Language Processors

COMS W4115

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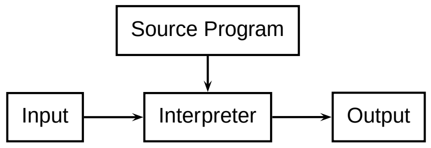
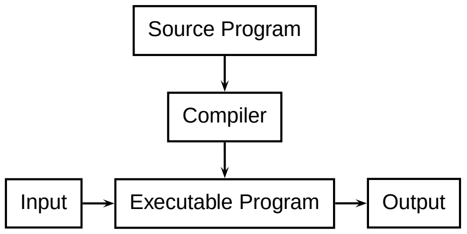
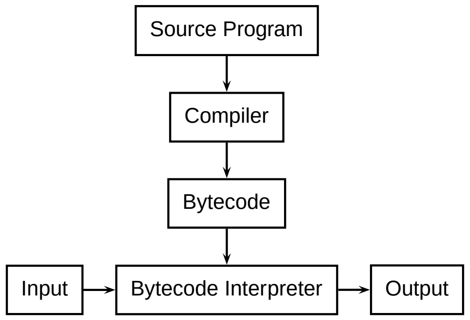
Interpreter



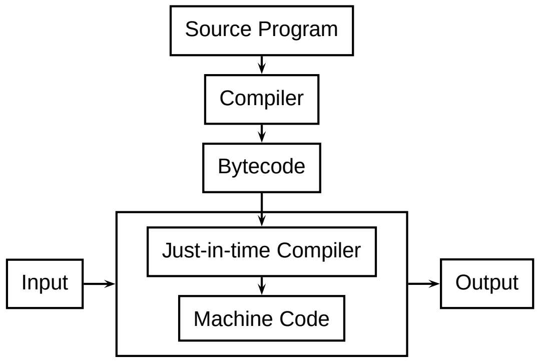
Compiler



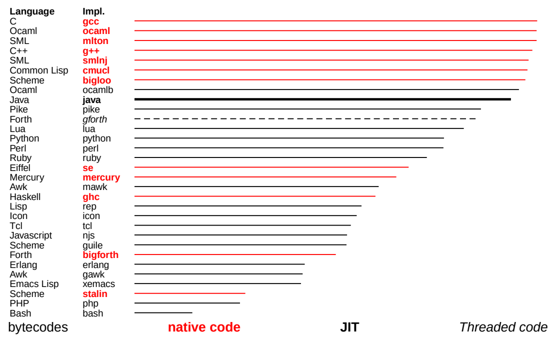
Bytecode Interpreter



Just-in-time Compiler

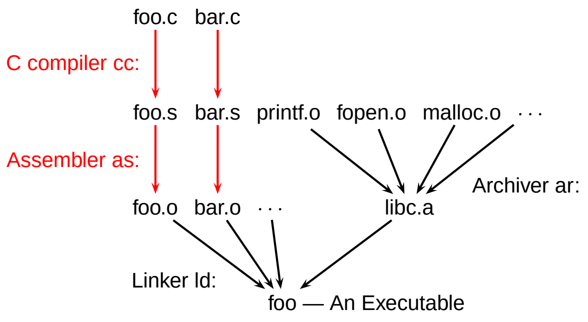


Language Speeds Compared



http://www.bagley.org/˜doug/shootout/

Separate Compilation



Preprocessor

"Massages" the input before the compiler sees it.

- Macro expansion
- File inclusion
- Conditional compilation

The C Preprocessor

```
#include <stdio.h>
#define min(x, y) \
  ((x)<(y))?(x):(y)
#ifdef DEFINE_BAZ
int baz();
#endif
void foo()
{
  int a = 1;
  int b = 2;
  int c;
  c = min(a,b);
}
```

`cc -E example.c` gives

```
extern int
printf(char*,...);
```

... many more declarations from stdio.h

```
void foo()
{
  int a = 1;
  int b = 2;
  int c;
  c = ((a)<(b))?(a):(b);
}
```

Compiling a Simple Program

```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

What the Compiler Sees

```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

```
i  n  t sp  g  c  d  (  i  n  t sp  a  , sp  i
n  t sp  b  ) nl  { nl sp sp  w  h  i  l  e sp
(  a sp  !  = sp  b  ) sp  { nl sp sp sp sp  i
f sp  (  a sp  > sp  b  ) sp  a sp  -  = sp  b
; nl sp sp sp sp  e  l  s  e sp  b sp  -  = sp
a  ; nl sp sp  } nl sp sp  r  e  t  u  r  n sp
a  ; nl  } nl
```

Text file is a sequence of characters

Lexical Analysis Gives Tokens

```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

$\boxed{\texttt{int}}\ \boxed{\texttt{gcd}}\ \boxed{\texttt{(}}\ \boxed{\texttt{int}}\ \boxed{\texttt{a}}\ \boxed{\texttt{,}}\ \boxed{\texttt{int}}\ \boxed{\texttt{b}}\ \boxed{\texttt{)}}\ \boxed{\texttt{\{}}$

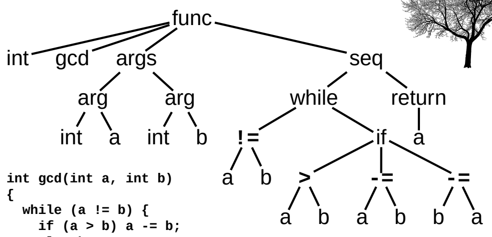
$\boxed{\texttt{while}}\ \boxed{\texttt{(}}\ \boxed{\texttt{a}}\ \boxed{\texttt{!=}}\ \boxed{\texttt{b}}\ \boxed{\texttt{)}}\ \boxed{\texttt{\{}}\ \boxed{\texttt{if}}\ \boxed{\texttt{(}}\ \boxed{\texttt{a}}$

$\boxed{>}\ \boxed{\texttt{b}}\ \boxed{\texttt{)}}\ \boxed{\texttt{a}}\ \boxed{\texttt{-=}}\ \boxed{\texttt{b}}\ \boxed{\texttt{;}}\ \boxed{\texttt{else}}\ \boxed{\texttt{b}}\ \boxed{\texttt{-=}}\ \boxed{\texttt{a}}$

$\boxed{\texttt{;}}\ \boxed{\texttt{\}}}\ \boxed{\texttt{return}}\ \boxed{\texttt{a}}\ \boxed{\texttt{;}}\ \boxed{\texttt{\}}}$

A stream of tokens. Whitespace, comments removed.

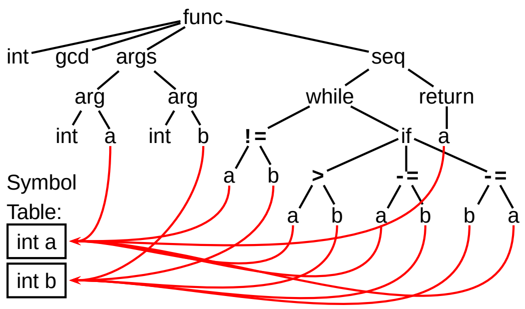
Parsing Gives an AST



```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

Abstract syntax tree built from parsing rules.

Semantic Analysis Resolves Symbols



Types checked; references to symbols resolved

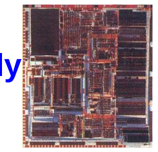
Translation into 3-Address Code

```
L0: sne   $1,  a, b
    seq   $0, $1, 0
    btrue $0, L1    % while (a != b)
    sl    $3,  b, a
    seq   $2, $3, 0
    btrue $2, L4    % if (a < b)
    sub    a,  a, b % a -= b
    jmp    L5
L4: sub    b,  b, a % b -= a
L5: jmp    L0
L1: ret    a
```

```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

Idealized assembly language w/ infinite registers

Generation of 80386 Assembly



```
gcd:  pushl %ebp          % Save FP
      movl  %esp,%ebp
      movl  8(%ebp),%eax  % Load a from stack
      movl  12(%ebp),%edx % Load b from stack
.L8:  cmpl  %edx,%eax
      je    .L3           % while (a != b)
      jle   .L5           % if (a < b)
      subl  %edx,%eax     % a -= b
      jmp   .L8
.L5:  subl  %eax,%edx     % b -= a
      jmp   .L8
.L3:  leave               % Restore SP, BP
      ret
```