MediaBench II

Consortium
MediaBench Consortium

**Consortium’s Mission:**
- Provide a benchmark representative of the multimedia and communications industry for computer architecture and compiler research

**Why a Consortium?**
- Facilitate continual updates of MediaBench, enabling MediaBench to better characterize multimedia and communications industry
- Ensure Representability of Benchmark:
  - Include various specialists when defining benchmark suite
    - Multimedia and communication application application specialists
    - Computer architecture and compiler specialists
  - Rely on consensus of experts in updating benchmark
Consortium Organization

Directors:
- Jason Fritts, Washington Univ.
- Bill Mangione-Smith, UCLA

Steering Committee
- Eric Debes, Intel
- Wen-Mei Hwu, UIUC
- Ruby Lee, Princeton
- Subramania Sudharsanan, Queen’s Univ.
- Wayne Wolf, Princeton
- additional members – TBA
MediaBench I

MICRO-30 (‘97)
Early Goals for MediaBench

- Test full applications, not just kernels
- High level language for compilation-based systems, not assembly code
- Widely available components
- Distinct from other available benchmarks
- Results useful for making design decisions
Focus Areas

- **Video**
  - DCT/IDCT, Motion Estimation, Entropy Coding

- **Image Compression**
  - DCT/IDCT, Entropy Coding, Wavelets

- **Audio**
  - ADPCM

- **Speech**
  - GSM compression, speech recognition

- **Security**
  - MD5, IDEA, DES, RSA

- **Graphics**
  - Rendering, Lighting, Shading
Applications

- **MPEG-2**: video compression codec
- **JPEG**: image compression codec
- **EPIC**: wavelet-based image compression codec
- **Ghostscript**: PostScript language interpreter
- **Mesa**: 3-D graphics library clone of OpenGL
- **ADPCM**: adaptive differential pulse code modulation
- **GSM**: European GSM 06.10 standard for speech transcoding
- **G.721**: CCITT G.721 speech compression codec
- **RASTA**: speech recognition
- **PGP**: encryption and decryption
- **PEGWIT**: elliptic curve encryption
Limitations

Problems with distribution
- Links to original code complicated by X-windows code and changing releases

Reference release environment not easy to reproduce

Only one data set

Absence of kernel codes

Some specific failures of code selection
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Goals
Short-Term Goals

- Update benchmark to include major applications in multimedia and applications
  - eliminate outdated applications
  - reflect characteristics of most advanced and most widely-used applications
  - provide less widely-used applications for comparison

- Multi-purpose organization, including both composite benchmark ($\text{MB}_{\text{comp}}$) and area-specific benchmarks ($\text{MB}_{\text{video}}$, $\text{MB}_{\text{audio}}$, etc.)

- Provide kernels ($\text{MB}_{\text{kernel}}$) for research use in environments where hand-coding is appropriate
Short-Term Goals cont.

Provide multiple data sets for evaluation and comparison

- enable architecture evaluation across wide variety of inputs
- enable comparison of different benchmarks using same inputs
- accurately compare effect of input parameters (e.g. frame size, bit rate, etc.) on specific architectures

Provide complete source packages that have no graphical input/output

Study run-time characteristics to identify appropriate simulation environment
Long-Term Goals

- Provide applications both with and without subword parallelism (SWP)
  - enables evaluation of benefit of SWP for each application
  - requires simulators, and potentially compilers, to support intrinsics

- Parallel versions of applications for multi-processor research
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Implementation
Adding, Dropping, Updating Applications…

Adding new benchmark areas:
- Analysis/Synthesis
- Kernels

Many new applications
- MPEG-4, JPEG2000, H.264, 3G/Turbo Coding, AES, G.723.1, G.729A/B

Dropping some applications
- Pegwit, Epic, Rasta, ADPCM

Update remaining applications to latest release
- JPEG, MPEG-2, Ghostscript, Mesa (w/ new demos), GSM, G.7xx
<table>
<thead>
<tr>
<th>MB_{video}</th>
<th>MB_{image}</th>
<th>MB_{audio}</th>
<th>MB_{speech}</th>
</tr>
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<tbody>
<tr>
<td>MPEG-4</td>
<td>JPEG-2000</td>
<td>MP3</td>
<td>GSM</td>
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<tr>
<td>H.26L</td>
<td>JPEG</td>
<td>MPEG-2/4 AAC</td>
<td>G.7xx</td>
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<tr>
<td>H.263</td>
<td>TIFF/GIF?</td>
<td>Dolby DTS</td>
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<table>
<thead>
<tr>
<th>MB_{security}</th>
<th>MB_{graphics}</th>
<th>MB_{analysis}</th>
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<tbody>
<tr>
<td>PGP</td>
<td>Rendering</td>
<td>Segmentation</td>
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<td>AES</td>
<td>Lighting</td>
<td>Feature</td>
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<td>Perspective</td>
<td>extraction</td>
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<td>generation</td>
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<td>Character recog.</td>
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<table>
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<th>MB_{comp}</th>
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<tr>
<td>contains 1-2 key applications from each area-benchmark</td>
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Kernels

- Enable evaluation of kernel performance
- Enable comparison of MB w/ all other benchmark standards, both application- and kernel-based

Kernels:
- FFT/DCT
- FIR/IIR
- Motion Estimation
- Wavelet Transformation
- 2D Convolution
- Optical Flow
- etc.
Analysis (MB\textsubscript{analysis})

Provide area indicative of evolving content-based multimedia applications, such as content-based image retrieval (CBIR)

- use full applications where possible
- otherwise use key components (e.g. segmentation)

Applications:
- segmentation
- feature extraction
- computer vision
- character recognition
Utilize Multiple *MB* Benchmark Characteristics to Model Products

🌟 Wireless video phone
- Low bit-rate video codec
- Audio codec
- Network stack \textit{(from CommBench or NetBench)}
- Cryptography

🌟 Real-time 3D video game
- 3D rendering, lighting, and perspective generation
- Audio codec
- Network for multiplayer \textit{(from CommBench or NetBench)}
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Application Details
New to MB\textsubscript{image}

\textbf{JPEG-2000}

\begin{itemize}
  \item Superior low bit-rate performance
    \begin{itemize}
      \item blurring/ringing compression artifacts vs. blocking artifacts
    \end{itemize}
  \item Progressive transmission by pixel accuracy and resolution
  \item Region-of-Interest (ROI) Coding
  \item Lossless and lossy compression
  \item Random codestream access and processing
  \item Robustness to bit errors (error resilience)
  \item Open architecture
  \item Optional image security (watermarking, labeling, stamping)
\end{itemize}
New to MB\textsubscript{video}

\textbullet\hspace{1em} \textbf{MPEG-4 (DivX Codec)}
- Content-based video compression
- Content-based compression enables better inter-frame redundancy elimination, since there is generally little intra-object change from frame to frame
- Multiple levels in standard; later levels still under development

\textbullet\hspace{1em} \textbf{H.264 Codec}
- Very-low bit rate video codec (successor to H.263)
- Utilizes a 4x4 integer (DCT-like) transform instead of the 8x8 DCT, with content-based arithmetic encoding
- Intra-frame predictive coding
New to MB_{audio}

- MPEG-1 Layer 3 (MP3)
- MPEG-2/4 Advanced Audio Coding (AAC)
- Dolby AC-3
- Dolby DTS
Analysis Benchmarks (MB\textsubscript{analysis})

**Segmentation:**
- Edge-based segmentation
- Cluster-based segmentation
- Threshold-based segmentation
- Hierarchical segmentation

**Feature extraction:**
- Color histograms
- Wavelet transformations
  - Texture and orientation
  - Gabor transform considered best wavelet for feature extraction
- Shape coding
  - Various alternatives available (w/ widely varying complexities)
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Preliminary Results – $\frac{MB_{\text{image}}}{MB_{\text{video}}}$
Basic Block Sizes
Data Types
Average Number of Loop Iterations

The diagram shows the average number of iterations per loop for various benchmarks. The benchmarks include h263dec, h264dec, jpegdec, jpegenc, jpg2kdec, jpg2kenc, mpeg2dec, mpeg2enc, mpeg4dec, and mpeg4enc. The average values are also provided for decode and encode operations. The graph indicates that the average number of iterations varies significantly across different benchmarks, with some showing much higher iteration counts than others.
Instructions per Cycle

- 8-issue VLIW
- 8-issue in-order superscalar
- 8-issue out-of-order superscalar

Applications:
- h263dec
- h263enc
- h264dec
- h264enc
- jpegdec
- jpegenc
- jpeg2kdec
- jpeg2kenc
- mpeg2dec
- mpeg2enc
- mpeg4dec
- mpeg4enc
- average
- decode
- encode

Instructions per Cycle (IPC)
Status

Many new applications now supported under SimpleScalar and Simpact:

- Audio, video, and image benchmarks are complete

Have not selected/found source for all applications yet

- Speech, Analysis, Kernel, and Security benchmarks
- New versions of: Mesa/OpenGL demos

Website will come up this semester

Your Input...

🌟 We are anxious to hear your input, and hope for your involvement