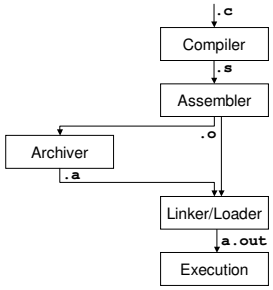
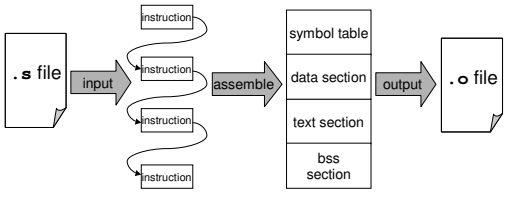
Your Assembler

CS 217

Compilation Pipeline



Assembler



disk | in memory structure | in memory structure | disk

Input Function

- Lexical Analyzer
  - group a stream of characters into tokens

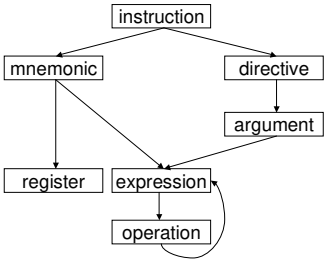
```
   add   "hello"  %r1     ,     10
<MNEMONIC><STR><REG><COMMA><INT>
```

- Syntactic Analyzer
  - check the syntax of the program

```
   instruction =
<MNEMONIC><REG><COMMA><REG><COMMA><REG>
```

- Instruction List Producer
  - produce an in-memory list of instruction data structures

Input Data Structures



Input Structure: `instruction`

- Three types of assembly instructions
  - label (symbol definition)
  - mnemonic (real or synthetic instruction)
  - directive (pseudo operation)

```
struct instruction {
   int instr_type; ──────────► LBL, MNM, DIR
   union {
      char *lbl;
      struct mnemonic *mnm;
      struct directive *dir;
   } u;
   struct instruction *next;
};
```

Input Structure: **mnemonic**

- Two types of operands in each mnemonic
  - register (e.g., **%r1**)
  - expression (e.g., **1+2**)

```
struct mnemonic {
   Mnemonic_Type mnm_type; ──► ADD, LD, CALL, …
   int format;
   union {
      struct register_info *reg;
      struct expression *exp;
   } u[3];
};
```

possible combinations of operands

Example Formats for Load

```
ld   [reg + reg], reg
     [reg + exp], reg
     [exp + reg], reg
     [reg – exp], reg
     [reg], reg
     [exp], reg
```

each of these formats tells you how to interpret the operands: **u[0]**, **u[1]**, and **u[2]**

Input Structure: **register**

```
struct register_info {
   Register_Type reg_type; ──► R, G, O, L, I
   int reg_number; ──► O..31, 0..7
};
```

Input Structure: **`expression`**

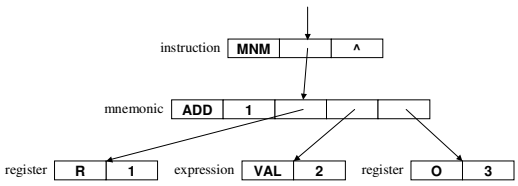
- Three types of expressions
  - symbol (e.g., **`loop`**)
  - integer (e.g., **`1`**)
  - operation (e.g., **`1+2`**)

```
struct expression {
   int exp_type;  ──────────►  SYM, VAL, OP
   union {
      char *sym;
      int val;
      struct operation *op;
   } u;
};
```

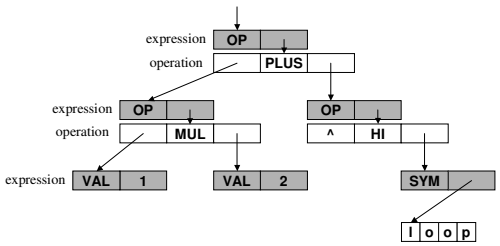

Input Structure: **`operation`**

```
struct operation {
   Operation_Type op_type; ──►  PLUS, MUL, HI, …
   struct expression *left;
   struct expression *right;
};
```


Example: **`add %r1, 2, %o3`**



Example: `1*2+%hi(loop)`



Input Structure: `directive`

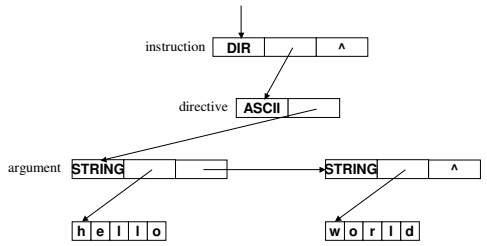
```
struct directive {
   Directive_Type dir_type; ──► ASCII, BYTE, …
   struct argument *arg_list;
};
```


Input Structure: `argument`

- Two types of arguments
  - string (e.g., `"hello"`)
  - expression (e.g., `1+2`)

```
struct argument {
   int arg_type; ──────────► STRING, EXP
   union {
      char *string;
      struct expression *exp;
   } u;
   struct argument *next;
};
```

Example: `ascii "hello", "world"`



Output Interface

- Your two passes produce…

```
Table_T symbol_table;
struct section *data;
struct section *text;
struct section *bss;
```

these are global variables assumed by the output function

Output Interface (cont)

- Symbol table…

use Hanson's Table ADT, where each *value* is given by…

```
typedef struct {
   Elf32_Word    st_name;   = 0
   Elf32_Addr    st_value;  = offset in object code
   Elf32_Word    st_size;   = 0
   unsigned char st_info;   = see next slide
   unsigned char st_other;  = unique seq num
   Elf32_Half    st_shndx;  = DATA_NDX,
} Elf32_Sym;                  TEXT_NDX,
                              BSS_NDX, or
                              UNDEF_NDX
```

Output Interface (cont)

- To set **`st_info`** field of **`Elf32_Sym`** structure
  use **`ELF32_ST_INFO(b,t)`** macro, where
  `b` specifies the symbol's binding attribute
  `t` specifies the symbol's type

b	possible symbols	t
`STB_GLOBAL`	section name	`STT_SECTION`
	local variable name	`STT_NOTYPE`
`STB_LOCAL`	global variable name	

Output Interface (cont)

- Each section…

```
struct section {
   unsigned int      obj_size;
   unsigned char     *obj_code;
   struct relocation *rel_list;
};
```

`obj_size` is given in bytes
`size = 0` and **`obj_code = NULL`** for BSS

```
struct relocation {
   Elf32_Rela rela;
   struct relocation *next;
}
```


Output Interface (cont)

- Each relocation entry…

```
typedef struct {
   Elf32_Addr   r_offset;
   Elf32_Word   r_info;
   Elf32_Sword  r_addend;
} Elf32_Rela;
```

offset w/in block at which relocation action is needed

constant to be added to value stored in relocatable field

use **`ELF32_R_INFO(s,t)`** macro to set, where
`s` is the unique number for the symbol that is to be used (must match that entry's **`st_other`** field)
`t` identifies the type of relocation action to be applied
`R_SPARC_WDISP30`, **`R_SPARC_WDISP22`**, **`R_SPARC_HI22`**, or **`R_SPARC_LO10`**

Implementation Strategy

- Write **`pass1()`** first
  - section initialization
  - label definitions

```
.section ".data"
label:
```

- Write **`pass2()`** in stages: for each instruction…
  - register operands
  - register aliases
  - simple expressions
  - full expressions
  - relocation
  - external labels
  - synthetic instructions

```
ld [%r1 + %r2], %r3
ld [%g1 + %g2], %r3
ld [%r1 + 2], %r3
ld [%r1 + 1*(2+3)/4], %r3
ld [%r1 + label], %r3
call printf
cmp %r1, %r2
```