IN2: Trusting Trust

Introduction to Compilers

CMPT 379: Compilers

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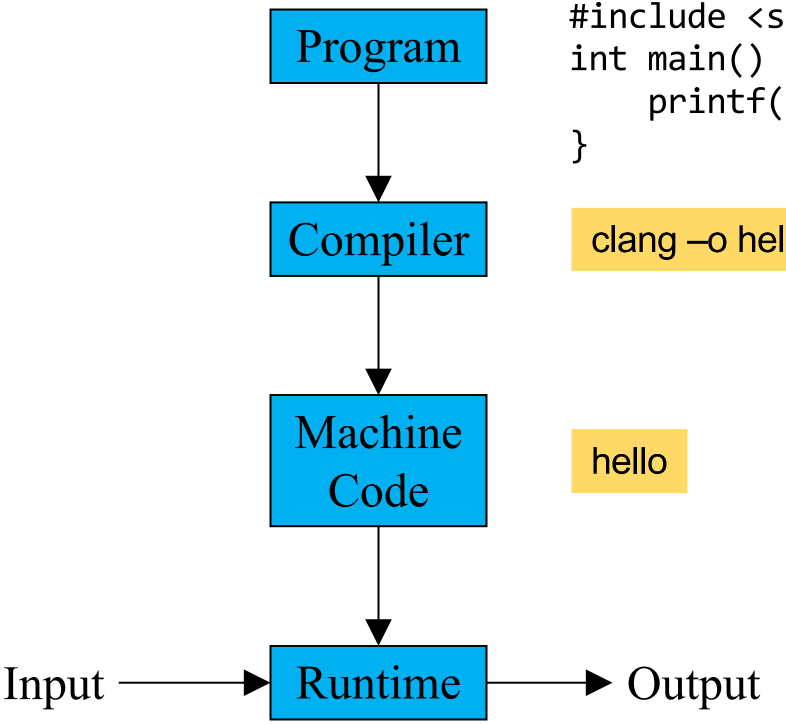
anoopsarkar.github.io/compilers-class



Program

Compiler

Machine Code

Input

Runtime

Output

hello.c

```
#include <stdio.h>
int main() {
    printf("hello world!\n");
}
```

```
clang –o hello hello.c
```

hello

```
$ ./hello
```

Program

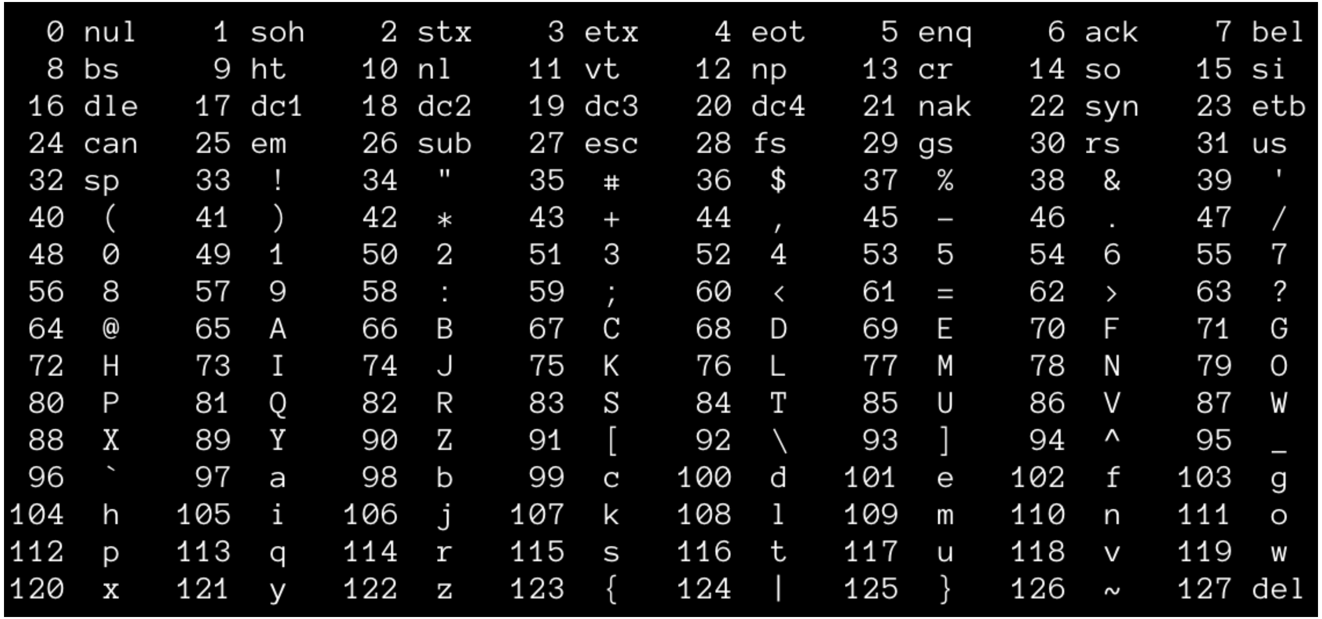
What is a program?

hello.c

```
#include <stdio.h>
int main() {
    printf("hello world!\n");
}
```

```
$ file hello.c
hello.c: c program text, ASCII text
```

ASCII character set



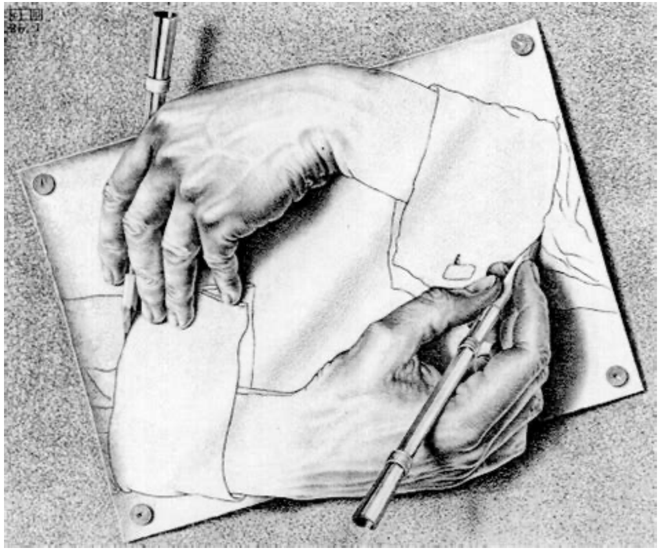
```
  0 nul    1 soh    2 stx    3 etx    4 eot    5 enq    6 ack    7 bel
  8 bs     9 ht    10 nl    11 vt    12 np    13 cr    14 so    15 si
 16 dle   17 dc1   18 dc2   19 dc3   20 dc4   21 nak   22 syn   23 etb
 24 can   25 em    26 sub   27 esc   28 fs    29 gs    30 rs    31 us
 32 sp    33  !    34  "    35  #    36  $    37  %    38  &    39  '
 40  (    41  )    42  *    43  +    44  ,    45  -    46  .    47  /
 48  0    49  1    50  2    51  3    52  4    53  5    54  6    55  7
 56  8    57  9    58  :    59  ;    60  <    61  =    62  >    63  ?
 64  @    65  A    66  B    67  C    68  D    69  E    70  F    71  G
 72  H    73  I    74  J    75  K    76  L    77  M    78  N    79  O
 80  P    81  Q    82  R    83  S    84  T    85  U    86  V    87  W
 88  X    89  Y    90  Z    91  [    92  \    93  ]    94  ^    95  _
 96  `    97  a    98  b    99  c   100  d   101  e   102  f   103  g
104  h   105  i   106  j   107  k   108  l   109  m   110  n   111  o
112  p   113  q   114  r   115  s   116  t   117  u   118  v   119  w
120  x   121  y   122  z   123  {   124  |   125  }   126  ~   127 del
```

Q: Why 128?

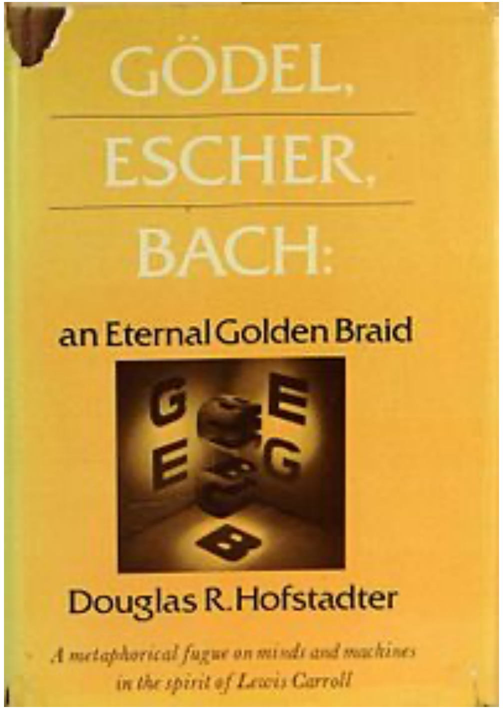
A Quine is a program that generates its own code

- A program is just a text ASCII file
- `printf` prints out ASCII text
- There must be a program that can print out ASCII text that is itself source code for a program
- This would be a program that is a program generator
- A program generator that generates itself is called a Quine

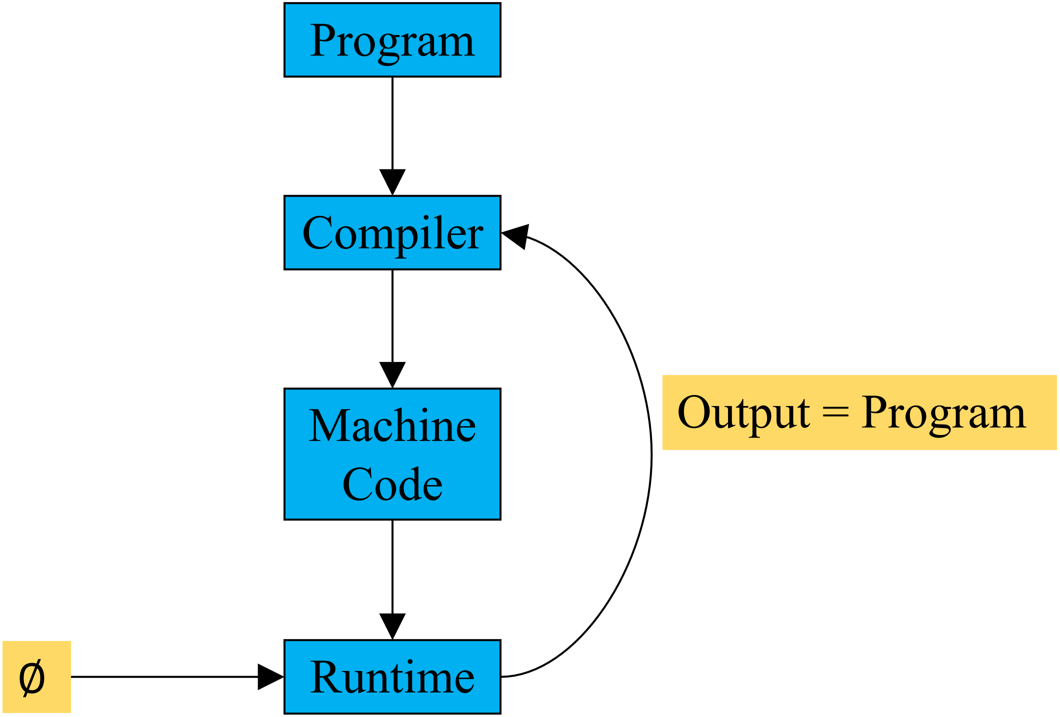
A Quine is a program that generates its own code



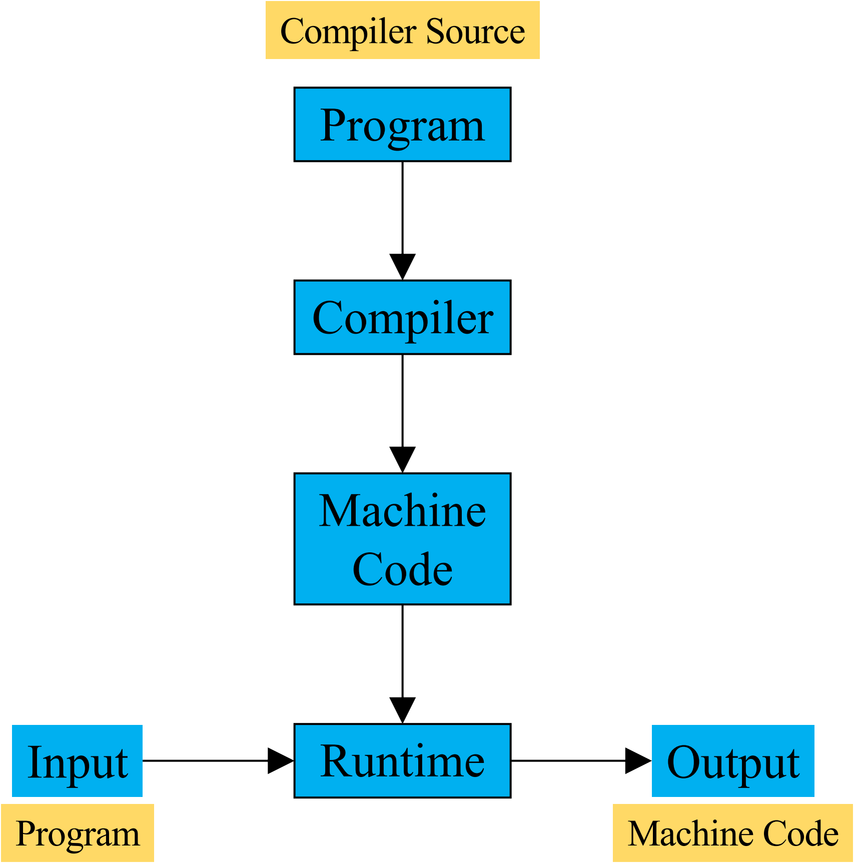
M.C. Escher. “Drawing Hands”


GÖDEL,
ESCHER,
BACH:
an Eternal Golden Braid
G E B
Douglas R. Hofstadter
A metaphorical fugue on minds and machines in the spirit of Lewis Carroll

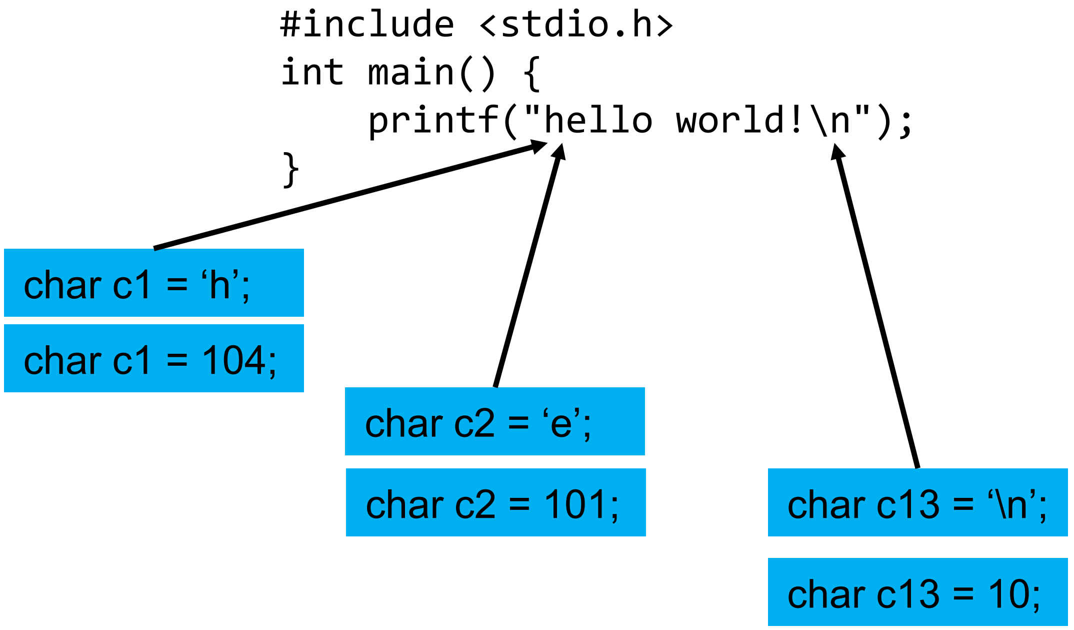
```
#include <stdio.h>
int main(){char *c="#include <stdio.h>%cint main(){char
*c=%c%s%c;printf(c,10,34,c,34,10);}%c";printf(c,10,34,c,34,10);}
```



The compiler has source code – must be compiled


Compiler Source
Program
Compiler
Machine Code
Input
Runtime
Output
Program
Machine Code

Character constants in programming languages



```
#include <stdio.h>
int main() {
    printf("hello world!\n");
}
```

char c1 = ‘h’;

char c1 = 104;

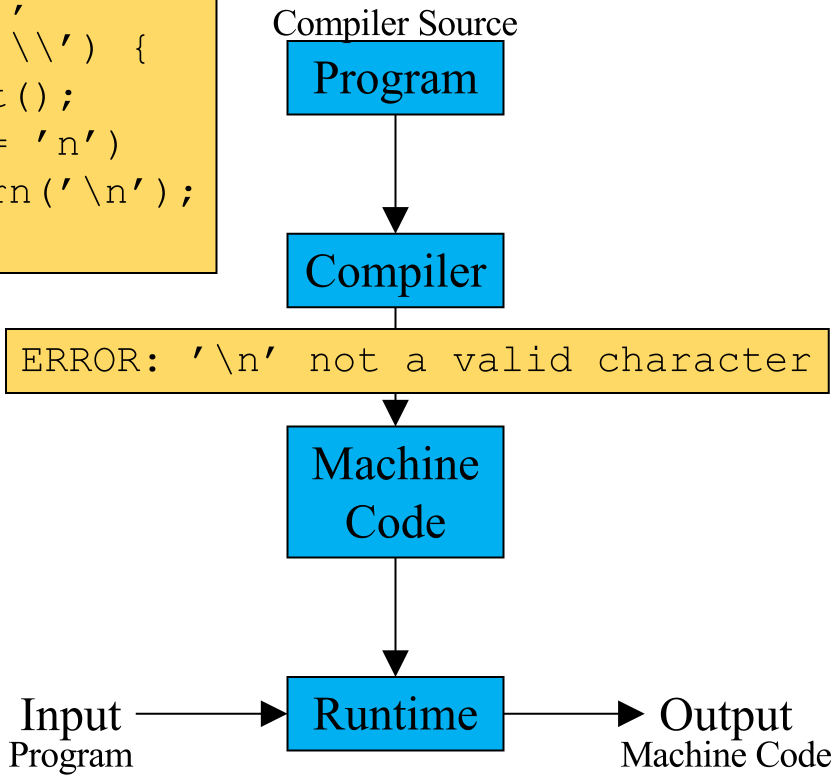
char c2 = ‘e’;

char c2 = 101;

char c13 = ‘\n’;

char c13 = 10;

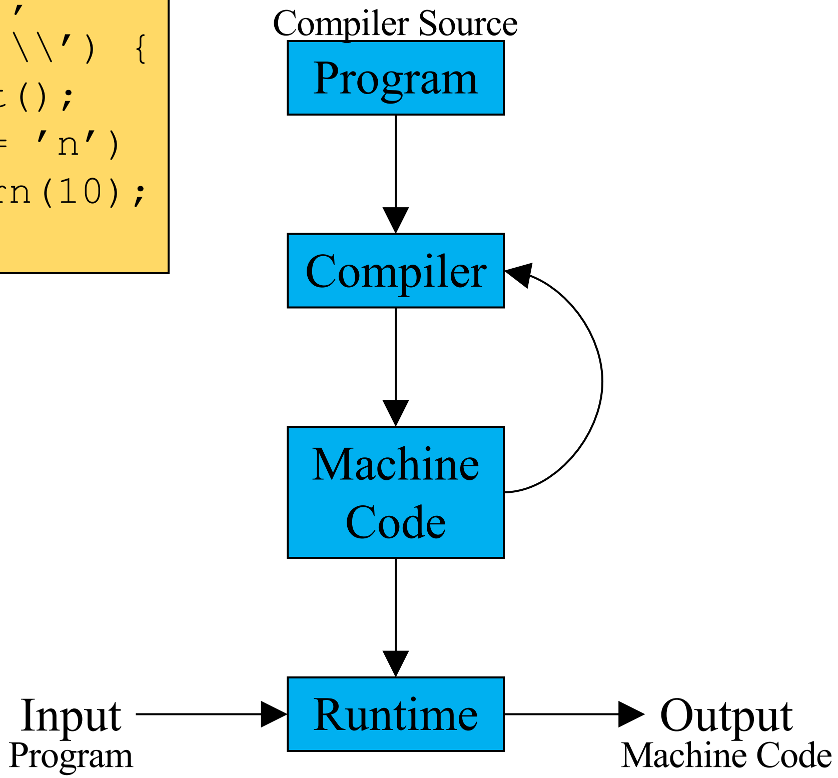
```
c = next();
if (c == ’\\’) {
  c = next();
  if (c == ’n’)
     return(’\n’);
}
```



```
ERROR: ’\n’ not a valid character
```

```
printf(”hello world\n”)
```

```
c = next();
if (c == ’\\’) {
  c = next();
  if (c == ’n’)
     return(10);
}
```



Compiler Source

Program

Compiler

Machine Code

Runtime

Input

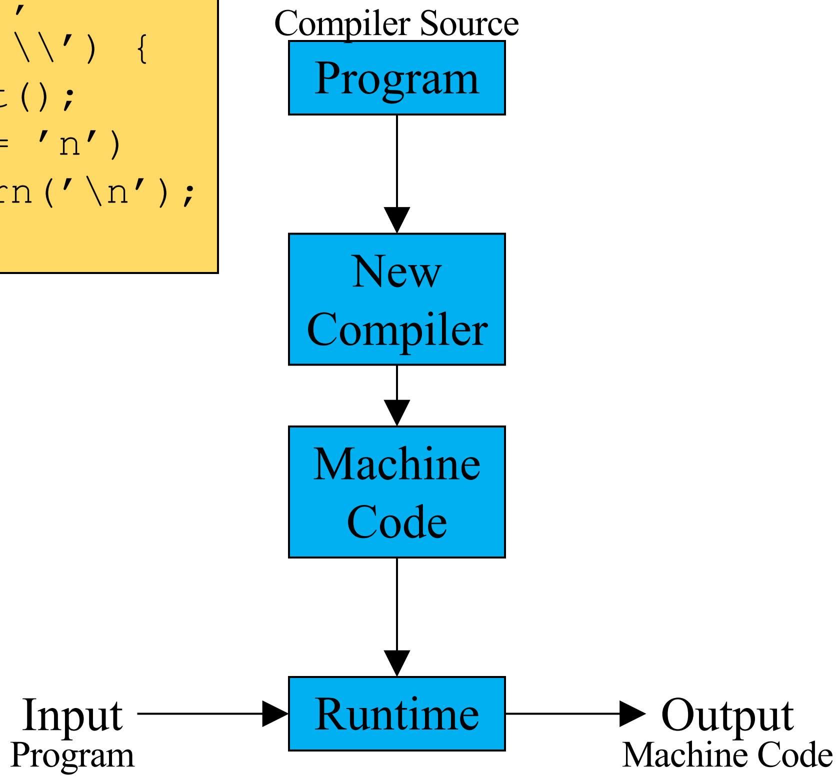
Program

Output

Machine Code

```
printf(”hello world\n”)
```

```
c = next();
if (c == ’\\’) {
  c = next();
  if (c == ’n’)
     return(’\n’);
}
```



Compiler Source

Program

New Compiler

Machine Code

Input

Program

Runtime

Output

Machine Code

```
printf(”hello world\n”)
```

login is just another program

login code from the freebsd GitHub repository:
https://github.com/freebsd/freebsd

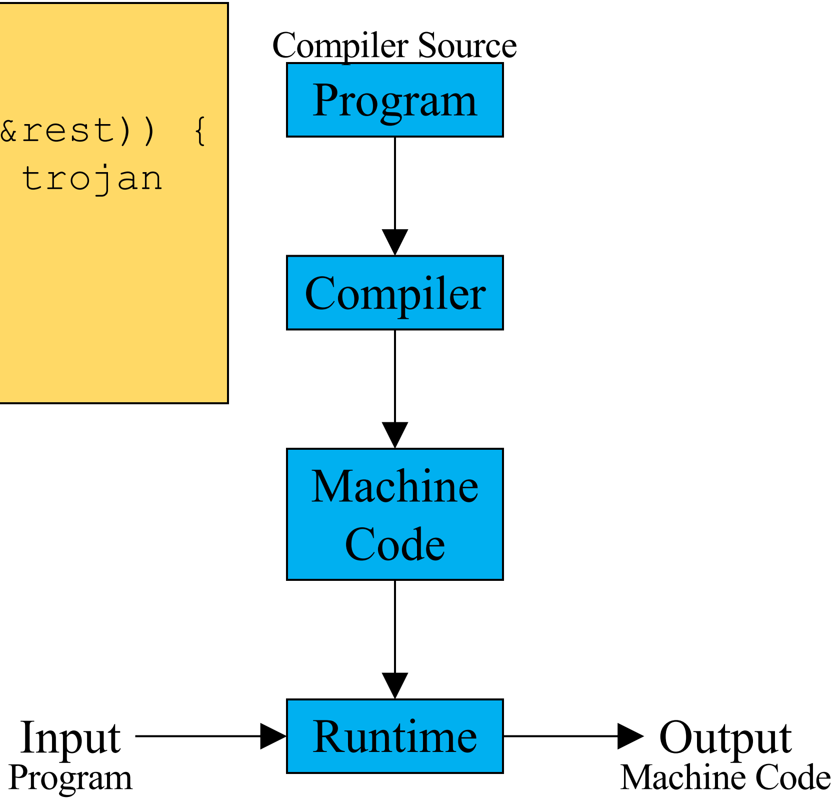
```
static void
do_login(const struct passwd *pwd, char *tty, char *ttyn)
{
  …
  struct spwd *sp = getspnam(pwd->pw_name);
  check_shadow(pwd, sp);
  …

}
```

Get password from system

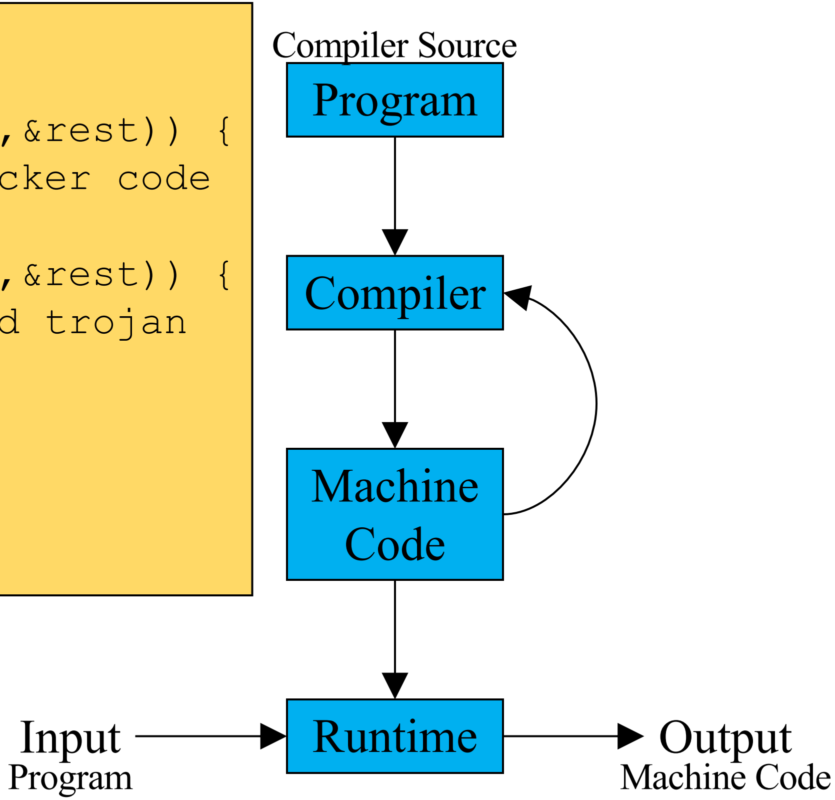
Check entered password against system password

```
compile(char *s)
{
  if(match(s,”login(”,&rest)) {
    // add root passwd trojan
    compile(rest);
  }
  …
}
```



Compiler has login crack

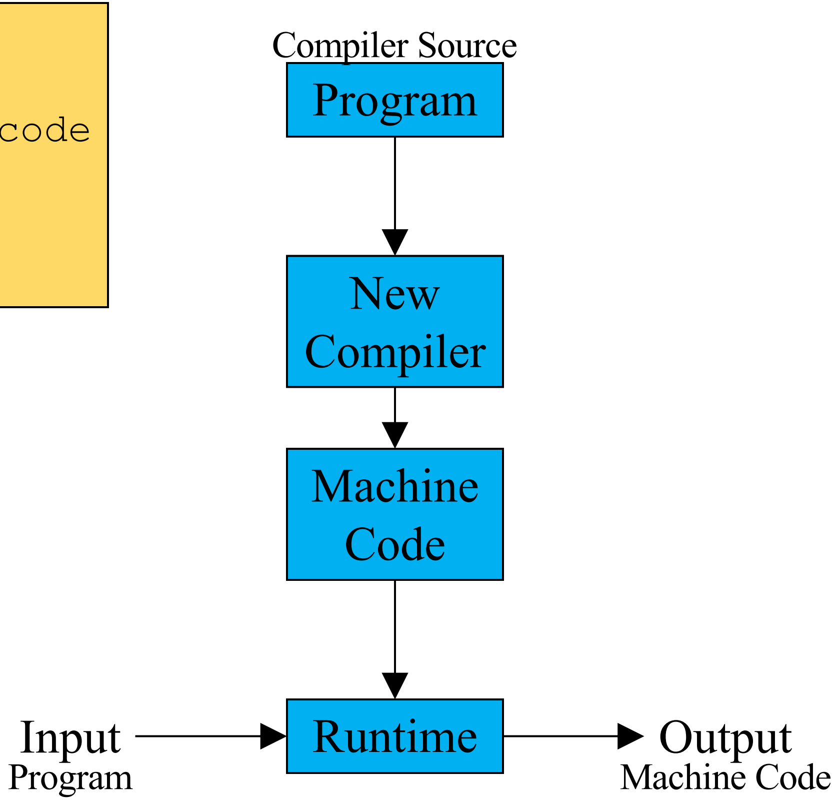
```
compile(char *s)
{
  if(match(s,”compile(”,&rest)) {
    // insert login cracker code
    compile(”
    if(match(s,”login(”,&rest)) {
      // add root passwd trojan
      compile(rest);”);
  }
  compile(rest);
  …
}
```



`Compiler has login crack`

```
compile(char *s)
{
  // standard compiler code
  // no login crack
  …
}
```

Reflections on Trusting Trust,
Ken Thompson.
CACM 27(8), pp. 761-763,
1984.



Compiler Source

Program

New Compiler

Machine Code

Input

Program

Runtime

Output

Machine Code

`Compiler inserts login crack`