Script **generated by TTT**

Title: Petter: Compiler Construction (02.07.2020) - 49: Introduction to R-CMa

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Topic:

Code Synthesis

Generating Code: Overview

We inductively generate instructions from the AST:

- there is a rule stating how to generate code for each non-terminal of the grammar
- the code is merely another attribute in the syntax tree
- code generation makes use of the already computed attributes

In order to specify the code generation, we require

- a semantics of the language we are compiling (here: C standard)
- a semantics of the machine instructions

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$\rightsquigarrow$ we commence by specifying machine instruction semantics

The Register C-Machine (R-CMa)

We generate Code for the Register C-Machine.
The Register C-Machine is a virtual machine (VM).

- there exists no processor that can execute its instructions
- . . . but we can build an interpreter for it
- we provide a visualization environment for the R-CMa
- the R-CMa has no **`double`**, **`float`**, **`char`**, **`short`** or **`long`** types
- the R-CMa has no instructions to communicate with the operating system
- the R-CMa has an unlimited supply of registers

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The R-CMa is more realistic than it may seem:

- the mentioned restrictions can easily be lifted
- the *Dalvik VM/ART* or the *LLVM* are similar to the R-CMa
- an interpreter of R-CMa can run on any platform

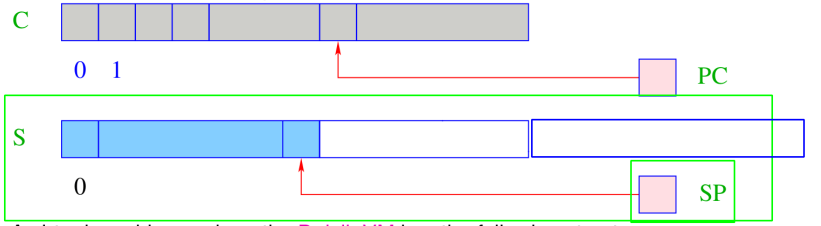
Virtual Machines

A virtual machine has the following ingredients:

- any virtual machine provides a set of instructions
- instructions are executed on virtual hardware
- the virtual hardware is a collection of data structures that is accessed and modified by the VM instructions
- ... and also by other components of the run-time system, namely functions that go beyond the instruction semantics
- the interpreter is part of the run-time system

Components of a Virtual Machine

Consider Java as an example:



A virtual machine such as the Dalvik VM has the following structure:

- S: the data store – a memory region in which cells can be stored in LIFO order $\rightsquigarrow$ stack.
- SP: ($\widehat{=}$ stack pointer) pointer to the last used cell in S
- beyond S follows the memory containing the heap

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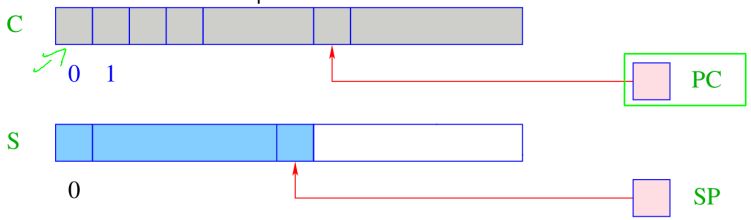

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- SP: (≙ stack pointer) pointer to the last used cell in S
- beyond S follows the memory containing the heap
- C is the memory storing *code*
  - each cell of C holds exactly one virtual instruction
  - C can only be *read*
- PC (≙ program counter) address of the instruction that is to be executed next
- PC contains 0 initially

Executing a Program

- the machine loads an instruction from C[PC] into the instruction register IR in order to execute it
- before evaluating the instruction, the PC is incremented by one

```
while (true) {
  IR = C[PC]; PC++;
  execute (IR);
}
```

- node: the PC must be incremented before the execution, since an instruction may modify the PC
- the loop is exited by evaluating a halt instruction that returns directly to the operating system