APT Session 7: Compilers

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What to expect from this session

1. Building a compiler.

Prerequisites

1. Have the programming language of your choice (e.g. Java, Python) installed and running on your computer.
2. Clone and compile Mark Ormesher's Stack Program Visualiser.
3. For Java: clone and compile Sam White's parser.
4. For Python: download my simple parser.

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- Our starting grammar:

```
Stmt   ::= Assign | While | Print
Assign ::= ID = Expr ;
Expr   ::= INT + Expr | INT - Expr | INT < Expr
           | INT > Expr | INT
While  ::= WHILE Expr { stmt* }
Print  ::= PRINT Expr ;
```

- Python and Java tree-creating parsers are provided for this grammar.

Compilers (2)

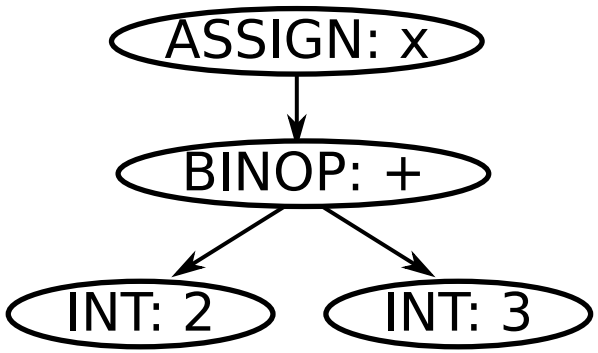
- The transformation our compiler needs is fairly simple. For example `print 2 + 3;` should be transformed to:

```
INT 2
INT 3
ADD
PRINT
EXIT
```

- The trick is to break this transformation into phases. The first is parsing (which we did in the last session). The second is code generation (which we'll do today). The (optional) third is optimisation (which we don't need).

Parse trees

- Last time we wrote a ‘yes/no’ parser. More commonly we want a parse tree as output.
- For example the parse tree for `x = 2 + 3;` is:



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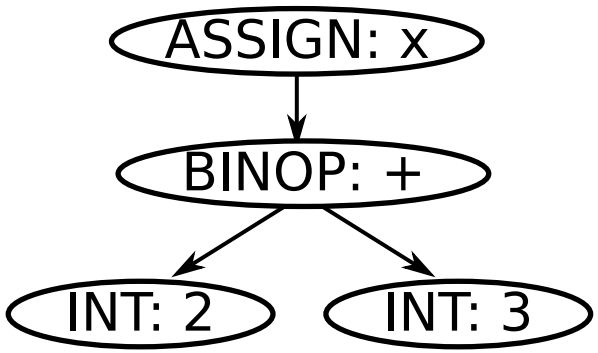

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Exercises:

1 Use your chosen parsing library to parse `print 2`.

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Exercises:

1. Write the program `print 2;` into a file `ex1.hll`.
2. Write a simple compiler which reads a file in, parses it, converts it to a stack-based format and prints the output to `stdout`. Initially you only need to handle parse trees of the form `print(int(`*n*`))` (where *n* is an integer). Run the output in the stack visualiser.

More sophisticated traversal

- Compilers mostly do a *preorder* traversal: process the node; process the LHS of the node (all the way); process the RHS of the node (all the way).
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Exercises:

1. Adjust your previous compiler to be a class with traversal functions `t_` and a general `preorder` function.
2. Write the program `print 2 + 3` into a file `ex2.hll`.
3. Add a binop traversal function.
4. Run the output in the stack visualiser.

Variables

- Working only with the stack is frustrating; we want a heap. Variables are named parts of the heap.
- The stack machine has two variable instructions:

```
VAR_SET x
VAR_LOOKUP y
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`VAR_SET` sets the variable `x` to the (peeked) top of the stack.
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Exercises:

1. Write the program `x=2; y=2+3; print y+1;` into a file `ex3.hll`.
2. Add variable traversal functions.
3. Run the output in the stack visualiser.

Conditionals

- The stack machine defines `LESS_THAN`, `MORE_THAN`, and `EQUALS` which do:

```
rhs = stack.pop()
lhs = stack.pop()
stack.push(lhs op rhs)
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  where `op` is <, >, or ==. 0 is pushed for false, 1 for true.

Exercises:

1. Write the program `print 2 < 3;` into a file `ex4.hll`.
2. Add conditional traversal functions.
3. Run the output in the stack visualiser.

Loops

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Exercises:

1. Write the program

```
i = 0;
while i < 10 {
    print i;
    i = i + 1;
}
```

   into a file `ex5.hll`.

2. Add a while loop traversal function. You will need labels and jumps.

3. Run the output in the stack visualiser.

Post-session exercises

Try these (no particular order):

- Extend the parser to handle functions and update the compiler accordingly.
- Read how difficult is it to write a compiler? in light of your experiences.