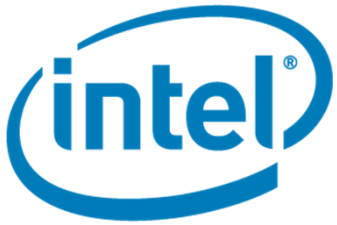

Efficient (Parallel) System Programming for Heterogeneous SoC Platforms

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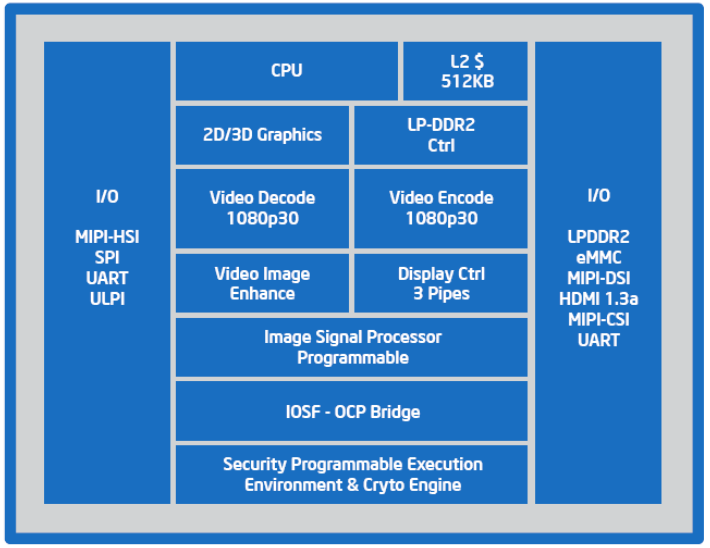
Heterogeneous System-on-Chip

- Heterogeneous platform consists of many IP blocks
  - Application processor/CPU
  - ISP, DSP, GPU, Video processors …

- Specialized accelerators are efficient for *domain-specific* computations
  - \+ Higher performance
  - \+ Less power
  - \+ Smaller size
  - – Limited programmability



The Intel®Atom™ processor Z2460 is a highly integrated system-on-a-chip (SoC), delivering powerful graphics and video capabilities needed for smartphones.

- SoC is becoming mainstream computing

Impose grand SW challenges

Software Key to SoC Success

- Software delivers experiences to end users
  - SoC vendors provide complete SW stack with SoC
  - SW must ship with the SoC silicon

- SoC software is very *complex*
  - SW harnesses the complex SoC
  - Across multiple SW layers (FW, driver, framework, apps)
  - Across multiple segments/platforms/OSes
  - Millions lines of code today and keep increasing…

Parallelism becomes the DEFAULT

Key Challenges for SoC Software

- To-to-market (TTM)
  - Critical to be competitive in mobile market
  - Reduce the traditional HW/SW development cycle
- Multiple products support
  - Different market segments
    - smart phone, tablet, smart TV, in-vehicle infotainment etc
  - Different OSes
    - Windows, Android, Linux, RTOS etc.
- High SW Quality
  - Maintain SW quality under tight TTM
- Innovations: differentiate the product!

Key Challenges for Programmers

- Need efficient way to develop new features
  - Copy-paste? ➔ Use existing library/module
  - Avoid parallel programming or parallelism awareness?
    ➔ No way!

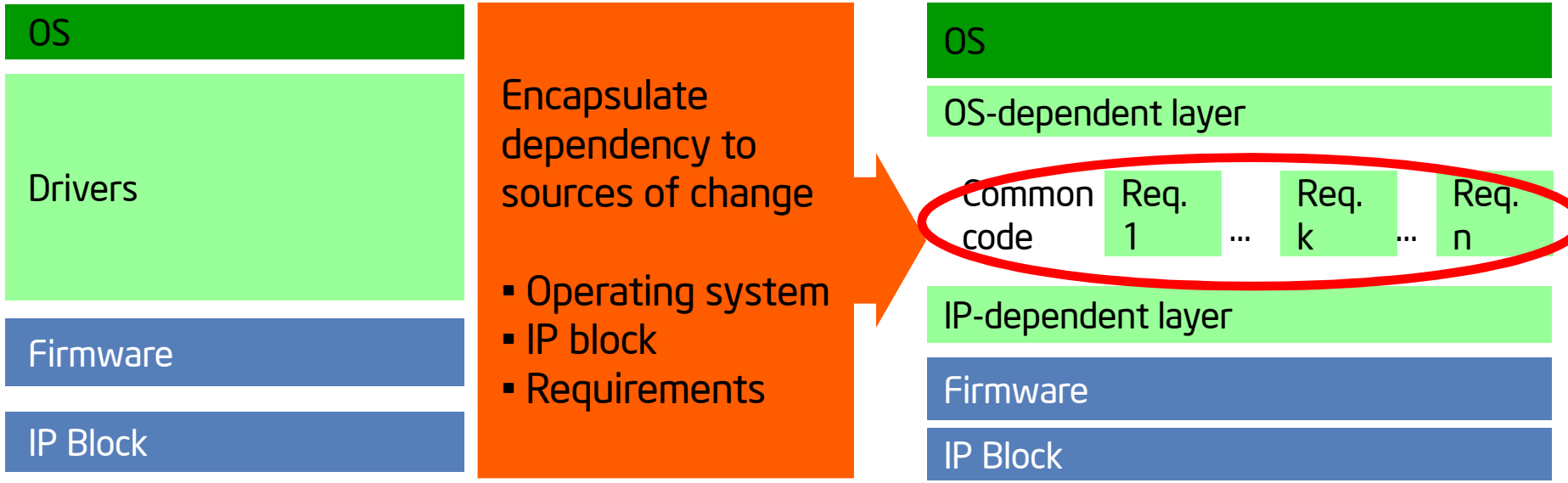
- Need efficient tools for programming
  - Visibilities to black boxes
  - Visibilities to multiple components
  - Bug reproducibility
  - etc.

Efficient SW development: methodology, programming and debugging

Outline

- Motivation
- Modular Software Architecture
- System Software Programming
- Conclusions

Modular Software Architecture



Monolithic drivers

Work well with one or two products but not scalable

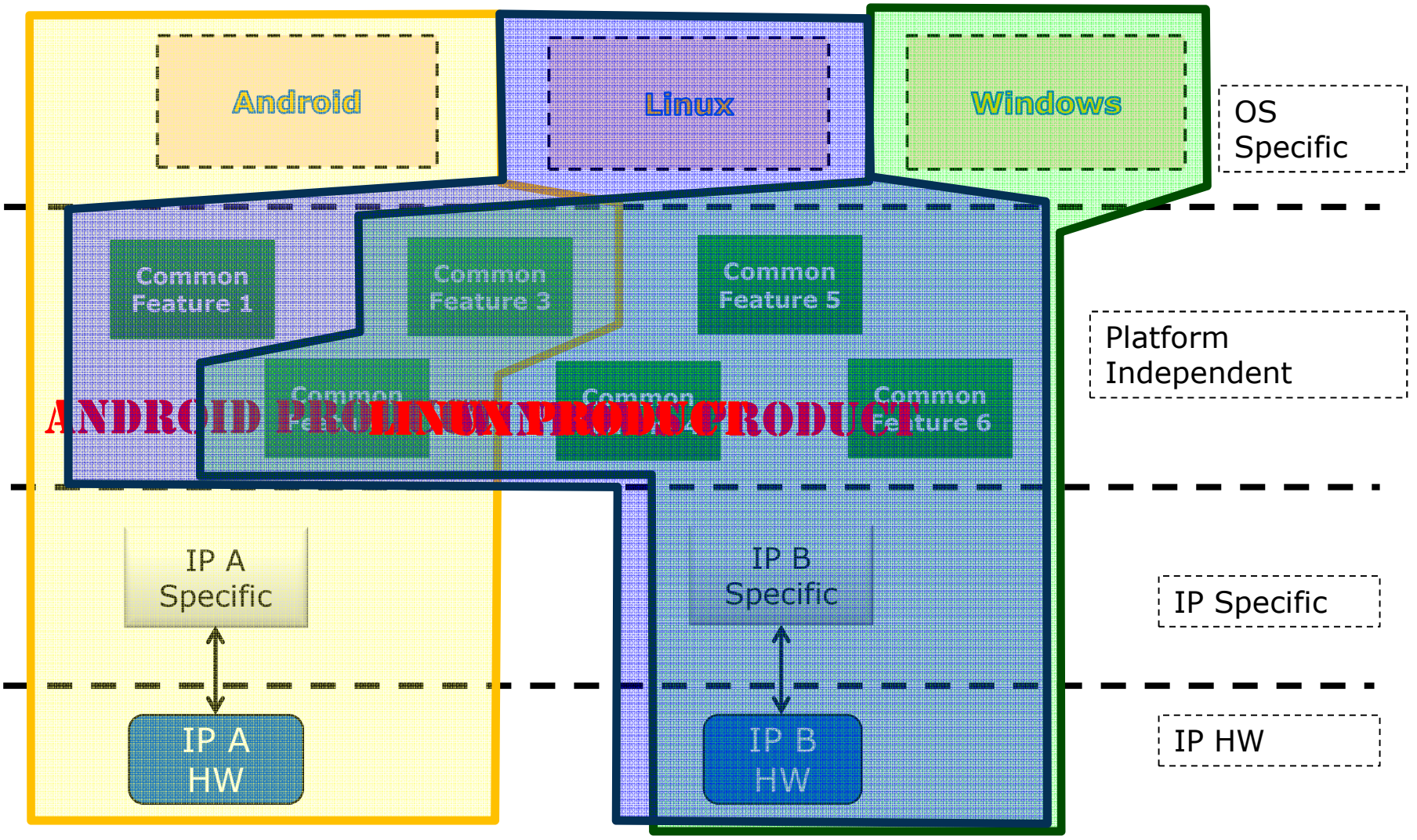
Layered drivers

OS and IP block dependencies encapsulated
- Ease OS and platform customization

Shared code modularized to atomic requirements
- Ease feature customization

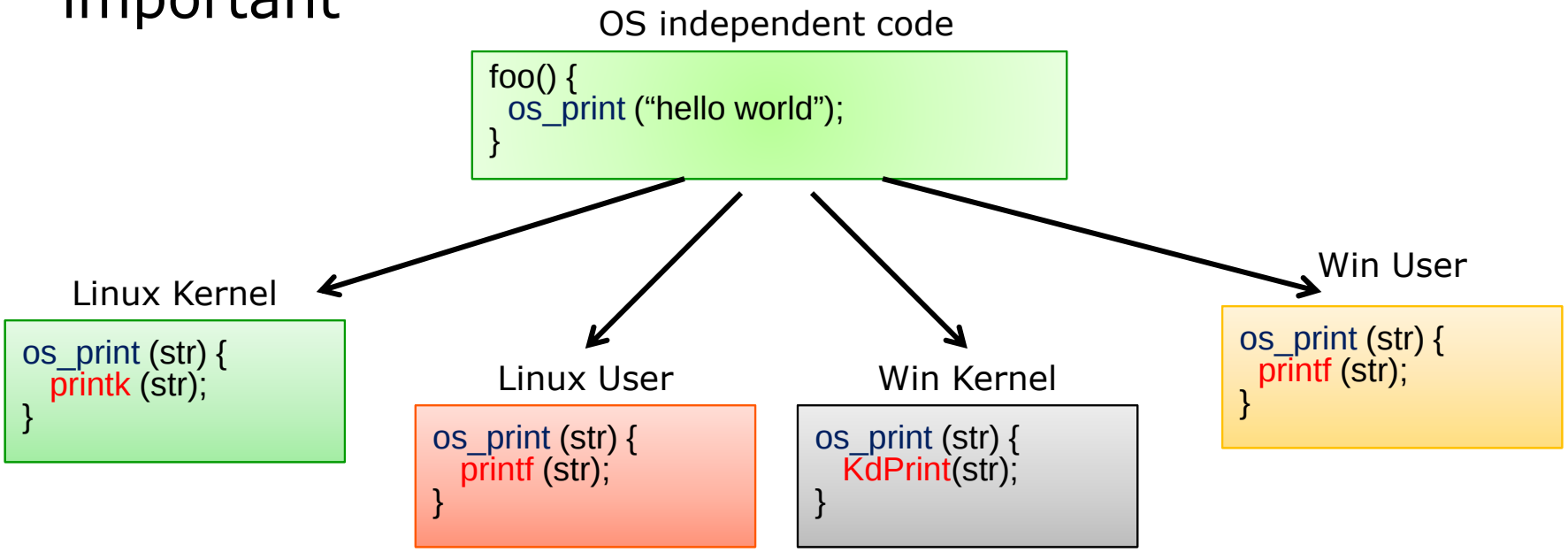
Enable Reuse across OSes and products

Product Customization



Cross OS Reuse

- Pervasive OS services make OS abstraction very important



- OS abstraction must support:
  - Interaction with upstream Linux kernel
  - Cross-OS reuse at the user level and kernel level
  - Kernel-user reuse

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Why is SoC System Programming Different?

- User experience are the driving force for mobile
  - Not only the performance
- SW and HW are optimized for the whole system
  - Not only the individual components
- SW is integrated by SoC vendors as reference
  - Not only the isolated drivers

Need System View for SW Development

Where is the Difficulty From?

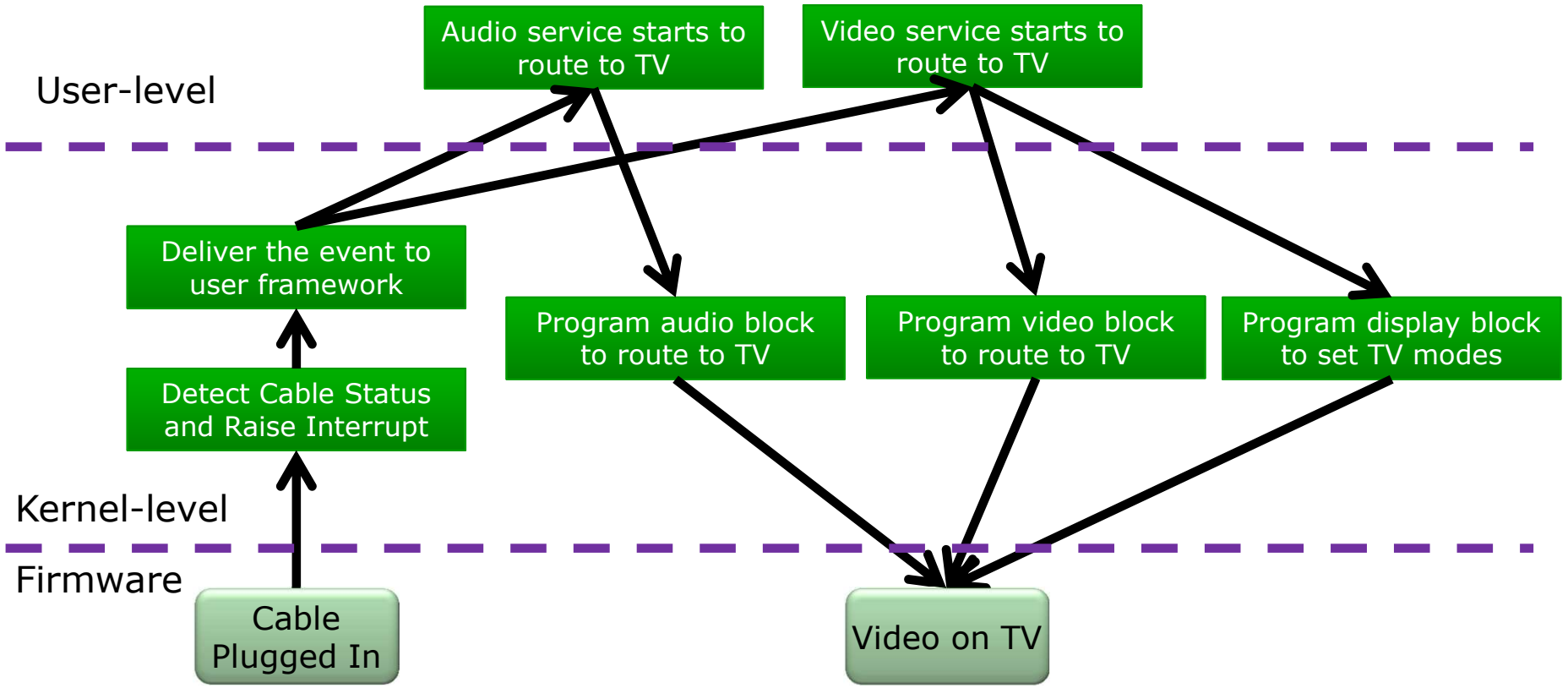
- "*Difficult*" system bugs are the long-pole of products
  - Interactions between layers (framework, driver, FW)
  - Interactions between components (audio, video, display etc)
  - 80/20 rule applies

- Why? (not complete, but some insights)
  - Difficult to track between layers
  - Often different ISA between IP blocks
  - Not well thought/designed interaction between components
  - Most of them are non-deterministic bug and hard to reproduce
    - Thanks to parallelism. ☺

Case Study: Connect Smartphone to TV

- Playback your favorite video to TV
- User Expectation
  - HDMI cable connected:
    - Audio/Video automatically goes to TV
  - HDMI cable disconnected:
    - Audio/Video automatically comes back to smartphone

Behind the Scene



- Multiple flows going on at the same time
- More system interactions can happen unexpectedly
  - Cable disconnected
  - Other audio streams
  - etc

What Do We Need in System Programming Model?

- Explicit Concurrency Awareness
  - Model can be used to check any violations
  - Force programmers to think in term of possible races
- Tolerate unexpected interrupts
  - e.g. cable disconnected, phone call comes in
- Synchronization support across user and kernel
- Enable debugging tools
  - Trace across components and layers
  - Reproducibility

Summary

- SoC, as a heterogeneous system, poses new challenges to computing
- **Software** is the key to success of system-on-chip
- Modular SW architecture and system-centric programming models are desirable
- Open challenges for the community
  - New SW methodology required for SoC software development
  - Programming, debugging, verification
  - System optimizations to leverage different IPs

Questions?