SIMD extensions

- Multimedia extension – MMX
- Streaming SIMD extensions
  - SSE, SSE2, SSE3, SSE4.1, SSE4.2
- Advanced Vector Extensions
  - AVX
- Usage:
  - Voice processing, filtering, recognition, coding
  - Video processing, filtering, recognition, coding
  - 3D graphics, CAD models
  - Security algorithms

SIMD extensions

- Identification of SIMD support

```
...
mov eax, 1
cpuid
test edx, 00800000h
jnz   mmx_found
...
```

SIMD extensions

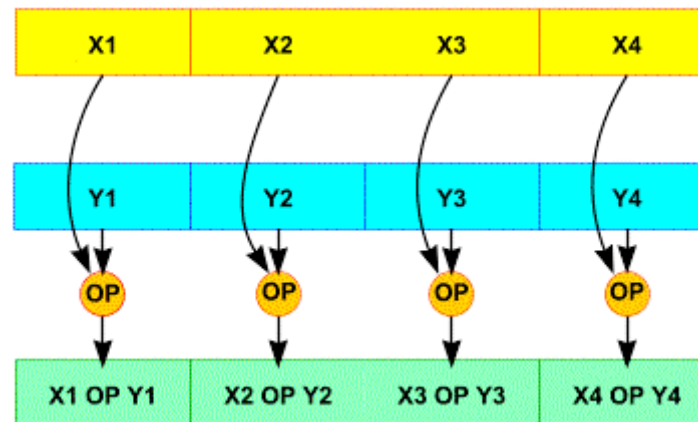- MMX and SSE registers set

64-bit MMX Registers
MM7
MM6
MM5
MM4
MM3
MM2
MM1
MM0

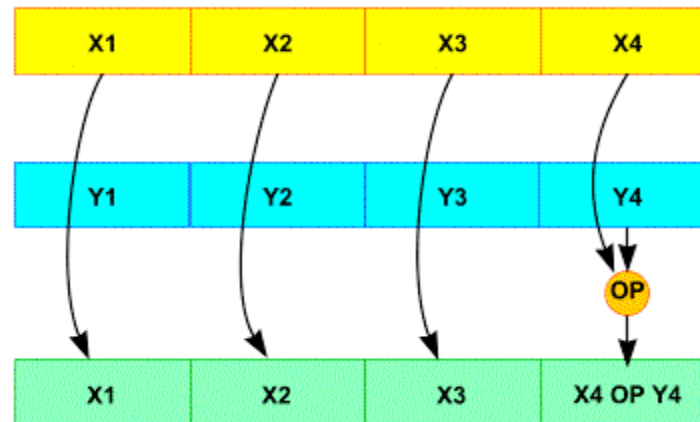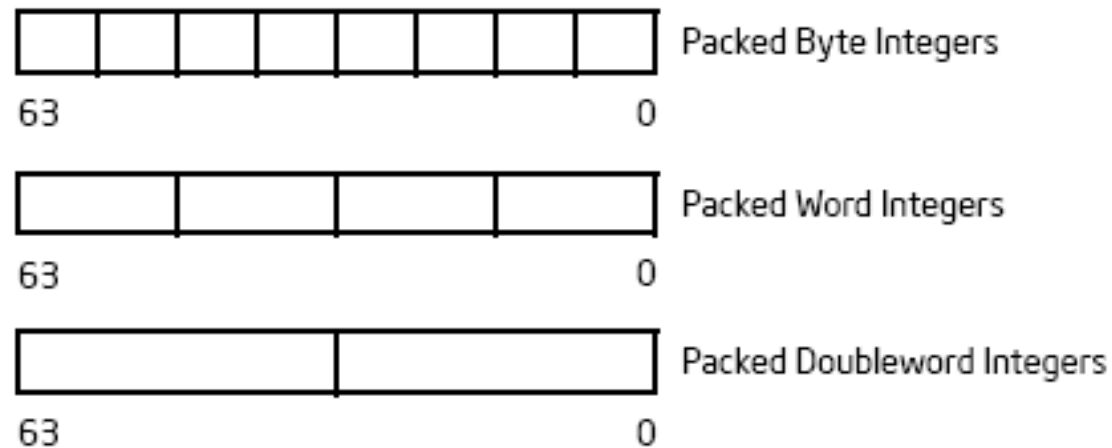| 128-bit XMM Registers |
|---|
| XMM7 |
| XMM6 |
| XMM5 |
| XMM4 |
| XMM3 |
| XMM2 |
| XMM1 |
| XMM0 |

SIMD extensions

- SIMD operations and operands
  - Packed instructions

SIMD extensions

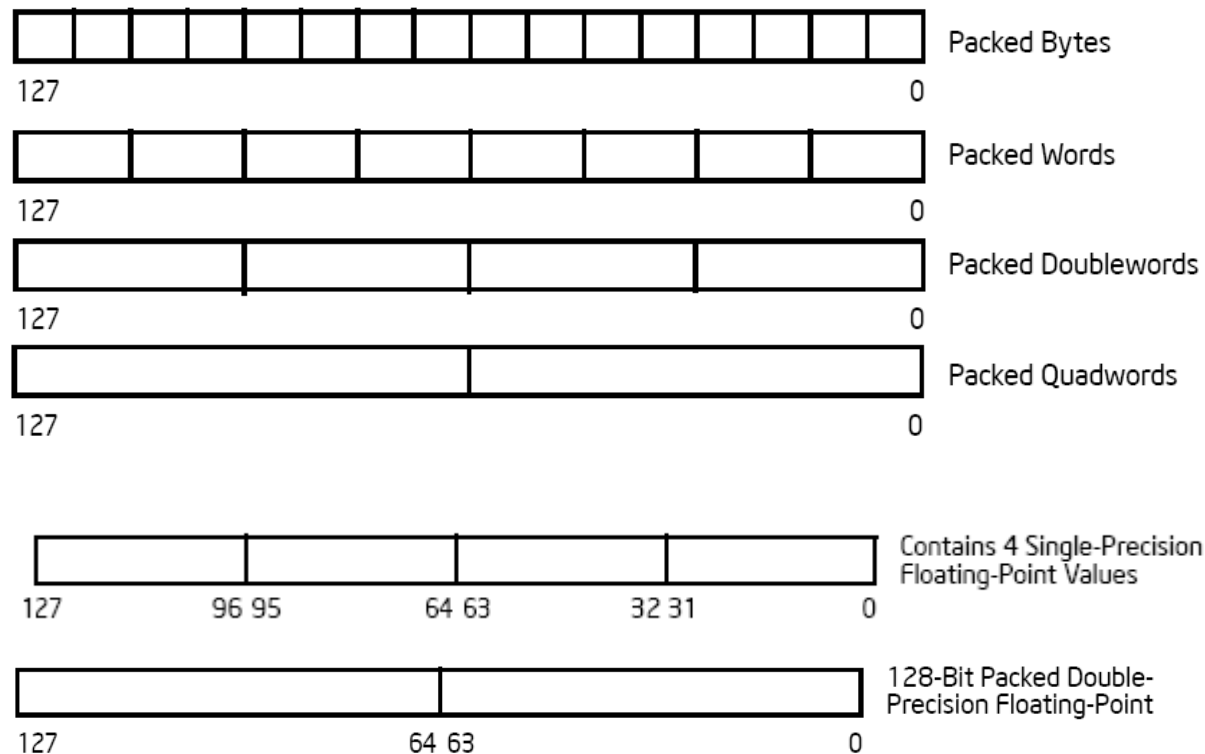- SIMD operations and operands
  - Scalar instructions

X1	X2	X3	X4

Y1	Y2	Y3	Y4

OP

X1	X2	X3	X4 OP Y4

SIMD extensions

- SIMD operations and operands (MMX)

								Packed Byte Integers
63							0	

				Packed Word Integers
63			0	

		Packed Doubleword Integers
63	0	

SIMD extensions

- SIMD operations and operands (SSE, SSE2)

Fundamental 128-Bit Packed SIMD Data Types

Packed Bytes
127   0

Packed Words
127   0

Packed Doublewords
127   0

Packed Quadwords
127   0

Contains 4 Single-Precision Floating-Point Values
127   96 95   64 63   32 31   0

128-Bit Packed Double-Precision Floating-Point
127   64 63   0

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SIMD extensions

```
int i;
for( i = 0; i < 4; i++ )
{
    c[i] = a[i] + b[i];
}


paddd xmm1, xmm2
```

_mm_add_ps(A, B)

| A3 | A2 | A1 | A0 | | B3 | B2 | B1 | B0 |

| A3+B3 | A2+B2 | A1+B1 | A0+B0 |

SIMD extensions

- Arithmetic

Category		Wraparound	Signed Saturation	Unsigned Saturation
Arithmetic	Addition	PADDB, PADDW, PADDD	PADDSB, PADDSW	PADDUSB, PADDUSW
	Subtraction	PSUBB, PSUBW, PSUBD	PSUBSB, PSUBSW	PSUBUSB, PSUBUSW
	Multiplication	PMULL, PMULH		
	Multiply and Add	PMADD		

- Comparison

Comparison	Compare for Equal	PCMPEQB, PCMPEQW, PCMPEQD		
	Compare for Greater Than	PCMPGTPB, PCMPGTPW, PCMPGTPD		

SIMD extensions

- PMADDWD

a3	a2	a1	a0
*	*	*	*

b3	b2	b1	b0

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

SIMD extensions

- Overflow handling
  - Wraparound – remove most significant bits of the result
  - Signed saturation – limit the result to min/max signed value the data type can support
  - Unsigned saturation – limit the result to min/max unsigned value the data type can support

Data Type	Lower Limit		Upper Limit	
	Hexadecimal	Decimal	Hexadecimal	Decimal
Signed Byte	80H	-128	7FH	127
Signed Word	8000H	-32,768	7FFFH	32,767
Unsigned Byte	00H	0	FFH	255
Unsigned Word	0000H	0	FFFFH	65,535

SIMD extensions

- Pack and Unpack

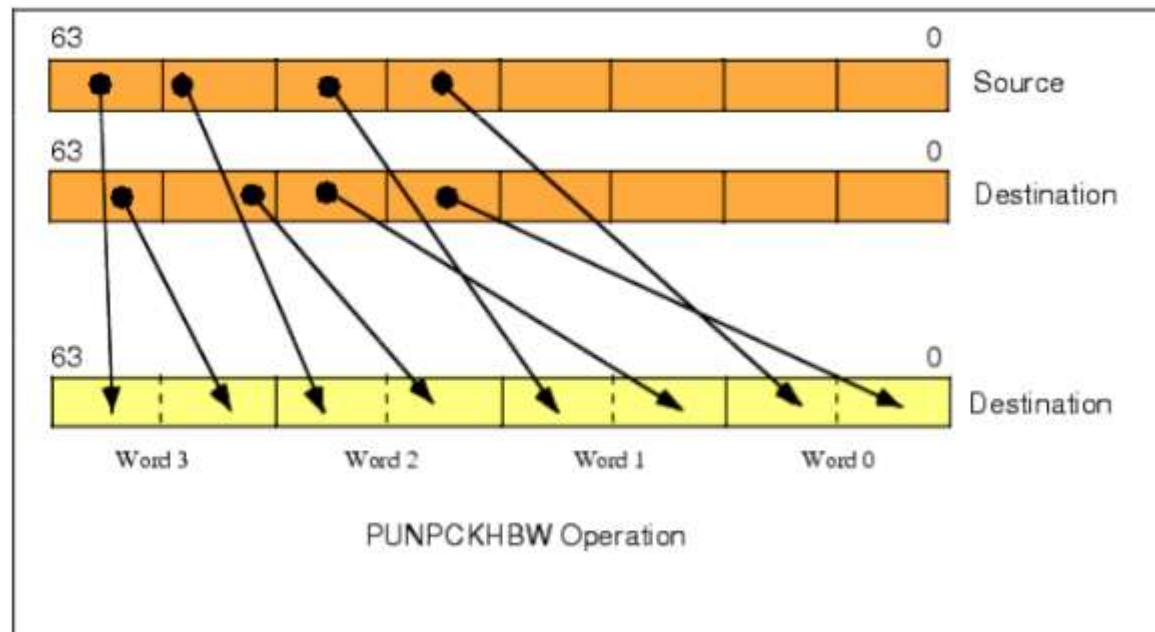| Conversion	Pack		PACKSSWB, PACKSSDW	PACKUSWB
Unpack	Unpack High	PUNPCKHBW, PUNPCKHWD, PUNPCKHDQ		
	Unpack Low	PUNPCKLBW, PUNPCKLWD, PUNPCKLDQ		
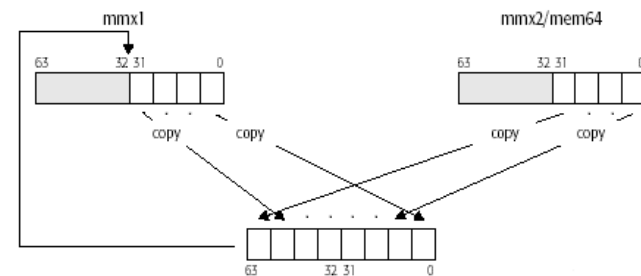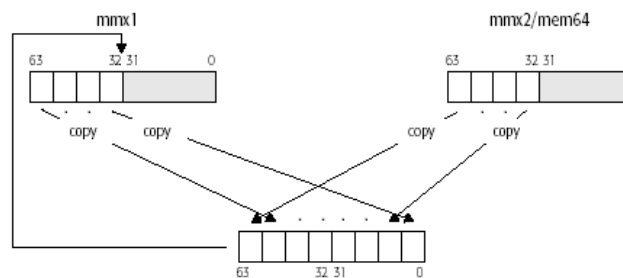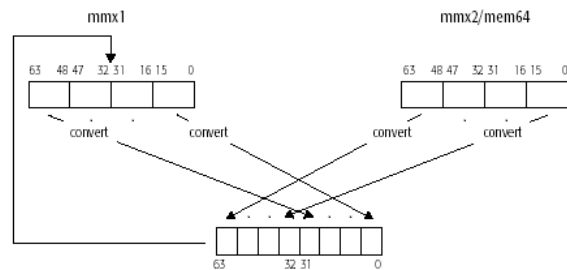
SIMD extensions

- Unpack from lower order elements
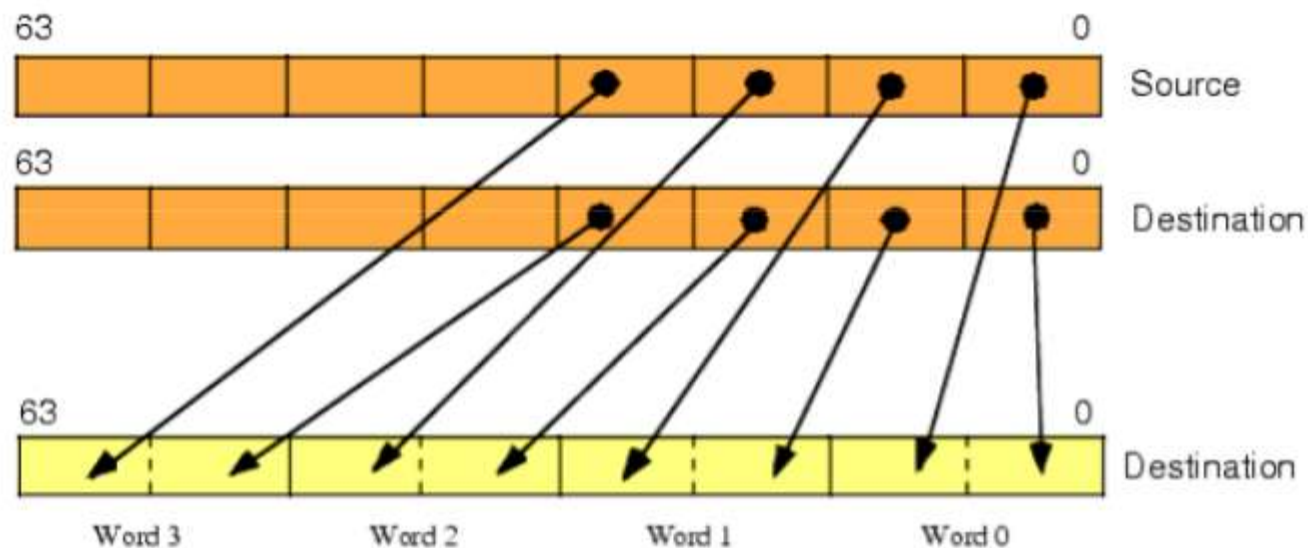
SIMD extensions

- Unpack from higher order elements

PUNPCKHBW Operation

SIMD extensions

- Shuffle
  - Requires 2 operands and 1 mask
  - Selects 2 elements from each operand (register) based on the mask.
  - Frequent usages of shufps are broadcast, swap and rotate.