- http://en.wikipedia.org/wiki/Dennis_Ritchie

Plans for Monday

- Lab / Lecture
- Lab due: Monday by 11am

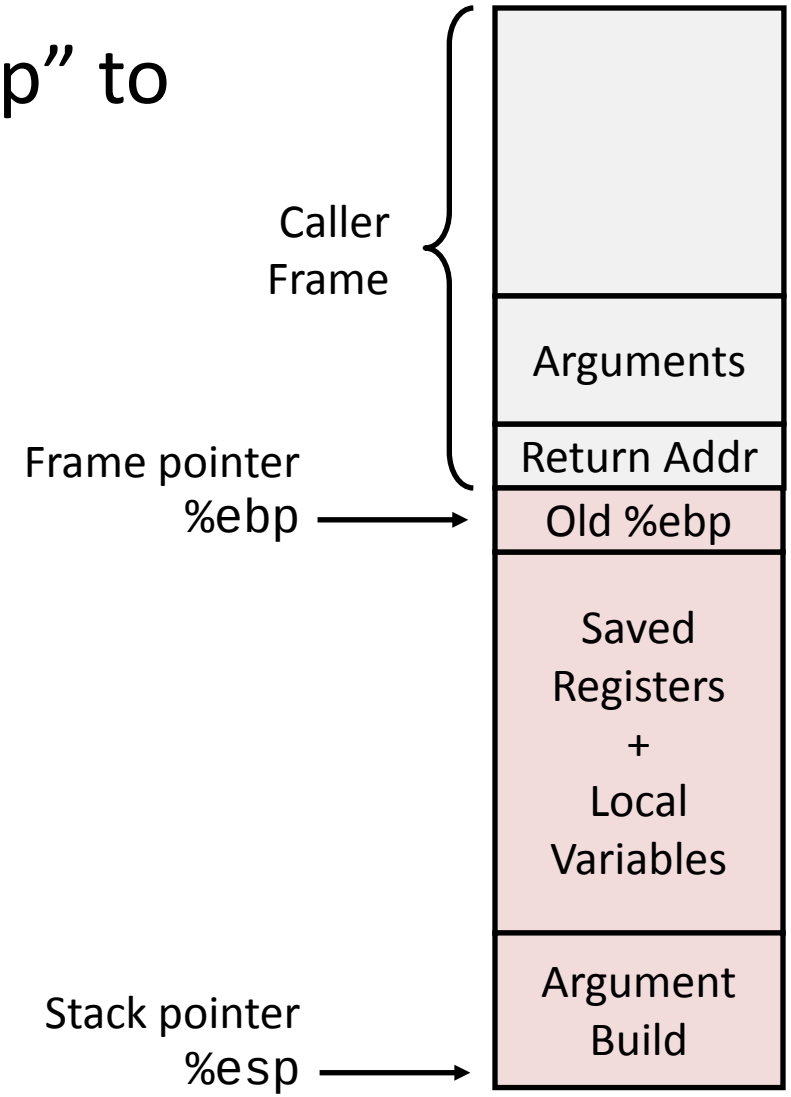
- Wednesday: Midterm
- If you don’t have last year’s midterm, get a copy

- Labs graded by Monday

IA32/Linux Stack Frame

- Current Stack Frame ("Top" to Bottom)
  - "Argument build:"
    Parameters for function about to call
  - Local variables
    If can't keep in registers
  - Saved register context
  - Old frame pointer

- Caller Stack Frame
  - Return address
  - Pushed by **`call`** instruction
  - Arguments for this call



Revisiting swap

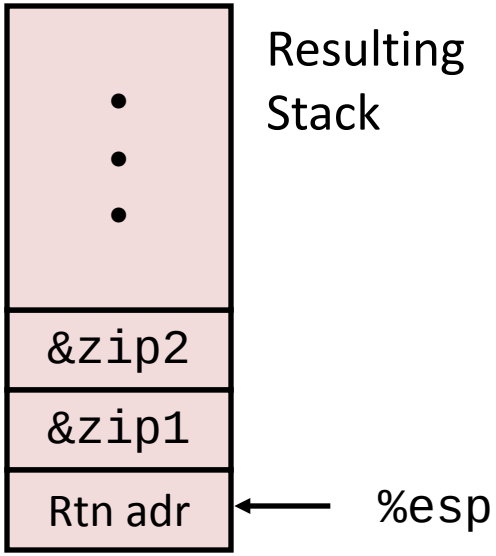
```
int zip1 = 15213;
int zip2 = 91125;

void call_swap()
{
  swap(&zip1, &zip2);
}
```

Calling swap from call_swap

```
call_swap:
    • • •
    pushl $zip2   # Global Var
    pushl $zip1   # Global Var
    call swap
    • • •
```

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



Mid-semester feedback

1. What’s been most useful to you (and why)?

2. What could be going better / be more useful (and why)?

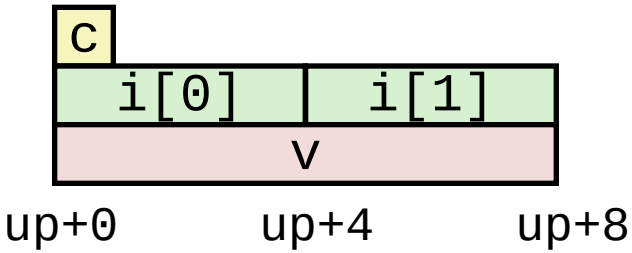
3. What could students do to improve the class?

4. What could Matt do to improve the class?

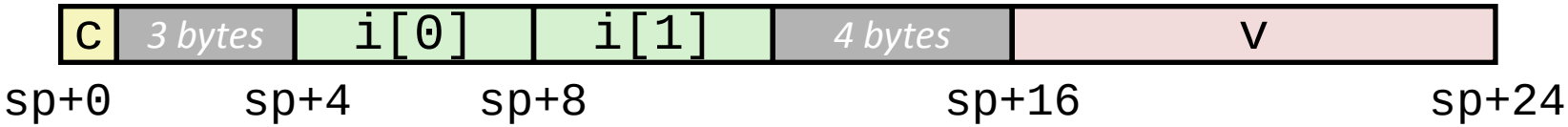
Union Allocation

- Allocate according to largest element
- Can only use ones field at a time

```
union U1 {
  char c;
  int i[2];
  double v;
} *up;
```

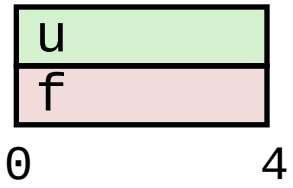



```
struct S1 {
  char c;
  int i[2];
  double v;
} *sp;
```



Using Union to Access Bit Patterns

```
typedef union {
  float f;
  unsigned u;
} bit_float_t;
```




```
float bit2float(unsigned u)
{
  bit_float_t arg;
  arg.u = u;
  return arg.f;
}
```

```
unsigned float2bit(float f)
{
  bit_float_t arg;
  arg.f = f;
  return arg.u;
}
```

Same as `(float) u` ?

Same as `(unsigned) f` ?

Alignment

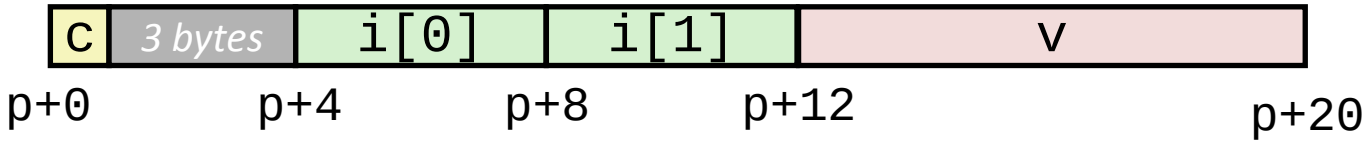
- Aligned Data
  - Primitive data type requires K bytes
  - Address must be multiple of K
  - Required on some machines; advised on IA32
    - treated differently by IA32 Linux, x86-64 Linux, and Windows!
- Motivation for Aligning Data
  - Memory accessed by (aligned) chunks of 4 or 8 bytes (system dependent)
    - Inefficient to load or store datum that spans quad word boundaries
    - Virtual memory very tricky when datum spans 2 pages
- Compiler
  - Inserts gaps in structure to ensure correct alignment of fields

Specific Cases of Alignment (IA32)

- 1 byte: `char`, …
  - no restrictions on address
- 2 bytes: `short`, …
  - lowest 1 bit of address must be 0_2
- 4 bytes: `int`, `float`, `char *`, …
  - lowest 2 bits of address must be 00_2
- 8 bytes: `double`, …
  - Windows (and most other OS's & instruction sets):
    - lowest 3 bits of address must be 000_2
  - Linux:
    - lowest 2 bits of address must be 00_2
    - i.e., treated the same as a 4-byte primitive data type
- 12 bytes: `long double`
  - Windows, Linux:
    - lowest 2 bits of address must be 00_2
    - i.e., treated the same as a 4-byte primitive data type

Different Alignment Conventions

```
struct S1 {
  char c;
  int i[2];
  double v;
} *p;
```

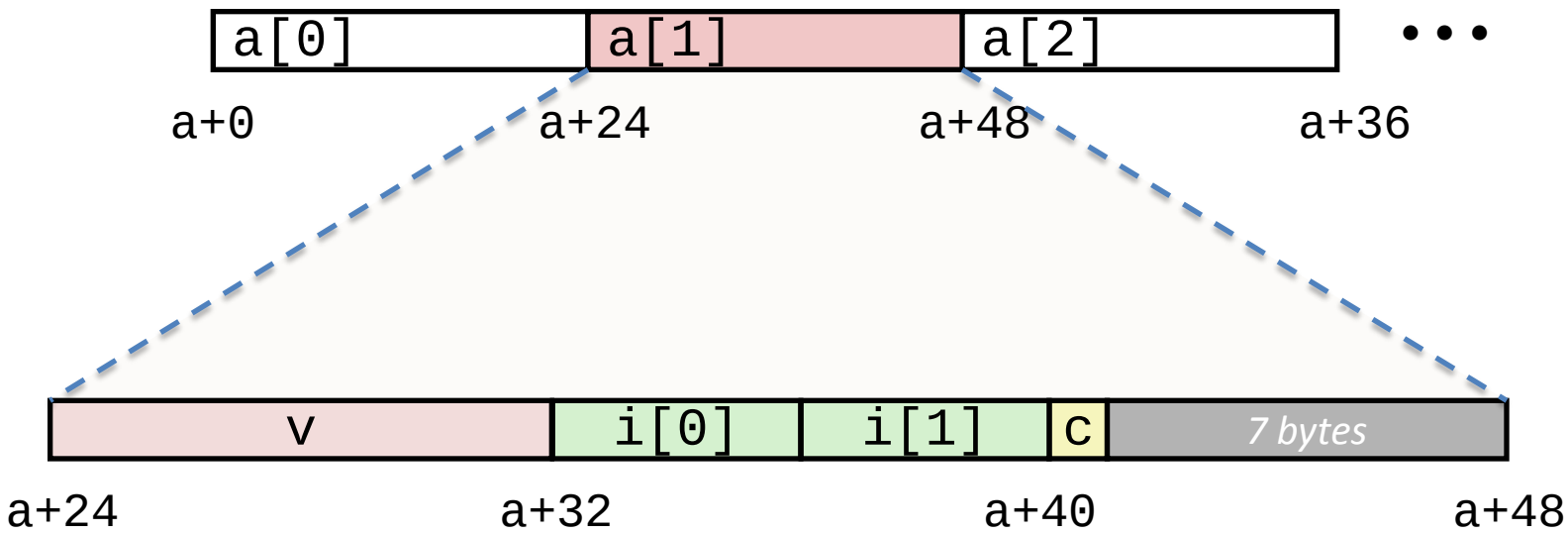


- IA32 Linux
  - K = 4; **`double`** treated like a 4-byte data type

Arrays of Structures

- Satisfy alignment requirement for every element

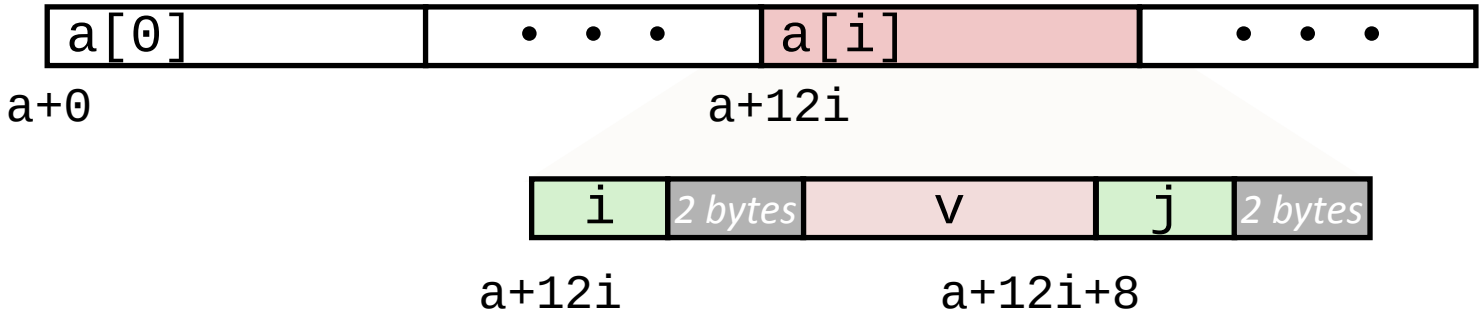
```
struct S2 {
  double v;
  int i[2];
  char c;
} a[10];
```



Accessing Array Elements

```
struct S3 {
  short i;
  float v;
  short j;
} a[10];
```

- Compute array offset 12i
- Compute offset 8 with structure
- Assembler gives offset a+8
  - Resolved during linking




```
short get_j(int idx)
{
  return a[idx].j;
}
```

```
# %eax = idx
leal (%eax,%eax,2),%eax # 3*idx
movswl a+8(,%eax,4),%eax
```

```
char *gets(char *s)
{
   int c;
   char *dest = s;
   int gotchar = 0;
   while ((c = getchar()) != '\n' && c != EOF){
    *dest++ = c;
    gotchar = 1;
   }
   *dest++ = '\0';
   if (c == EOF && !gotchar)
    return NULL;
   return s;
}

void echo()
{
   char buf[8];
   gets(buf);
   puts(buf);
}
```