GREENDROID:
AN ARCHITECTURE FOR DARK SILICON AGE

February 23, 2013
GO GREEN FOR A BETTER TOMORROW....

What is this GREEN concept???

- Green technology points to energy efficient techniques.
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- Scarcity for energy resources
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- Green technology points to energy efficient techniques.
- Scarcity for energy resources
- Looking for energy efficient designs & architectures.
Mobile application processors are soon to replace desktop processors as the focus of innovation in microprocessor technology. Smart phones sales surpass those of desktops.
ANDROID PLATFORM

- A Linux based operating system
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- An open source, developed by the open handset alliance led by Google.
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- An open source, developed by the open handset alliance led by Google.
- A multi-channel, multi-core OS.
DRAWBACKS OF ANDROID

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- Normally uses 200 mah, where battery provides 1500 mah.
WHAT IS THIS DARK SILICON??

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- Dark silicon is necessary, because engineers are unable to reduce chips’ operating voltages any further to offset increases in power consumption and waste heat produced by smaller, faster chips.
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- With each process generation, power budget becomes exponentially more valuable in comparison.
- Dark silicon is necessary, because engineers are unable to reduce chips’ operating voltages any further to offset increases in power consumption and waste heat produced by smaller, faster chips.
- This dark silicon limits the utilization of the application processors to the fullest.
SCALING THEORY

Scaling Theory:
- Transistors and power budgets no longer balanced

<table>
<thead>
<tr>
<th>Classical scaling</th>
<th>Leakage-limited scaling</th>
</tr>
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<tbody>
<tr>
<td>Device count</td>
<td>S^2</td>
</tr>
<tr>
<td>Device frequency</td>
<td>S</td>
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<tr>
<td>Device cap (power)</td>
<td>1/S</td>
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<tr>
<td>Device V&lt;sub&gt;dd&lt;/sub&gt; (power)</td>
<td>1/S^2</td>
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<td>Utilization ?</td>
<td>1</td>
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<tr>
<td></td>
<td>S^2</td>
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</tbody>
</table>

Exponentially increasing problem!!
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Need to give more focus on energy efficiency....
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WHAT DO WE DO WITH DARK SILICON??

- Insights
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  - Specialised logic has been shown as an effective way to improve energy efficiency (10-1000x)

- **Our Approach:**
  - Fill dark silicon with specialised cores to save energy on common apps
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- **Our Approach:**
  - Fill dark silicon with specialised cores to save energy on common apps
  - Power savings can be applied to other programs, increasing throughput
  - C-cores provide an architectural way to trade area for an effective increase in power budget!
CONSERVATION CORES

- Specialised cores for reducing energy
  - Automatically generated from hot regions of program source
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  - Drop-in replacements for code
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- Fully automated toolchain
  - Drop-in replacements for code
  - Hot code implemented by C-core cold code runs on host CPU
  - HW generation/SW integration.
- Energy efficient
  - Up to 16x for targeted hot code.
GREENDROID: a boon to the dark silicon problem.
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It targets the Android mobile phone software stack and can execute general purpose mobile programs with 11 times less energy than most energy efficient designs at similar or better levels of performance.
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Then it can dream up a processor design that best takes advantage of those usage habits, creating a CPU that’s both faster and more energy efficient.
Architecture...

Figure 2. The GreenDroid architecture. The GreenDroid mobile application processor (a) is made up of 16 non-identical tiles. Each tile (b) holds components common to every tile — the CPU, on-chip network (OCN), and shared L1 data cache — and provides space for multiple c-cores (labeled C) of various sizes. (c) shows connections among these components and the c-cores.
Continues...

- C-cores are most useful when they target code that execute frequently.
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Android comprises three main components. Linux kernel, a collection of native libraries (written in c and c plus), virtual machine. These all are hot codes.
C-cores are most useful when they target code that execute frequently. C-core tool chain transforms the most frequently executed code into c-core hardware. ANDROID is an excellent target for GREENDROID style architecture. Android comprises three main components. Linux kernel, a collection of native libraries (written in c and c plus), virtual machine. These all are hot codes. On profiling diverse set of android applications including web browser, mail, video player it can be found that this workload spends 95% of its time executing just 43,000 static instruction. Just 7nm of a 45nm process will replace these key instructions.
HOW THE CODES ARE GENERATED: An example

Figure 3. Conservation core example: an example showing the translation from C code (a), to the compiler's internal representation (b), and finally to hardware for each basic block (c). The hardware datapath and state machine correspond very closely to the data and control flow graphs of the C code.
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Figure 5. Energy savings in c-cores. Eliminating instruction fetch and decoding as well as overheads such as register files, bypass paths, and ALU muxes drops per-instruction energy by 91 percent.
CONCLUSION

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- The GREENDROID prototype is a demonstration vehicle that shows the wide spread application of c-cores to android.
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- C-core make use of selective de pipelining & reduce energy consumption by 91%
References

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