Optimized DSP Software • Independent DSP Analysis

Benchmarking Processors for DSP Applications

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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

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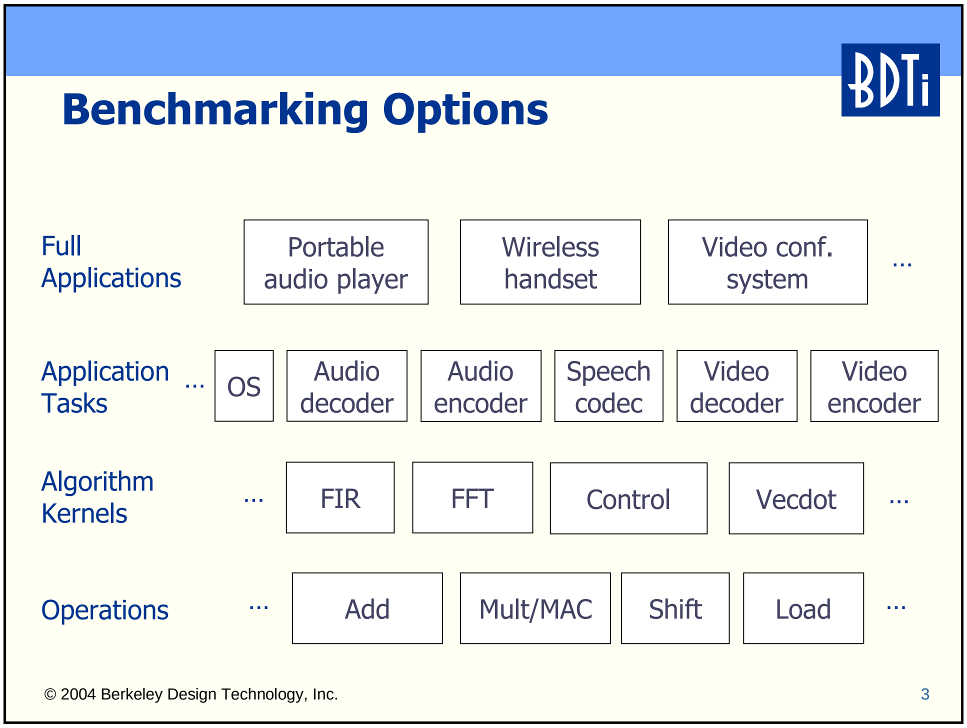
Benchmarking Options
BDTi
Full Applications
Portable audio player
Wireless handset
Video conf. system
…
Application Tasks
…
OS
Audio decoder
Audio encoder
Speech codec
Video decoder
Video encoder
Algorithm Kernels
…
FIR
FFT
Control
Vecdot
…
Operations
…
Add
Mult/MAC
Shift
Load
…
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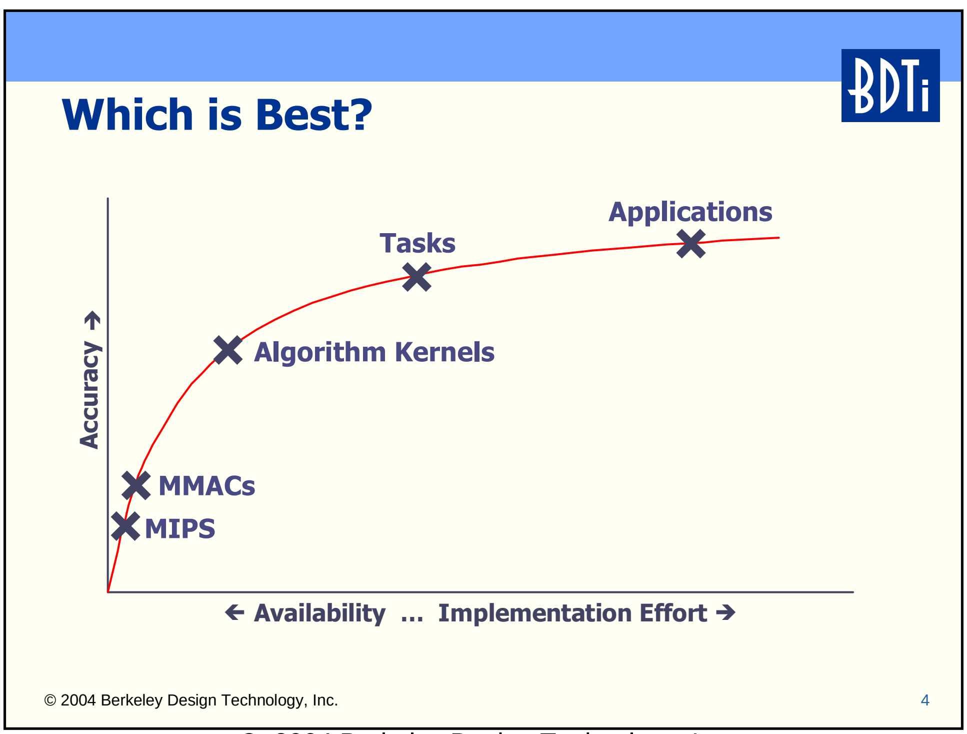
Which is Best?
BDTi
Applications
Tasks
Algorithm Kernels
MMACs
MIPS
Accuracy →
← Availability … Implementation Effort →
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What's Wrong with MIPS?

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
```

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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!

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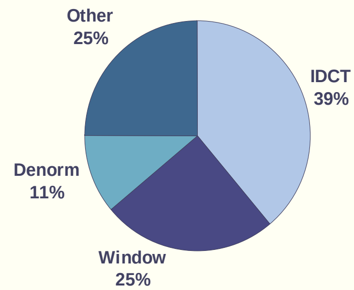
Kernels: A Good Compromise

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

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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

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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)

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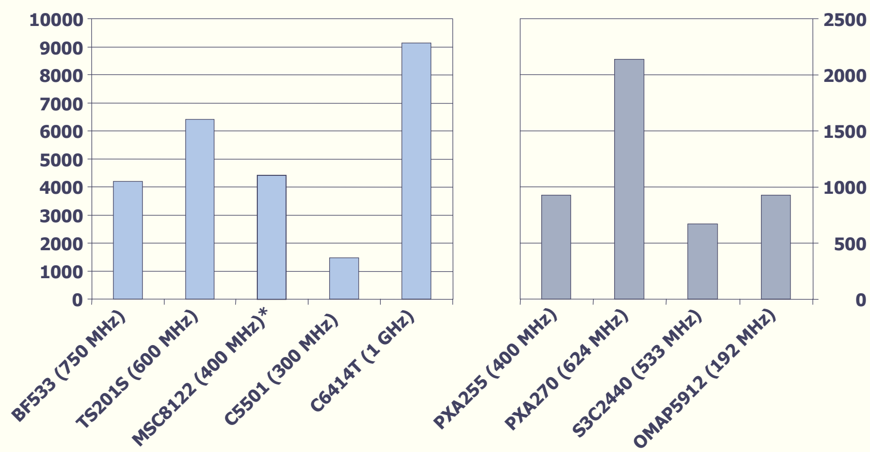
BDTImark2000™

Signal Processing Speed



*For one of four on-chip cores

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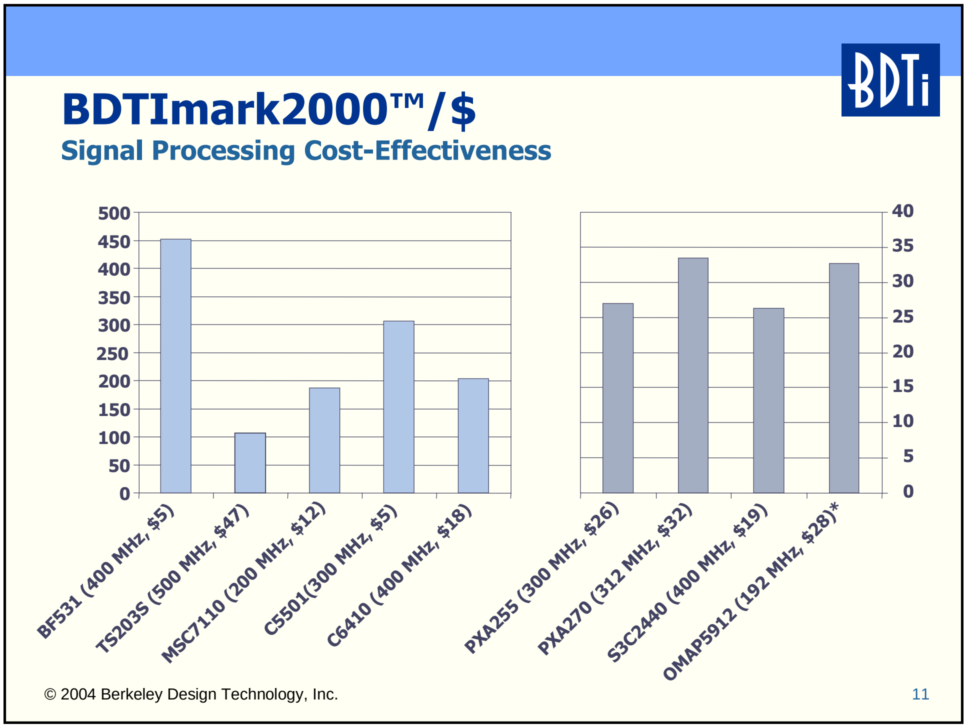
BDTi
BDTImark2000™/$
Signal Processing Cost-Effectiveness
500
450
400
350
300
250
200
150
100
50
0
BF531 (400 MHz, $5)
TS203S (500 MHz, $47)
MSC7110 (200 MHz, $12)
C5501(300 MHz, $5)
C6410 (400 MHz, $18)
40
35
30
25
20
15
10
5
0
PXA255 (300 MHz, $26)
PXA270 (312 MHz, $32)
S3C2440 (400 MHz, $19)
OMAP5912 (192 MHz, $28)*
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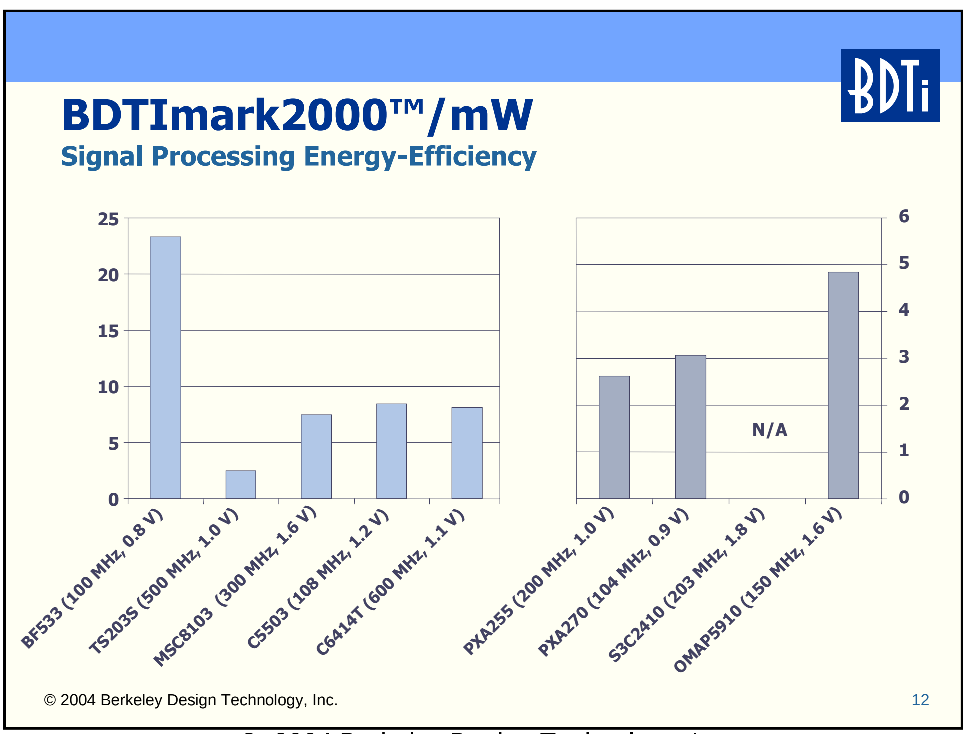
BDTi
BDTImark2000™/mW
Signal Processing Energy-Efficiency
25
20
15
10
5
0
BF533 (100 MHz, 0.8 V)
TS203S (500 MHz, 1.0 V)
MSC8103 (300 MHz, 1.6 V)
C5503 (108 MHz, 1.2 V)
C6414T (600 MHz, 1.1 V)
6
5
4
3
2
1
0
N/A
PXA255 (200 MHz, 1.0 V)
PXA270 (104 MHz, 0.9 V)
S3C2410 (203 MHz, 1.8 V)
OMAP5910 (150 MHz, 1.6 V)
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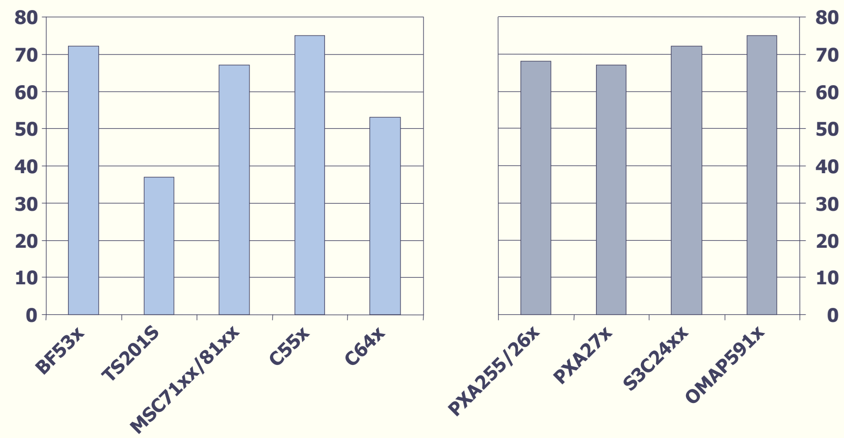
BDTImemMark2000™

Signal Processing Memory-Efficiency



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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.

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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

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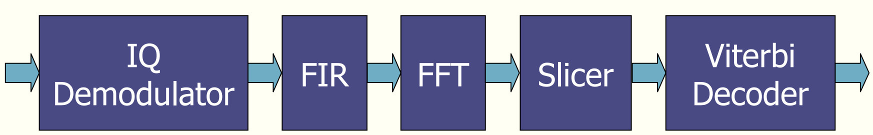
Example Task Benchmark

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



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BDTI Communications Benchmark™

	Freescale MSC7110 (200 MHz)	Altera Stratix 1S20-6 (Preliminary)	Altera Stratix 1S80-6 (Preliminary)
Channels	<<1	~20	~60
Cost (1 ku)	$13	$295	$4,510
Cost per channel	~$100	~$20	~$80

From BDTI's report, *FPGAs for DSP*.

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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

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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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For More Information…
www.BDTI.com

Inside [DSP] newsletter and quarterly reports

Benchmark scores for dozens of processors

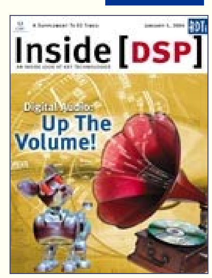
Pocket Guide to Processors for DSP

- Basic stats on over 40 processors

Articles, white papers, and presentation slides

- Processor architectures and performance
- Signal processing applications
- Signal processing software optimization

comp.dsp FAQ



2004 Edition

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