Trade-off Considerations and Performance of Intel's MMX™ Technology

Uri Weiser
Intel Corporation
Israel Design Center

August 20, 1996

intel®

Agenda

- The Opportunity
- Definition Consideration
- MMX™ Technology
- Performance/Example
- Conclusions

The Opportunity

- Emergence of new applications
  - Multimedia
  - Communication
- The need for performance
- Utilization of existing hardware
  - Datapath
  - Registers
  - Internal buses

intel®

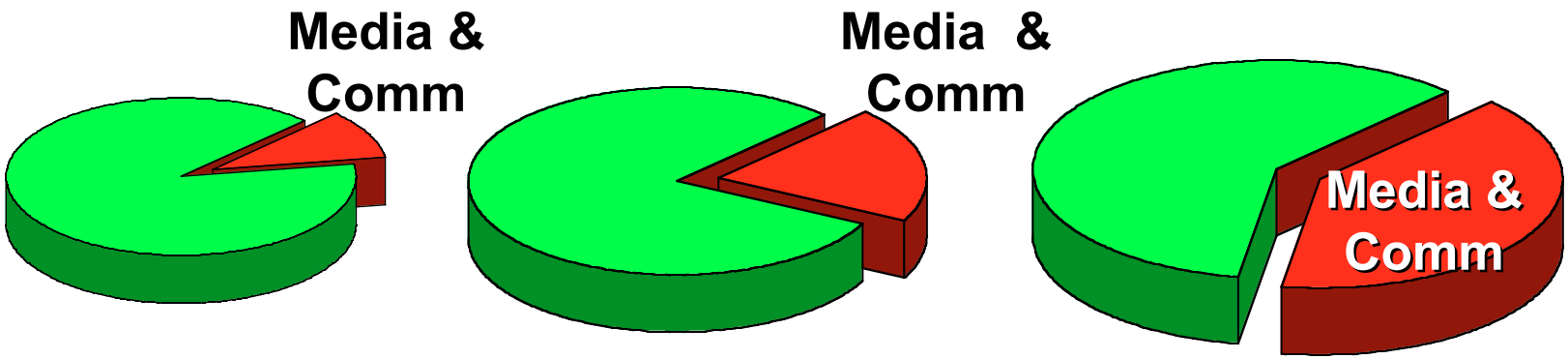
Evolution of the PC

- *The trend*: Multimedia and communications applications are driving the market
  - Video & audio compression (DVD, MPEG2, AC3), games (3D graphics), speech recognition, voice compression, image processing, video conferencing (POTS and LAN)

The Home PC
- Same as office

The Multimedia PC
- Audio
- CD-ROM
- Graphics accelerator
- Modem

Next ?



intel

Characteristics of Multimedia and Communication Apps/Algorithms

- Multimedia and communication applications built from basic algorithms “glued” together
- Large degree of commonality across the diverse algorithms
  - Computation intensive
  - Data streaming
  - Small data types
  - Potential data parallelism

Definition Consideration

- Full compatibility with existing Intel architecture software model
- Significant performance benefit
- General and flexible/not specific
- Minimal die size impact and design complexity

intel®

Compatibility

Requirements:

- Map into existing Intel Architecture
  - No new machine state
  - No new events
  - Availability of unused Op Code space

Approach:

- Use of FP registers structure (80/64 bit vs. 32 bit integer registers)
- No new exceptions
- Alias of FP OS handling mechanisms

Generality/Extensibility

- Define Atomic operations
  - Arithmetic ➡ add, sub, shift, mul, compare
  - Logic ➡ and, andnot, or, xor
  - Conversion
  - Exception: Muladd
- Straight forward migration into Intel's future processors

Intel's MMX™ Technology

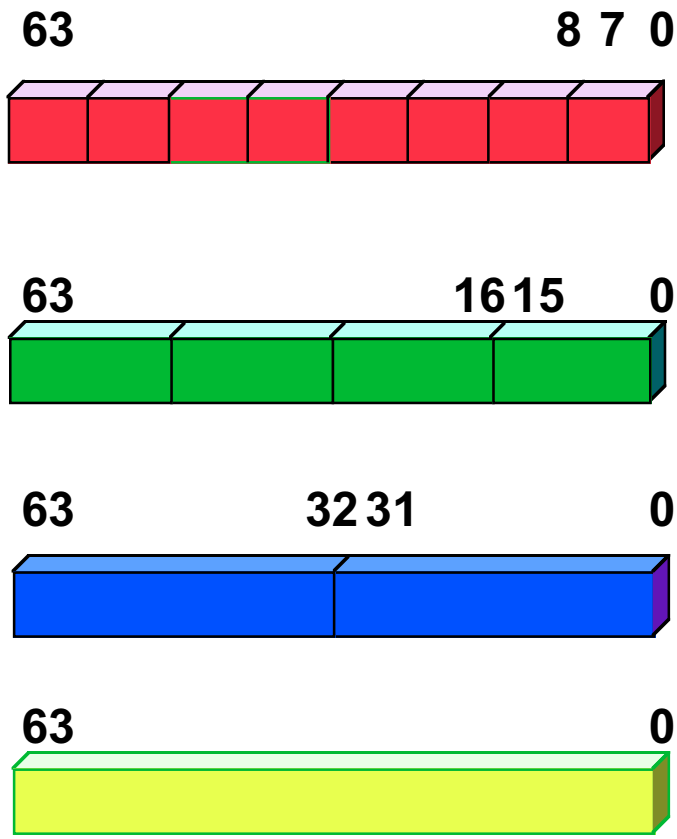
- 57 new Instructions
  - Single Instruction Multiple Data Architecture technique (SIMD)
  - Fixed point integer
- Map into 8 FP registers/direct access
- No new exceptions
- Low implementation complexity

The Most Significant Enhancement to Intel Architecture Since the i386™ Processor

intel®

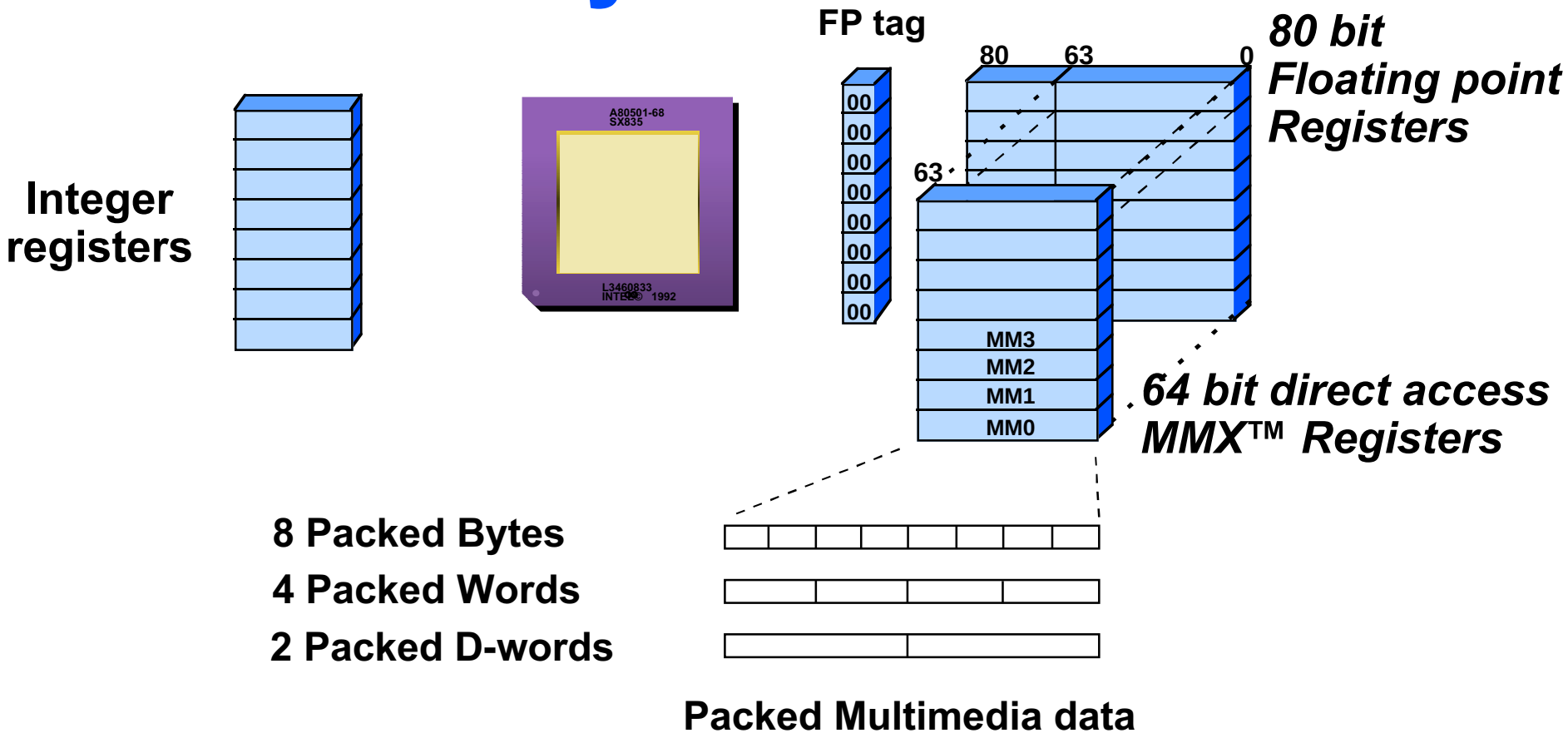
Data Types

- **Packed bytes**
  - Mainly for graphics and video
- **Packed words**
  - Used mainly for audio and comm.
- **Packed doublewords**
  - General purpose use
- **Quadword**
  - Bitwise operations and Data alignment



intel®

MMX™ Architecture Summary



intel®

A Compatible Extension Architecture

Sample MMX™ Technology Operations

Saturating Arithmetic

a3	a2	a1	FFFFh
+	+	+	+
b3	b2	b1	8000h
a3+b3	a2+b2	a1+b1	FFFFh

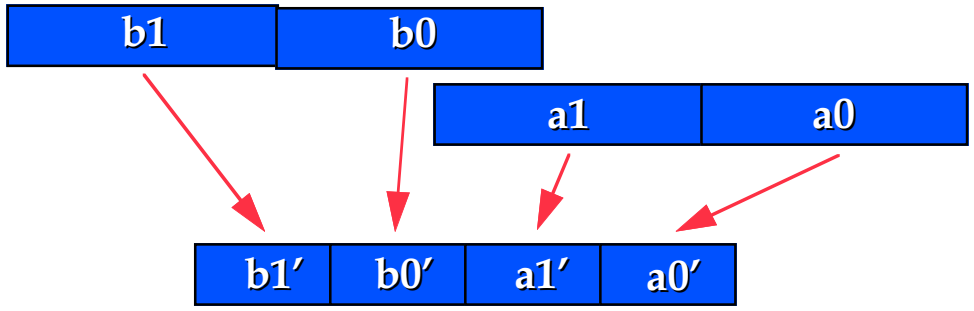
Parallel Compares

23	45	16	34
gt ?	gt ?	gt ?	gt ?
31	7	16	67
0000h	FFFFh	0000h	0000h

16b x 16b => 32b Multiply Add

a3	a2	a1	a0
*	*	*	*
b3	b2	b1	b0
a3*b3+a2*b2		a1*b1+a0*b0	

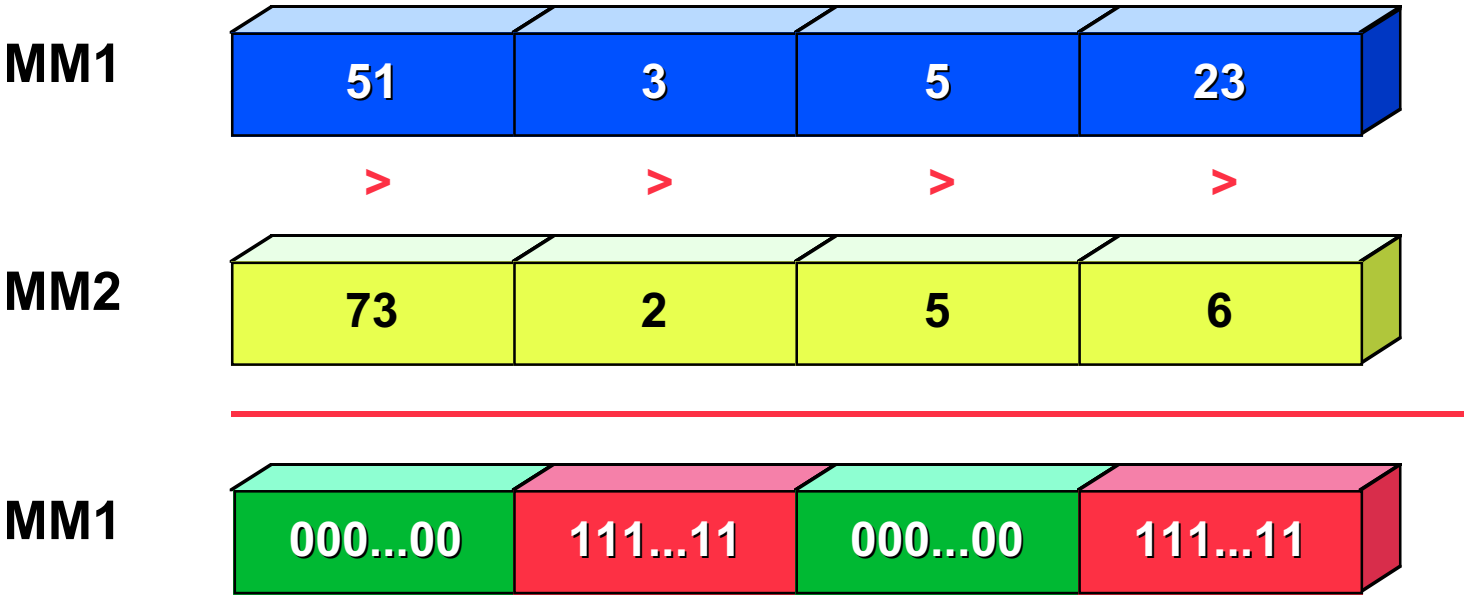
Data Conversion



intel®

What Is A Parallel Compare?

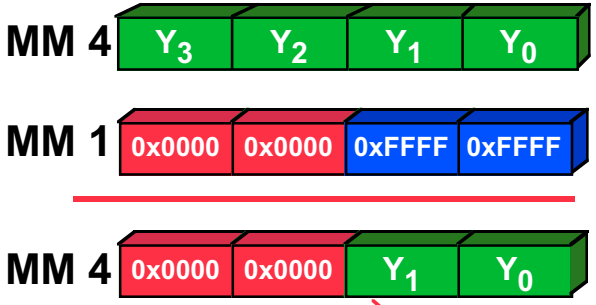
- No flags to store multiple results
- Result is a mask



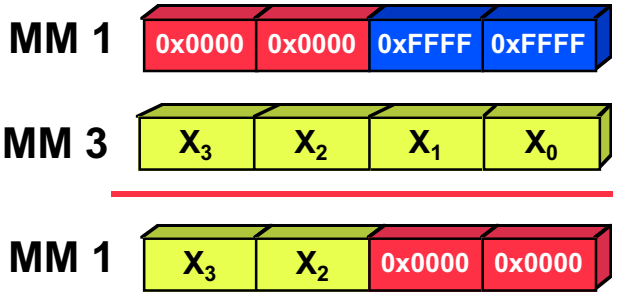
intel®

Conditional Selection

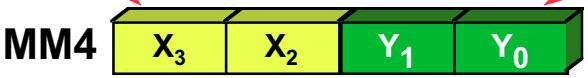
pand MM4, MM1



pandn MM1, MM3



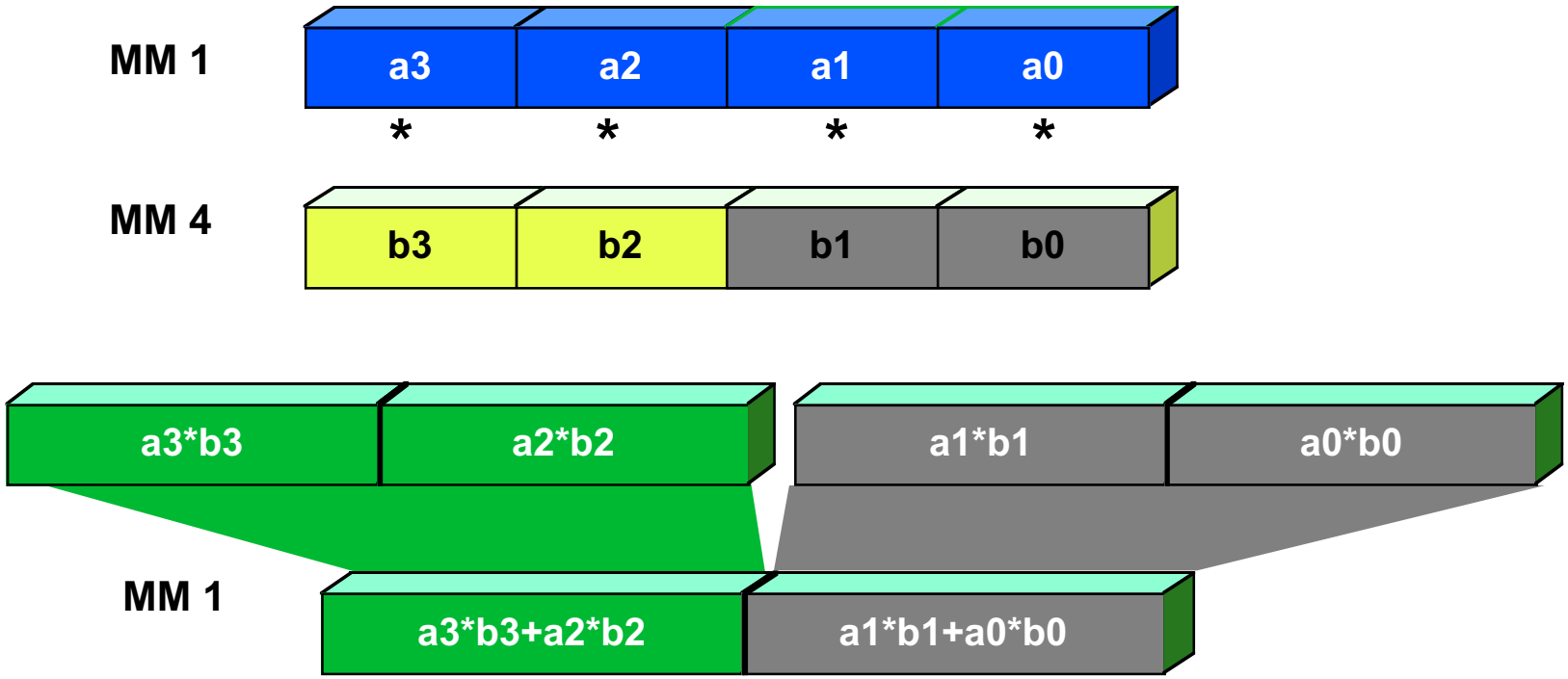
por MM4, MM1



PMADD

```
pmaddwd        MM1, MM4
```

packed multiply and add 4 words to 2 doublewords



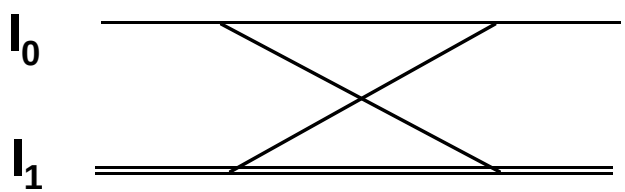
intel

MMX™ Technology Code Example

Inverse Discrete Cosine Transform (IDCT) Scalar vs. MMX™ Technology

Used in Video compression/decompression standards*

Basic Operation: A butterfly



$O_0 = I_0 + I_1$

$O_1 = I_0 - I_1$

Scalar

```
mov     eax, [edi]   /* load 1st value
mov     ebx, [edx]  /* load 2nd value
mov     eax, esi     /* Copy 1st value
sub     eax, ebx     /* O1  = I0 - I1
add     esi, ebx     /* O0 = I0 + I1
```

MMX Technology

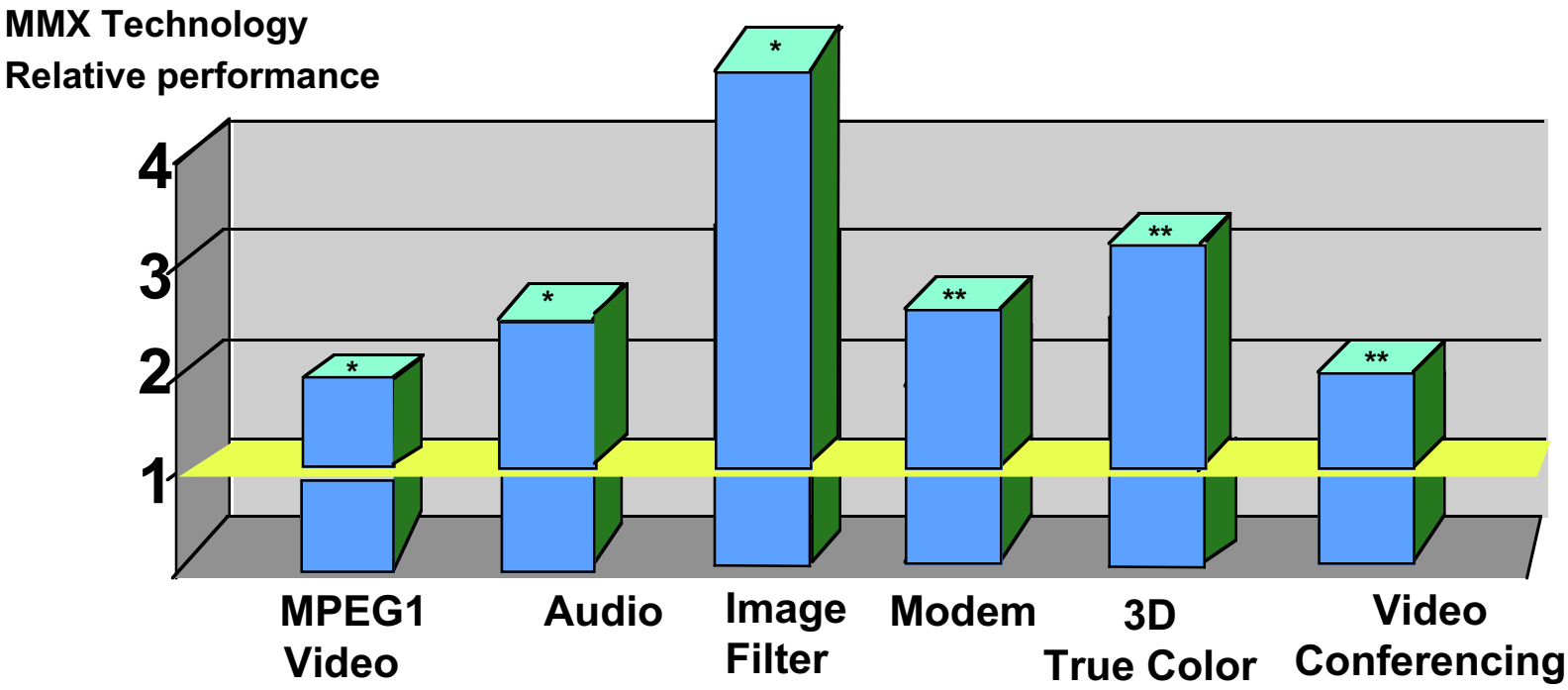
```
Movq    mm4, [edi]      /* load 1st 4 values
Movq    mm7, [edx]      /* load 2nd 4 values
Movq    %mm4,%mm0       /* Copy 1st values
Psubw   %mm7,%mm4       /* O1[0-3] = I0[0-3] -  I1[0-3]
Paddw   %mm0,%mm7       /* O0[0-3] = I0[0-3] + I1[0-3]
```

Same Operation, Same Amount of Instructions
MMX Technology 4X Faster

intel®

* LLM algorithm - Practical fast 1-D DCT - 1989 - assume data elements are 16 bits,

MMX™ Technology Performance



intel

* Measured: Components of Intel's Media Benchmark

** Estimated. Based on inner loops and algorithm analysis

Conclusions

- Implementation shows full compatibility with existing OS and applications
- Simple definition ➡ clean implementation
- Performance improvement of multimedia application 1.5- 5X

intel®