Interpreters and Transformers

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Outline

- Compilers and Interpreters
- Transformers
- Anatomy of a Compiler
- A notation for Interpreters
- A notation for Transformers
- Cross-Compilation and Boot-strapping

Compilers and Interpreters

- Compilers and Interpreters are often portrayed as two alternatives to language implementation. *This is a false dichotomy!*
- A more accurate view is:
  - An "interpreter" takes some representation of a program and executes it.
  - A "transformer" takes some representation of a program and creates an equivalent program.
- An interpreter may be implemented in software, hardware, or some combination.
- A transformer may take a representation of the program in one language and produce a representation in another. This is a "translator."
- A translator may do sophisticated whole-program analysis and produce code in a lower-level language. This a "compiler."
- A translator may use the same language for its input and output, but improve the efficiency of the code. This is an "optimizer."

Interpreters

- Perform localized change of program representation
- Execute program *as represented*
- View program as a request for services
- E.g. Byte-code interpreter in JVM
- E.g. PowerPC instruction interpreter in hardware

Transformers

- Take program as input, produce equivalent program as output.
- Can perform global “program-as-a-whole” analysis, translation and reorganization.
- Translators, e.g.

  Modula-3 → C

  Macsyma → Lisp

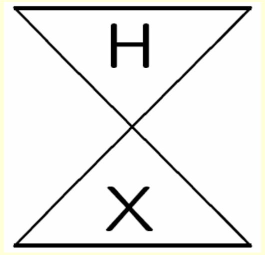
  Fortran → i686
- Optimizers
- Compilers, typically translators + optimizes

Compilation Phases – Simplified

- Lexical Analysis
- Syntactic Analysis
- Semantic Analysis
- Intermediate code generation
- Intermediate code improvement
- Machine-specific code generation
- Machine-specific code improvement

A Notation for Interpreters

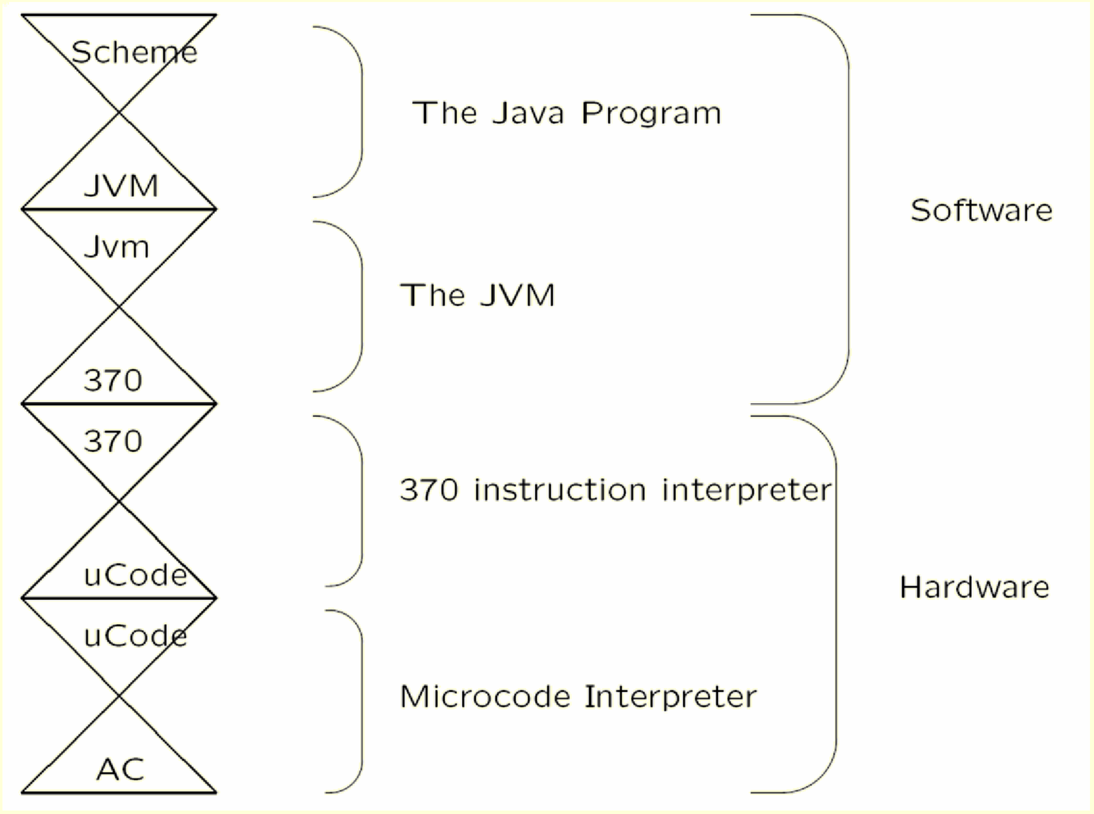
- We use the following diagram as the notation for an interpreter:



"H" is the language being interpreted.
"X" is the language in which the interpreter is implemented
(i.e. the language of it as a program)

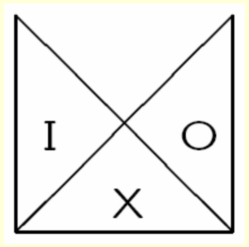
A Notation for Interpreters (cont'd)

- A Scheme interpreter written in Java and compiled to JVM running on an IBM mainframe can be seen as a composition of four interpreters, some in software, some in hardware.



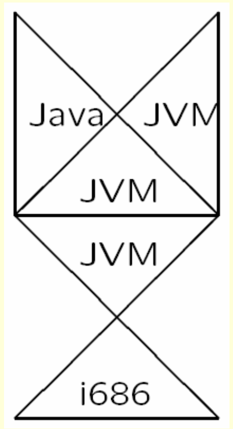
A Notation for Transformers

- We use the following diagram as the notation for a transformer:



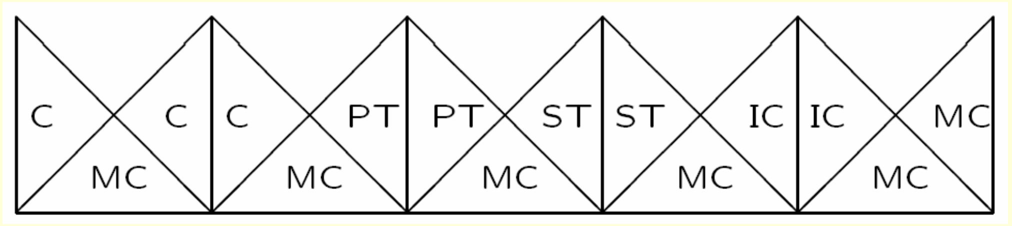
"I" is the language of the input program
"O" is the language of the output program
"X" is the language in which the transformer is implemented

- E.g. A Java compiler for a PC



A Notation for Transformers (cont'd)

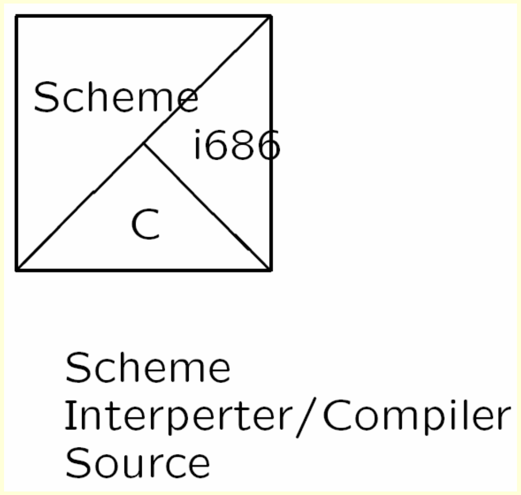
- E.g. A C compiler



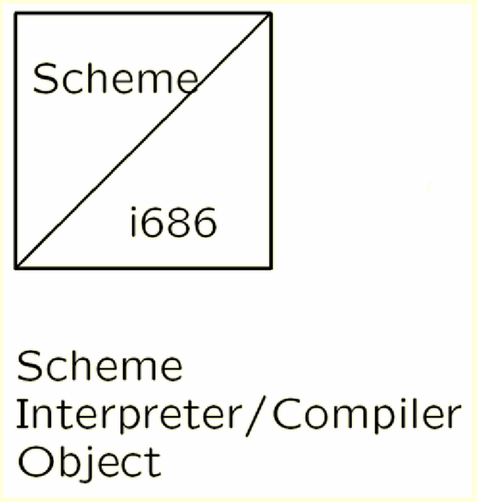
- The steps are
  - C preprocessor: takes C source code to C source code, handling #include, etc.
  - Parser: takes C source code to parse trees (PT)
  - Semantic analysis: takes parse trees to semantic trees (ST), e.g. with type info.
  - Intermediate code generation: Takes semantic trees to a machine-independent intermediate code (IC)
  - Intermediate code optimization (note shown): takes IC to IC
  - Target machine code generation: takes IC to target machine code (MC)
  - Target machine code optimization (not shown): takes MC to MC

Combinations

- Sometimes a program can both translate and interpret.



Scheme Interperter/Compiler Source

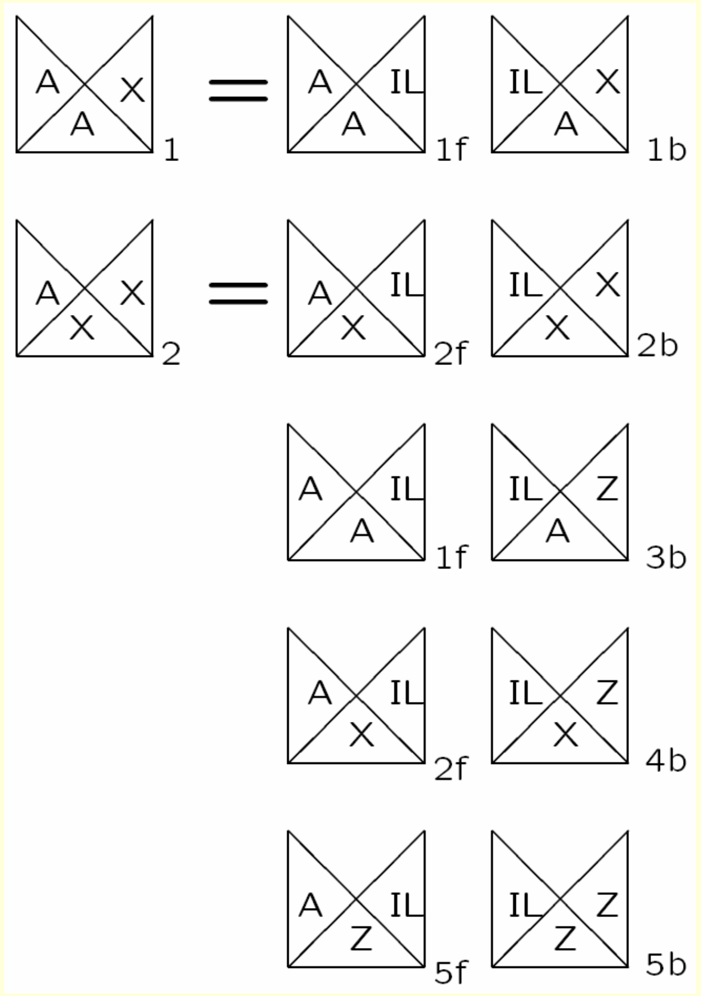


Scheme Interpreter/Compiler Object

- We see this
  - in integrated development environments (IDEs)
  - when dynamic compilation is used
  - in optimizers

Cross-Compilation and Boot-strapping

- Suppose we have a compiler for language A running on some machine X and we wish to construct a compiler which runs on machine Z.



Cross-comp. and Boot-strapping (cont'd)

- **Step 1** Have the source code (1) and executable program (2) for a compiler for language "A" on the machine "X"

  Note that the compiler is composed of many phases, the first group produce a machine-independent form of the compiled program in an intermediate language (IL), and the second group takes this IL program to machine-specific code for "X".
  We group these as (1f)+(1b) and (2f) + (2b).

- **Step 2** Write an IL → Z code generator (3b) in source language A.
  This is the main job. It might be accomplished by adapting the program (1b).

  Compile the program (3b) on machine X using compiler (2) to get the executable program (4b).

- **Step 3** Now (3b) together with (1f) form the source for a full compiler for machine Z.
  And (2f) + (4b) provide an executable compiler running on machine X to produce code for machine Z.

  We now have a "cross-compiler" for machine Z running on X.

- **Step 4** Use the cross-compiler (2f)+(4b) to recompile the source programs (1f)+(3b) to get the executable programs (5f)+(5b) which run on machine Z.
  We are done!