Embedded Processors Target

Digital Entertainment Applications
Digital Entertainment Represents Many Market Segments

In car entertainment
Set top boxes
Mobile phones
PDAs
Portable audio products
Still and video digital cameras
Digital Entertainment Represents Major Growth Opportunities

- Numbers don’t include IP set top box market
  - Expected to grow linearly over next 5 years
- IP set top box major consumer of MPEG ‘bandwidth’
Benchmarking is Critical for Different Stakeholders

- Processor vendors and compiler vendors
  - Performance tuning and evolution

- Platform OEMs
  - Determine performance bottlenecks
  - Understand how to improve end user performance

- Service providers (e.g., Vodafone, DoCoMo)
  - Choosing the best platform to offer subscribers

- End users
  - Need help determining what to buy
  - Experience running real-world content
The EEMBC Evolution: Digital Entertainment

New digital media benchmarks

- Includes enhanced first generation Consumer version 1.1 benchmarks
- New datasets for JPEG and filter benchmarks
- Moving towards application-level focus

Growing performance requirement

- More processor performance
- More demand on caches
- More system bandwidth
- More extensive coverage compared to Consumer Version 1.1
Digital Entertainment Benchmark Details - Dynamic

- **MP3 Decode**
  - EEMBC has more focus on reprogrammable solutions for mobile phones, PDAs, etc.

- **MPEG-4 Video encode and decode benchmarks**
  - Focus on mobile market
  - Also used in set top boxes for lower bit-rate streams

- **MPEG-2 Video encode and decode benchmarks**
  - More high-end focused
  - Fixed and floating point versions of encode

- **Cryptography**
  - AES, DES, RSA, and Huffman
  - Rapidly rising demand for random numbers
  - Across the net, applications need cryptography
Digital Entertainment Benchmark
Details - Static

- Digital photography manipulation
  - RGB to YIQ Conversion
  - RGB to HPG Conversion
  - RGB to CMYK
  - JPEG compression and decompression

- Multiple datasets represents a variety of workloads
Why a Portable Test Harness?

**Question**

How to get dozens of individual benchmarks to build and run on hundreds of embedded systems?

- Nearly all of which do not have operating systems
- Big endian, Little endian 16, 32, 64 bit
- Dozens and dozens of C compilers, libraries, header files
- Different kinds of timers, host-target interfaces

**Answer**

EEMBC Portable Test Harness
EEMBC Test Harness
- Runs on host and on target, communicates
- Provides timing, program control, and download support.
  - Results sent back up to Host for Logging, PSNR, post-processing, etc.

Target Hardware

System Memory
- Digital Entertainment Benchmark Code
  - 'Media Stream'
- Test Harness Control Code

Memory Controller

Processor
- I cache
- D cache

Timers

Download benchmark and encapsulated data from host to target

Start/stop timers, controls execution

RS-232, JTAG, Parallel, or Ethernet supported
Test Harness Functionality

• Abstracts individual benchmark kernels and applications from the underlying hardware and/or RTOS (if present)
• Functional Layer remains consistent
• Adaptation Layer is ported by individual companies or EEMBC Certification Lab (ECL)
  • ECL certifies ports according to strict rules to help assure consistency and accuracy
• Versions for Host-Target, Target-Only (TH Lite), Simulators
• Provides mechanisms for self-checking accuracy of resultant calculations (CRC, PSNR)
• Works for both small kernels (e.g. FFT) and for very large applications (e.g. Ghostscript)
Performance and Quality Metrics

- Big challenge to verify correctness of execution on something that is not bit exact
  - Used for MP3 decoder, MPEG-2 encoder/decoder, MPEG-4 encoder/decoder
- EEMBC uses a peak signal-to-noise-ratio (PSNR) method
  - PSNR = ratio between the SIGNAL to the NOISE
  - Higher SIGNAL, lower noise is better
- Generates separate encode and decoder PSNR scores that preserves double ended signal quality measurement.
  - This method is automated, processing several hundred intermediate files into a single score for each benchmark
- Developed by ECL
Two Ways of Calculating Benchmark Scores

“Out-of-the-box” scores
- Must use standard benchmark source code
- Must disclose compiler, flags, environment

“Optimized” or “full-fury” scores
- Vendors can rewrite benchmark source code, even substitute assembly language
- EEMBC Certification Lab (ECL) checks code to prevent cheating
## Processor Feature Comparison

<table>
<thead>
<tr>
<th>Processor Name-Clock</th>
<th>ADSP-BF533 - 594 MHz</th>
<th>AMD Geode NX1500@6W - 1GHz</th>
<th>Freescale MPC7447A - 1.4GHz</th>
<th>IBM 750GX - 1 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compiler Model and Version</td>
<td>GHS 4.2 for Blackfin</td>
<td>GCC 3.3.3</td>
<td>GHS Version 4.1</td>
<td>Green Hills Software MULTI 4.0</td>
</tr>
<tr>
<td>Native Data Type</td>
<td>16/32-bit</td>
<td>32</td>
<td>32</td>
<td>32-bit</td>
</tr>
<tr>
<td>L1 Instruction Cache Size (kbyte)</td>
<td>16Kbytes</td>
<td>64Kbytes</td>
<td>32Kbytes</td>
<td>32Kbytes</td>
</tr>
<tr>
<td>L1 Data Cache Size (kbyte)</td>
<td>32Kbytes</td>
<td>64Kbytes</td>
<td>32Kbytes</td>
<td>32Kbytes</td>
</tr>
<tr>
<td>External Data Bus Width</td>
<td>16 bits</td>
<td>32 bits</td>
<td>64 bits</td>
<td>64 bits</td>
</tr>
<tr>
<td>Memory Clock</td>
<td>118.8 MHz</td>
<td>166MHz</td>
<td>166MHz</td>
<td>200MHz</td>
</tr>
<tr>
<td>L2 Cache Size (kbyte)</td>
<td>0</td>
<td>256Kbytes</td>
<td>512Kbytes</td>
<td>1024 Kbytes</td>
</tr>
<tr>
<td>L2 Cache Clock</td>
<td>1.4GHz</td>
<td>1.4GHz</td>
<td>1 GHz</td>
<td>1 GHz</td>
</tr>
<tr>
<td>Chip set and/or memory interface chip</td>
<td>NA</td>
<td>VT8235</td>
<td>Marvell Discovery III</td>
<td>Marvell Discovery III</td>
</tr>
</tbody>
</table>

Table illustrates some of the key performance-related features that will have impact on benchmark scores.
**MPEG Encodemark Performance Comparison**

- IBM 750GX - 1 GHz
- Freescale MPC7447A - 1.4GHz
- AMD Geode NX1500@6W - 1GHz
- ADSP-BF533 - 594 MHz

**Question**
What’s enough performance to do the job?

**Answer**
It depends on the application.
Overall Performance Comparison

Scores Normalized to AMD processor
Performance/MHz Tells A Different Story

Demonstrating architectural efficiency by measuring the amount of work per clock.
There’s more to the story than meets the eye.
Performance/Watt Provides A Clear Differentiator

Power (and price) categorizes processor for the application

BF533 = 0.5W; Geode = 6W; MPC7447A = 18.3W; 750GX = 8.3W
Conclusion

- EEMBC provides an industry standard method for evaluating processing subsystems
- Demonstrates value propositions in different areas: raw performance, operating efficiency, power, code size, cost
- Digital Entertainment benchmarks address a wide range of applications
  - Processor performance is a key component of a platform’s success