goto in C

The goto statement allows transfer of control to any labelled point with a function. For example, this code:

```c
for (int i = 1; i <= 10; i++) {
    printf("%d\n", i);
}
```

can be written as:

```c
int i = 1;

loop:
    if (i > 10) goto end;
    i++;
    printf("%d", i);
    printf("\n");
    goto loop;

end:
```
• goto statements can result in very difficult to read programs.
• goto statements can also result in slower programs.
• In general, use of goto is considered poor programming style.
• Do not use goto without very good reason.
• kernel & embedded programmers sometimes use goto.
Writing correct assembler directly is hard. Recommended strategy:

- develop the solution in C
- map to “simplified” C
- translate each simplified C statement to MIPS instructions

Simplified C

- does not have while, compound if, complex expressions
- does have simple if, goto, one-operator expressions

Simplified C makes extensive use of

- labels ... symbolic name for C statement
- goto ... transfer control to labelled statement

Example:
Mapping C into MIPS

Things to do:

• allocate variables to registers/memory
• place literals in data segment
• transform C program to:
  ▪ break expression evaluation into steps
  ▪ replace control structures by goto
add: C to simplified C

Standard C

```c
int main(void) {
    int x = 17;
    int y = 25;
    printf("%d\n", x + y);
}
```

Simplified C

```c
int main(void) {
    int x, y, z;
    x = 17;
    y = 25;
    z = x + y;
    printf("%d", z);
    printf("\n");
}
```
add: simplified C to MIPS

Simplified C

```c
int main(void) {
    int x, y, z;
    x = 17;
    y = 25;
    z = x + y;
    printf("%d", z);
    printf("\n");
}
```

MIPS

```mips
main:
    li $t0, 17
    li $t1, 25
    add $t2, $t1, $t0
    move $a0, $t2
    li $v0, 1
    syscall
    li $a0, '\n'
    li $v0, 11
    syscall
    jr $ra
```
while: C to simplified C

Standard C

i = 0;
n = 0;
while (i < 5) {
    n = n + i;
i++;
}

Simplified C

i = 0;
n = 0;

loop:
    if (i >= 5) goto end;
    n = n + i;
i++;
    goto loop;
end:
while: simplified C to MIPS

**Simplified C**

```
i = 0;
n = 0;

loop:
    if (i >= 5) goto end;
    n = n + i;
    i++;
    goto loop;

end:
```

**MIPS**

```
li $t0, 0  # i in $t0
li $t1, 0  # n in $t1

loop:
    bge $t0, 5, end
    add $t1, $t1, $t0
    add $t0, $t0, 1
    goto loop

done:
```
if: C to simplified C

Standard C

```c
if (i < 0) {
    n = n - i;
} else {
    n = n + i;
}
```

Simplified C

```c
if (i >= 0) goto else1;
    n = n - i;
    goto end1;
else1:
    n = n + i;
end1:
```

Note: you can’t use else as a label in C
if: simplified C to MIPS

**Simplified C**

```c
if (i >= 0) goto else1;
    n = n - i;
    goto end1;
else1:
    n = n + i;
end1:
```

**MIPS**

```mips
# assume i in $t0
# assume n in $t1
bge $t0, 0, else1
sub $t1, $t1, $t0
goto end1
else1:
    add $t1, $t1, $t0
end1:
```
if/and: C to simplified C

Standard C

```c
if (i < 0 && n >= 42) {
    n = n - i;
} else {
    n = n + i;
}
```

Simplified C

```c
if (i >= 0) goto else1;
if (n < 42) goto else1;
    n = n - i;
    goto end1;
else1:
    n = n + i;
end1:
```
if/and: simplified C to MIPS

Simplified C

```c
if (i >= 0) goto else1;
if (n < 42) goto else1;
    n = n - i;
    goto end1;
else1:
    n = n + i;
end1:
```

MIPS

```assembly
# assume i in $t0
# assume n in $t1
bge $t0, 0, else1
blt $t1, 42, else1
sub $t1, $t1, $t0
goto end1
else1:
    add $t1, $t1, $t0
goto end1
end1:
```
Standard C

```c
if (i < 0 || n >= 42) {
    n = n - i;
} else {
    n = n + i;
}
```

Simplified C

```c
if (i < 0) goto then1;
if (n >= 42) goto then1;
goto else1;
then1:
    n = n - i;
    goto end1;
else1:
    n = n + i;
end1:
```
int main(void) {
    for (int i = 0; i <= 10; i++) {
        printf("%d\n", i);
    }
}
Example Printing First 10 Integers

Convert to goto and simple C statements and decide where variables will be stored.

```c
int main(void) {
    int i;       // in register $t0
    i = 0;

    loop:
        if (i >= 10)
            goto end;
        i++;
        printf("%d", i);
        printf("%c", '\n');
    goto loop;

    end:
        return 0;
}
```
Example Printing First 10 Integers

```assembly
main:
    li $t0, 0     # i = 0;

loop:
    bge $t0, 10 end  # if (i >= 10) goto end;
    add $t0, $t0 1  # i++;
    move $a0, $t0  # printf("%d" i);
    li $v0, 1
    syscall
    li $a0, \n      # printf("\n");
    li $v0, 11
    syscall
    b loop        # goto loop;

end:
    jr $ra        # return
```