Frontend SoC design: The neglected frontier

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NSF Workshop: Electronic Design Automation — Past, Present, and Future
Arlington, VA
July 8-9, 2009

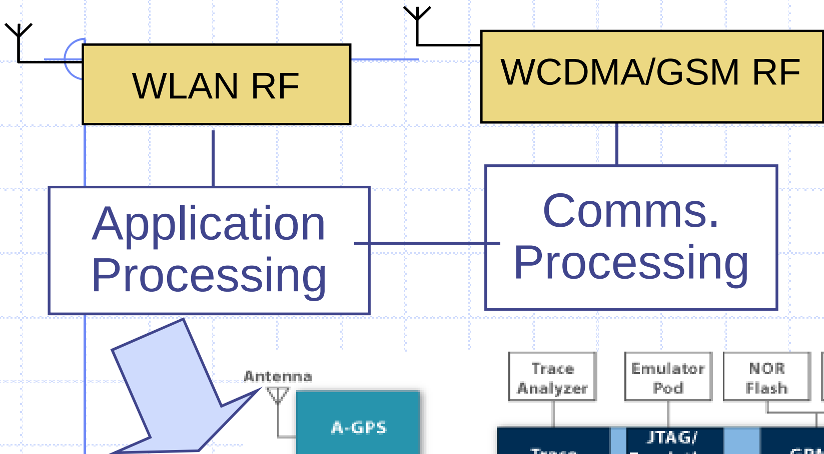
The future would be dominated by the concerns of

- Cheap & powerful handheld devices

and

- Powerful infrastructure needed to support services on these devices.

Current smart phone Architecture



Two chips, each with an ARM general-purpose processor (GPP) and a DSP (TI OMAP 2420) +

~80 complex specialized blocks

Real power saving implies specialized hardware

- H.264 video decoder implementations in software vs. hardware
  - the power/energy savings could be 100 to 1000 fold

but our mind set is that hardware design is:

- Difficult, risky
  - Increases time-to-ma
- Inflexible, brittle, er
  - Difficult to deal with changing standards, ...

New design flows and tools can change this mind set

What we need: # 1

Design methodologies and tools *to facilitate extreme IP reuse*

What we need: # 2

Design methodologies and tools *to facilitate architectural exploration*

What we need: # 3

Design methodologies and tools with *abstraction and composition rules with predictable outcome*

Verification?

- The degree of correctness required depends upon the application
  - Different applications require vastly different formal and informal techniques
- Formal tools must be tied directly to high-level design languages
- Formal techniques should be presented as debugging aids during the design process
  - A designer is unlikely to do any thing for the sake of helping the post design verification
  - Specifications of complex systems evolve continuously

Desired level of verification depends upon the application

Increasingly challenging

- IP Lookup in a router
  - Functional correctness is easy, proving that packets come out in order is difficult
- 802.11a Transceiver
  - Few lost packets do not matter but showing that all the correctable packets are being received is tough
- H.264 Video Codec
  - Lossy encoding! Theoretical criteria for good encoding are of no use in verification
- OOO Processors
  - One would want total correctness but usually correct results on old programs gets one most of the way
- Cache Coherence Protocols
  - Total correctness essential – even the designer does not trust testing

A designer wants

- To trust commonly used components
  - Arithmetic; common datastructures like queues, lists, hash tables, ...; common routines like sorting, maps, folds, ...;
- To trust commonly used tools and tool flow
  - Compilers, simulators, ...
  - “no silent failures”

Cost Matters

- The goal is to design systems that meet cost, performance, power, correctness, compatibility, robustness, etc.
  - Design time ≅ $$$
- Designers will use any technique that increases their confidence in the system provided it:
  - gives useful feedback quickly
  - is better than manual debugging
  - doesn't require learning a "foreign language"
  - is not elitist (No PhD requirement)

Some “Do”s and “Don’t”s

- Most successful formal techniques (e.g. types) help the designer, *not* just the verifier

- Separation of design and verification languages is a non-starter
  - what are you verifying?
  - manual abstraction, changing specs, ...

- Writing specs is a good idea, but it rarely happens
  - error prone
  - time consuming
  - incomplete
  - incomprehensible
  - changing requirements

What about technology related issues

- Increasing uncertainty
- Increasing variability
- Increasing soft-errors

all these issues have to be dealt with by essentially masking them at the lowest possible level of design

Front-end design needs a big boost

- High-level notation
  - capable of expressing parallelism and nondeterminism
  - amenable to synthesis of actual implementation
  - Must include proven language concepts: e.g., types, abstractions, higher-order functions
- Powerful tools for
  - synthesis
  - proving properties of such designs
  - estimating area, speed, power, …
- Rich and ever increasing set of IP blocks

Thanks!