Insight, Analysis, and Advice on Signal Processing Technology

Benchmarking Processors for DSP Applications

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Why Do Benchmarks Matter?

Assess key processor metrics accurately, e.g.,
- Speed (*not* cycle counts!)
- Cost efficiency
- Energy efficiency (*not* power consumption!)
- Memory efficiency

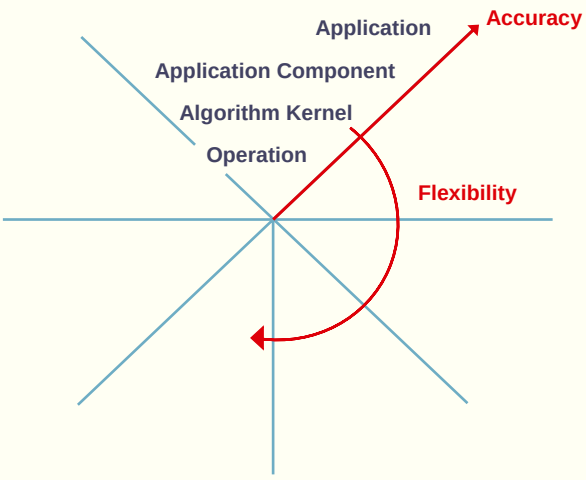
Use limited engineering resources effectively

Compare performance across a wide range of architectures, applications

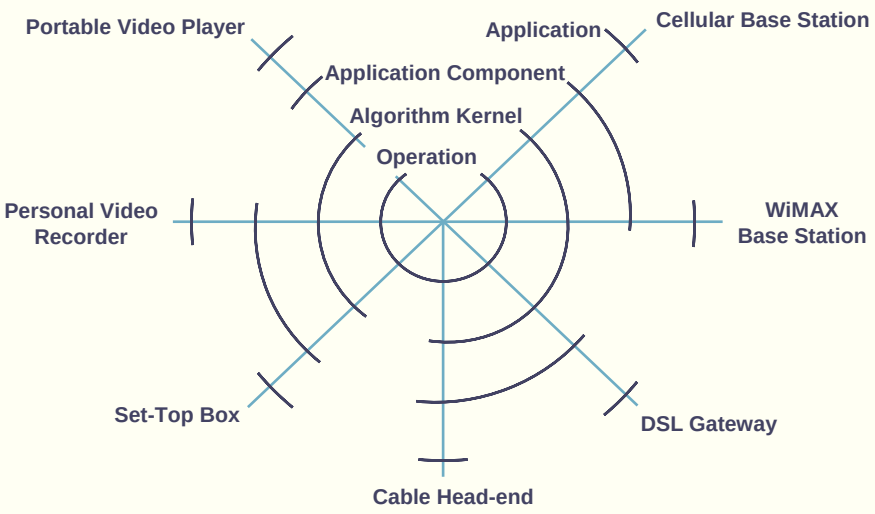
Typical Application Decomposition

Applications	Portable audio player	Wireless handset	Video conf. system	…		
Application Components	OS	Audio decoder	Audio encoder	Speech codec	Video decoder	Video encoder
Algorithm Kernels	FIR	FFT	DCT	VECADD	…	
Operations	Add	Mult/MAC	Shift	Load	…	

Flexibility vs. Accuracy



Flexibility vs. Accuracy



What's Wrong with MMACS?

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

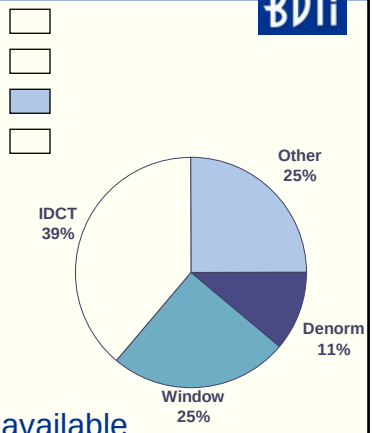
- It ignores other operations required to sustain repeated MACs
- It ignores memory bandwidth bottlenecks
- Many important signal processing algorithms don't use MACs!

Example: 'C5510 and PXA260

- 200 MHz 'C5510: 400 MMACS and 1,200 million bytes/sec
- 400 MHz PXA260: 800 MMACS and 1,600 million bytes/sec
- These two processors have comparable signal processing speed!

Algorithm Kernels

- Computationally intensive portions of signal processing applications
  - FFTs, filters, bit unpack, …
- ↑ Strong predictors of performance
  - ↓ Do not measure system-level performance or OS overhead
- ↑ Modest programming effort
- ↑ Results for common kernels widely available
- ↓ Difficult to apply to multi-core processors, hardware accelerators, FPGAs, etc.
- Examples: BDTI DSP Kernel Benchmarks™, BDTI Video Kernel Benchmarks™

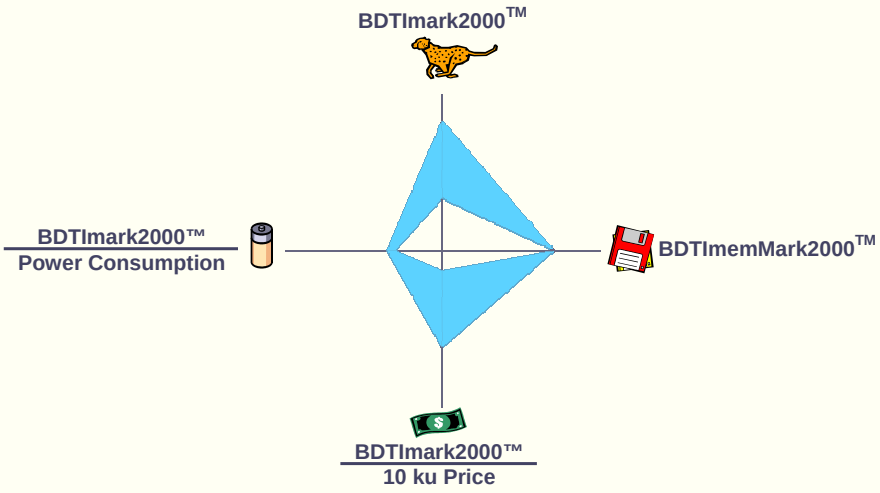


Example: BDTI DSP Kernel Benchmarks™

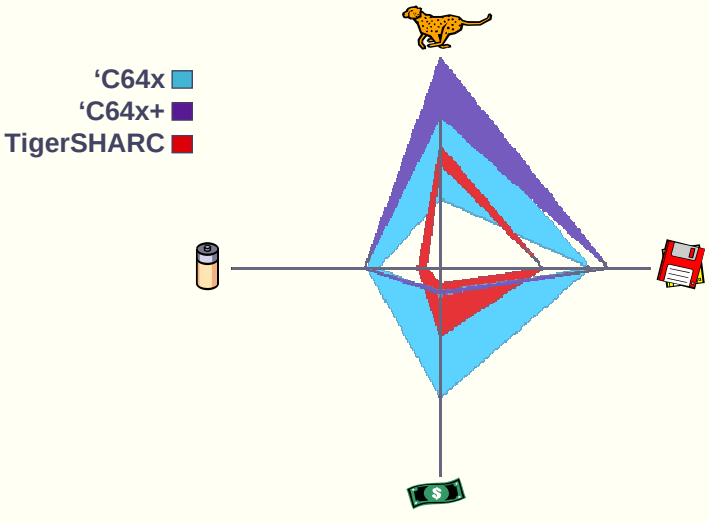
- Hand optimized
  - ↑ Reflects common coding practice
  - ↑ Accurate representation of architecture capability
  - Moderate level of effort
- Detailed programming rules
  - ↑ Ensures fair comparison between architectures
  - ↓ Complicates programming
- ↑ Large base of results available for comparison
  - ↑ About 80 architectures already benchmarked
  - ↑ Provides easy means for quick *and* accurate analysis

Benchmark Results

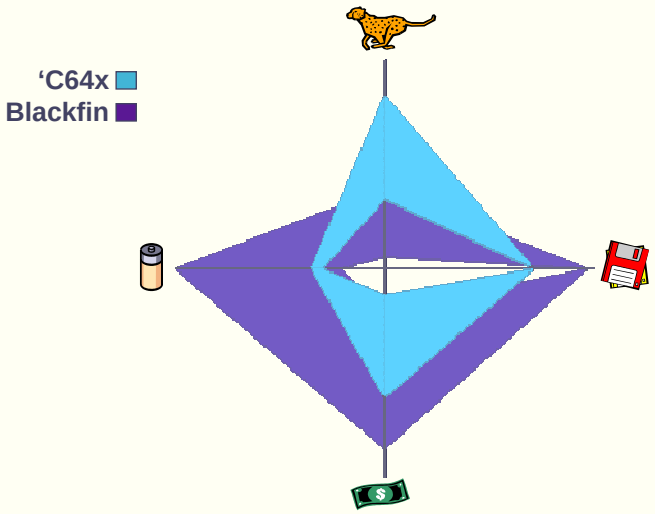
Example: 'C64x Family



Benchmark Results



Benchmark Results



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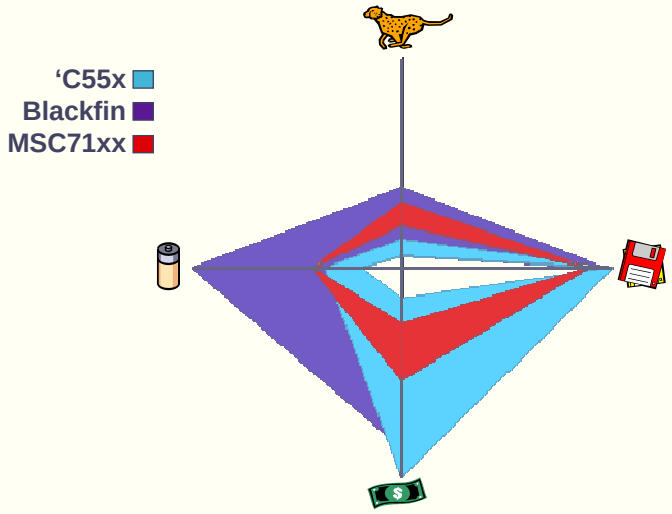
11

Benchmark Results



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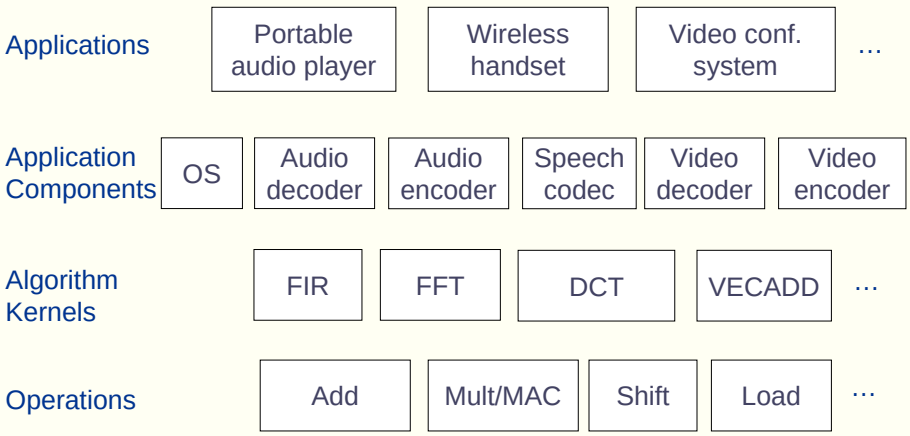
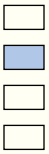
12

Typical Application Decomposition



Application Components



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

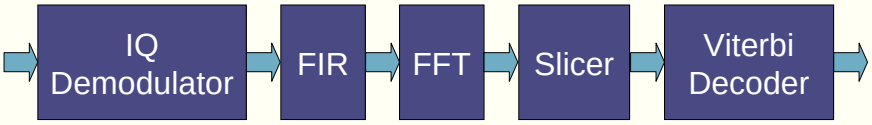
Larger workload vs. kernel benchmarks
- Allows comparison of different types of architectures
- Simplifies programming rules

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

Example Application Component Benchmark

BDTI Communications Benchmark™ (OFDM) is based on a simplified 10 Mbps OFDM receiver

- Closely resembles a real-world task
- Simplified to enable optimized implementations
- Constrained to ensure consistent, reasonable implementation practices



BDTI Communications Benchmark™

	Freescale MSC7110 (200 MHz)	TI 'C6410 (400 MHz)	Altera Stratix 1S20-6	Altera Stratix 1S80-6
Bit rate	5.6 Mbit/s	12 Mbit/s	800 Mbit/s	2400 Mbit/s
Cost (1 ku)	$14	$18	$120	$600
Cost per Mbit/s	$2.50	$1.45	$0.15	$0.25

From BDTI's report *FPGAs for DSP* and unpublished benchmarks.

BDTI Communications Benchmark™

Estimated Engineering Effort (for an Optimized Implementation)

	Typical DSP	Typical FPGA*
With Block Libraries	1-2 weeks	~40 weeks
Without Block Libraries	8-10 weeks	???

*Assumes traditional HDL design flow

Full Application Benchmarks

- Potential for highly accurate results
  - Results useful only for specific application (or highly similar applications)
  - Applications tend to be ill-defined
- May be able to use existing application code as a benchmark …
  - Example: BDTI H.264 Decoder Solution Certification™
- … but costly and time-consuming to implement a new application
- For processors, similar results via simpler approaches
  - But this is not true for all implementation technologies

The Problem with "Solutions"

Vendors increasingly offer HW +SW "solutions"

But solution performance claims are very difficult to use and compare…

"Hantro's H.264 player for series 60 handsets is based on the 6100 software decoder and PlayEngine middleware. Running on the Nokia 7610 handset, full screen video (208x176 resolution) at 15 frames per second can be achieved."

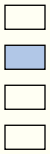
"We're shipping today, running a 90-MHz processor and delivering 20-frame per second QCIF video, which is a very acceptable level." – Agere

"H.264 player on 600 MHz Blackfin, CIF (360 x 240) at 30 fps: 111 MHz" – ADI

Application Code as a Benchmark

- Actual application code can give the most accurate and relevant measure of performance
- Usually impractical to implement application code solely for benchmarking purposes
- Vendor's data is often difficult to interpret
  - Varying configurations and conditions
  - Varying performance metrics
  - Inability to quickly distinguish real solutions from vaporware

BDTI's Methodology



Standardization:
- Operating points
- Test streams
- Metrics

Certification (independent verification):
- Functionality
- Performance

Benefits:
- Meaningful, comparable performance data
- Real solutions distinguished from vaporware

BDTI H.264 Decoder Solution Certification™

Primary Operating Point:
- Baseline profile, level 1.3
- D1 resolution (720 × 480)
- 30 frames per second
- 2 Mbit/second bitstream

Secondary operating points are used to provide a complete performance picture

Metrics:
- CPU use (MHz, % loading)
- Memory bandwidth use (Mbit/second, % loading)
- Energy consumption (mJ/frame)
- Cost or die area ($ or mm²)
- Program and data memory use (Mbytes)

Conclusions

Benchmarks are invaluable, if you…

- Choose the right benchmarking approach for the task at hand
  - Different approaches make different trade-offs
- Consider all the relevant metrics
- Beware the many benchmarking pitfalls
- Don't loose sight of non-performance considerations

For More Information…
www.BDTI.com

Inside DSP newsletter

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

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