Hardware/Software Interactions on the Mpact Media Processor

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Overview

- Reason for media processors
- Mpact Media Processor implementation
  - Hardware/Software architecture
- Examples of HW/SW interaction

Media Processors

- Provide high performance and quality for multimedia
- Permit flexibility for new or better multimedia algorithms
- Use silicon efficiently
- Achieve this through a combination of hardware and software architectures

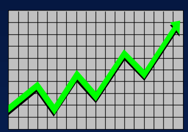
MPACT

Mpact:
7 Multimedia Functions

1. Video

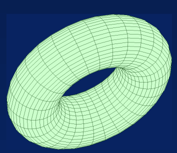
- •MPEG-1 real-time encode
- •MPEG-1 decode (full screen, 30 fps)
- •MPEG-2 decode (full screen, 30 fps)

2. 2D Graphics



- •Windows GUI acceleration
- •1280 x 1024 x TrueColor, 75Hz
- •VGA

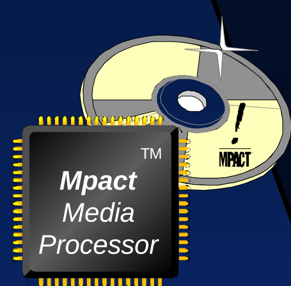
3. 3D Graphics



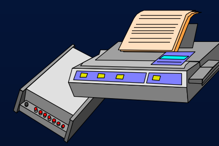
- •Windows 95 Direct3D
- •Texture mapping
- •Perspective correction

4. Audio

- •MPEG audio
- •Dolby AC-3 audio
- •Wavetable synthesis
- •Waveguide synthesis
- •3D sound and effects
- •General MIDI
- •FM synthesis
- •Sound card compatibility

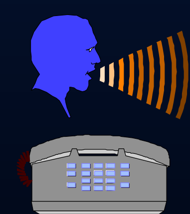


5. FAX/Modem



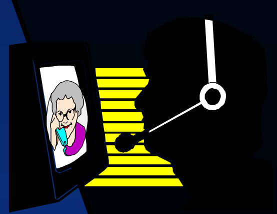
- •33,600 baud (V.34 *bis*)
- •DSVD

6. Telephony



- •Speakerphone
- •Caller ID
- •Voicemail

7. Videoconferencing



- •H.320 (ISDN)
- •H.324 (POTS)
- •H.323 (Internet/LAN)

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Value of Programmable MeP

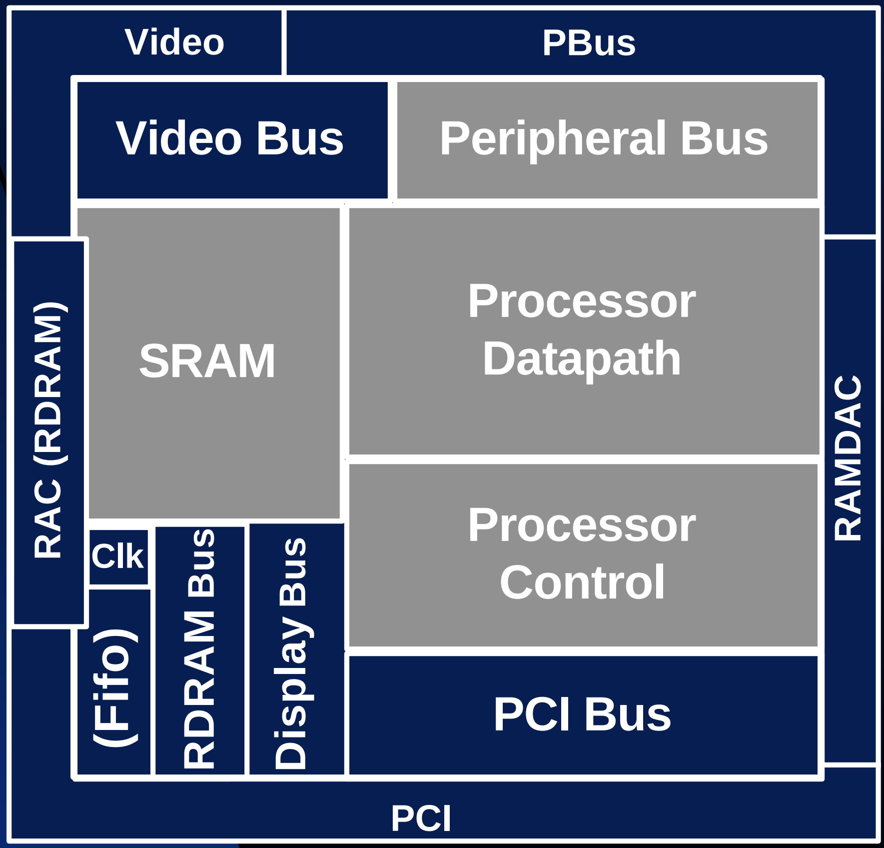
- Proliferation of MM functions makes dedicated HW unreasonable
  - Gate count not cost effective
  - Intractable design and verification
  - Not all MM functions used simultaneously
    - Must re-use hardware
- Support new MM standards without new Si
- Faster time to market
  - Parallelize HW and SW efforts

Media/Host Processor

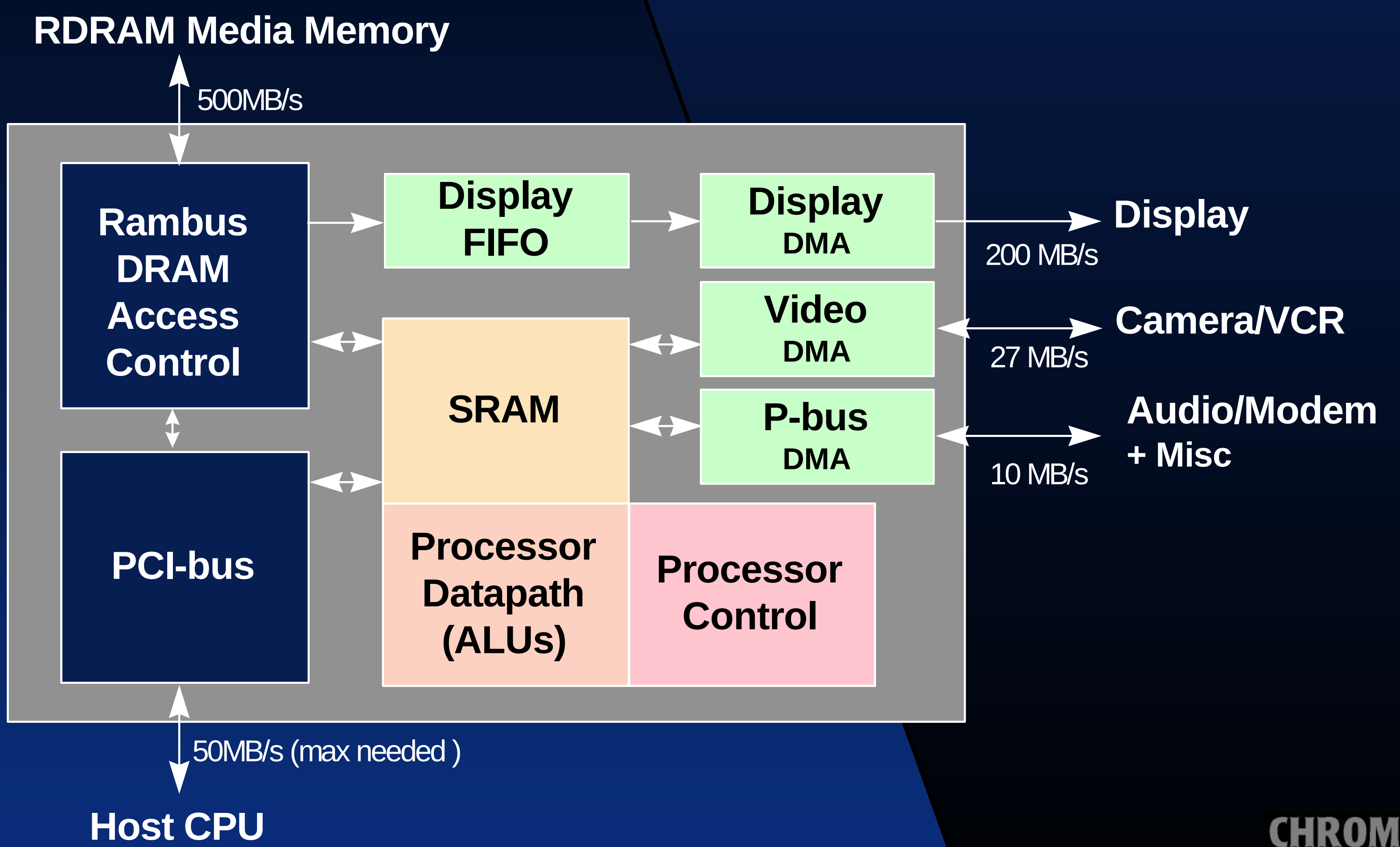
- Real-time OS required
  - Most popular host OS's not real-time
- Microprocessor cost/gate very high
- Host processor arch tuned for general purpose computing
  - MM functions frequently not seamlessly integrated
  - Caches useless for streaming media data
  - VM not required for multimedia processing
  - Floating point use very limited in multimedia

Programmable/Hardwired

- Mpact mostly programmable
  - Programmable
    - Media algorithms
    - Emulation of legacy HW
      - Sound card, VGA, COM ports
    - Codec control engine
  - Hardwired
    - Bus interfaces
    - Display refresh
    - RDRAM memory controller



Mpact System



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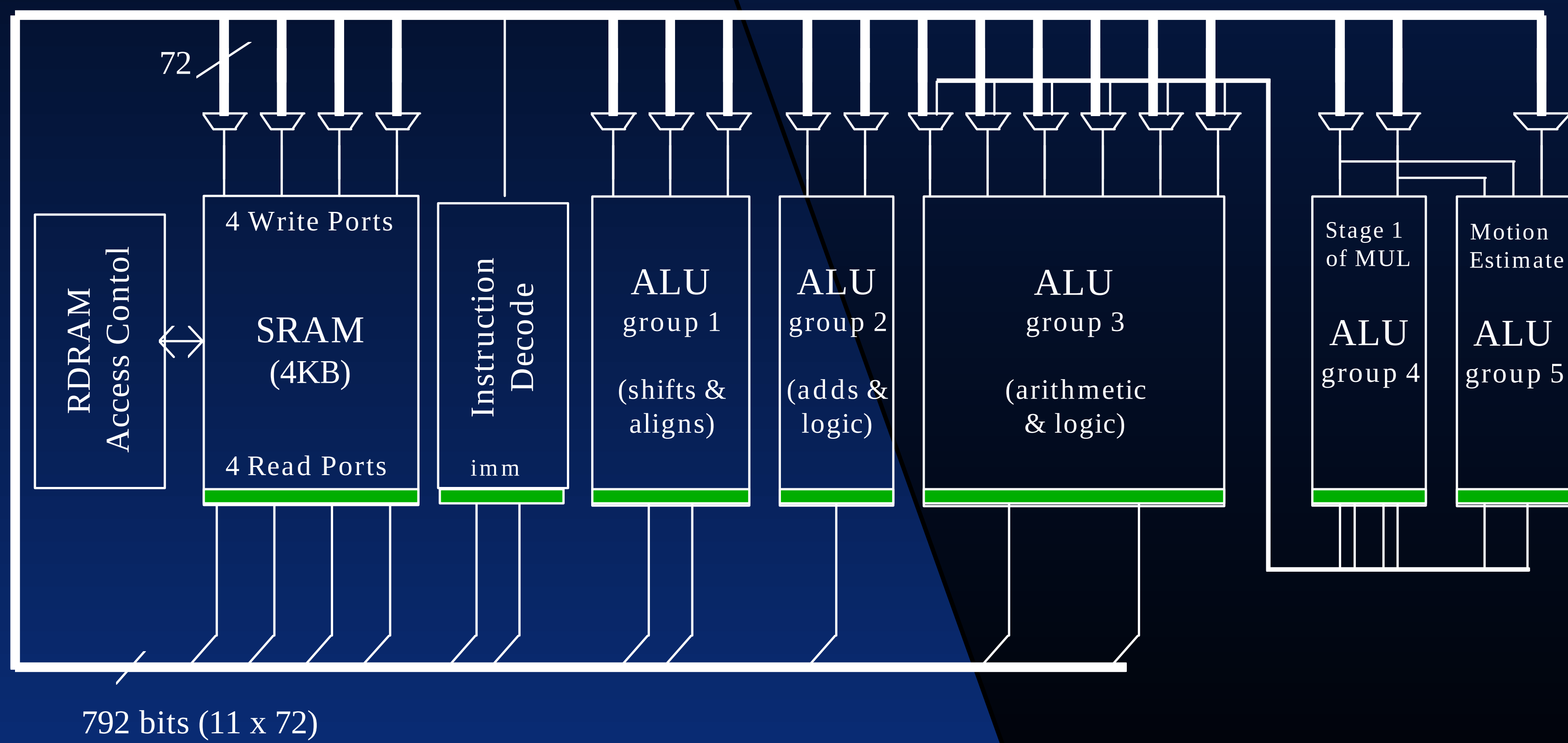
Mpact Processor Data Path



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Processor Arch. Tradeoffs

- No data cache needed
  - Poor locality of reference for streaming data
- Large multiport register file (512 x 72)
  - Hide/amortize memory access
  - 4R/4W ports needed for VLIW ISA
- High memory bandwidth (RDRAM)
  - Good for streaming data
  - Display refresh from same memory
  - Low pin count

Processor Arch. Tradeoffs

- Huge data crossbar (11 GB/s)
- Result bypassing & forwarding
- Clock cycle limited by SRAM & DP paths
  - Reg file (SRAM) BW in excess of 4 GB/s
  - Higher clock rate achievable in technology
  - But, performance declines with DP pipelining

Mpact Processor Architecture

- Fixed dual-issue instruction dispatch
- Fixed-length instruction pairs
  – Concurrent or sequential execution
- VLIW-style DP controls
  – Single instructions control multiple ALUs
- Mem ops are ld/st variants with masking
  – Can ld/st 1-32 DWORDs per ld/st
- Explicit forwarding
  – ALU result registers architecturally visible

Mpact ISA

- MM data types: 9 (x8), 18 (x4), 24, 36 (x2)bits
- Flow control
  - Vector instructions
    - Vector length 0 to 255
  - Zero-overhead loops
    - Hardware loop count with no branch overhead
  - Traditional branches, jumps, calls

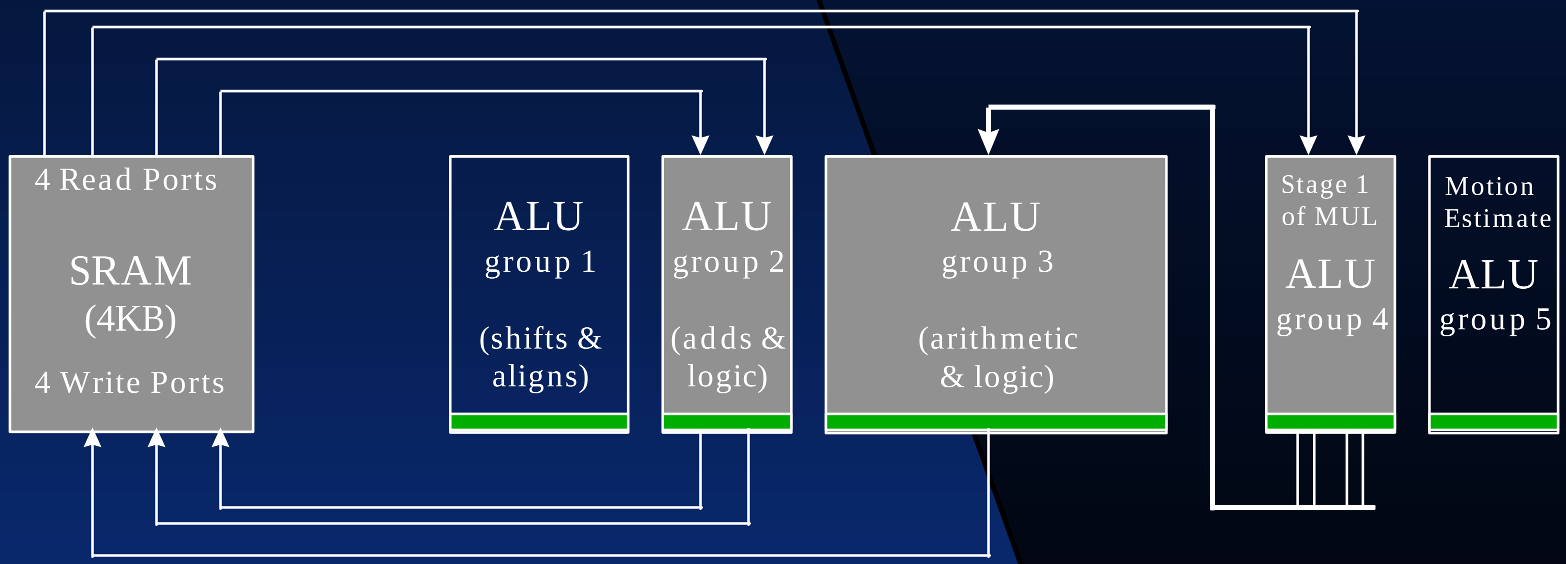
Mpact ISA

- Operators
  - Rich set of shift/swap/mask instructions
  - Special purpose ops
    - Motion Estimation
    - IDCT (Inverse DCT - for video decompression)
    - BFY (butterfly - for FFT)
    - SHAQ (SHift & Align Quad - for GUI accel.)
    - ROP2, ROP3 (Raster-ops - for GUI accel.)
  - Variety of integer arithmetic ops
    - add, sub, cmp, mul, mac, etc.

Mpact ISA example

vector1 [mac.b %0, %32 ||| bfy.b %64, %128]

- **vector multiply-accumulate & sum/diff of registers**



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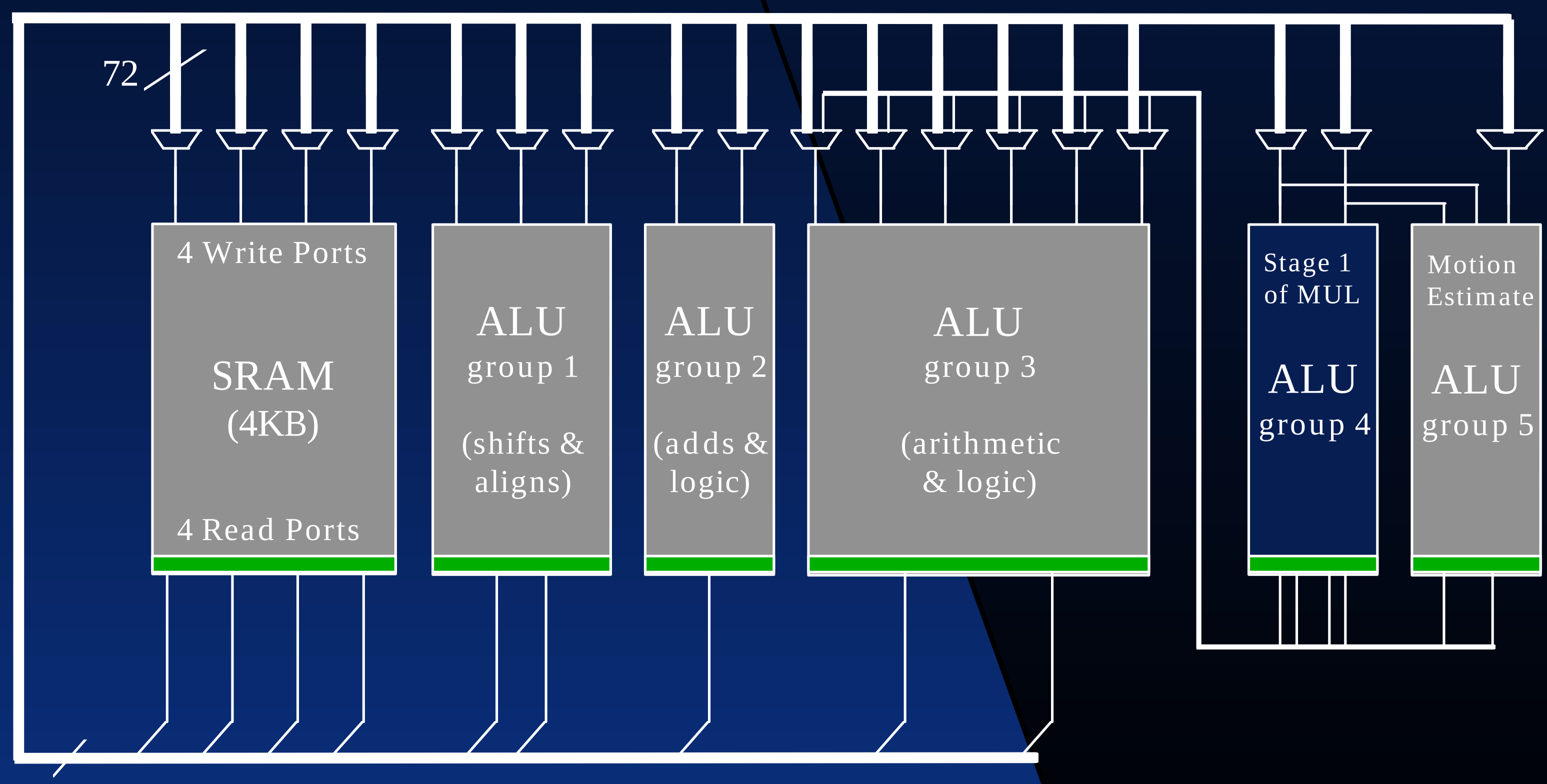
Mpact ISA example

[bsh.b @, @p0++,@p1++ ||| me.b @.1, ageF,%64]
- fragment of inner loop of video motion estimation



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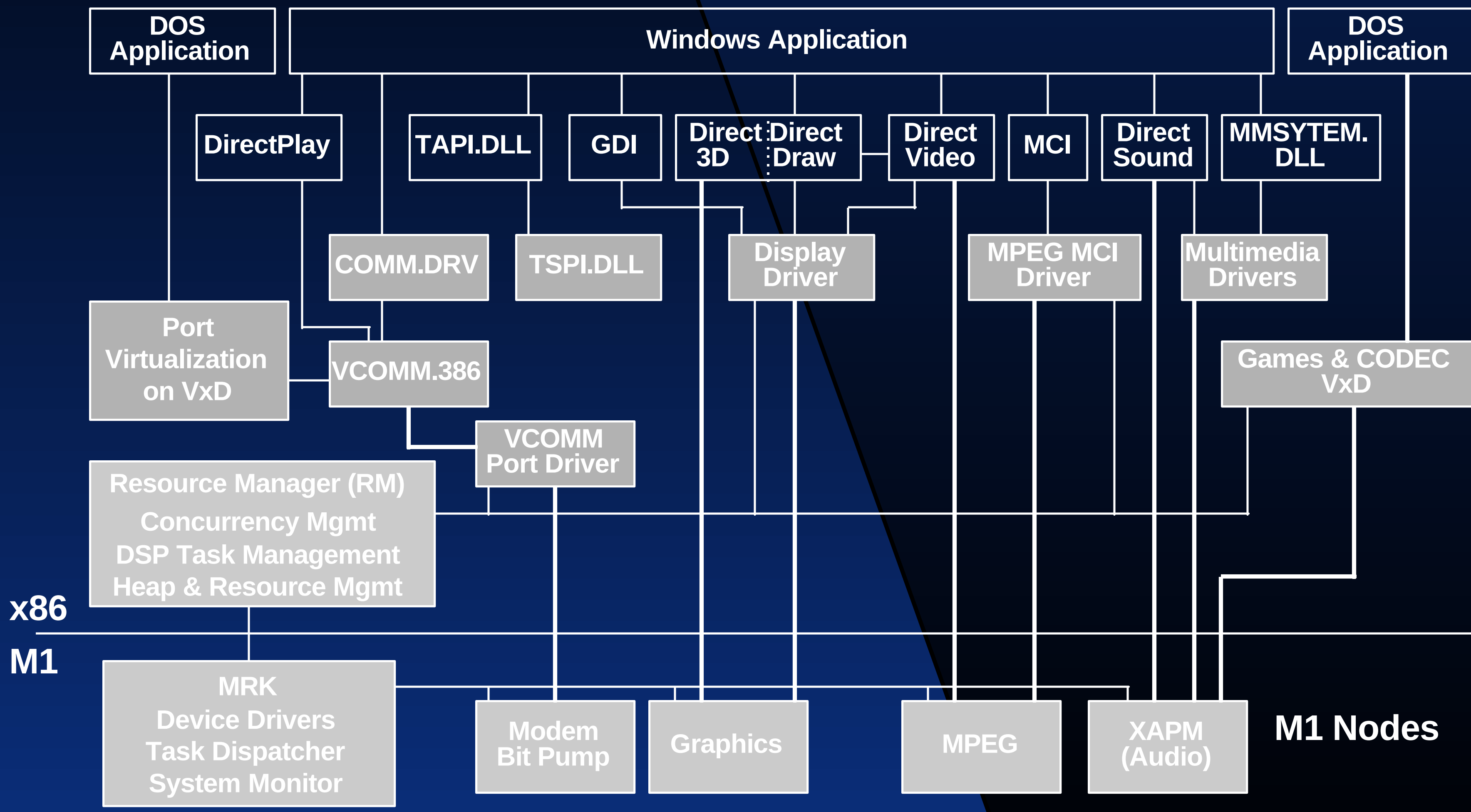
Software use of Hardware Resources

- Multimedia software split between x86 and Mpact-1
- Host/Mpact decision made on efficiency basis
  - API architectures force certain structures
    - E.g, GDI primarily unidirectional
  - Performance issues drive other structures
    - E.g, MPEG video/audio streams split by x86

Mediaware Architecture



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Mediaware Architecture

- RM/MRK Partitioning
  - Resource Manger (RM) - Host side - non-real-time
  - Mpact Real-time Kernel (MRK)- Mpact - real-time
- MRK Architecture
  - Real-time, nearest deadline scheduling
  - Pre-emptive scheduling multitasking
  - Interrupt driven
    - Host interrupts do not block Mpact processes, merely post event and exit

Mpact Real Time Kernel

- Critical requirement for quality delivery of concurrent multimedia
  - Providing immunity from system latencies and interupt demands
    - Memory latency
    - PCI bus latency
    - Other arbitration latencies
  - Maintaining audio/video synchronization
  - No corrupted audio! (human ear too sensitive)
    - 3D audio has very tight synchronization and latency requirements

Mediaware Architecture

- Primary RM/MRK IPC mechanisms
  - RDRAM data structures & queues
  - Hardware semaphores
  - Hardware queues for legacy emulation

Performance: GDI Acceleration

- Architecture
  - GDI command/data queue in RDRAM
    - GDI writes “undigested” DDI commands directly to queue
    - Allows immediate return from GDI calls
    - Mpact processes queue in order
  - Queued/non-queued request synchronization
    - Host memory MUTEX
    - Acquire MUTEX, write to queue, release MUTEX

GDI Acceleration cont'd

- Performance
  - RDRAM queue never fills running Winbench
  - Winbench performance limited by application/GDI production rate

Flexibility: Dolby AC-3

- Media processor programmability allows easy adoption of new algorithms
- Mpact-1 supports full DVD decode
  - MPEG2 video
  - Dolby AC-3 audio
- Algorithm specifications not complete at Mpact-1 tape-out
- Easily implemented in SW when defined

Conclusions

- Media processor advantages
  - Achieve high performance with a programmable architecture
  - Are flexible platforms for new multimedia algorithms
  - Provides real-time behavior which is inescapable for audio, modem, etc.
  - Have dramatically lower silicon area compared to equivalent hard-wired solutions