Assembly: Review

Lecture 14

Definition

- Recall: Translation
  - A source program is translated into a target program
  - Each language corresponds to an abstract machine
  - Source program is not directly executed
- When source is a symbolic representation of machine language:
  - Source language is _____
  - Translator is _____
- When source is higher-level, translator usually called a _____

Advantage of Assembly

- Over machine code
  - Easier to remember/read mnemonic operations vs actual opcodes
  - Easier to use symbolic addresses
- Over higher-level languages
  - Access to full capabilities of the machine at the lowest level
  - Speed? Not generally true because:
    - Optimizing compilers
    - Algorithm design and insights are more significant

Best of Both Worlds

- Systems programming often done in a language like C
- Syntax of a higher-level language
- Control of lower-level concerns, like memory allocation

So Why Bother With Assembly?

- Might need to write/read/maintain some critical bit of assembly code
- Similar to (but simpler than) compiler
- Good way to learn about computer architecture
- Insights into workings of higher-level languages
- The world still needs compilers, and therefore assembly too

Assembly: Syntax

- One statement / line
- Four fields (not all are necessary):
  - Label
  - Operation
  - Operands
  - Comment
- Example

```
Test  BRZ Loop  ;if R1=0 repeat
```

Label Field

- Symbolic name for the instruction address
- Clarifies branching to a particular instruction
  - BRNP Loop1
- Clarifies target for loading/storing data to memory
  - LD R3, Sum
- Often severely limited in length

Operation Field

- Mnemonic for a machine instruction
  - Eg, ADD, SUB, BRZ
- Mnemonic for a “pseudo operation”
  - Eg, .FILL
  - More about these in a moment

Operand Field

- Arguments to the function
- Registers, immediate data, address used by the instruction
  - What to add, where to branch, where to store, etc.
- Information used by pseudo operations
  - Information for the assembler to produce the object file
  - Program name, how much space to save, etc.

Comment Field

- No effect on assembler
  - No difference in resulting object file
  - No semantic impact on program
- But huge impact on legibility
  - Strictly for human consumption

Pseudo Operations

- Unlike instructions, pseudo ops do not have a corresponding machine instruction in the ISA
- Give information to assembler itself
  - "assembler directive"
  - Control various aspects of resulting object file
- Uses
  1. Segment definition
  2. Symbol definition
  3. Memory initialization
  4. Storage allocation

Segment Definition

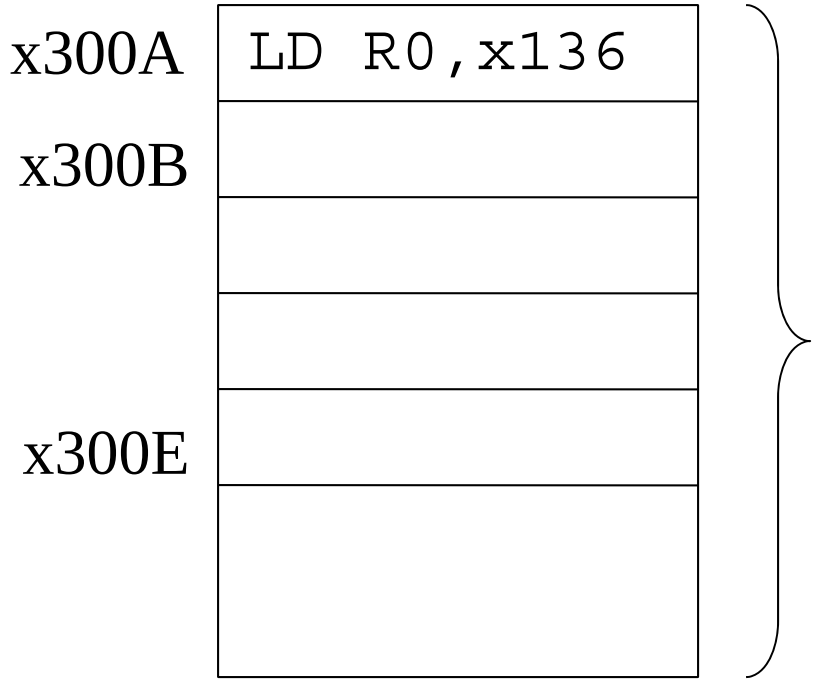
- Recall object file header & end records
  - Segment name
  - Segment load address
  - Segment length
  - Initial execution address
- All of this information comes directly from pseudo ops
  - Exception: _____

Segment Definition

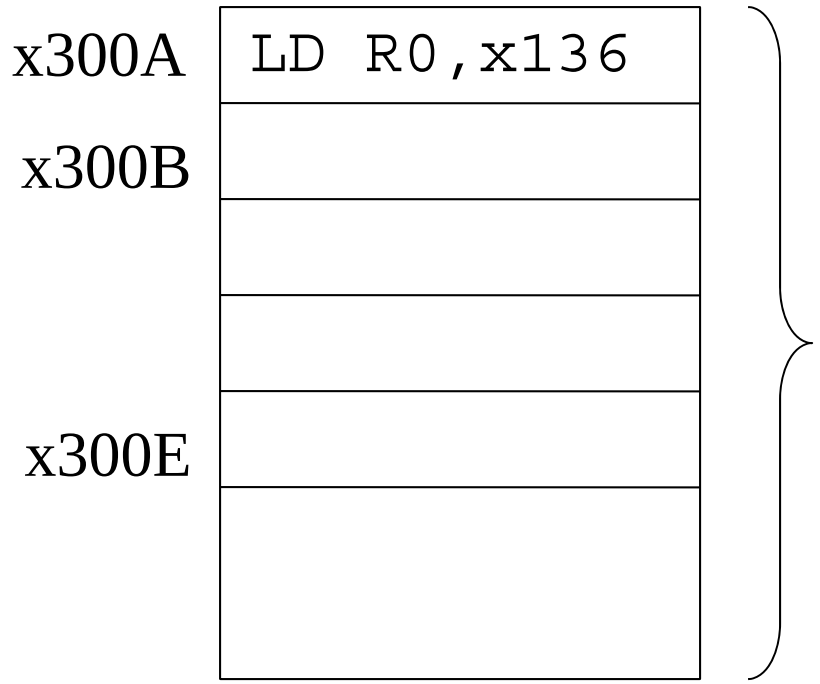
- Two important pseudo ops:
  - .ORIG (for “origin”)
  - .END
- Example

```
MainP   .ORIG    x300A
        LD      R0,x126
…
        .END    x300E
```

- What are the header & end records of the resulting object file?



Header record: H
End record: E



Header record: `HMainP_300A????`
End record: `E300E`

Symbol Definition

- A label creates a symbol
- Symbol is implicitly defined to be the address of the instruction
- Example: What is the value of symbol Test?

```
Hello   .ORIG   x300A
        LD      R0,x126
Test    BRZ     x147
```

Explicit Symbol Definition

- Symbols can also be defined explicitly
- Pseudo Op:
  - .EQU (“equate”)
- Example

```
STEP    .EQU  #2    ;Skip odd indices
```

- Symbols are then used as program constants

```
        ADD   R1,R1,STEP
HALT    .EQU  x25
        TRAP  HALT
```

Summary

- Symbolic machine code
- Advantages/disadvantages
- Basic syntax
- Pseudo Operations
  - Segment definition
  - Symbol Definition