Language Processors

COMS W4115

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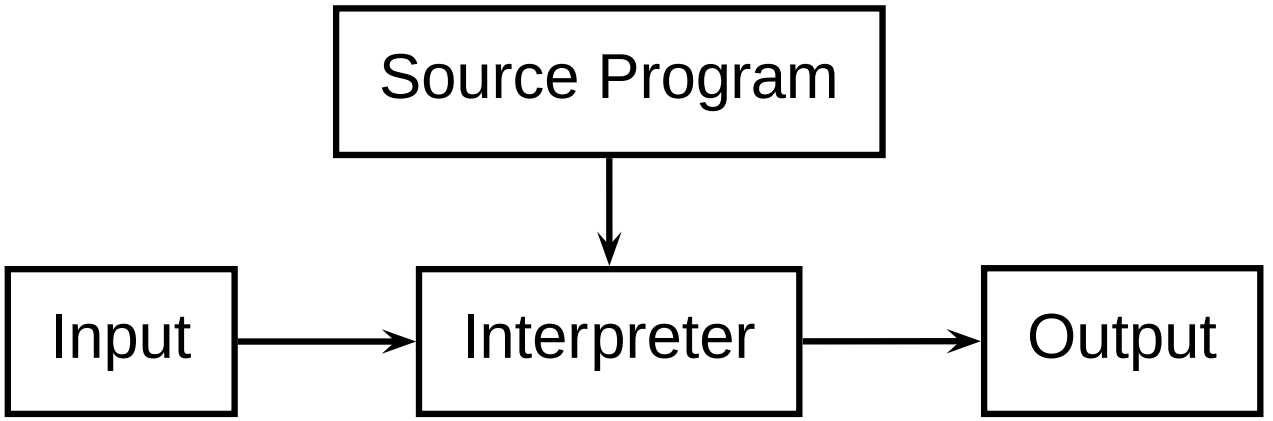
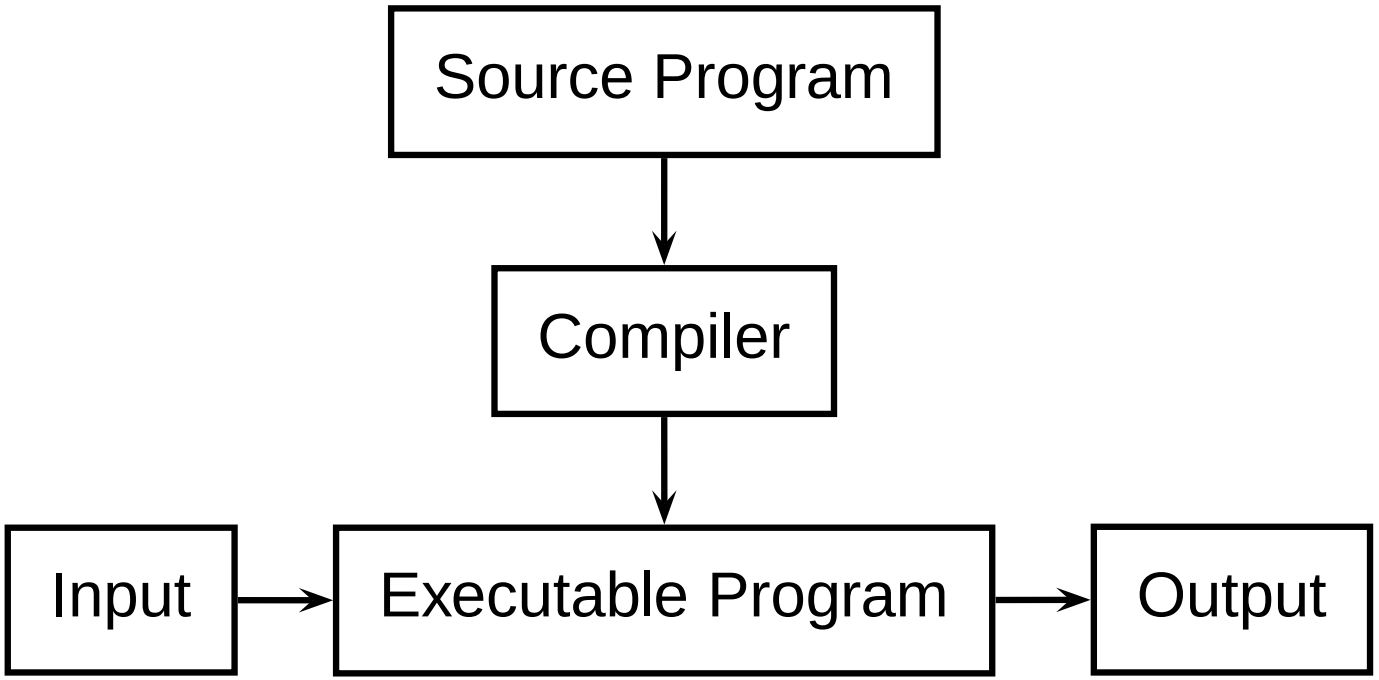
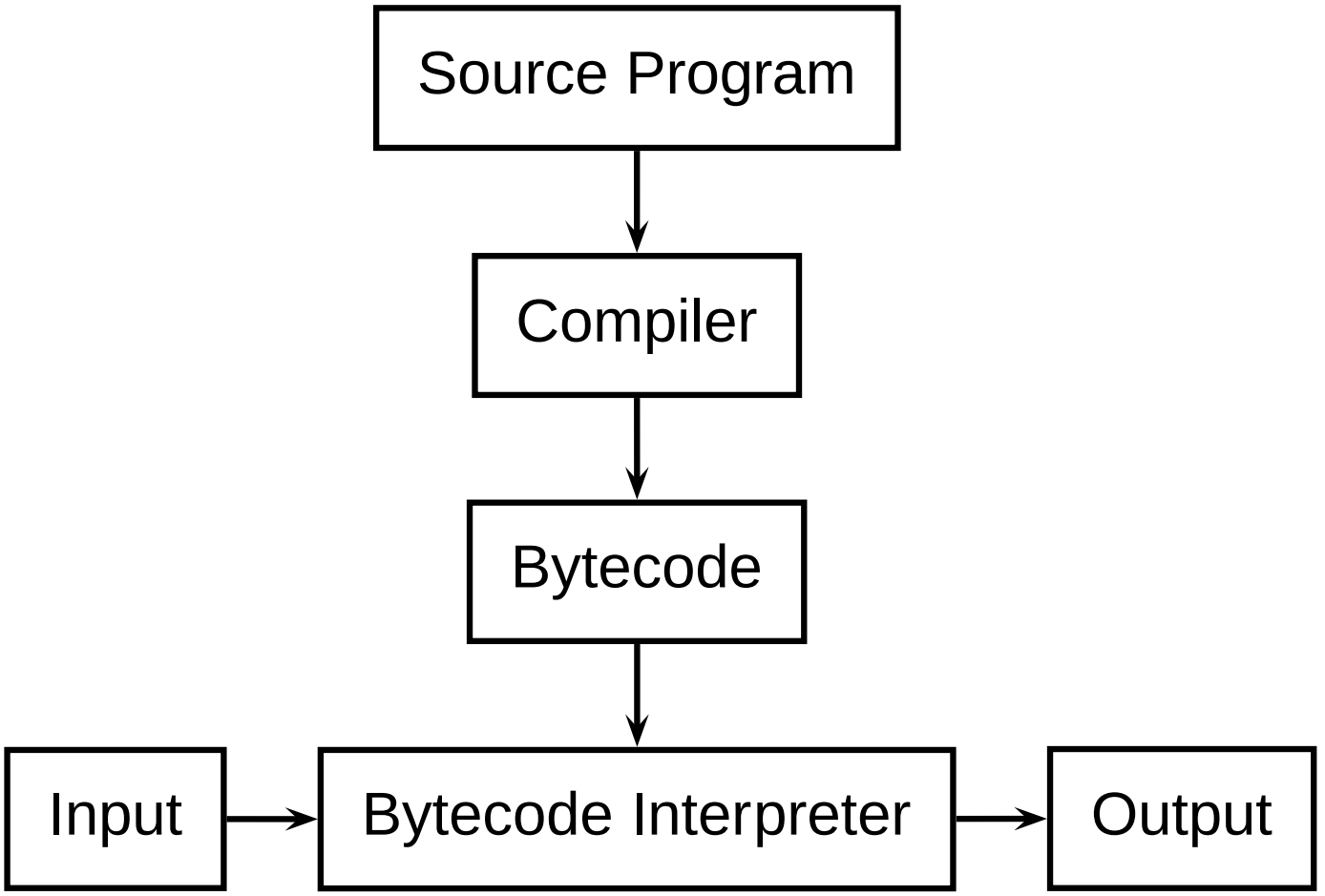
Interpreter



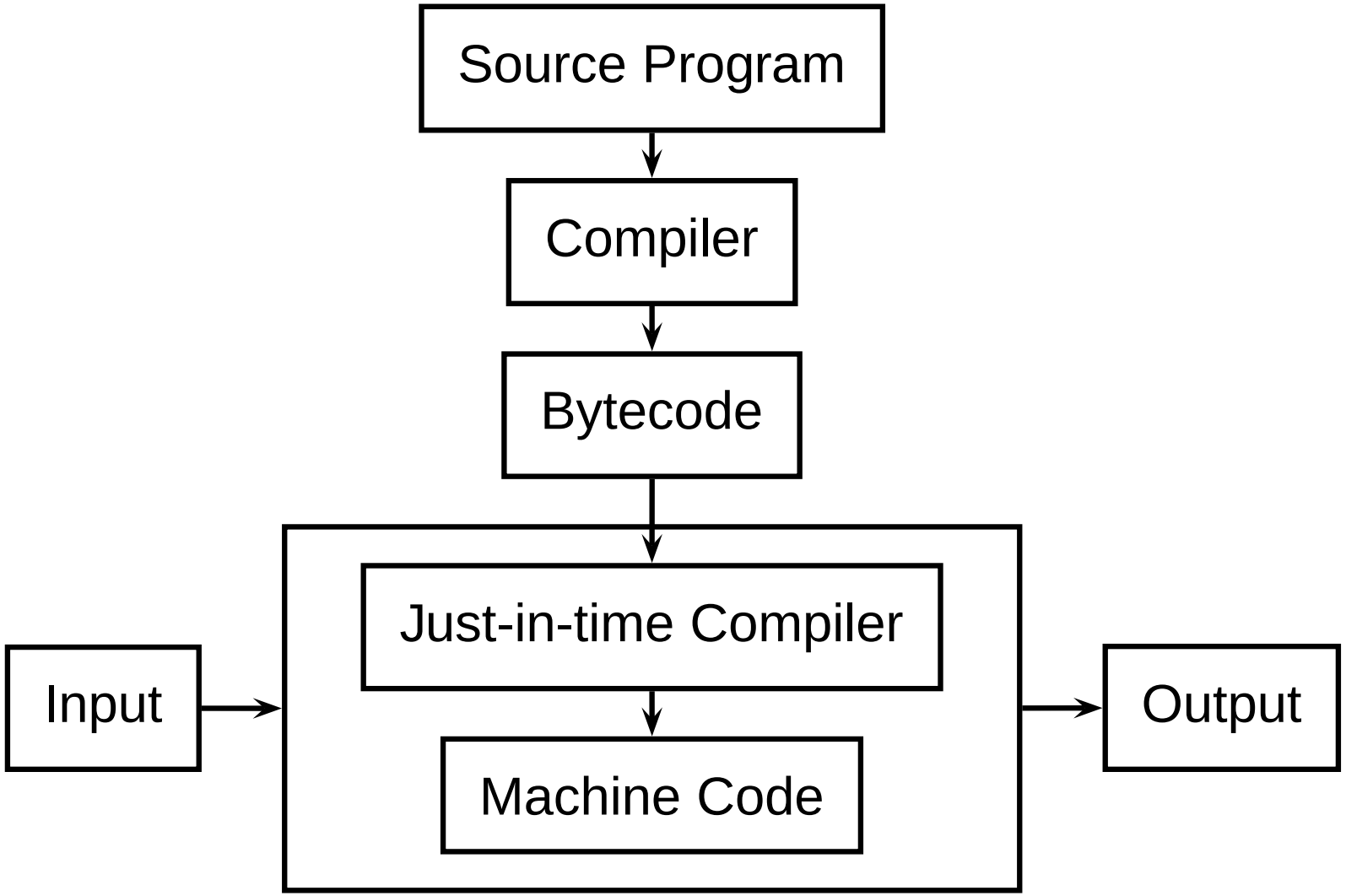
Compiler



Bytecode Interpreter

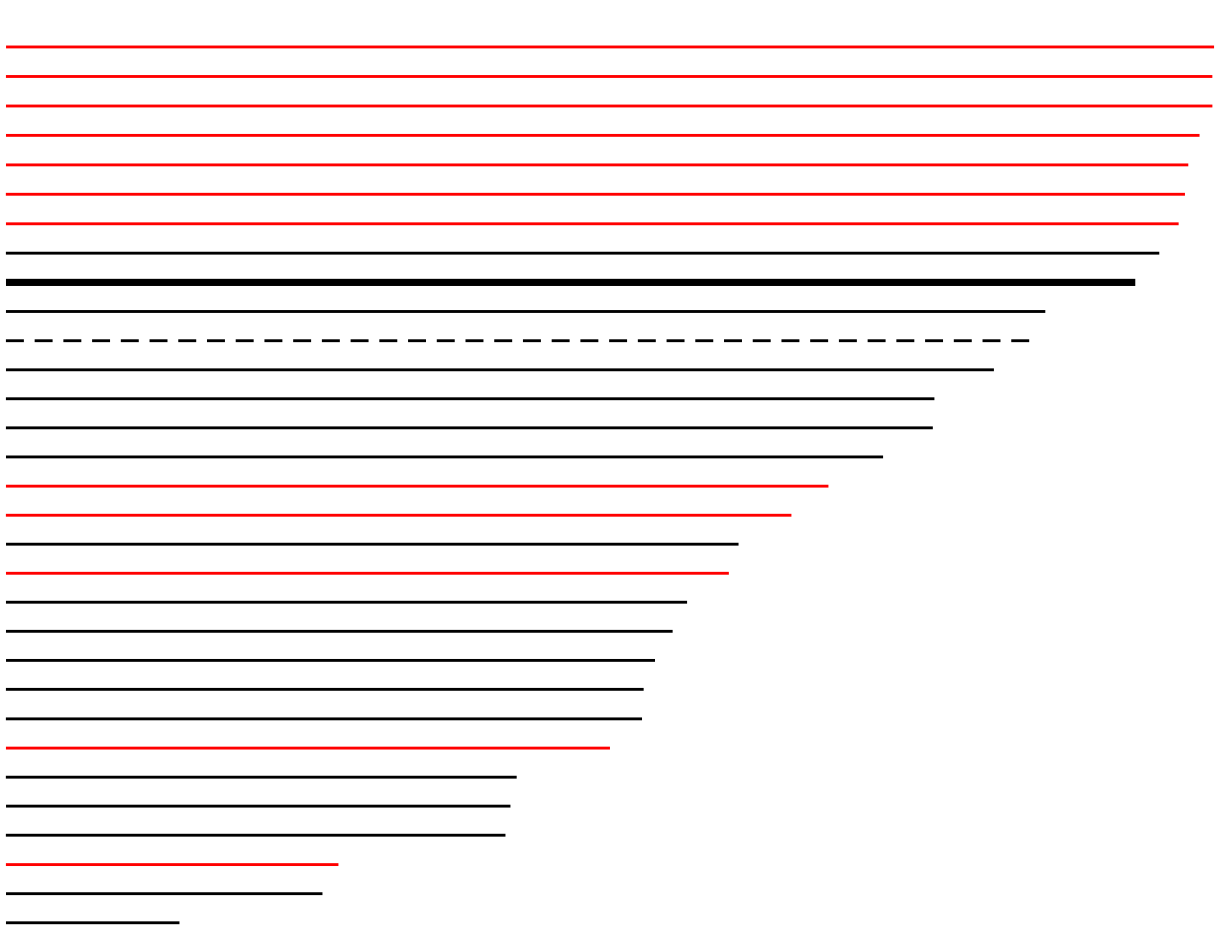


Just-in-time Compiler



Language Speeds Compared

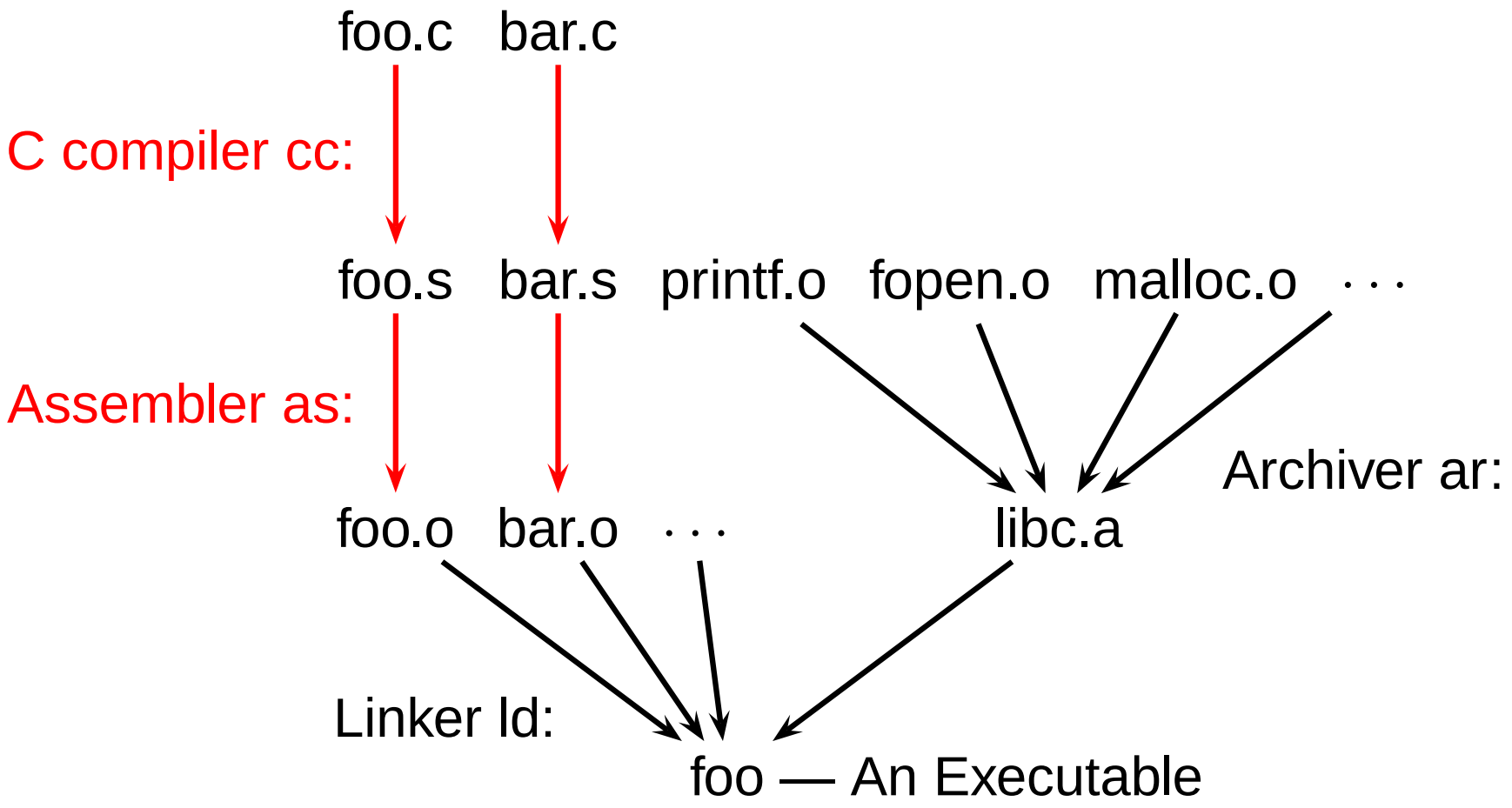
Language	Impl.
C	**gcc**
Ocaml	**ocaml**
SML	**mlton**
C++	**g++**
SML	**smlnj**
Common Lisp	**cmucl**
Scheme	**bigloo**
Ocaml	ocamlb
Java	**java**
Pike	pike
Forth	*gforth*
Lua	lua
Python	python
Perl	perl
Ruby	ruby
Eiffel	**se**
Mercury	**mercury**
Awk	mawk
Haskell	**ghc**
Lisp	rep
Icon	icon
Tcl	tcl
Javascript	njs
Scheme	guile
Forth	**bigforth**
Erlang	erlang
Awk	gawk
Emacs Lisp	xemacs
Scheme	**stalin**
PHP	php
Bash	bash



bytecodes **native code** **JIT** *Threaded code*

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

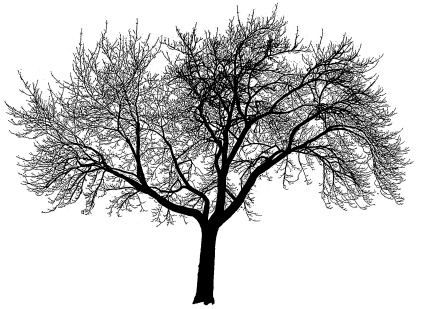
Lexical Analysis Gives Tokens

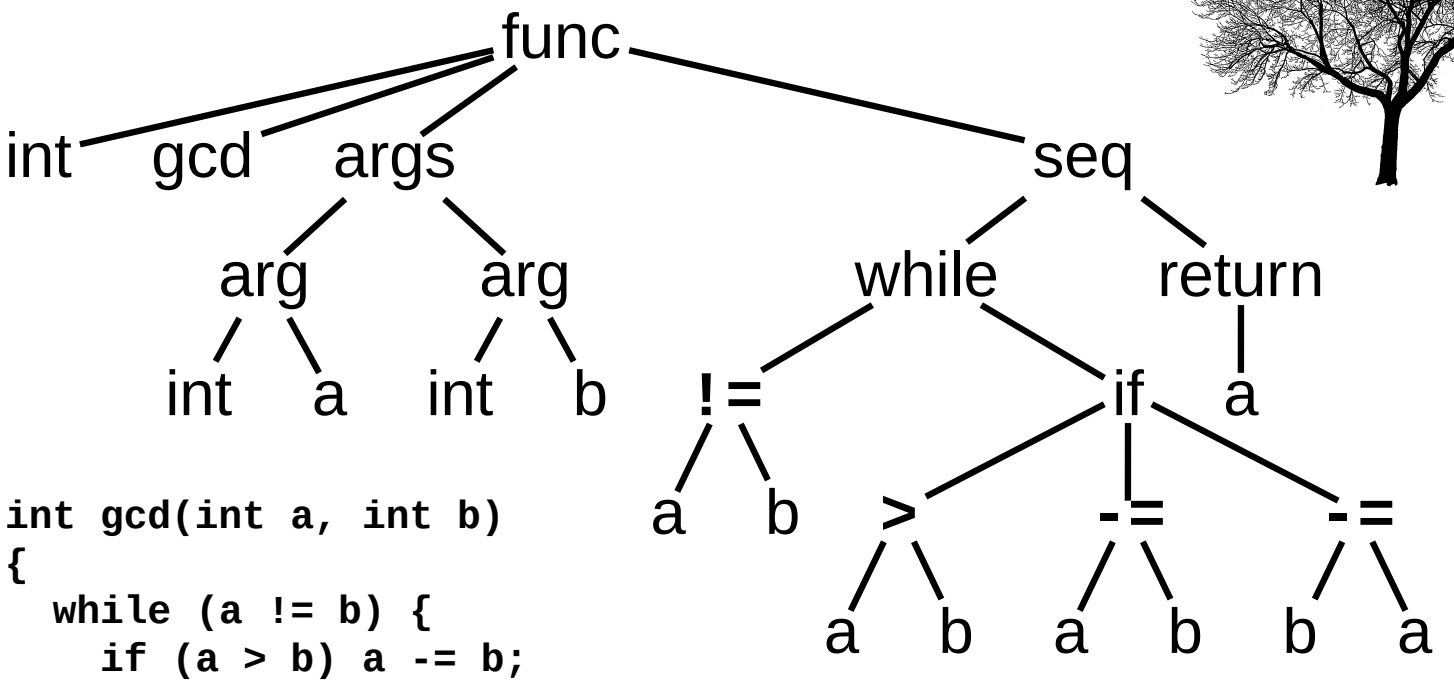
```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

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

A stream of tokens. Whitespace, comments removed.

Parsing Gives an AST

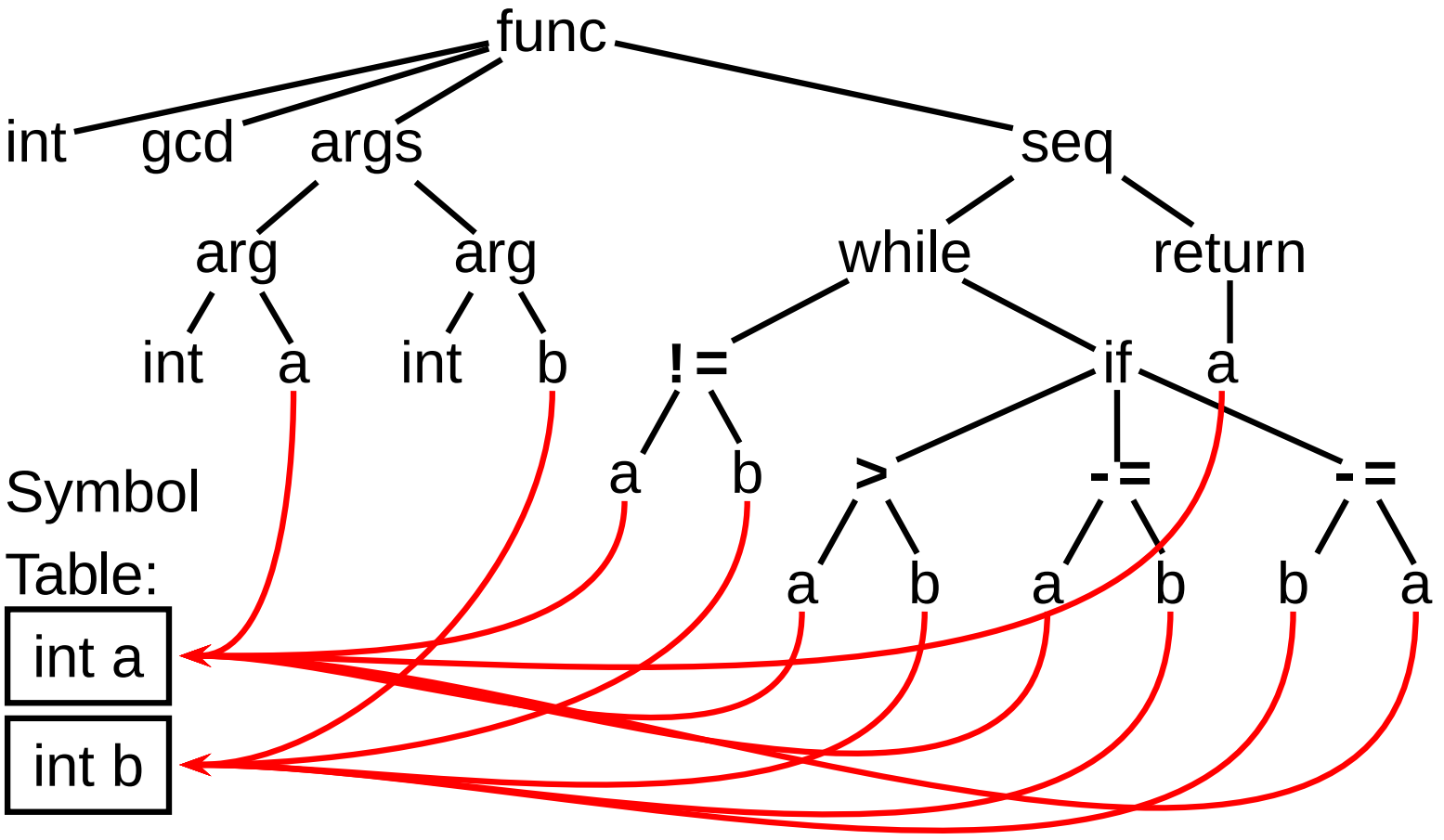





```
int gcd(int a, int b)
{
  while (a != b) {
    if (a > b) a -= b;
    else b -= a;
  }
  return a;
}
```

Abstract syntax tree built from parsing rules.

Semantic Analysis Resolves Symbols



Types checked; references to symbols resolved

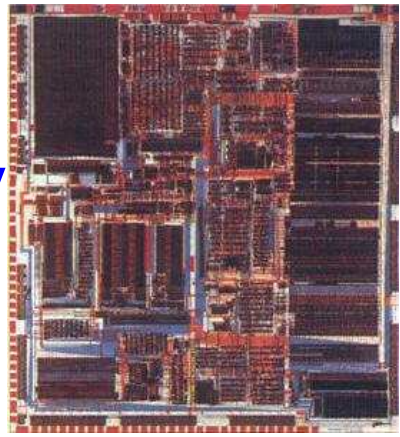
Translation into 3-Address Code

```
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
```