Why Do Benchmarks Matter?

Assess key processor metrics accurately...
- Speed
- Memory efficiency
- Energy efficiency
- Cost efficiency

...to determine the “best” processor
Use limited engineering resources effectively
Compare performance across a wide range of architectures
Benchmarking Processors for DSP Applications

Benchmarking Options

Full Applications
- Portable audio player
- Wireless handset
- Video conf. system

Application Tasks
- OS
- Audio decoder
- Audio encoder
- Speech codec
- Video decoder
- Video encoder

Algorithm Kernels
- FIR
- FFT
- Control
- Vecdot

Operations
- Add
- Mult/MAC
- Shift
- Load

Which is Best?

Accuracy →

- Algorithm Kernels
- MMACs
- MIPS

Task →

Application →

Availability → Implementation Effort →

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**What’s Wrong with MIPS?**

MIPS (millions of instructions per second) and MFLOPS (millions of floating-point operations per second) are easy to measure...

...but “instructions” and “operations” are poorly defined

Single DSP16410 instruction:
A0=A0+P0+P1 P0=Xh*Yh P1=Xl*Yl Y=*R0++ X=*PT0++

Single TMS320C6414 instruction:
ADD A0, A3, A0

**MMACS: Not Much Better**

MMACS approximate performance on some signal processing algorithms like FIR filters, but:

- It ignores other operations required to sustain repeated MACs
- It ignores memory bandwidth bottlenecks
- Many important signal processing algorithms don’t use MACs!

Example: ‘C5510 and PXA255

- 200 MHz ‘C5510: 400 MMACS and 1,200 million bytes/sec
- 400 MHz PXA255: 800 MMACS and 1,600 million bytes/sec

These two processors have comparable signal processing speed!
Kernels: A Good Compromise

Algorithm kernels are the most computationally intensive portions of signal processing applications. Example algorithm kernels include FFTs, IIR filters, and Viterbi decoders. Application-relevant algorithm kernels are strong predictors of overall performance. Kernels require only modest programming effort.

The BDTI Benchmarks™

• Hand optimized
  † Moderate level of effort
  † Reflects common coding practice
  † Accurate representation of architecture capability
• Detailed programming rules
  ‡ Complicates programming
  † Ensures fair comparison between architectures
  † Large base of results available for comparison
  † About 50 architectures already benchmarked
Benchmark Results

Digital signal processors (DSPs)
- Analog Devices BF53x (Blackfin)
- Analog Devices TS20x (TigerSHARC)
- Freescale MSC71xx/81xx
- Texas Instruments C55x
- Texas Instruments C64x

Application processors
- Intel PXA255/26x (XScale)
- Intel PXA27x (XScale + Wireless MMX)
- Samsung S3C24xx (ARM9)
- Texas Instruments OMAP591x (ARM9 + C55x)

BDTImark2000™

Signal Processing Speed
Benchmarking Processors for DSP Applications

**BDTImark2000™/$**

**Signal Processing Cost-Effectiveness**

- PXA255 (300 MHz, $26)
- PXA270 (312 MHz, $32)
- S3C2440 (400 MHz, $19)
- OMAP5912 (312 MHz, $28)
- BF531 (400 MHz, $5)
- TS203S (500 MHz, $47)
- MSC1501 (300 MHz, $2)
- C5501 (400 MHz, $9)
- P40C59 (350 MHz, $10)
- PA470 (312 MHz, $21)
- S5C2410 (400 MHz, $19)

**BDTImark2000™/mW**

**Signal Processing Energy-Efficiency**

- PXA255 (200 MHz, 1.0 V)
- PXA270 (104 MHz, 0.9 V)
- S3C2410 (200 MHz, 1.8 V)
- OMAP5910 (150 MHz, 1.6 V)
- BF533 (100 MHz, 0.8 V)
- TS203S (500 MHz, 1.0 V)
- MSC8103 (300 MHz, 1.6 V)
- C5503 (108 MHz, 1.2 V)
- C6414T (600 MHz, 1.1 V)
- N/A
Kernel Benchmark Weaknesses

Algorithm kernel benchmarks are good for measuring general signal processing performance, but they...

- Require careful application for multi-core processors
- Do not measure system-level performance
- Do not measure OS overhead
- Cannot be easily applied to hardware accelerators, FPGAs, etc.
Task Benchmarks

Model a key signal processing task
- Fairly representative of actual workload
- Easier to implement than a full application
- Less general than a set of kernel benchmarks

Provides greater level of abstraction
- Allows comparison of different types of architectures
- Simplifies programming rules

Can benchmark the entire system
- Capture effects of memory size, bandwidth, etc.
- Does not capture effects of combining multiple tasks

Example Task Benchmark

BDTI Communications Benchmark™ (OFDM) is based on a simplified OFDM receiver
- Closely resembles a real-world task
- Simplified to enable optimized implementations
- Constrained to ensure consistent, reasonable implementation practices

IQ Demodulator → FIR → FFT → Slicer → Viterbi Decoder
Benchmarking Processors for DSP Applications

**BDTI Communications Benchmark™**

<table>
<thead>
<tr>
<th></th>
<th>Freescale MSC7110 (200 MHz)</th>
<th>Altera Stratix 1S20-6 (Preliminary)</th>
<th>Altera Stratix 1S80-6 (Preliminary)</th>
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<tr>
<td>Channels</td>
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<td>Cost (1 ku)</td>
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<td>Cost per channel</td>
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</table>

From BDTI’s report, *FPGAs for DSP.*

**Full-Application Benchmarks**

- Potential for highly accurate results
- Results useful only for specific application (or highly similar applications)
- Applications tend to be ill-defined
- Costly and time-consuming to implement
- For processors, similar results via simpler approaches
  - But this is not true for all implementation technologies
Conclusions

Relevant, meaningful benchmark results are essential
  • Consider all relevant metrics
  • Fastest doesn’t mean best
Different benchmarking approaches make different trade-offs
  • Choose the right approach for the task at hand
  • Consider what’s available
Beware the many benchmarking pitfalls
Factors other than performance are always important

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