


# Control in ACSE

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# Control Statements



Control statements allows to customize the execution trace at run-time:

- if
- while
- for
- ...

They are implemented through *jumps*:

- special instructions
- allow to select the next instruction to execute at run-time


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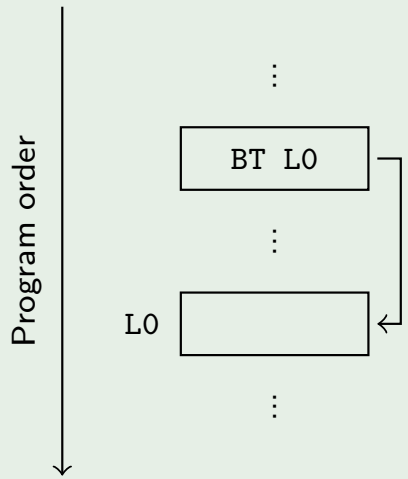
# Where to Jump? I

ACSE is a syntax-directed translator:

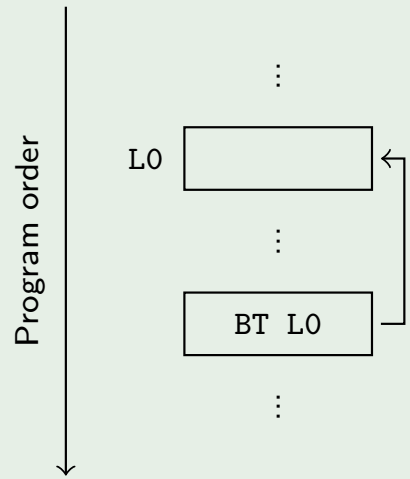
- instructions emission constrained by source code ordering

But jumps are specials:

## Forward jump




## Backward jump




# Where to Jump? II



Forward jumps:

- conditionals, loop exits
- when we generate the jump we only known that we must jump (jump target not yet emitted)

Backward jumps:

- found in loops
- when we generate the jump we known where to jump (we have already emitted the code where we want to jump)

# Where to Jump? III

To address jump translation:

- physical address vs logical location

*Labels* represent logical locations.

## Addresses

Consider a `while` statement containing 4 instructions:

physical address 4 instructions after loop head

logical address the statement following the loop

# Labels



The `axe_engine.h` contains APIs for label management:

**Label management APIs**

| Function | Meaning |
|---|---|
| `newLabel` | create a label |
| `assignLabel` | bind a label to a logical address [1] |
| `assignNewLabel` | combined operation |

Binding to physical addresses performed by ACSE.

[1] Fixing.


# Exploiting Labels



Two scenarios:

## Forward jump

1. create a label *lbl* when a jump is needed
2. jump to *lbl*
3. fix *lbl* when the corresponding statement is reached

## Backward jump

1. create and fix label at jump target
2. emit jump to *lbl* when the jump statement must be generated

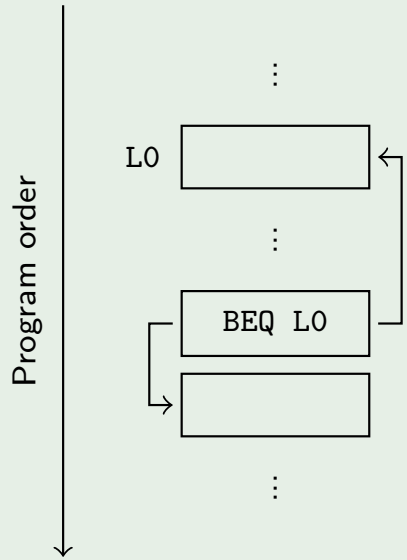
# Fall-through Path

Usually branches have two outgoing edges:

**jump** points to the label associated with the jump instruction

**fall-through** points to the next statement

## Branch paths

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# A Real Control Structure I

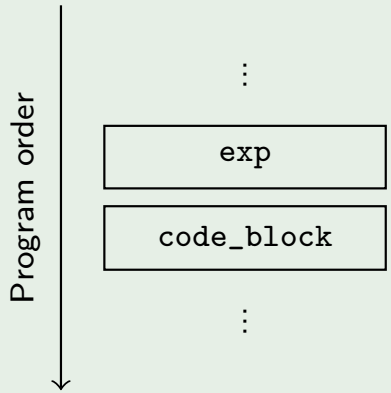
Consider the `while` statement:

## `while` grammar rule

```
while_statement:
  WHILE LPAR exp RPAR code_block;
```

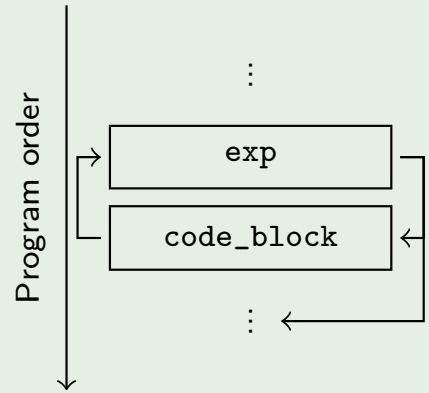
What we have:

## Naked `while`




What we would have:

## Theoretical flow



# A Real Control Structure II



Once `exp` has been evaluated we can:

- exit the loop
- enter the loop

We need a *conditional jump* to handle such case:

- two paths: taken and not taken

At the end of the `code_block` we need to re-evaluate the loop condition:

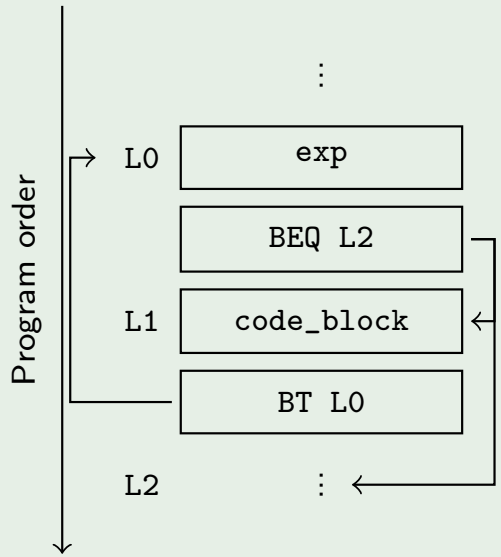
- unconditional branch to `exp` evaluation

All what we need is emitting jumps!

# While Layout I

By reserving spaces for jumps the code layout is:

## Code segment layout

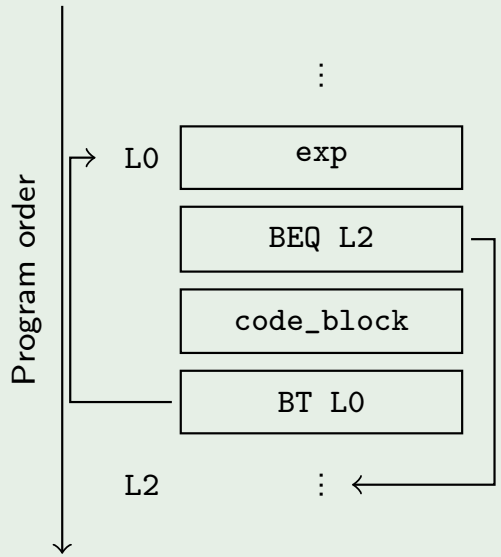


# While Layout II

Edges targets three instructions:

- the fall-through edge is implicit
- can be eliminated
- we need only two labels

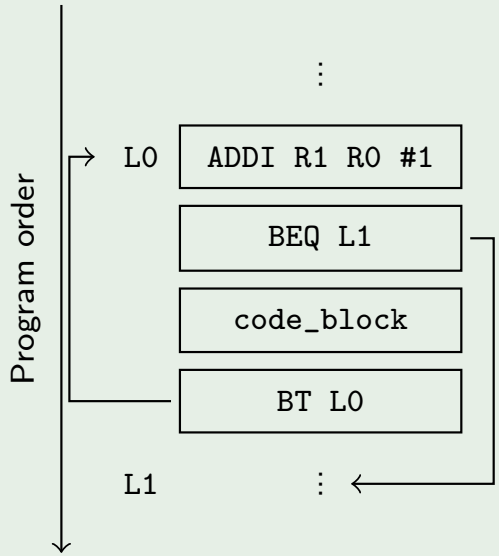
## Removing useless labels



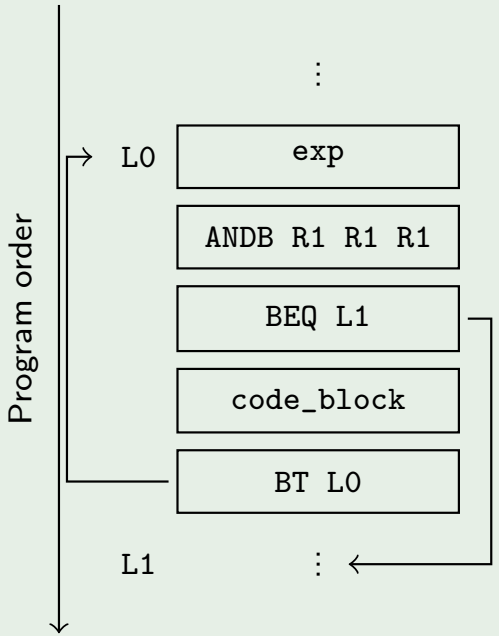
# While Layout III

Since the `BEQ` jumps predicates over the zero bit, we must enforce its evaluation:

## exp is an immediate




## exp is an intermediate



# While Sources



The `exp` type is known at compile-time:

- `while_statement` customization performed at compile-time

On sources (`Acse.y`):

- lookup the `while_statement` rule
- the `WHILE` token is *typed*

We need:

- an action in the middle to generate the loop exit jump
- an action to generate the backward jump and marking the statement end label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# Handling Constructs



All programming languages are built around few simple constructs:

- those not present in ACSE can be found in the test

Better to type rules related to complex constructs:

- keep code clean!

Try starting with a scheme:

- to get an overview
- some minds work better with pictures

Do not redo work:

- read the ACSE headers
- some code already present (e.g. `collections.h`)


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# Bibliography



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