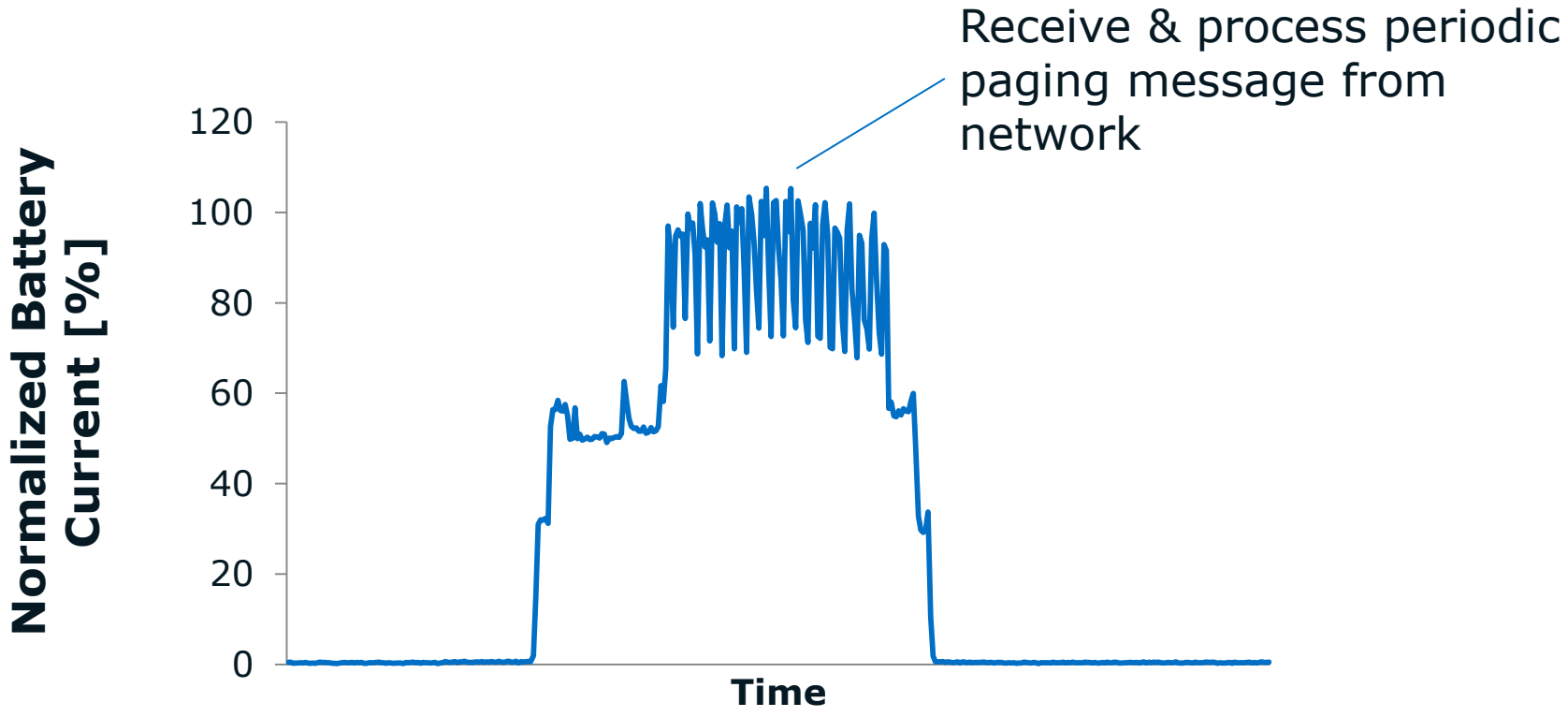
IM traffic heavily depends on IM client

Agenda

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

Power Optimization for Idle Modes

LTE idle mode

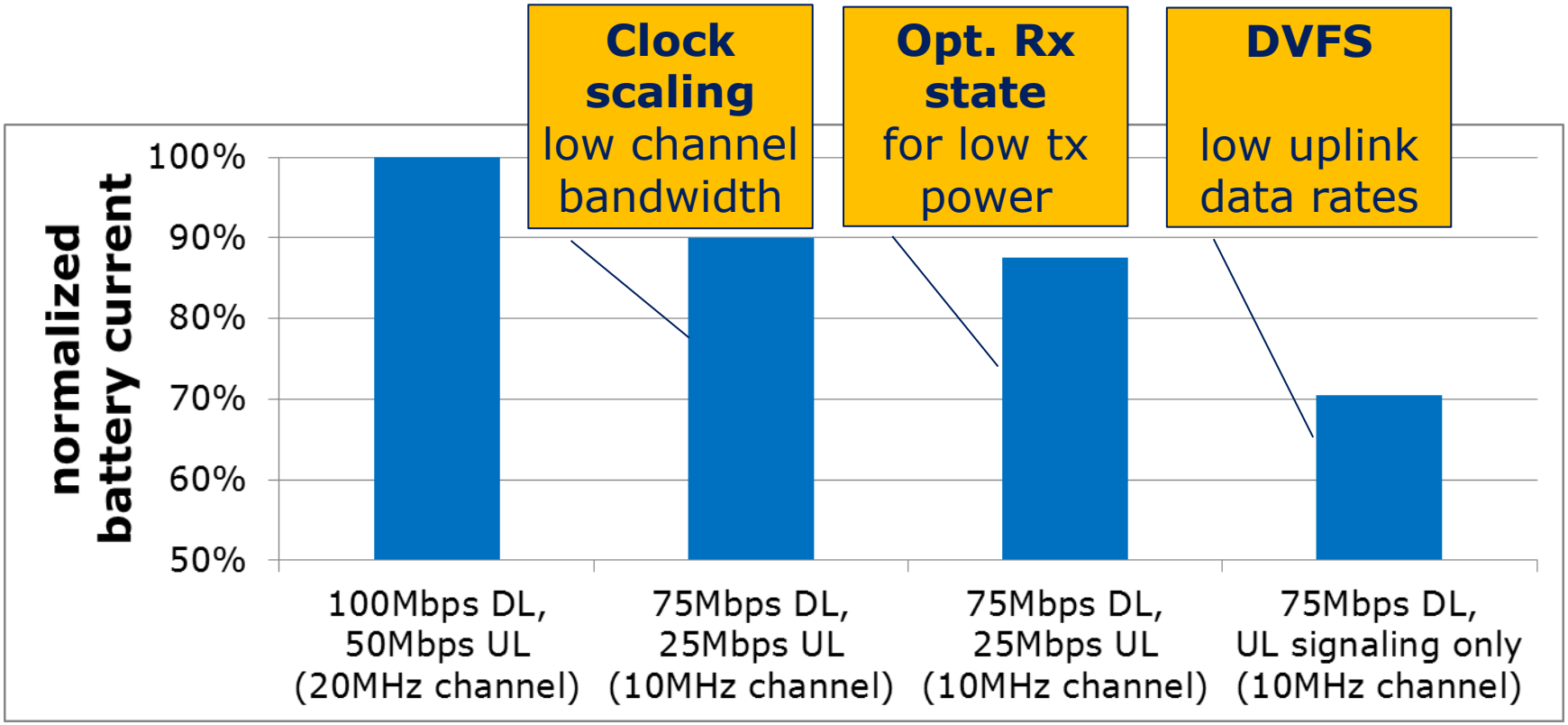


- Offloading main CPU tasks to power efficient HW accelerators
- Extensive use of DVFS
- All unused blocks are power gated

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

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

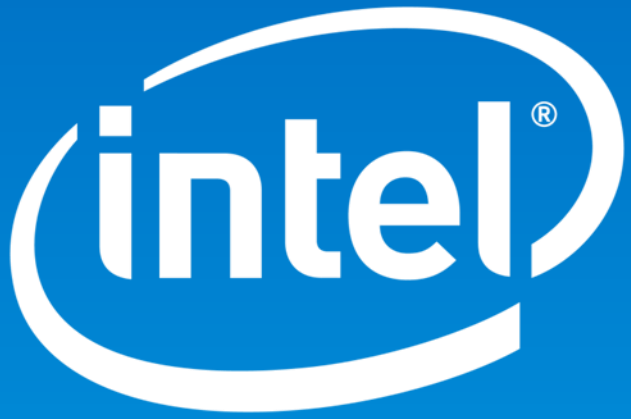
Power consumption optimization of mobile data devices goes beyond device boundaries

Agenda

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**

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