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6.033 Computer System Engineering  
Spring 2009

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# Libraries of Software Modularity

- C, C++, Java, Perl
- Database Systems
- Web Servers (e.g., Apache)
- GNU / Linux → gcc
- gcc file.o

Text  
rodata  
data  
symtab

## Steps:

- 1) Symbol resolution
- 2) Relocation
- 3) Loading



Linking

- Relocatable obj. file
- Shared obj. file

Executable  
out

1) Symbol resolution:

$$\begin{array}{ccc}
 f_1 \cdot o & f_2 \cdot o & \vdots \\
 \downarrow & \downarrow & \downarrow \\
 D_1 & D_2 & u \\
 U_1 & U_2 & \\
 \end{array}
 \quad
 \begin{array}{l}
 f_n \cdot o \quad - \text{lm} \\
 O \leftarrow O \cup \{f_i \cdot o\} \\
 D \leftarrow D \cup D_i \\
 U \leftarrow (U \cup U_i) \\
 \quad - (U \cap D)
 \end{array}$$

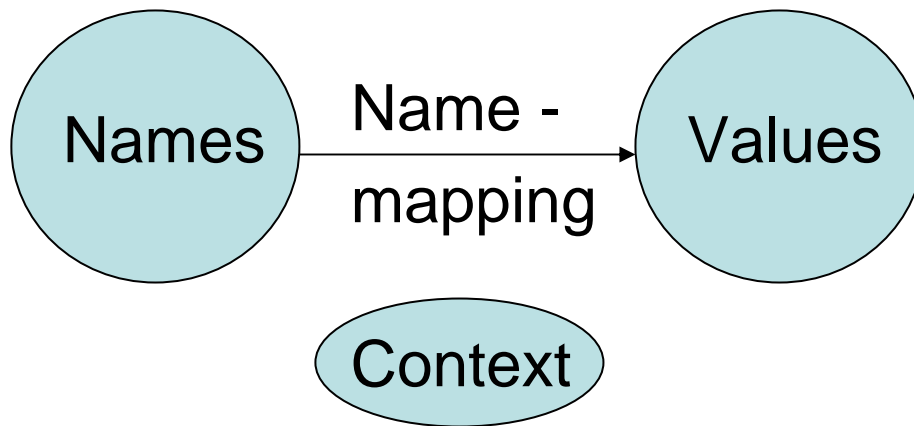
## 2) Relocation:

- Local table

## Resolution w/ libraries:

Include

# Generalizing



- 1) Table lookup.
- 2) Pathname res.
- 3) Search thru contexts.

### 3) Loading:

└─ execve

### Shared objects

- Position indep. code
- Dynamic linking