Integer Registers (IA32)

`movl` Operand Combinations

	Source	Dest	Src,Dest	C Analog
`movl`	*Imm*	*Reg*	`movl $0x4,%eax`	`temp = 0x4;`
		Mem	`movl $-147,(%eax)`	`*p = -147;`
	Reg	*Reg*	`movl %eax,%edx`	`temp2 = temp1;`
		Mem	`movl %eax,(%edx)`	`*p = temp;`
	Mem	*Reg*	`movl (%eax),%edx`	`temp = *p;`

Cannot do memory-memory transfer with a single instruction

Using Simple Addressing Modes

```
void swap(int *xp, int *yp)
{
  int t0 = *xp;
  int t1 = *yp;
  *xp = t1;
  *yp = t0;
}
```

```
swap:
  pushl %ebp
  movl  %esp,%ebp
  pushl %ebx

  movl  8(%ebp), %edx
  movl  12(%ebp), %ecx
  movl  (%edx), %ebx
  movl  (%ecx), %eax
  movl  %eax, (%edx)
  movl  %ebx, (%ecx)

  popl  %ebx
  popl  %ebp
  ret
```

Set Up

Body

Finish

Using Simple Addressing Modes

```
void swap(int *xp, int *yp)
{
  int t0 = *xp;
  int t1 = *yp;
  *xp = t1;
  *yp = t0;
}
```

```
swap:
   pushl %ebp
   movl  %esp,%ebp
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   movl  8(%ebp), %edx
   movl  12(%ebp), %ecx
   movl  (%edx), %ebx
   movl  (%ecx), %eax
   movl  %eax, (%edx)
   movl  %ebx, (%ecx)

   popl  %ebx
   popl  %ebp
   ret
```

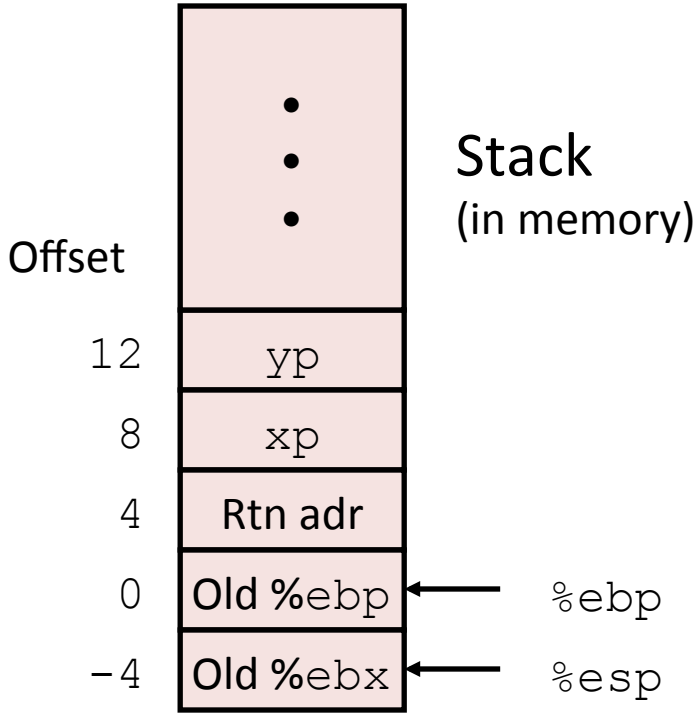
Set Up

Body

Finish

Understanding Swap

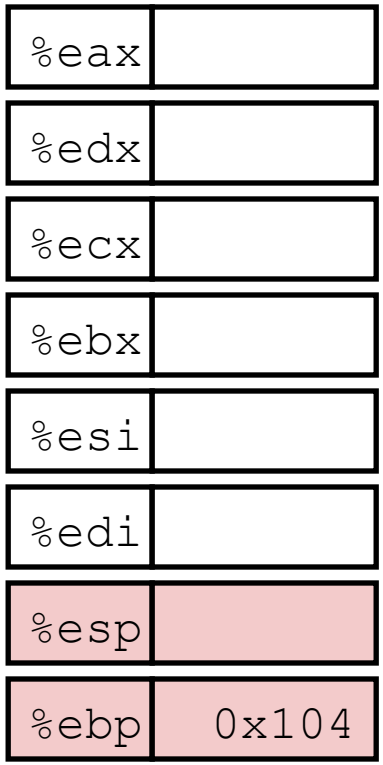
```
void swap(int *xp, int *yp)
{
  int t0 = *xp;
  int t1 = *yp;
  *xp = t1;
  *yp = t0;
}
```

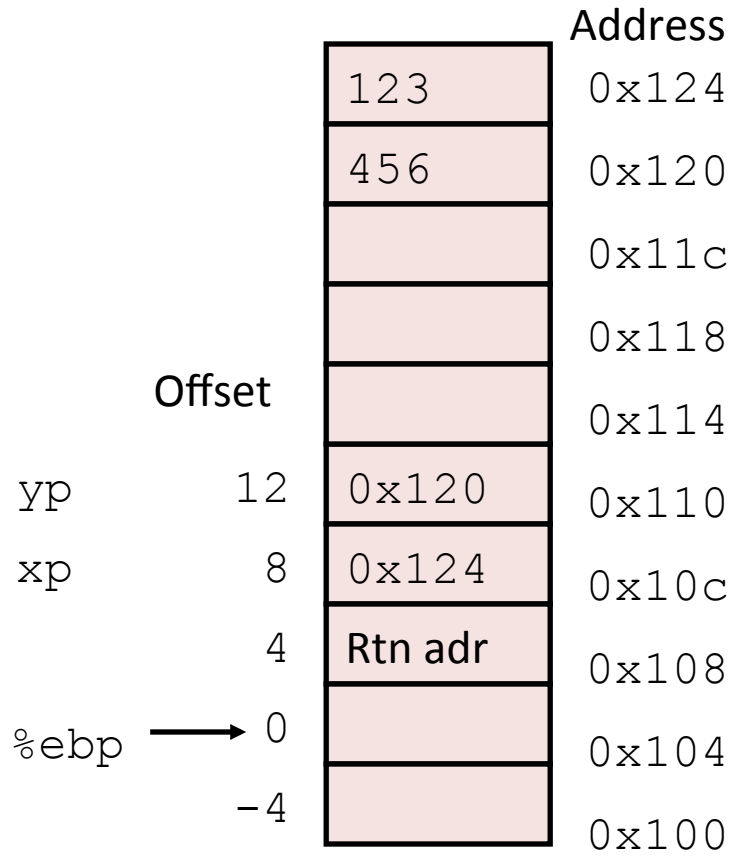


Register	Value
%edx	xp
%ecx	yp
%ebx	t0
%eax	t1

```
movl  8(%ebp), %edx    # edx = xp
movl  12(%ebp), %ecx   # ecx = yp
movl  (%edx), %ebx     # ebx = *xp (t0)
movl  (%ecx), %eax     # eax = *yp (t1)
movl  %eax, (%edx)     # *xp = t1
movl  %ebx, (%ecx)     # *yp = t0
```

Understanding Swap



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movl  (%edx), %ebx     # ebx = *xp (t0)
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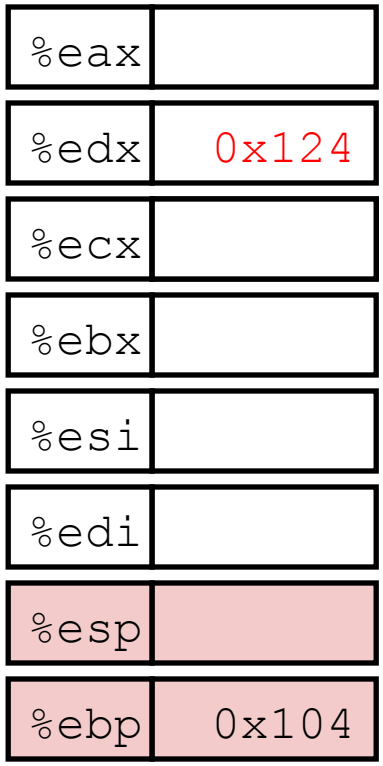
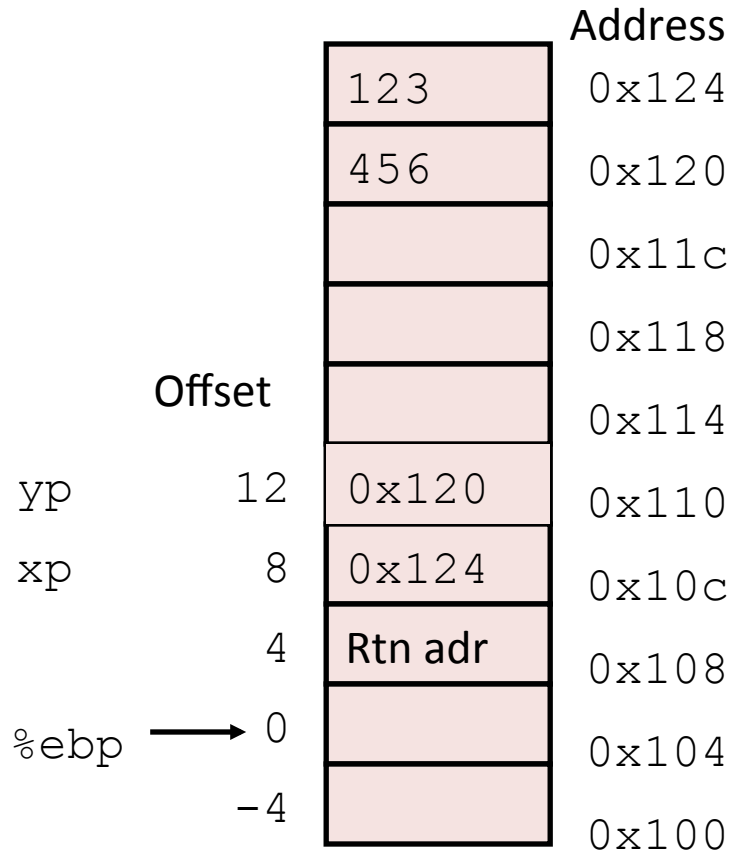
Understanding Swap



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movl   8(%ebp), %edx    # edx = xp
movl   12(%ebp), %ecx   # ecx = yp
movl   (%edx), %ebx     # ebx = *xp (t0)
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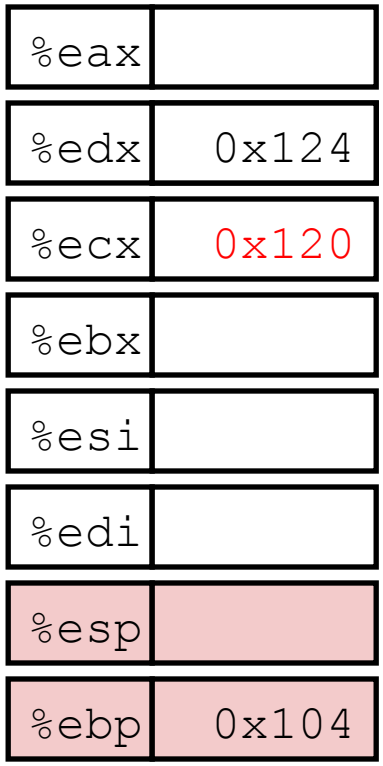
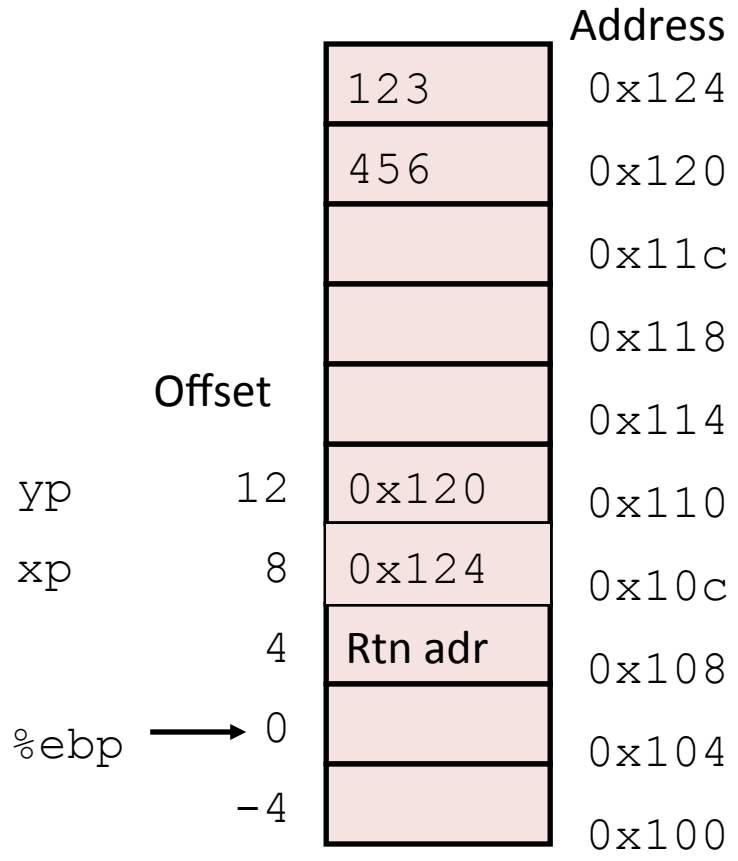
Understanding Swap



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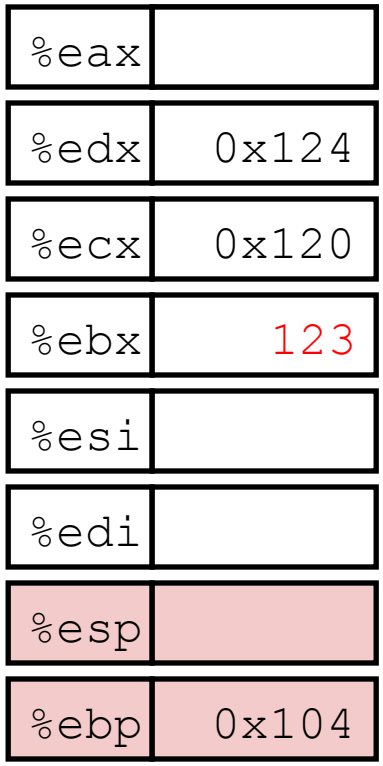
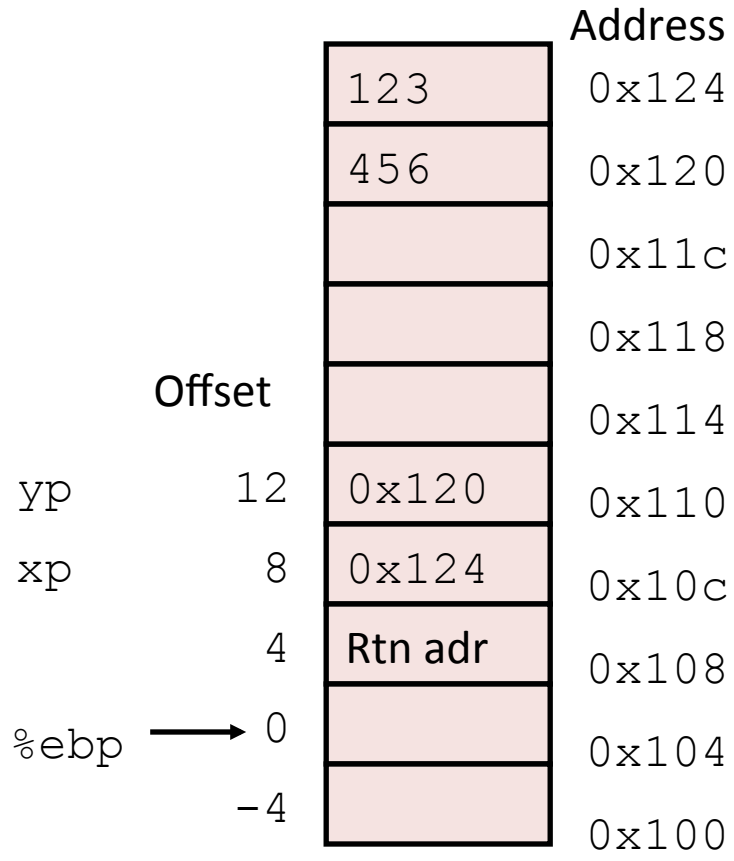
Understanding Swap



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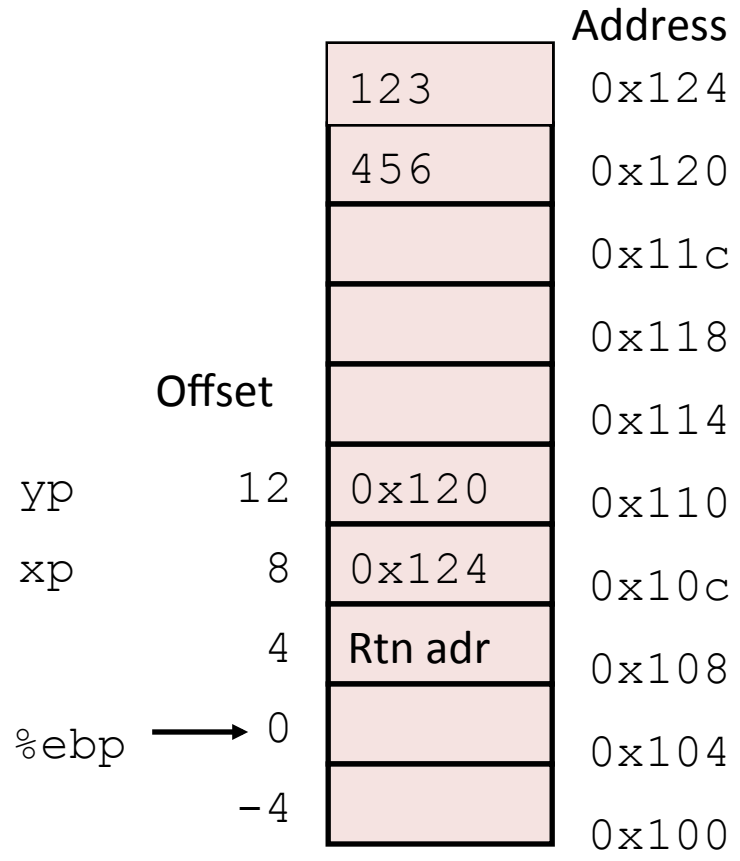
```

Understanding Swap

%eax	456
%edx	0x124
%ecx	0x120
%ebx	123
%esi	
%edi	
%esp	
%ebp	0x104




```
movl   8(%ebp), %edx     # edx = xp
movl   12(%ebp), %ecx    # ecx = yp
movl   (%edx), %ebx      # ebx = *xp (t0)
movl   (%ecx), %eax      # eax = *yp (t1)
movl   %eax, (%edx)      # *xp = t1
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Understanding Swap

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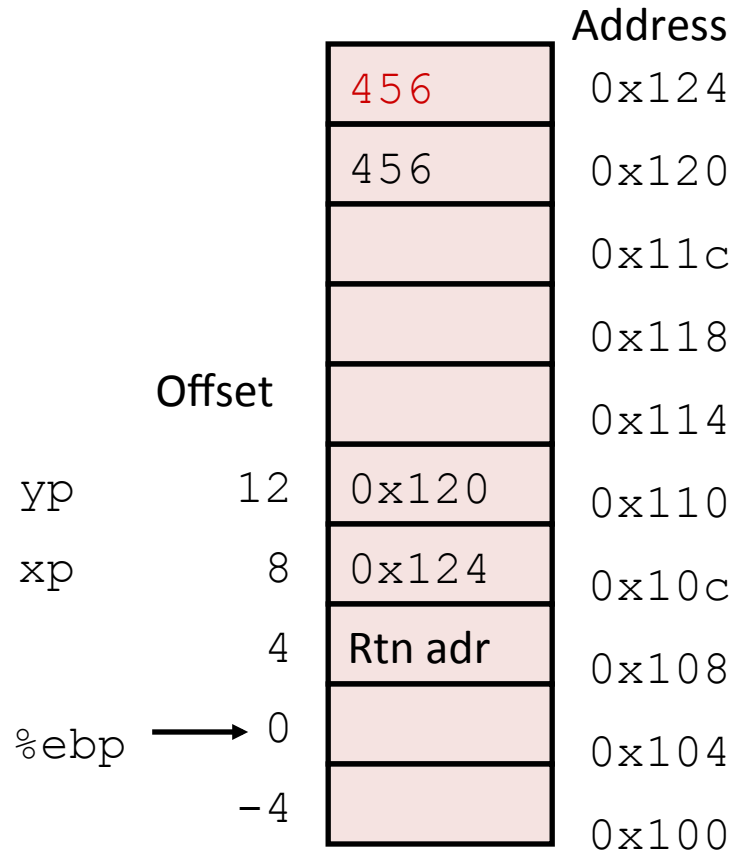


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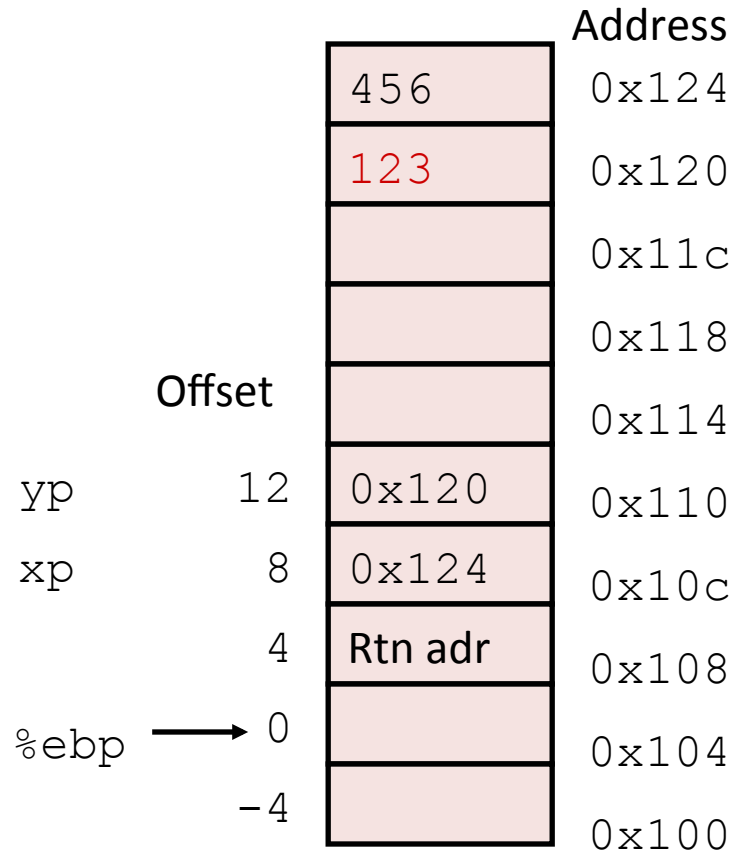


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movl   (%edx), %ebx      # ebx = *xp (t0)
movl   (%ecx), %eax      # eax = *yp (t1)
movl   %eax, (%edx)      # *xp = t1
movl   %ebx, (%ecx)      # *yp = t0
```

Condition Codes (Implicit Setting)

- **Single bit registers**
  - –CF Carry Flag (for unsigned) SF Sign Flag (for signed)
  - –ZF Zero Flag OF Overflow Flag (for signed)
- **Implicitly set (think of it as side effect) by arithmetic operations**

  Example: `addl/addq` Src,Dest ↔ `t = a+b`

  CF set if carry out from most significant bit (unsigned overflow)

  ZF set if `t == 0`

  SF set if `t < 0` (as signed)

  OF set if two's-complement (signed) overflow

  `(a>0 && b>0 && t<0) || (a<0 && b<0 && t>=0)`
- **Not set by `lea` instruction**

Condition Codes (Explicit Setting: Compare)

- **Explicit Setting by Compare Instruction**
  - `cmpl/cmpq` Src2, Src1
  - `cmpl b,a` like computing `a-b` without setting destination

  - CF set if carry out from most significant bit (used for unsigned comparisons)
  - ZF set if `a == b`
  - SF set if `(a-b) < 0` (as signed)
  - OF set if two's-complement (signed) overflow

```
(a>0 && b<0 && (a-b)<0) || (a<0 && b>0 && (a-b)>0)
```

Condition Codes (Explicit Setting: Test)

- **Explicit Setting by Test instruction**
  - `testl`/`testq` Src2, Src1
    `testl b,a` like computing `a&b` without setting destination
  - Sets condition codes based on value of Src1 & Src2
  - Useful to have one of the operands be a mask
  - ZF set when `a&b == 0`
  - SF set when `a&b < 0`

Reading Condition Codes

- **SetX Instructions**
  - Set single byte based on combinations of condition codes

SetX	Condition	Description
`sete`	`ZF`	Equal / Zero
`setne`	`~ZF`	Not Equal / Not Zero
`sets`	`SF`	Negative
`setns`	`~SF`	Nonnegative
`setg`	`~(SF^OF)&~ZF`	Greater (Signed)
`setge`	`~(SF^OF)`	Greater or Equal (Signed)
`setl`	`(SF^OF)`	Less (Signed)
`setle`	`(SF^OF)|ZF`	Less or Equal (Signed)
`seta`	`~CF&~ZF`	Above (unsigned)
`setb`	`CF`	Below (unsigned)

Jumping

- **jX Instructions**
  - Jump to different part of code depending on condition codes

jX	Condition	Description
`jmp` *Label*	`1`	Unconditional
`je` *Label*	`ZF`	Equal / Zero
`jne` *Label*	`~ZF`	Not Equal / Not Zero
`js` *Label*	`SF`	Negative
`jns` *Label*	`~SF`	Nonnegative
`jg` *Label*	`~(SF^OF)&~ZF`	Greater (Signed)
`jge` *Label*	`~(SF^OF)`	Greater or Equal (Signed)
`jl` *Label*	`(SF^OF)`	Less (Signed)
`jle` *Label*	`(SF^OF)|ZF`	Less or Equal (Signed)
`ja` *Label*	`~CF&~ZF`	Above (unsigned)
`jb` *Label*	`CF`	Below (unsigned)

Conditional Branch Example

```
int absdiff(int x, int y)
{
    int result;
    if (x > y) {
      result = x-y;
    } else {
      result = y-x;
    }
    return result;
}
```

```
absdiff:
    pushl   %ebp
    movl    %esp, %ebp
    movl    8(%ebp), %edx
    movl    12(%ebp), %eax
    cmpl    %eax, %edx
    jle     .L6
    subl    %eax, %edx
    movl    %edx, %eax
    jmp .L7
.L6:
    subl %edx, %eax
.L7:
    popl %ebp
    ret
```

Setup

Body1

Body2a

Body2b

Finish

Conditional Branch Example (Cont.)

```
int goto_ad(int x, int y)
{
  int result;
  if (x <= y) goto Else;
  result = x-y;
  goto Exit;
Else:
  result = y-x;
Exit:
  return result;
}
```

```
absdiff:
    pushl   %ebp
    movl    %esp, %ebp
    movl    8(%ebp), %edx
    movl    12(%ebp), %eax
    cmpl    %eax, %edx
    jle     .L6
    subl    %eax, %edx
    movl    %edx, %eax
    jmp .L7
.L6:
    subl %edx, %eax
.L7:
    popl %ebp
    ret
```

Setup

Body1

Body2a

Body2b

Finish

- **C allows "goto" as means of transferring control**
  - Closer to machine-level programming style
- **Generally considered bad coding style**

Conditional Branch Example (Cont.)

```
int goto_ad(int x, int y)
{
  int result;
  if (x <= y) goto Else;
  result = x-y;
  goto Exit;
Else:
  result = y-x;
Exit:
  return result;
}
```

```
absdiff:
    pushl   %ebp
    movl    %esp, %ebp
    movl    8(%ebp), %edx
    movl    12(%ebp), %eax
    cmpl    %eax, %edx
    jle     .L6
    subl    %eax, %edx
    movl    %edx, %eax
    jmp .L7
.L6:
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.L7:
    popl %ebp
    ret
```

Setup

Body1

Body2a

Body2b

Finish

Conditional Branch Example (Cont.)

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Exit:
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}
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    cmpl    %eax, %edx
    jle     .L6
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    movl    %edx, %eax
    jmp .L7
.L6:
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Setup

Body1

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Conditional Branch Example (Cont.)

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```

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absdiff:
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    movl    12(%ebp), %eax
    cmpl    %eax, %edx
    jle     .L6
    subl    %eax, %edx
    movl    %edx, %eax
    jmp .L7
.L6:
    subl %edx, %eax
.L7:
    popl %ebp
    ret
```

Setup

Body1

Body2a

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Finish