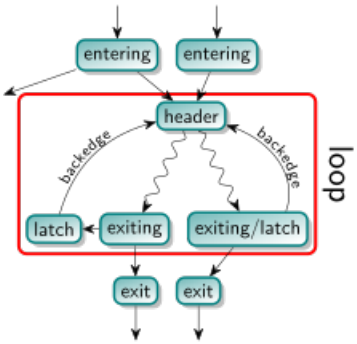
Loop in LLVM

1 Loop

I was surprised to learn that loops can be defined at the LLVM IR level. In higher-level programming languages like C, loops have their own syntax and are clearly a language structure. However, this is not the case in LLVM IR.

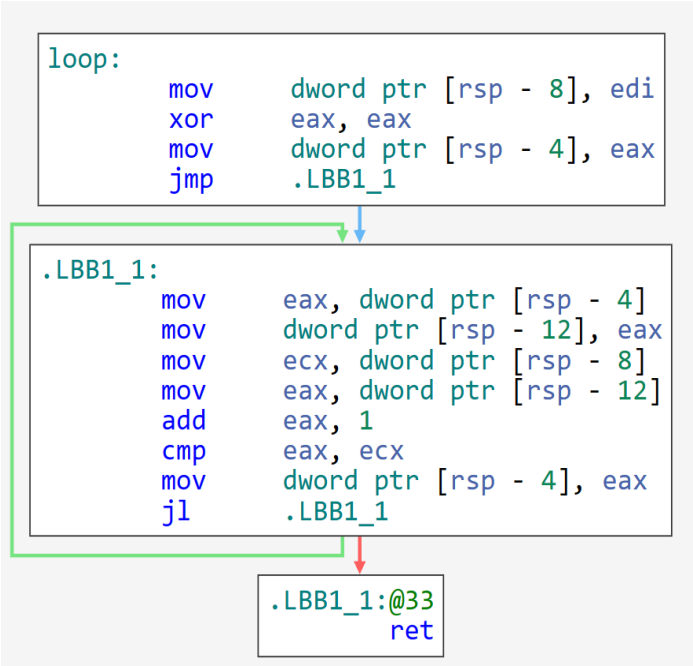
Despite this, LLVM IR does have a definition of a loop. A loop consists of three main parts: a header, an exiting block, and a latch.



Here is an example of loop written in LLVM IR.

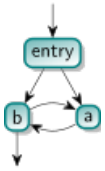
```
define void @test(i32 %n) {
entry:
  br label %body
body:
  %i = phi i32 [ 0, %entry ], [ %i.next, %latch ]
  ; Loop body
  br label %latch
latch:
  %i.next = add nsw i32 %i, 1
  %cond = icmp slt i32 %i.next, %n
  br i1 %cond, label %body, label %exit
exit:
  ret void
}
```

It's CFG generated by compiler explorer.



2 Cycle

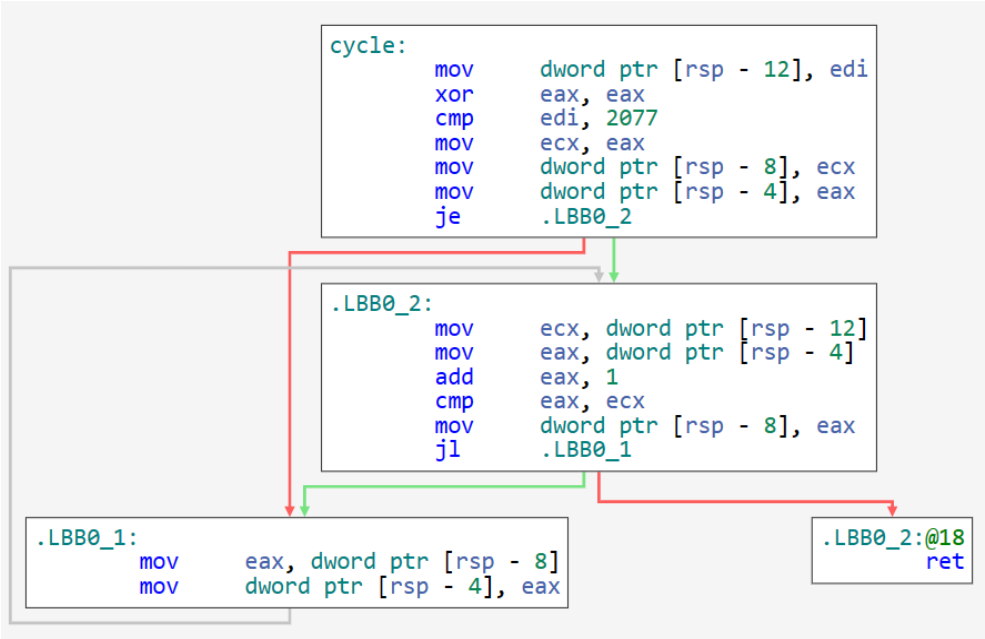
In LLVM, cycles are not considered loops. Instead, they are blocks that link to each other in the control flow graph (CFG) without a common header block to jump back to.



Here is a cycle:

```
define void @test(i32 %n) {
entry:
  ; Check if n is 2077
  %is2077 = icmp eq i32 %n, 2077
  ; If n is 2077, jump to latch, otherwise jump to body
  br i1 %is2077, label %latch, label %body
body:
  %i = phi i32 [ 0, %entry ], [ %i.next, %latch ]
  ; Loop body
  br label %latch
latch:
  %i.in = phi i32 [%i, %body], [0, %entry]
  %i.next = add nsw i32 %i.in, 1
  %cond = icmp slt i32 %i.next, %n
  br i1 %cond, label %body, label %exit
exit:
  ret void
}
```

And its CFG:



A cycle in LLVM IR becomes a loop if all edges from outside the subset of blocks that form the cycle point to the same node, which is called the header. Conversely, a cycle is not considered a loop if not all external edges point to the header.

3 Reference

Loop Definition (https://llvm.org/docs/LoopTerminology.html)