Lecture 8

Linkers

CS 241: Foundations of Sequential Programs
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Loading Review

Write the MERL file for the following MIPS code:

```
A: .word B
B: .word 7
C: .word 0xA
D: .word C
```

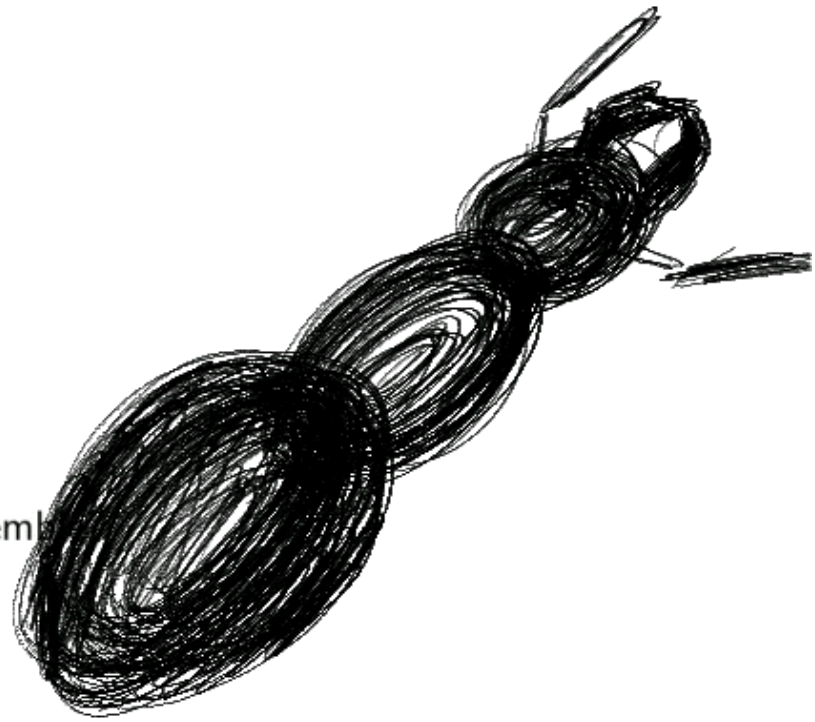
Loading Review

Changes that need to be made to the assembler:

- Pass 1:

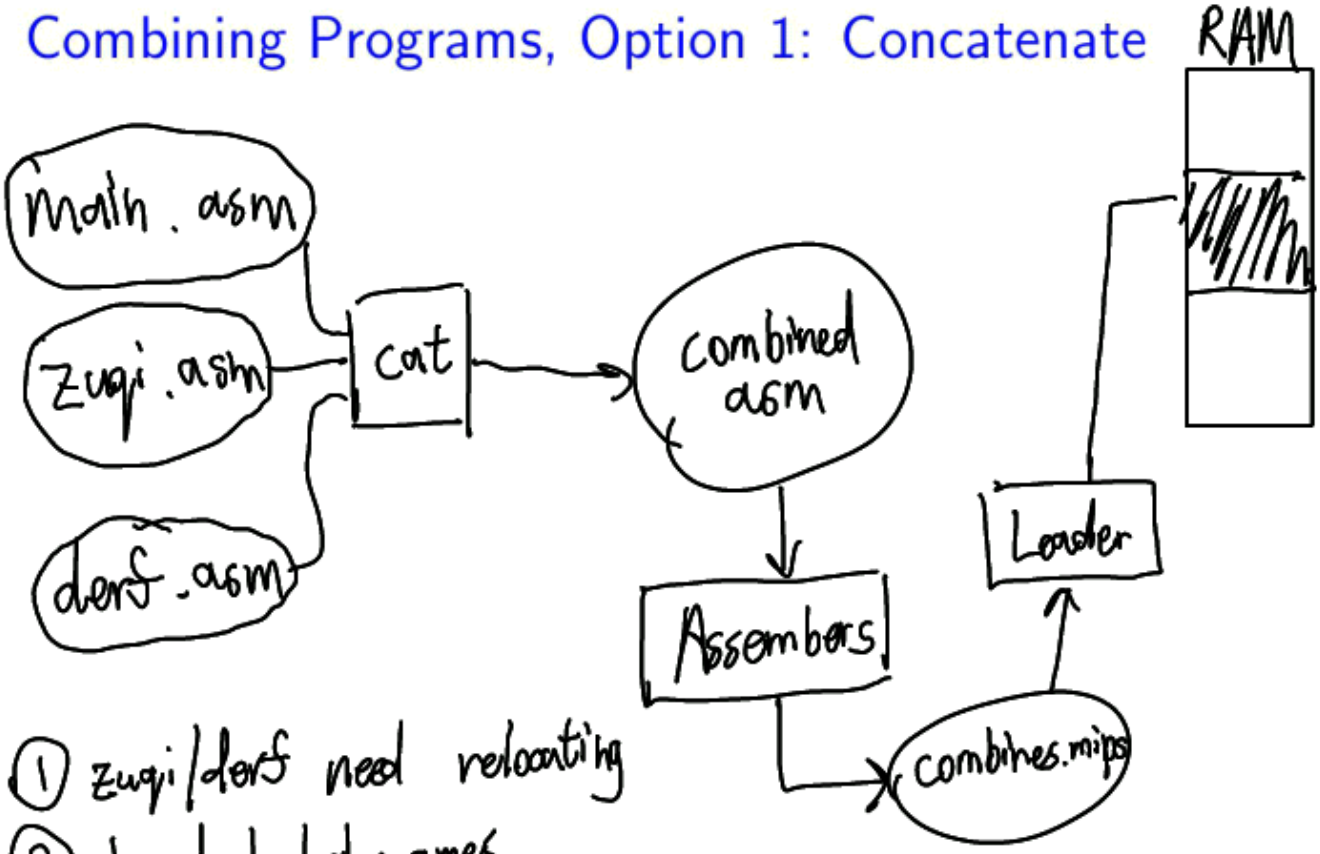
- Pass 2:

Combining Programs



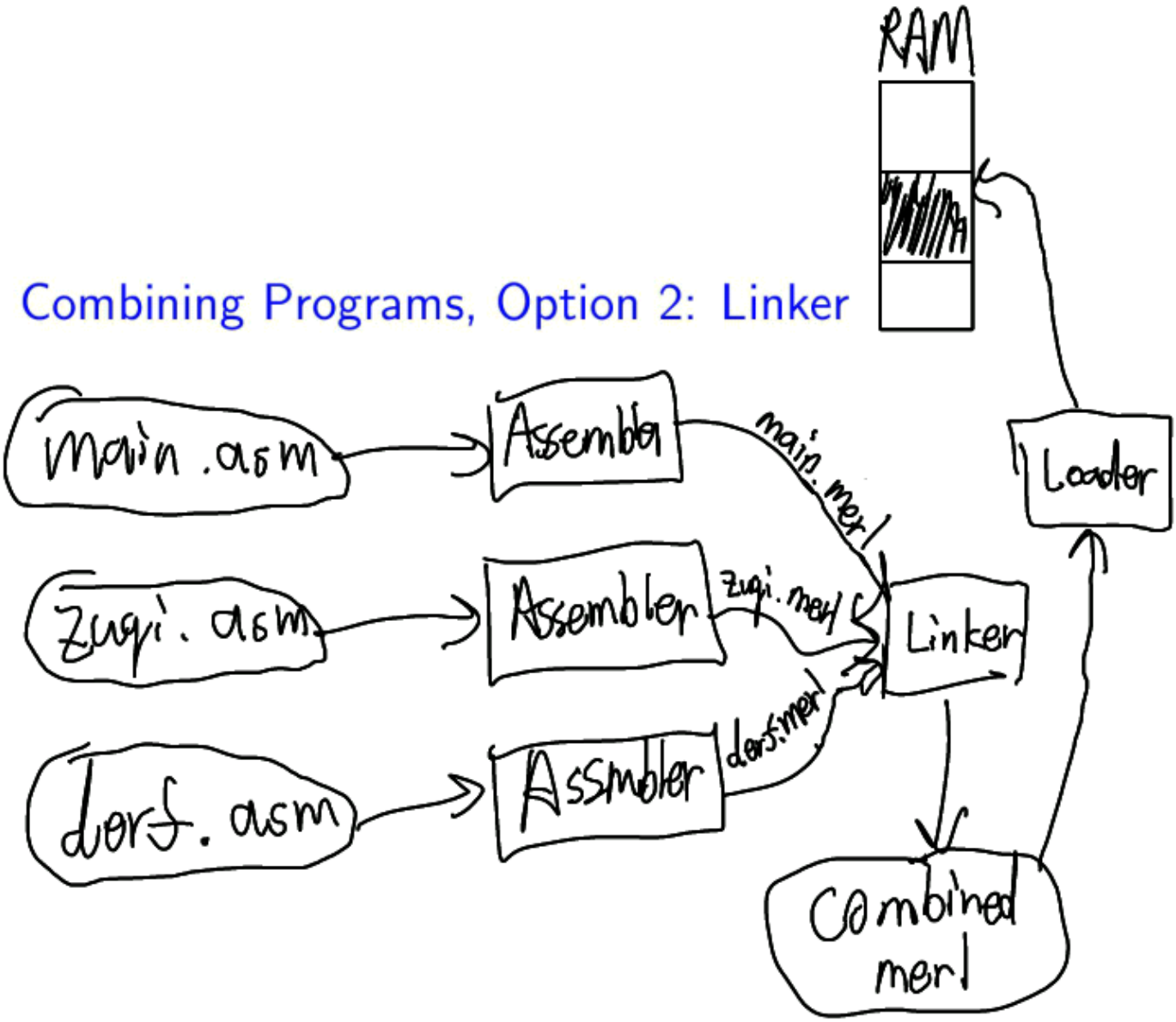
- Why?
- When would we want to assemb
- Example Slides 1 and 2

Combining Programs, Option 1: Concatenate

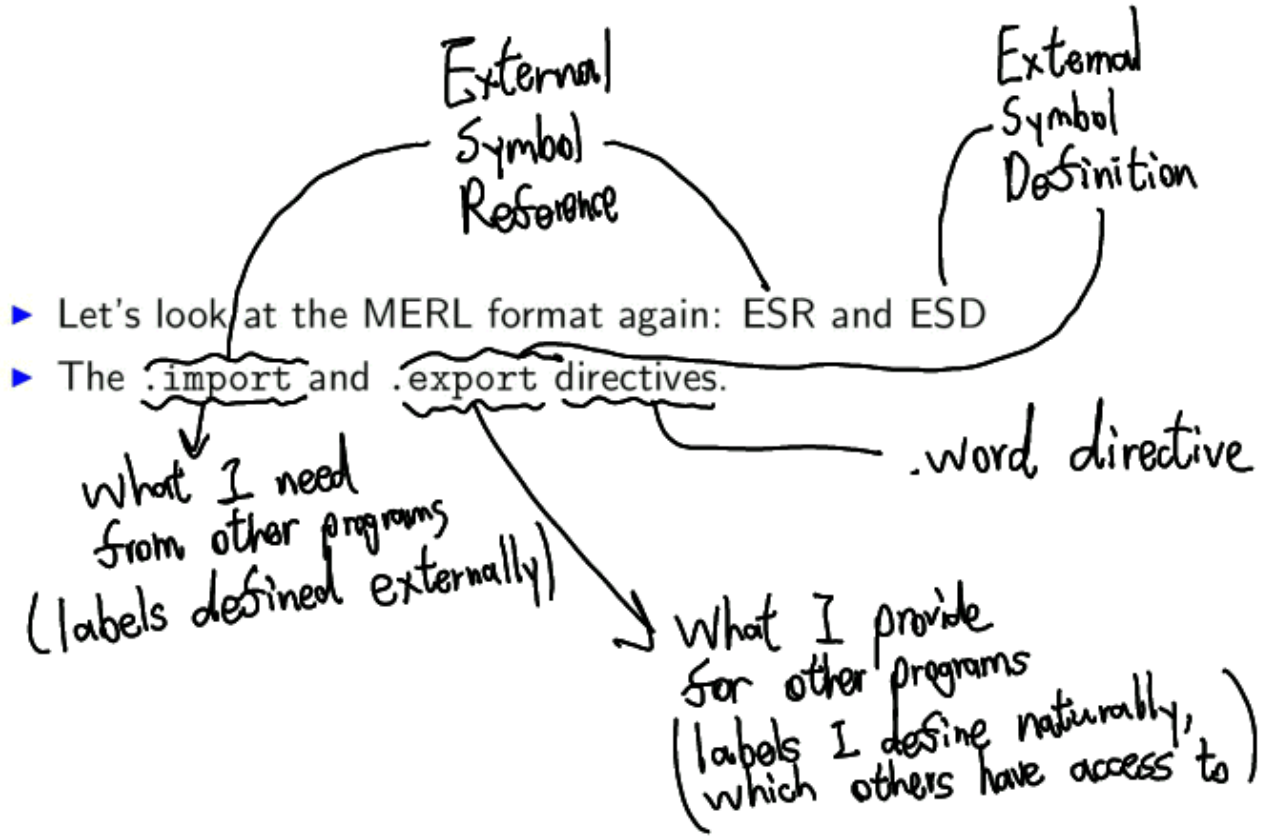


1. zuqi/derf need relocating
2. shared label names
3. errors are hard to track
4. Productivity problems

Combining Programs, Option 2: Linker



Modifying the assembler



Pass 1 and Pass 2 modifications

Pass 1 Changes:

.import: record somewhere (symbol table) each label which is imported.

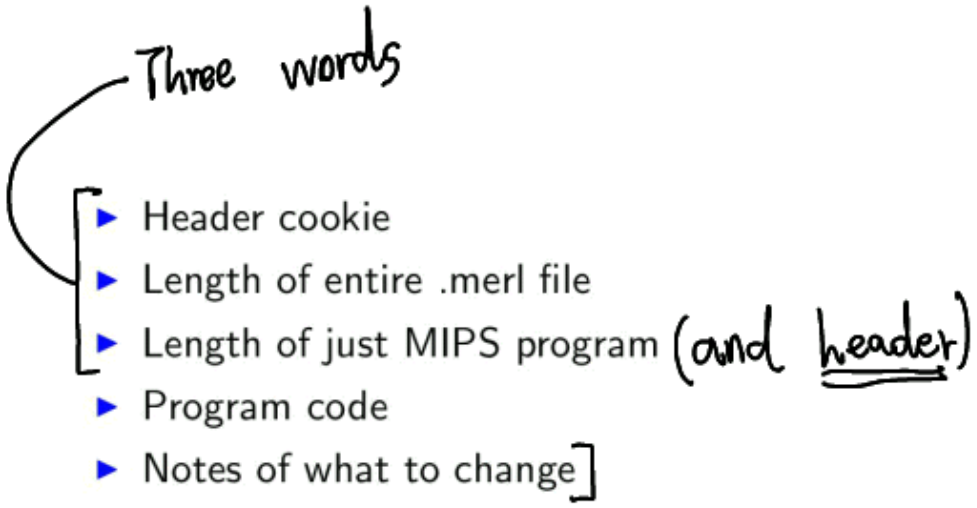
.export: record the fact that I will be creating an ESD

Pass 2 Changes:

.import: write out an ESR record everytime I encounter that external name

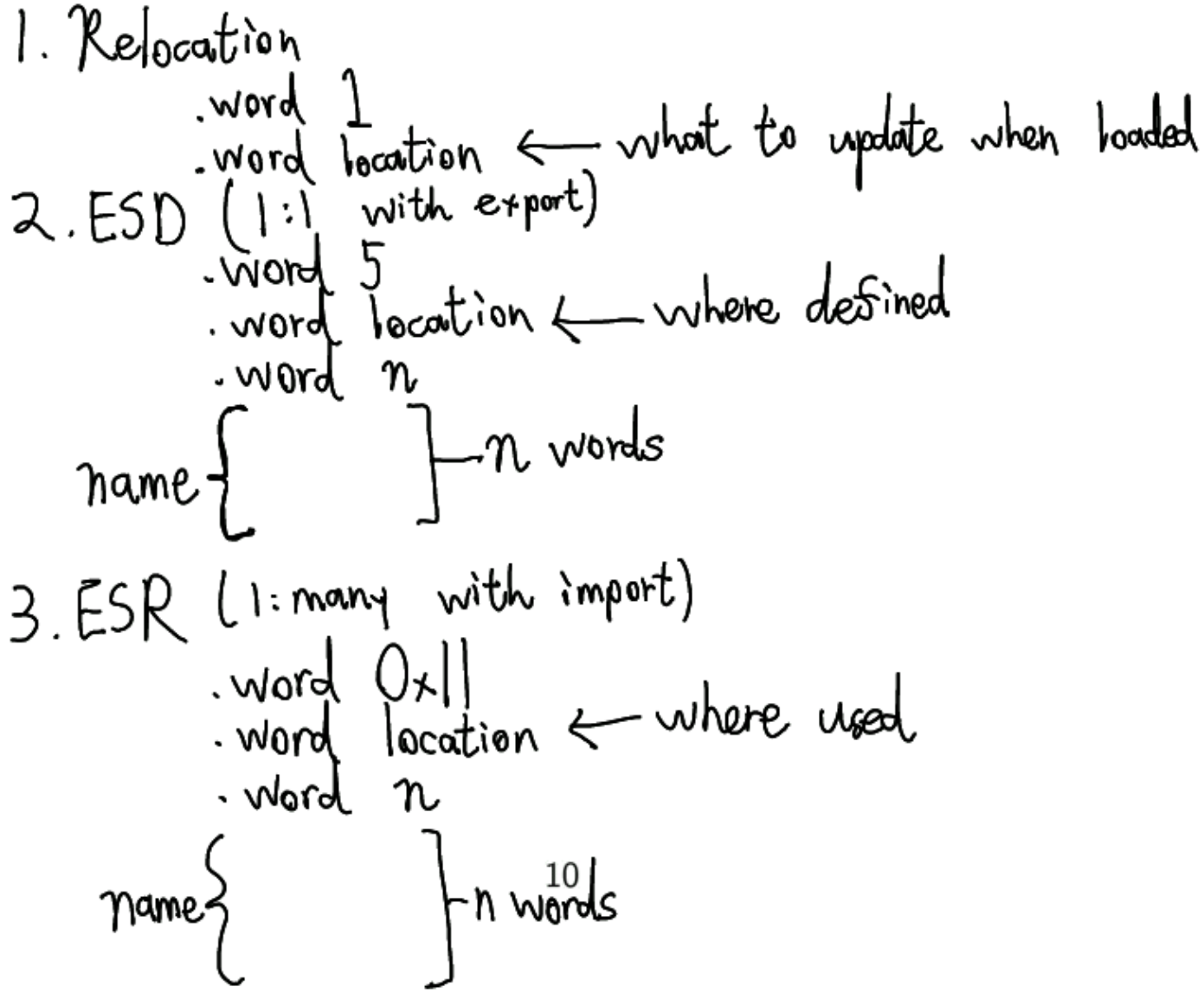
.export: write out an ESD record
⇒ Look in symbol table.

MERL Format



See full description on CS241 webpage.

What are these "notes of what to change"?

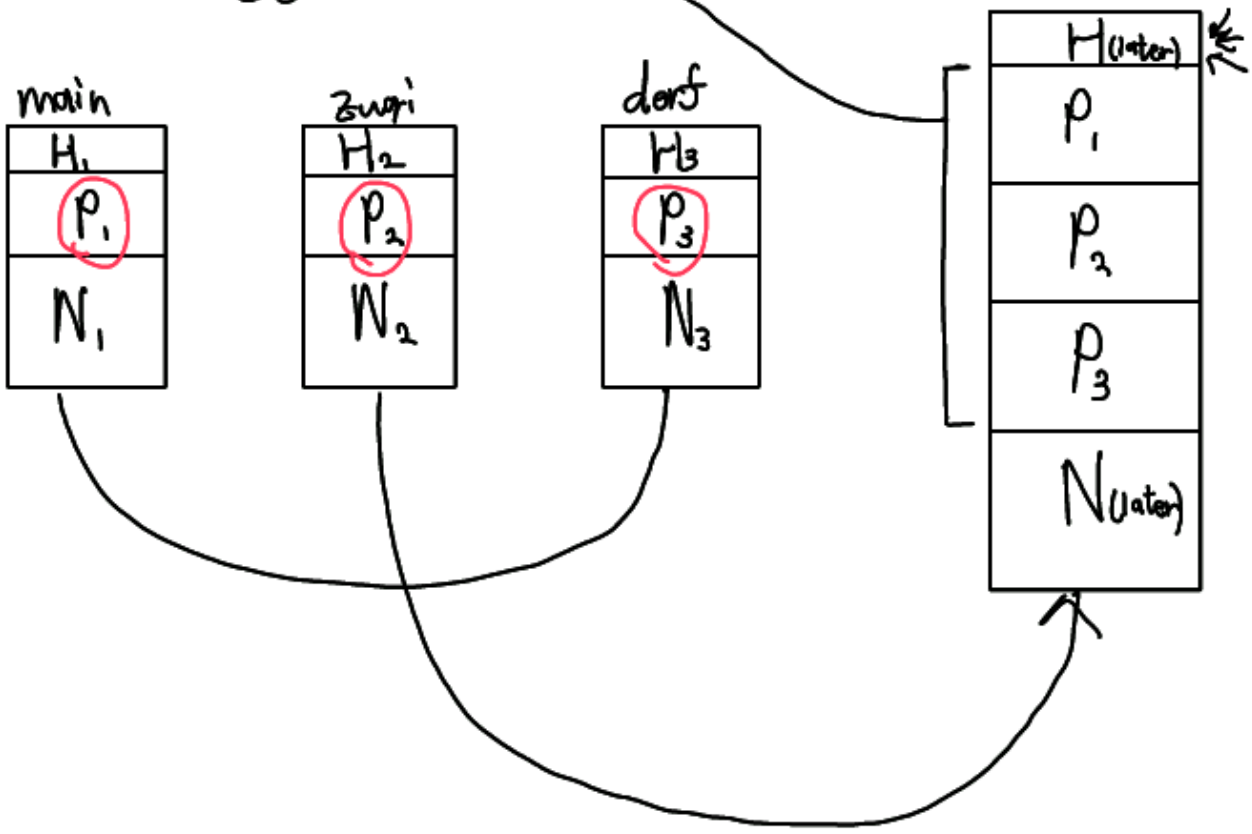


Linker Pseudocode

1. Concatenate the programs
2. Construct ESD
3. Use ESR
4. Relocate (internally)

Linker Pseudocode Step 1

Concatenate the programs



Linker Pseudocode Step 2

Construct ESD

Combine all the ESDs into one ESD
⇒ update addresses
main's (P_1) ESD ⇒ no change
Zuqi's (P_2) ESD ⇒ add $|P_1|$ to each address.
Derk's (P_3) ESD ⇒ add $|P_1|+|P_2|$ to each address.

Linker Pseudocode Step 3

Use ESR

→ For each ESR entry
⇒ look in the new ESD
if found [⇒ update the value at location plus the offset
if not found [⇒ write out a new ESR with offsets.

Linker Pseudocode Step 4

Relocate Internally

↳ why? ex: .word label in A2/A3 is encoded based on a different starting address.

↳ each relocation entry:
⇒ add the appropriate offset in code.
⇒ add the appropriate offset in relocation entry

Static Linking vs. Dynamic Linking

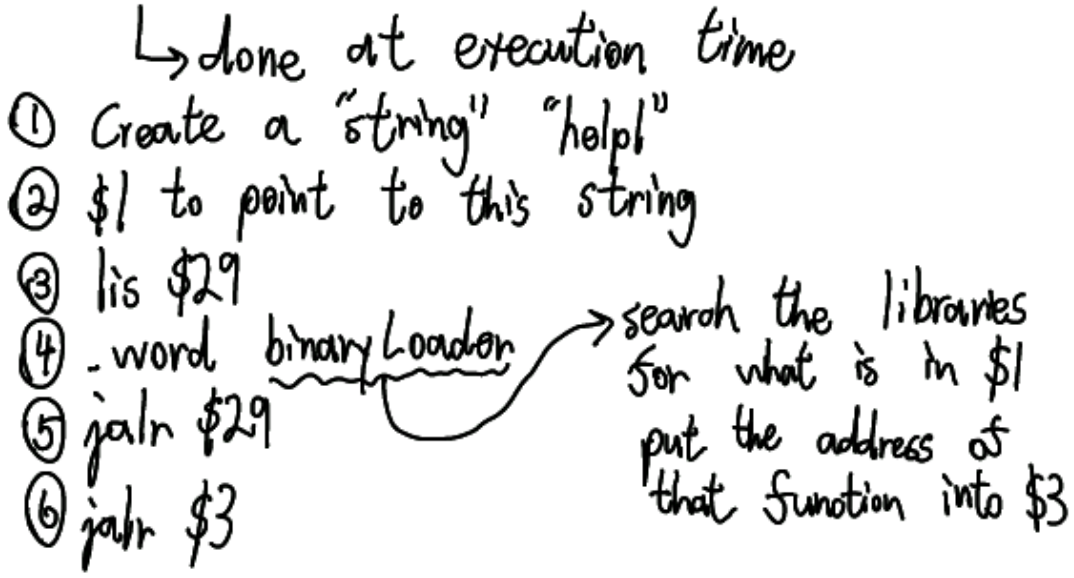
- Static linking example:

↳ just seen

↳ all linked before execution

- Dynamic linking example:

↳ done at execution time



Windows DLLs

↳ Dynamically Linked Library

Where are we now? Where to next?