Compiler Construction
Introduction

Guido Wachsmuth

TU Delft
Delft University of Technology

Challenge the future

Course IN4303, 2013/14
Compiler Construction

Overview

today's lecture

I
software languages

III
compiler construction

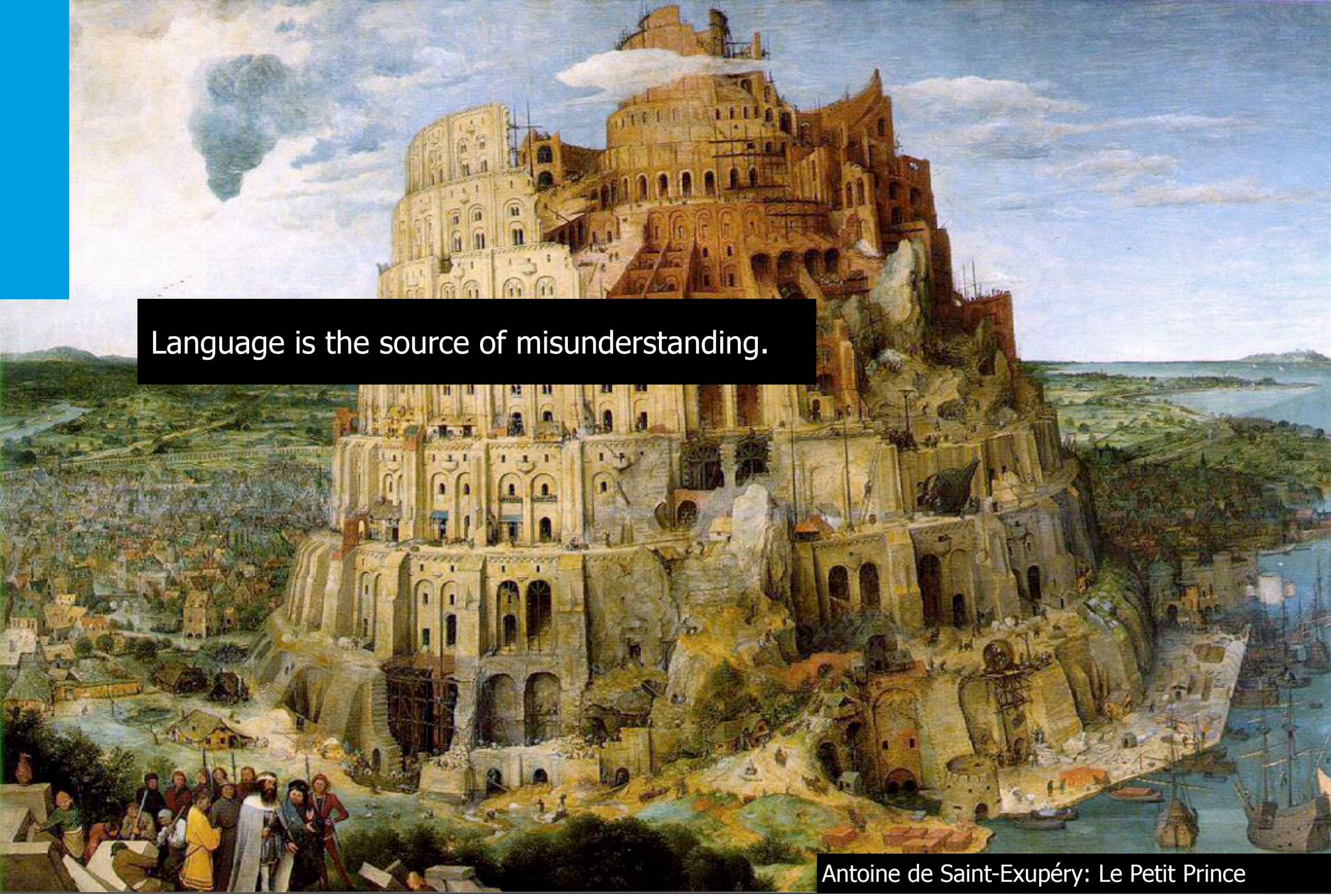
II
modern compilers

IV
organisation

I

software languages


language



Language is the source of misunderstanding.

Antoine de Saint-Exupéry: Le Petit Prince

Language is a

Edward Sapir: Language. An Introduction to the Study of Speech.

Language is a

purely human and non-instinctive method

Edward Sapir: Language. An Introduction to the Study of Speech.

Language is a

purely human and non-instinctive method

of communicating

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ideas, emotions, and desires

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Language is a

purely human and non-instinctive method

of communicating

ideas, emotions, and desires

by means of a system

of voluntarily produced symbols.

Edward Sapir: Language. An Introduction to the Study of Speech.

Language
properties

Language
properties

arbitrary

Language
properties

arbitrary

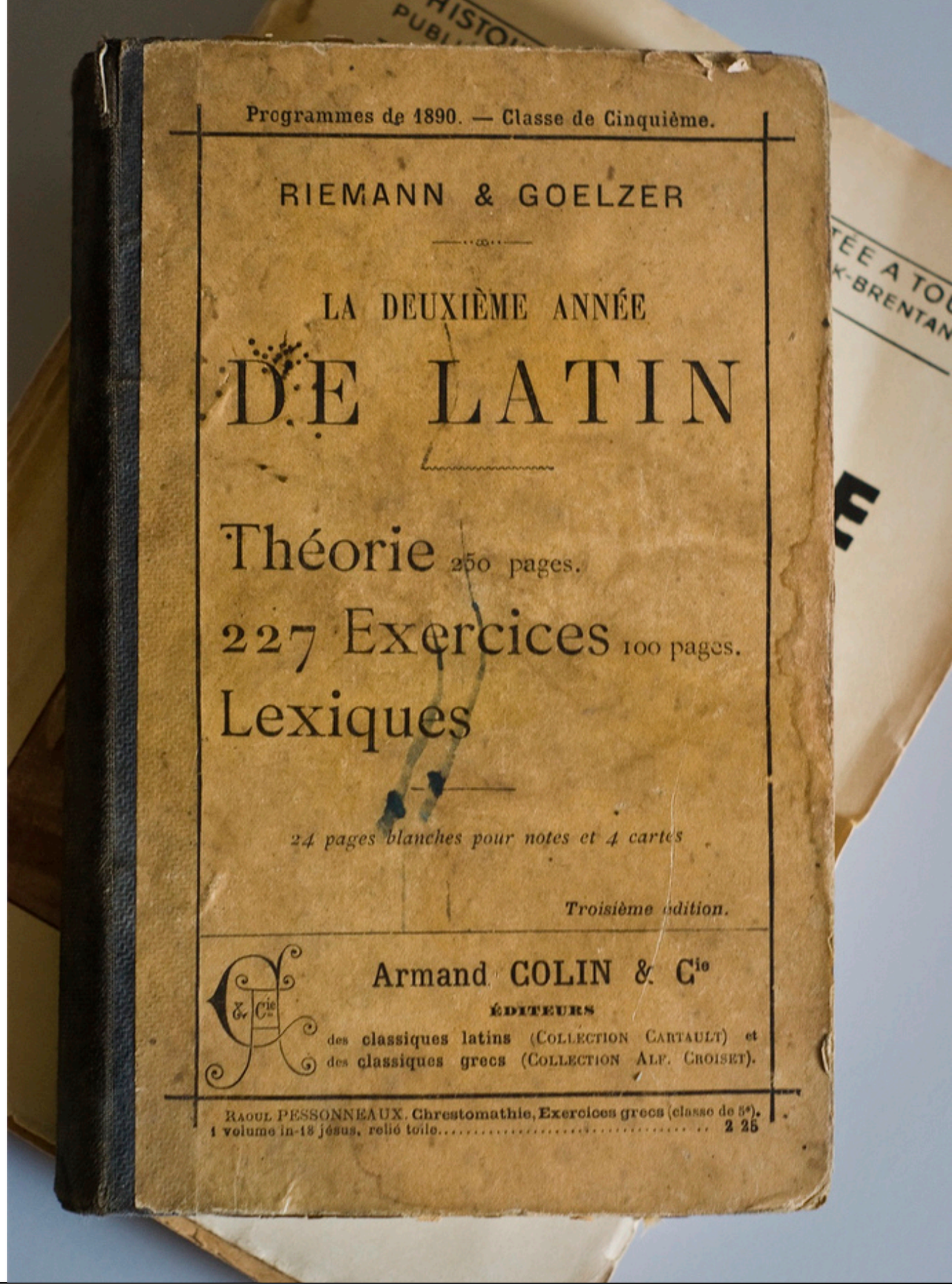
symbolic

Language
properties

arbitrary

symbolic

systematic



Language
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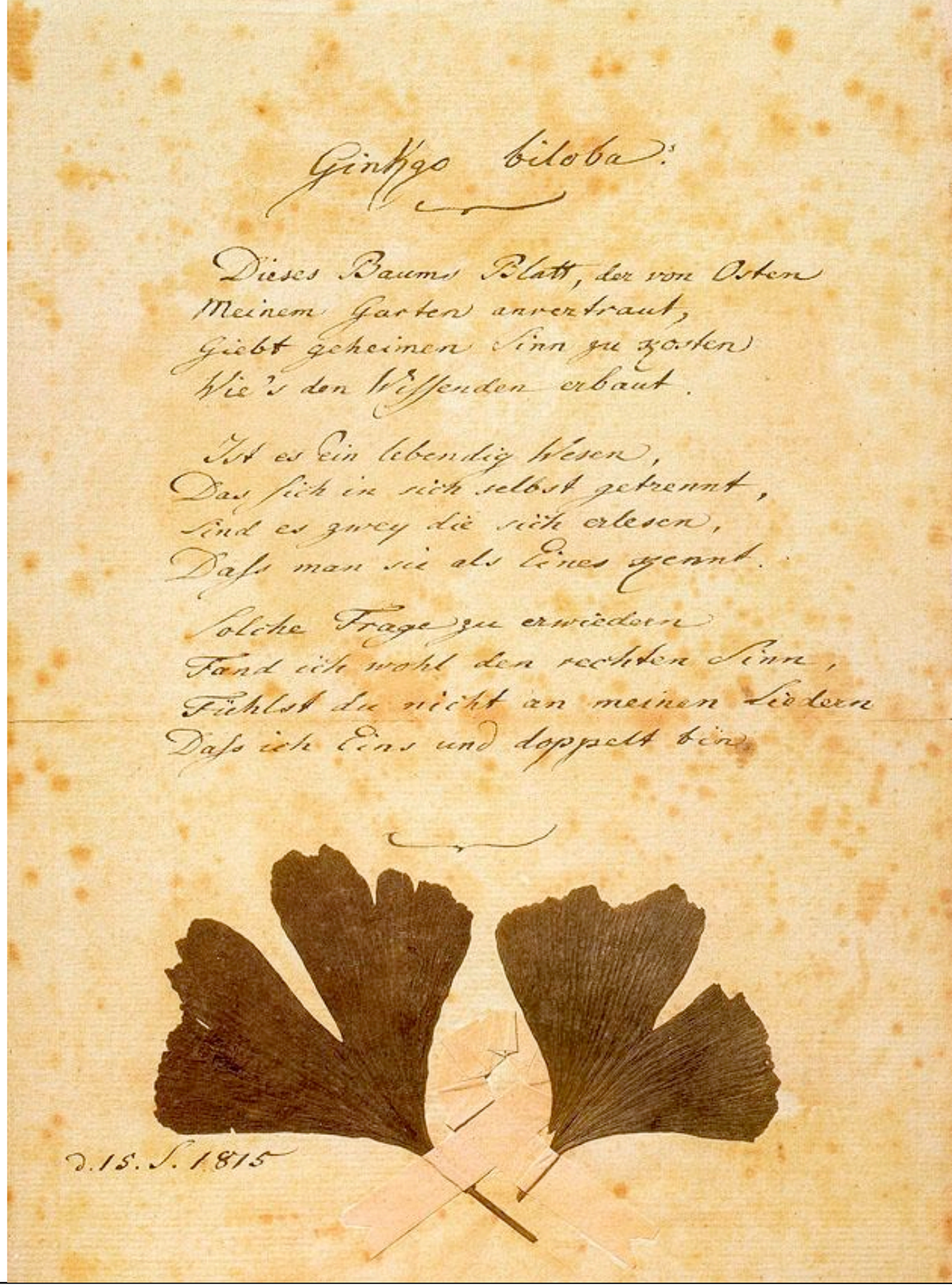
arbitrary

symbolic

systematic

productive



Language
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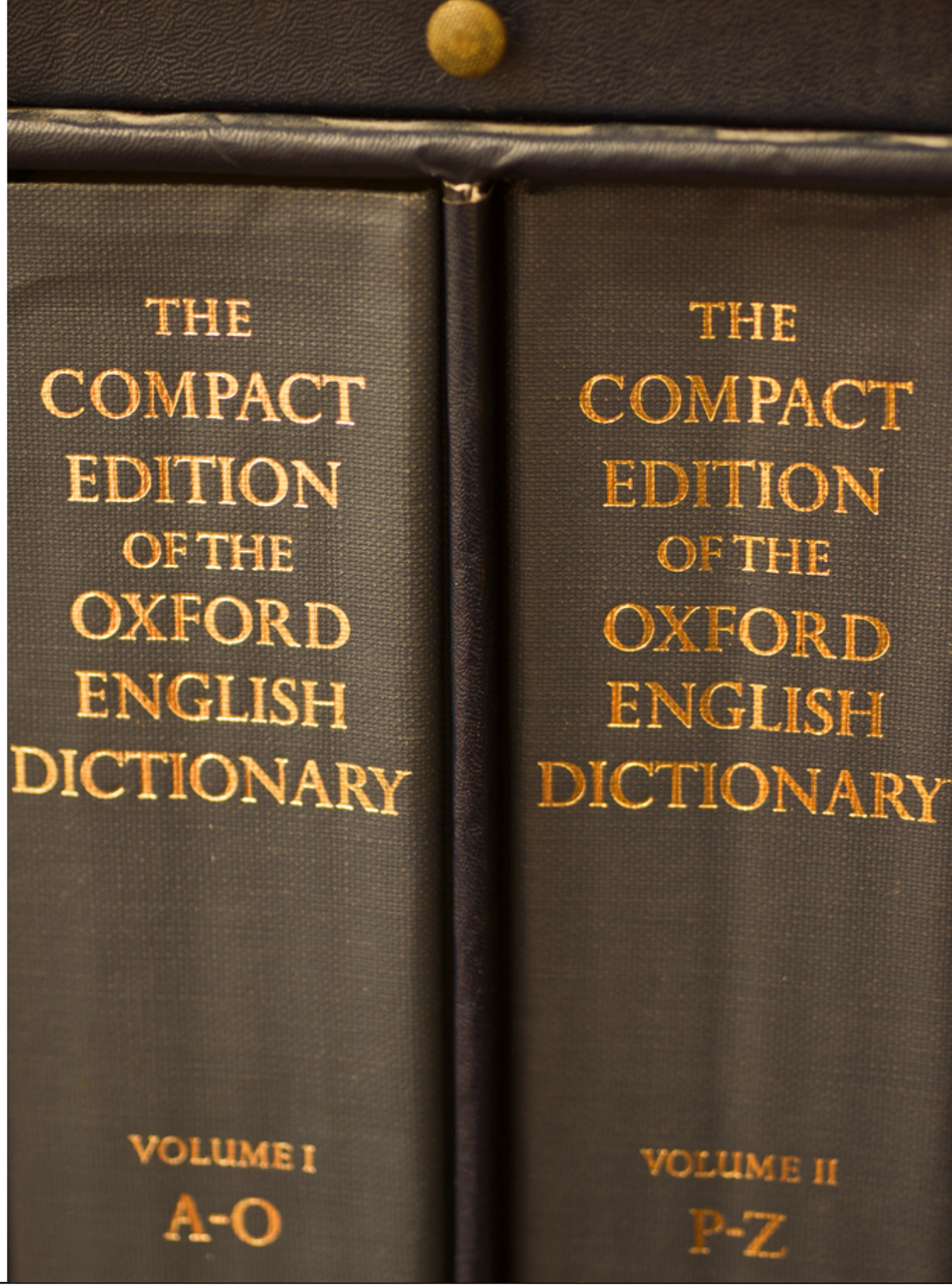
non-instinctive



Language
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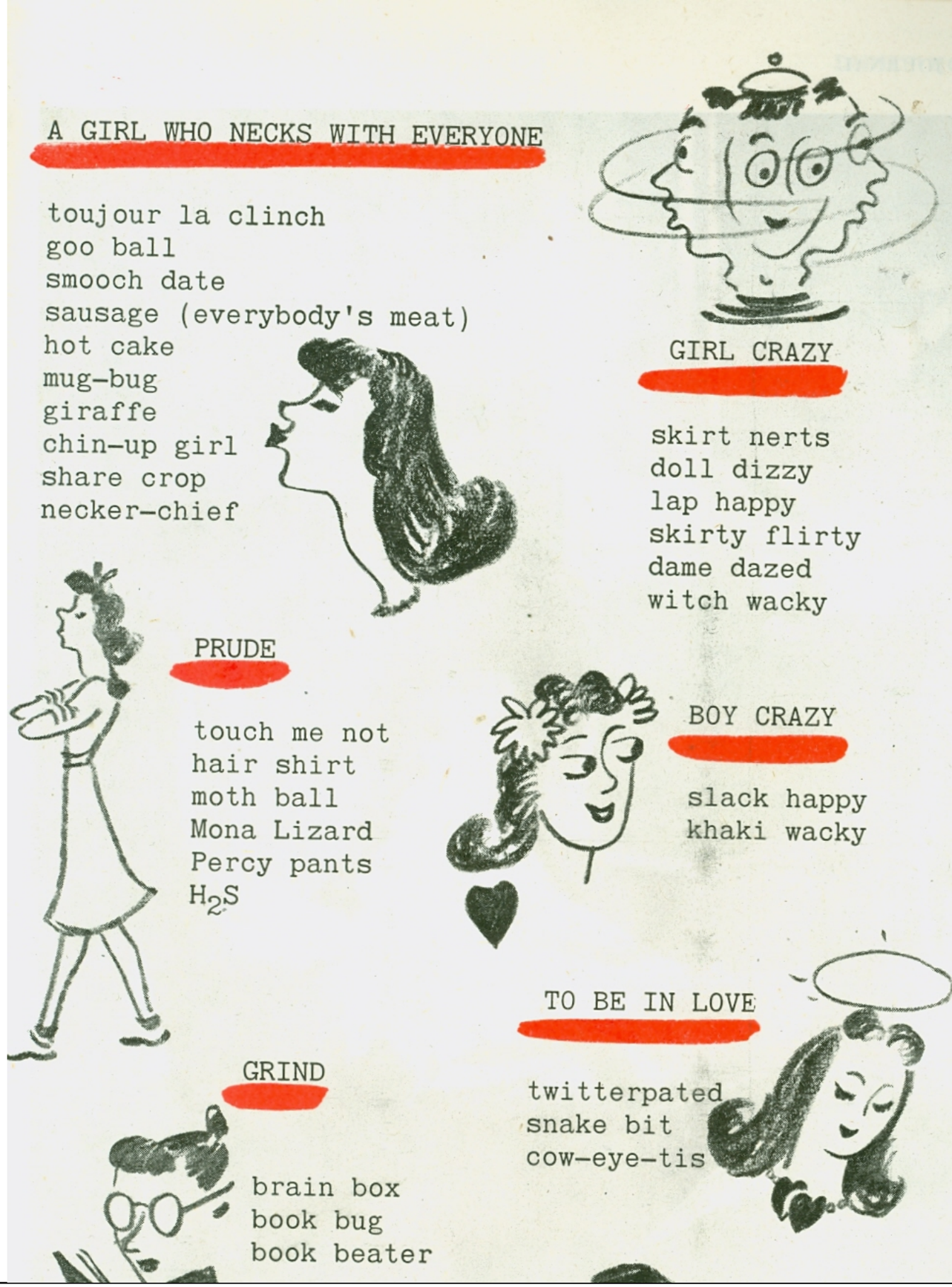
conventional



Language
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productive

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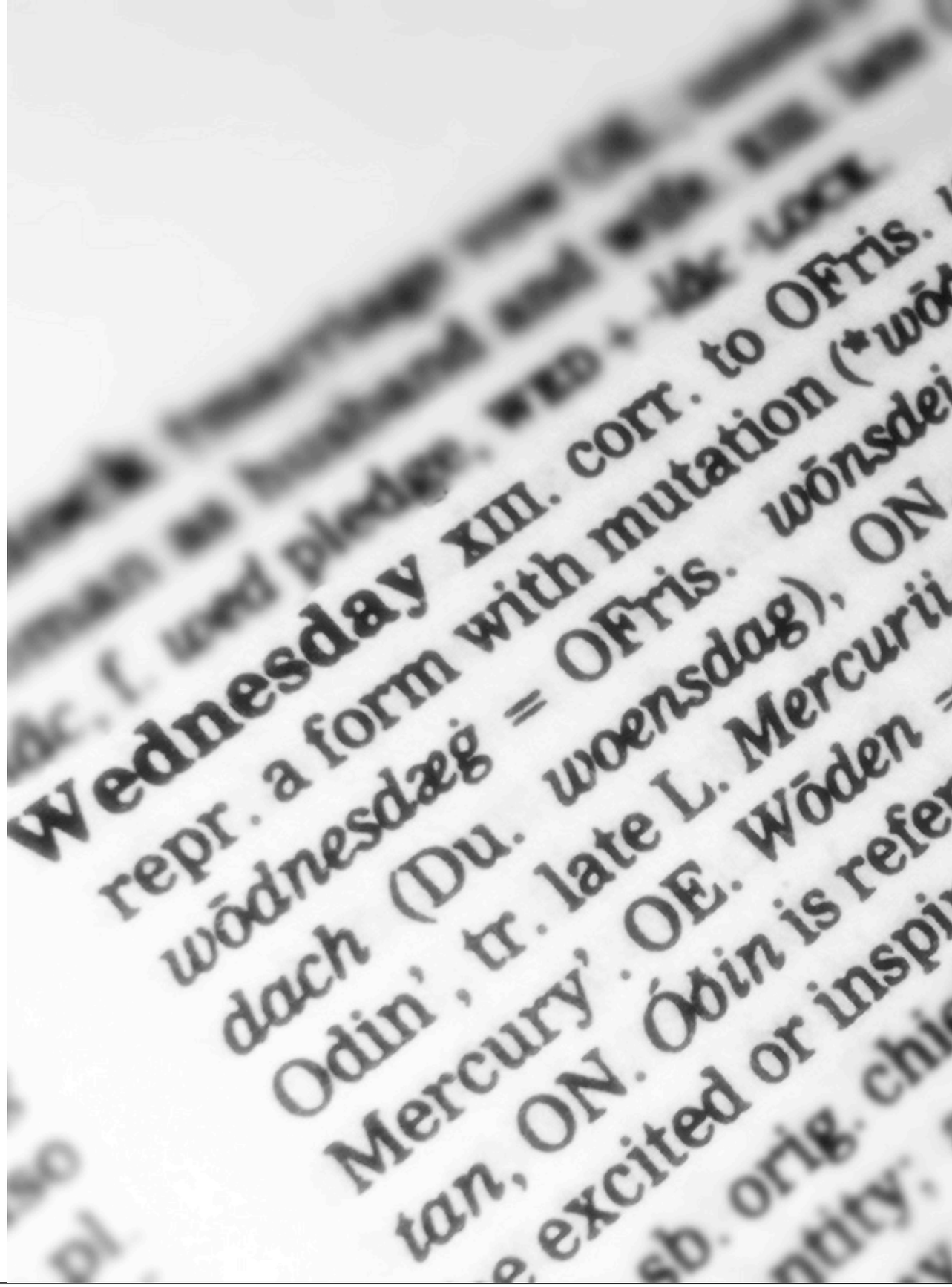
conventional

modifiable




metalanguage facility

Study of Language

linguistics and friends

philosophy

Study of Language

linguistics and friends

philosophy

linguistics

- lexicology
- grammar
  - morphology
  - syntax
  - phonology
- semantics

Study of Language

linguistics and friends

philosophy

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interdisciplinary

- applied linguistics
- computational linguistics
- historical linguistics
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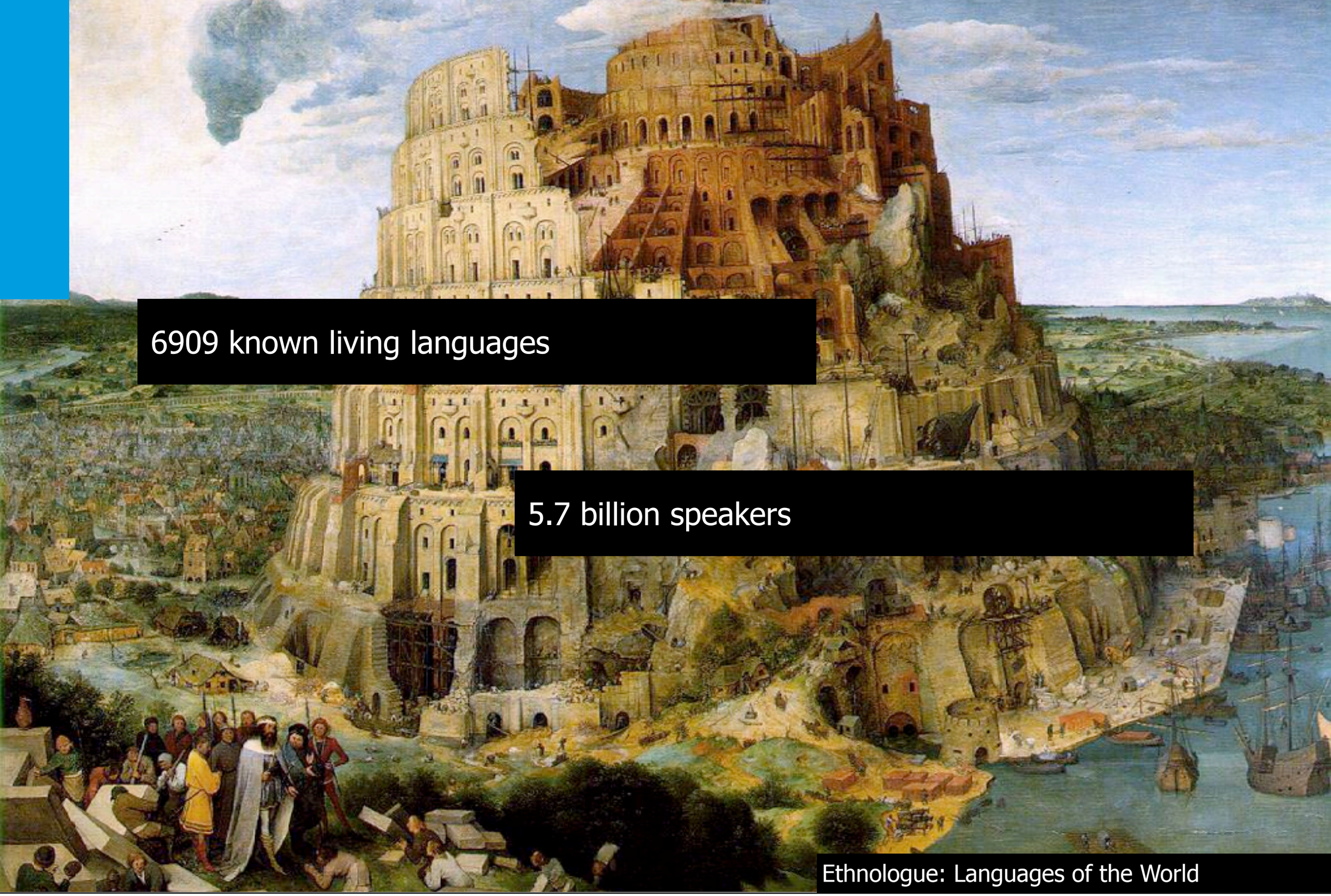
- psycholinguistics
- sociolinguistics

What is a language?

A language is a dialect with an army and navy.

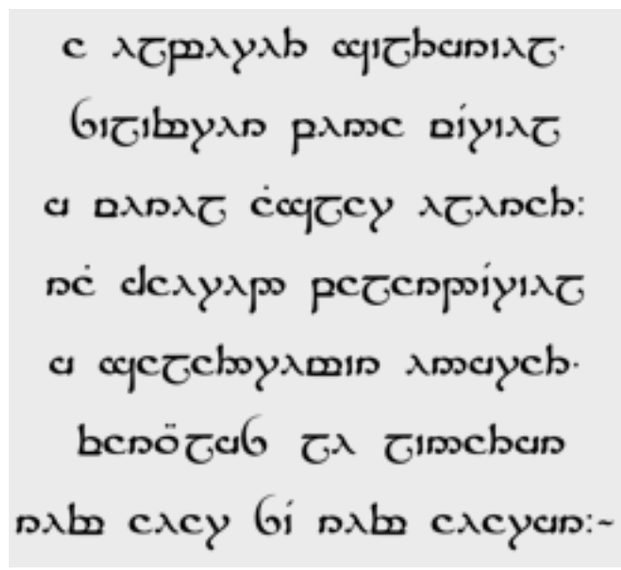
Max Weinreich: YIVO Bletter 25(1)

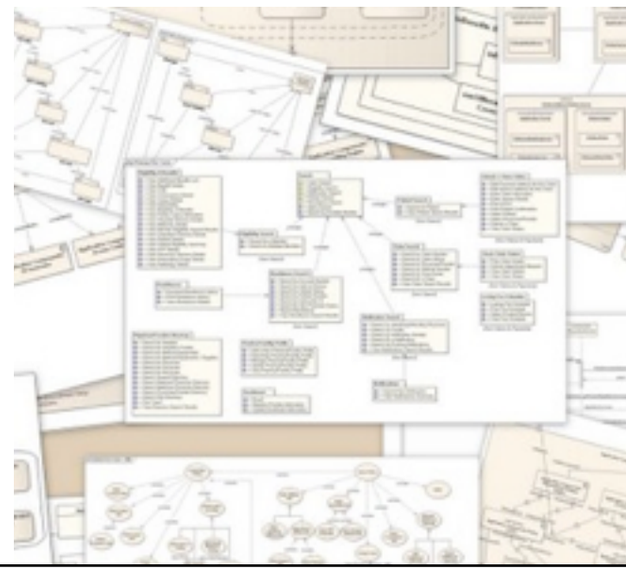

6909 known living languages
5.7 billion speakers
Ethnologue: Languages of the World

Language Control

towards artificial languages

Sanskrit Duden Simplified English



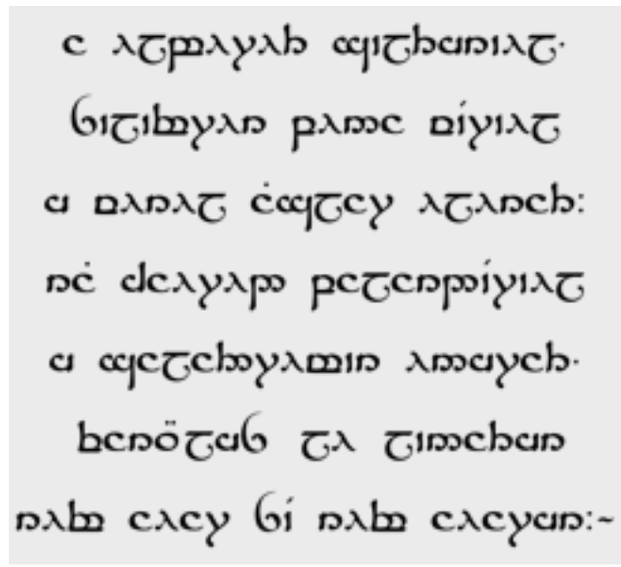


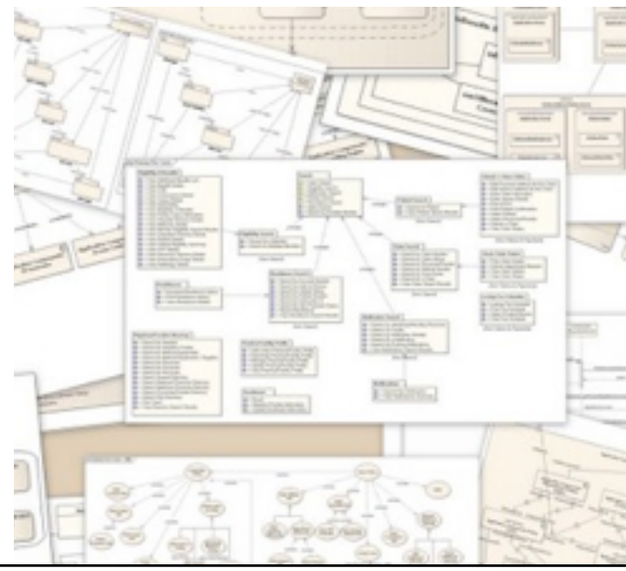
Language Control

towards artificial languages

Sanskrit Duden Simplified English

Esperanto Ido Interlingua





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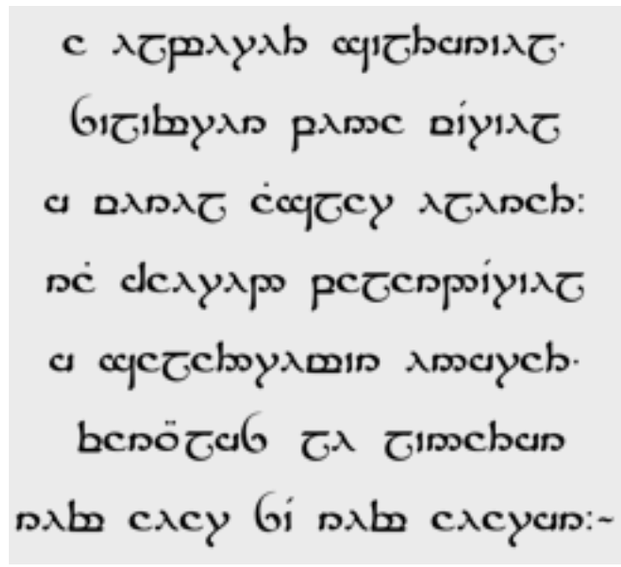
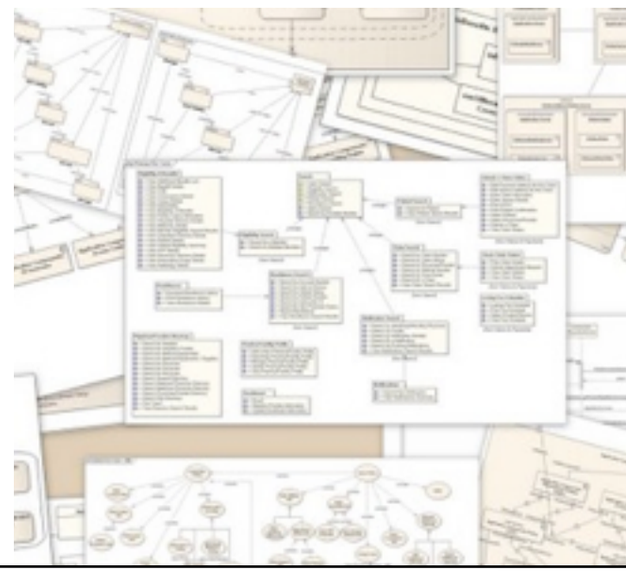
Quenya Klingon Na’vi





Language Control

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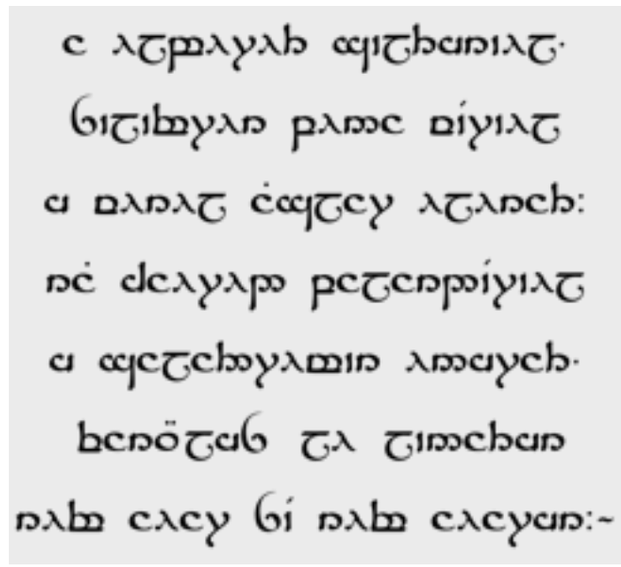
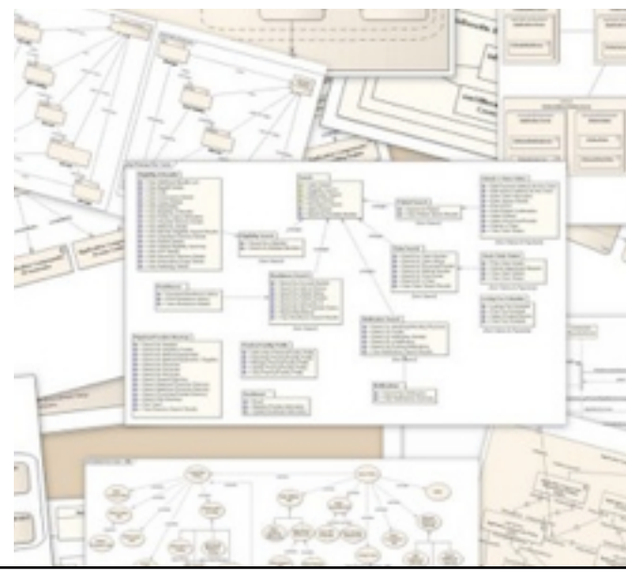
International Algebraic Language





Language Control

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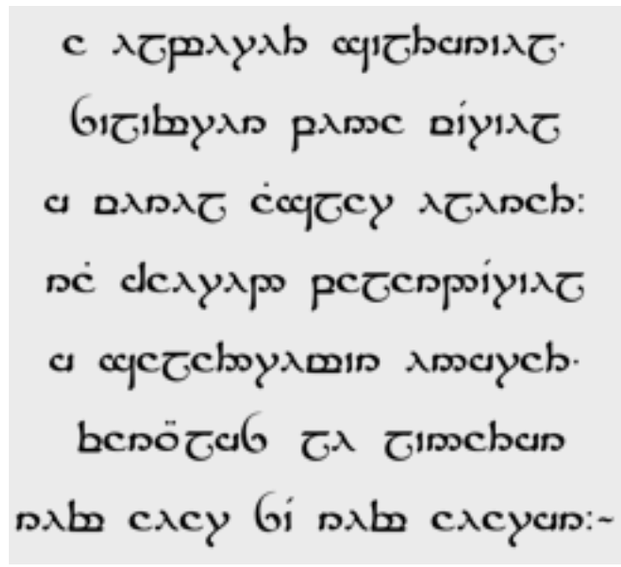
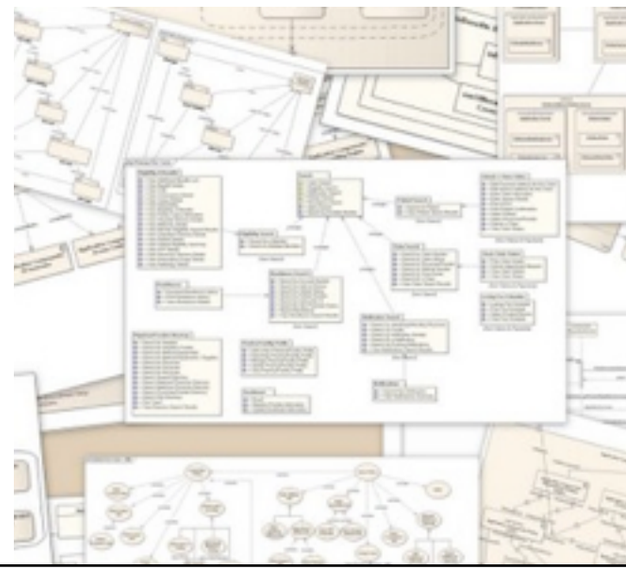
International Algebraic Language

Unified Modeling Language





To provide a means of communicating numerical methods and other procedures between people.

John W. Backus: The Syntax and Semantics of the Proposed International Algebraic Language of Zürich ACM-GAMM Conference.

To provide a means of communicating numerical methods and other procedures between

people.

To provide a means for realising a stated process

on a variety of machines …

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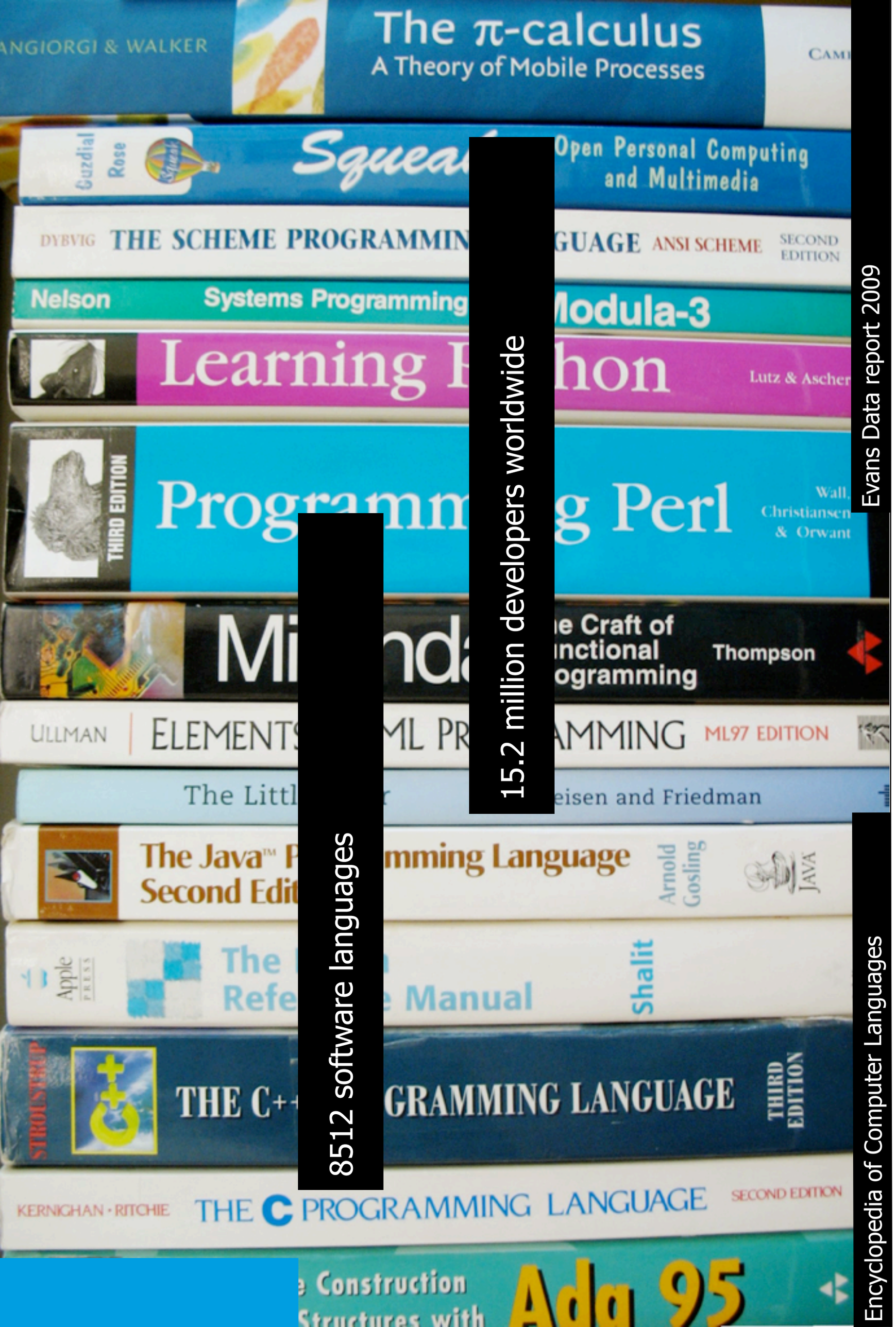
Software Languages

languages to engineer software


The π-calculus
A Theory of Mobile Processes
Open Personal Computing and Multimedia
THE SCHEME PROGRAMMIN
GUAGE ANSI SCHEME SECOND EDITION
Nelson Systems Programming
Modula-3
Learning
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Lutz & Ascher
THIRD EDITION
Programm
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Wall, Christiansen & Orwant
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ULLMAN
ELEMENTS
ML PR
AMMING
ML97 EDITION
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JAVA
Apple PRESS
The
Refe
e Manual
Shalit
STROUSTRUP
THE C++
GRAMMING LANGUAGE
THIRD EDITION
KERNIGHAN · RITCHIE
THE C PROGRAMMING LANGUAGE
SECOND EDITION
e Construction
Structures with
Ada 95
8512 software languages
15.2 million developers worldwide
Evans Data report 2009
Encyclopedia of Computer Languages

TU Delft

Study of Language

linguistics and friends

philosophy

linguistics

- lexicology
- grammar
  - morphology
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computer science

- grammar
- semantics

Tiger
the lecture language

```
/* factorial function */

let

   var x := 0

   function fact(n : int) : int =
      if n < 1 then 1 else (n * fact(n - 1))

in

   for i := 1 to 3 do (
      x := x + fact(i);
      printint(x);
      print(" ")
   )

end
```

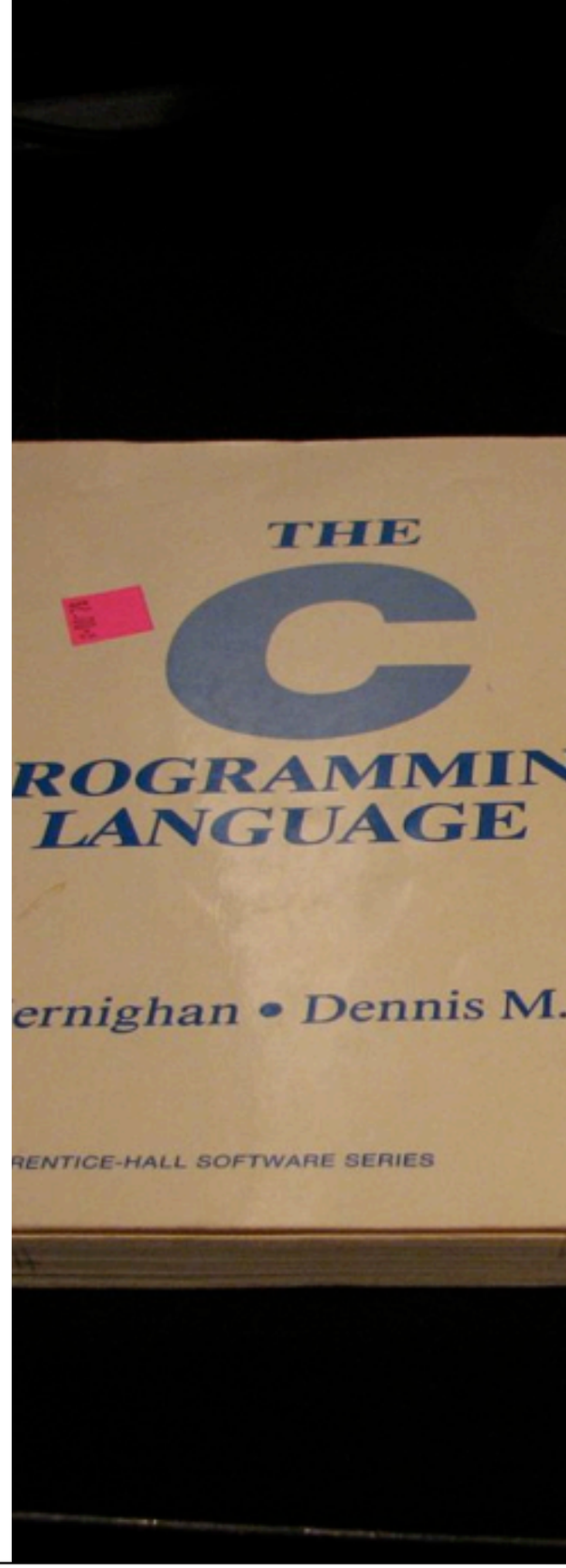
C
another lecture language

```c
#include <stio.h>

/* factorial function */

int fac(int num) {
    if (num < 1)
        return 1;
    else
        return num * fac(num - 1);
}

int main() {
    printf("%d! = %d\n", 10, fac(10));
    return 0;
}
```



MiniJava

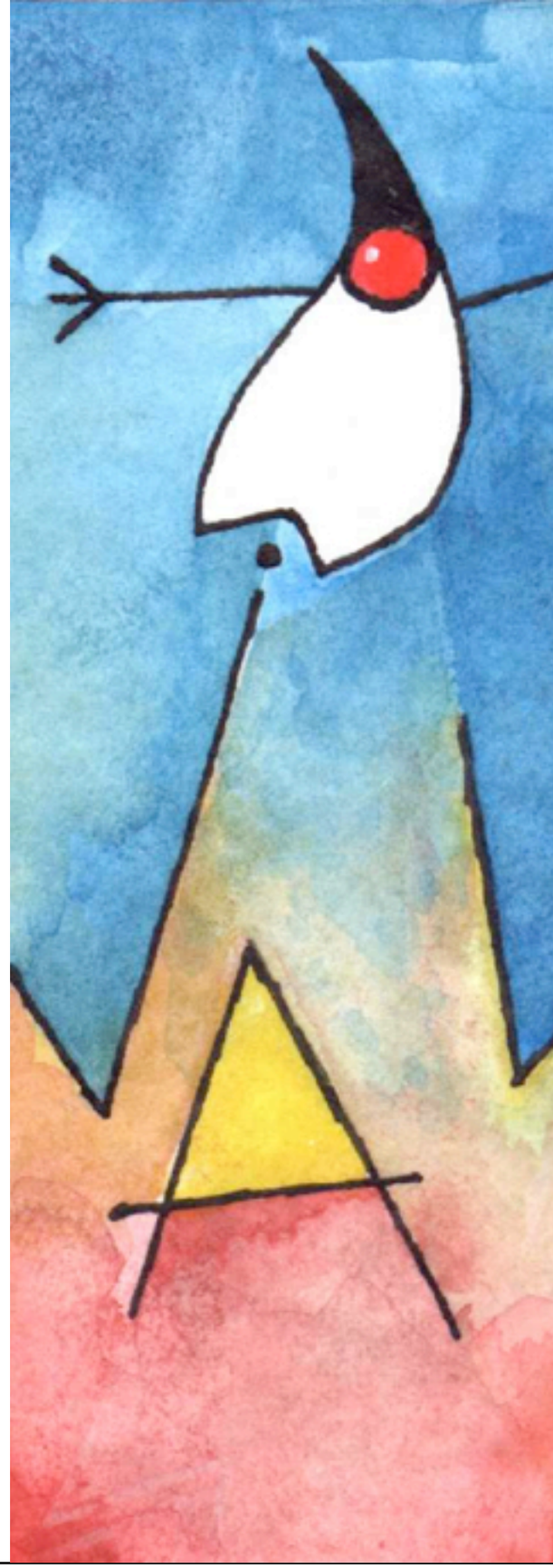
the lab language

```
class Main {

    public static void main(String[] args) {
        System.out.println(new Fac().fac(10));
    }
}

class Fac {

    public int fac(int num) {
        int num_aux;
        if (num < 1)
            num_aux = 1;
        else
            num_aux = num * this.fac(num - 1);
        return num_aux;
    }
}
```



II

modern compilers

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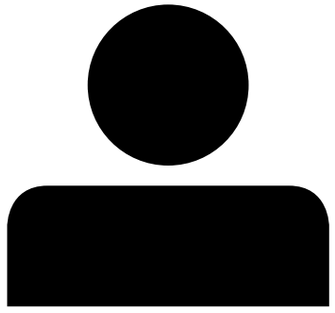
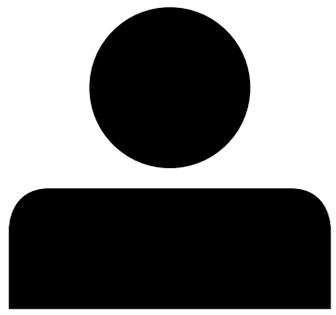
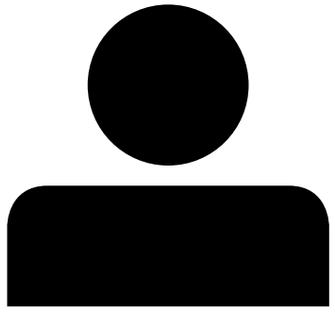
Communication

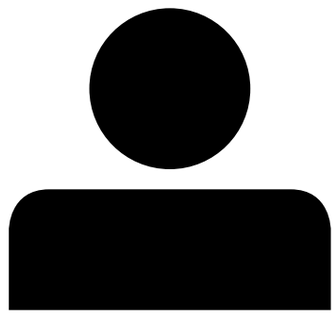
between people





Communication
between people

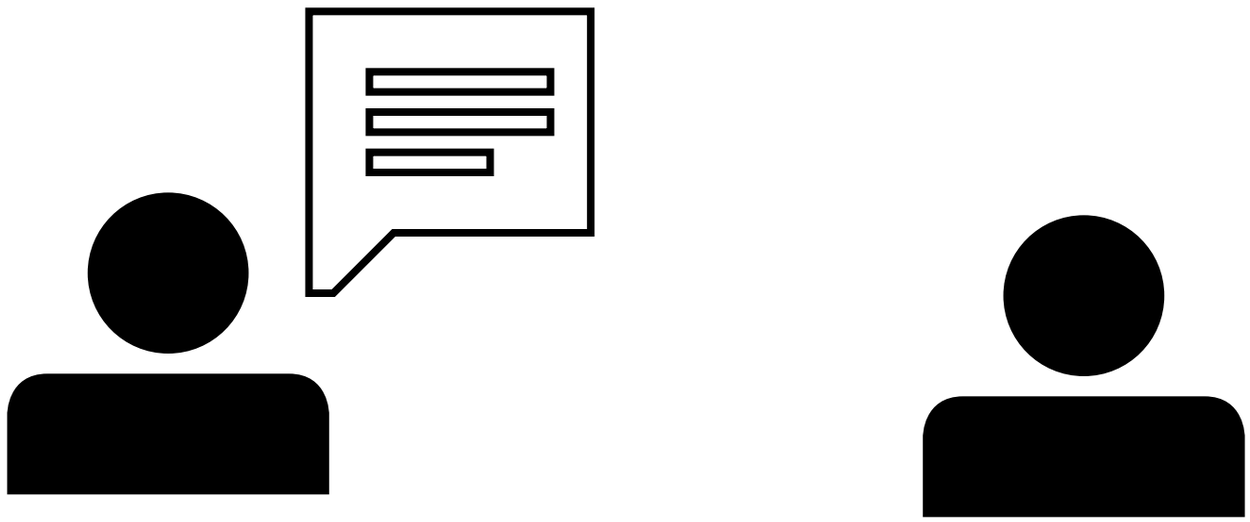




natural language

Communication

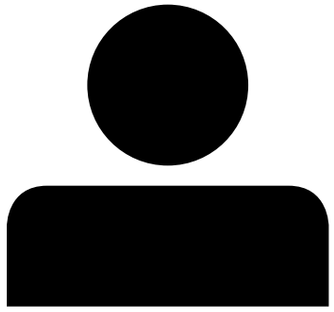
between people

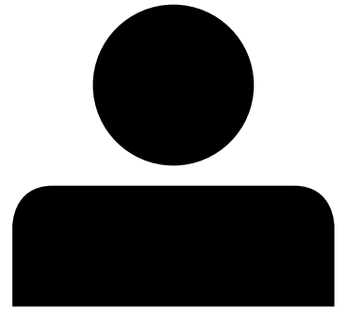


natural language

Communication

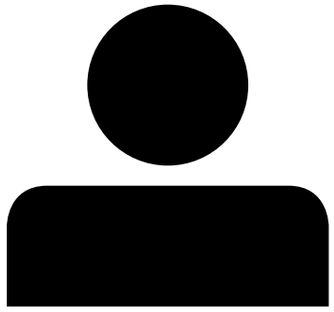
translation



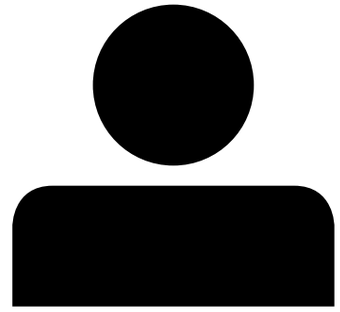


Communication

translation



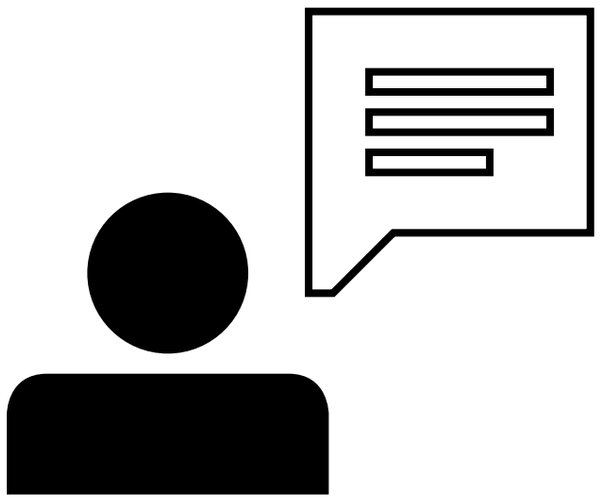
natural language



natural language

Communication

translation



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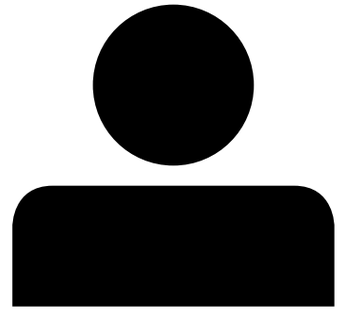
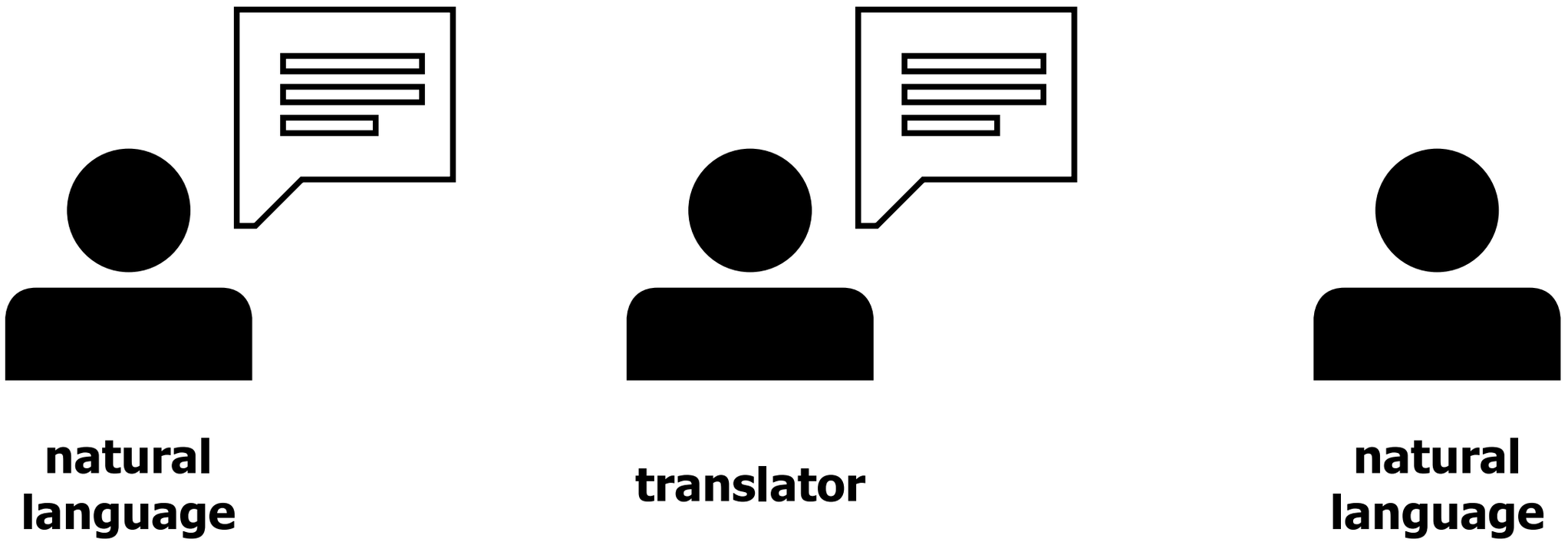


natural language

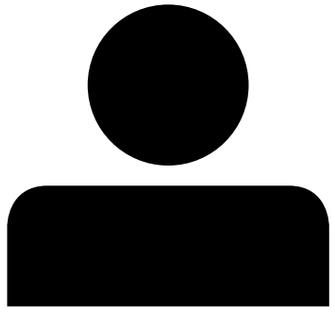
Communication

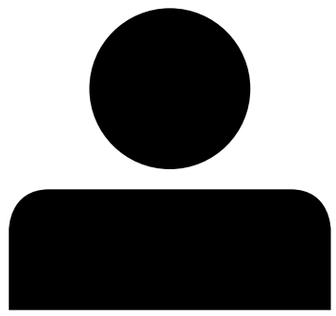
translation



Communication

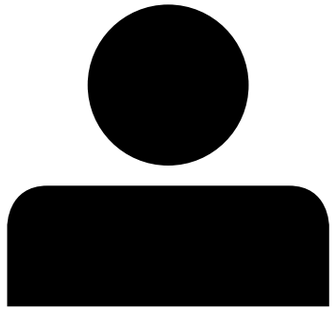
software language

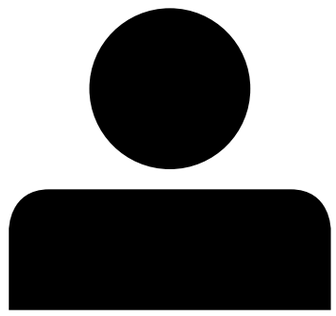




Communication

software language





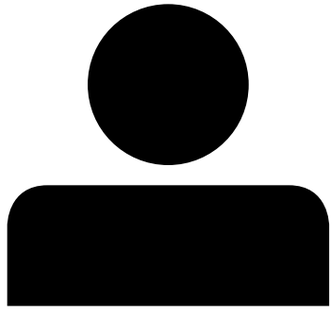
software language

Communication

software language

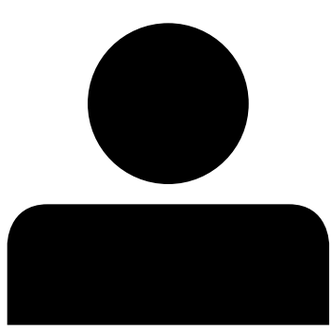
Communication

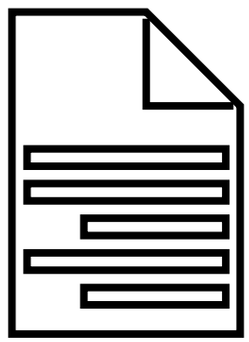
compilation

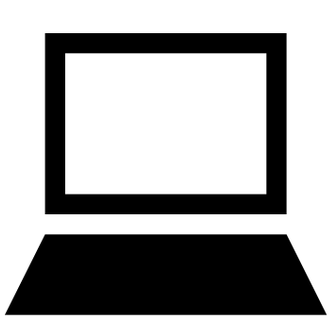


Communication

compilation







software language

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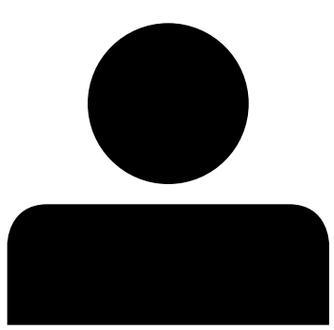
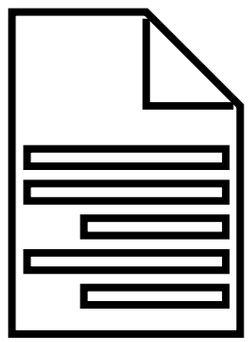


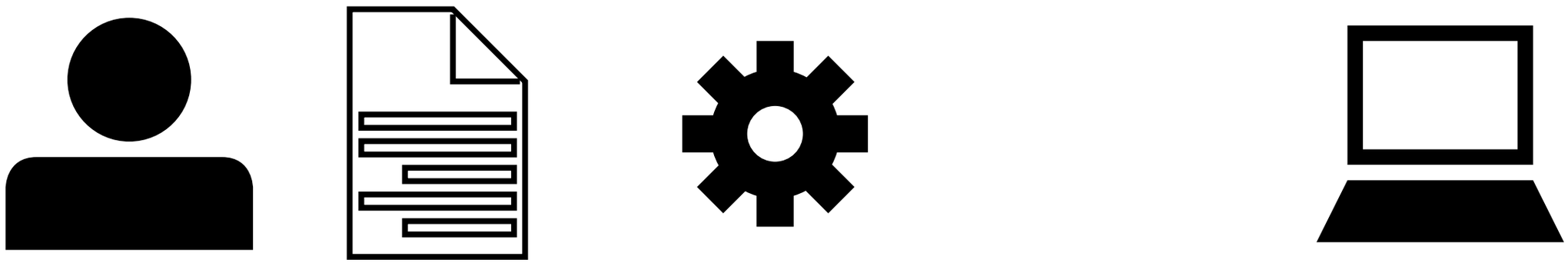


software language

machine language

Communication

compilation



software language

compiler

machine language

Communication

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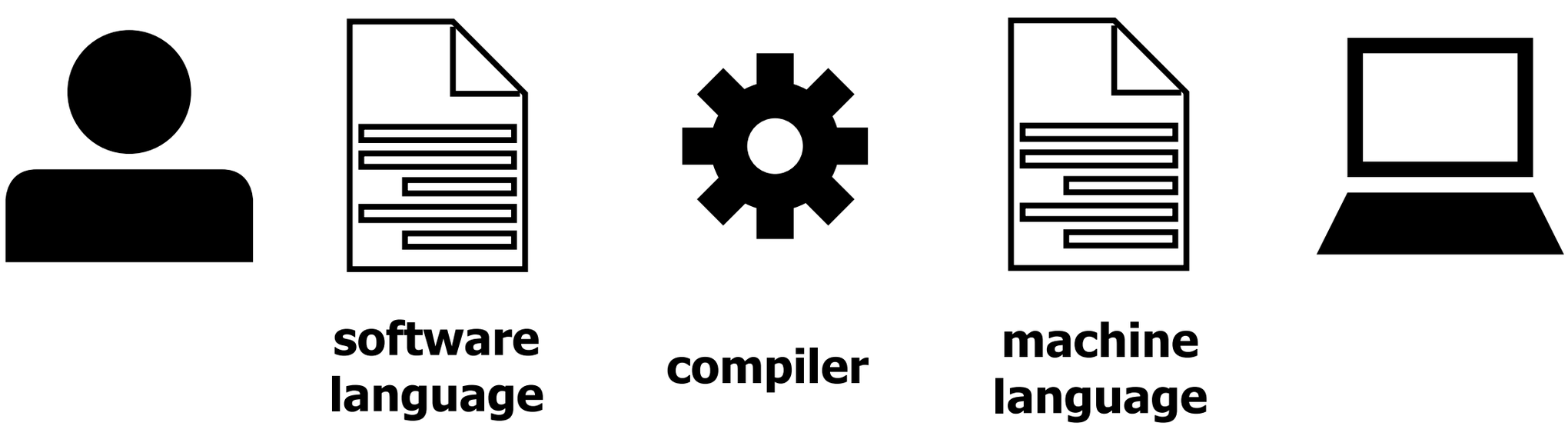

Traditional Compilers

example

Traditional Compilers

example

ls

Course.java

Traditional Compilers

example

ls

Course.java

javac -verbose Course.java

[parsing started Course.java]
[parsing completed 8ms]
[loading java/lang/Object.class(java/lang:Object.class)]
[checking university.Course]
[wrote Course.class]
[total 411ms]

Traditional Compilers
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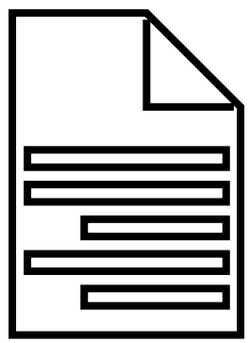
Course.class Course.java

Traditional Compilers

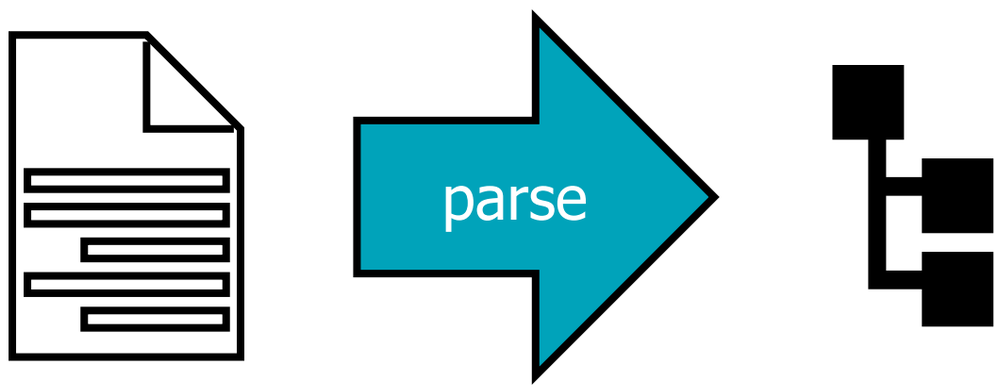
architecture



Source Code

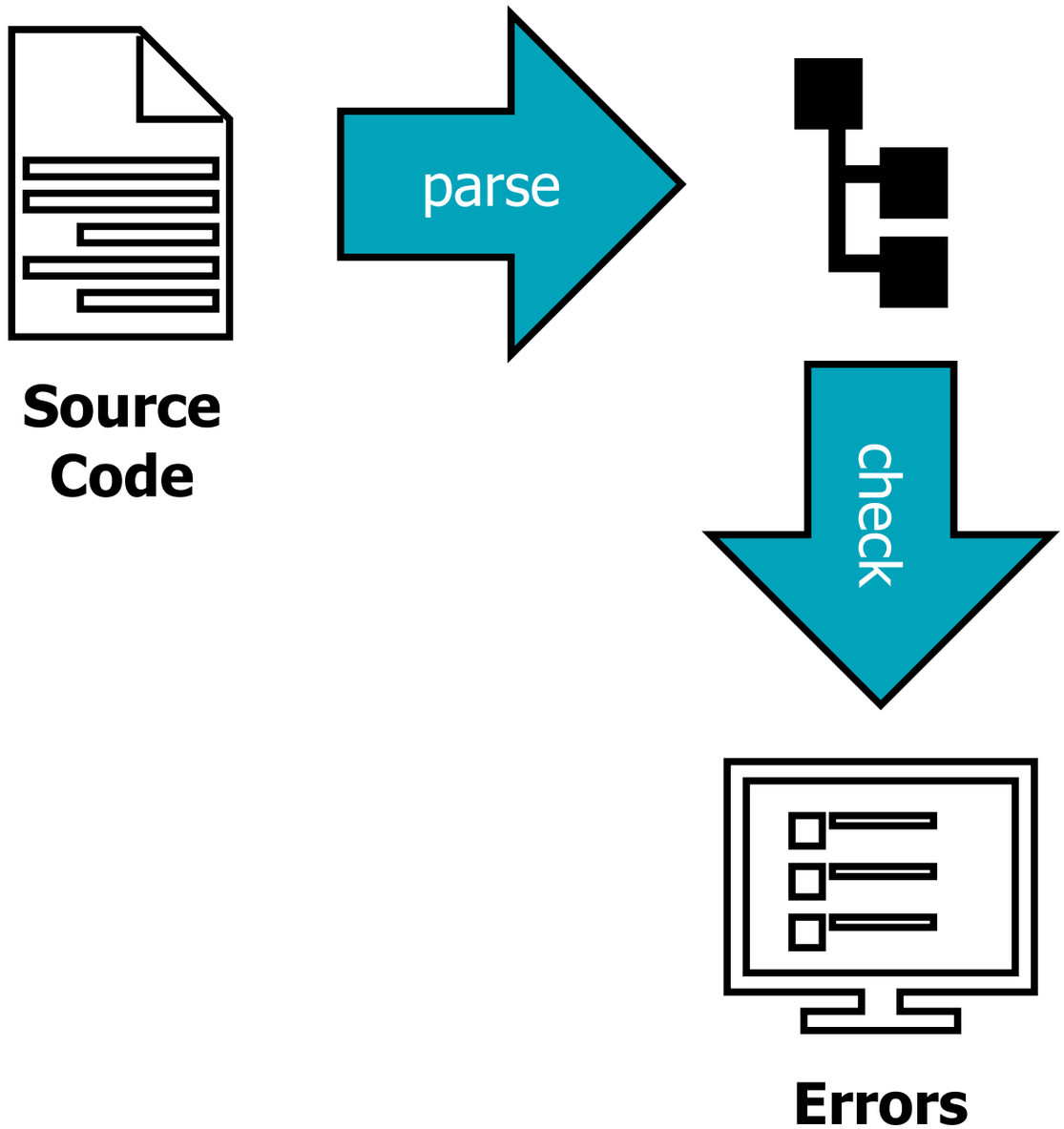
Traditional Compilers

architecture



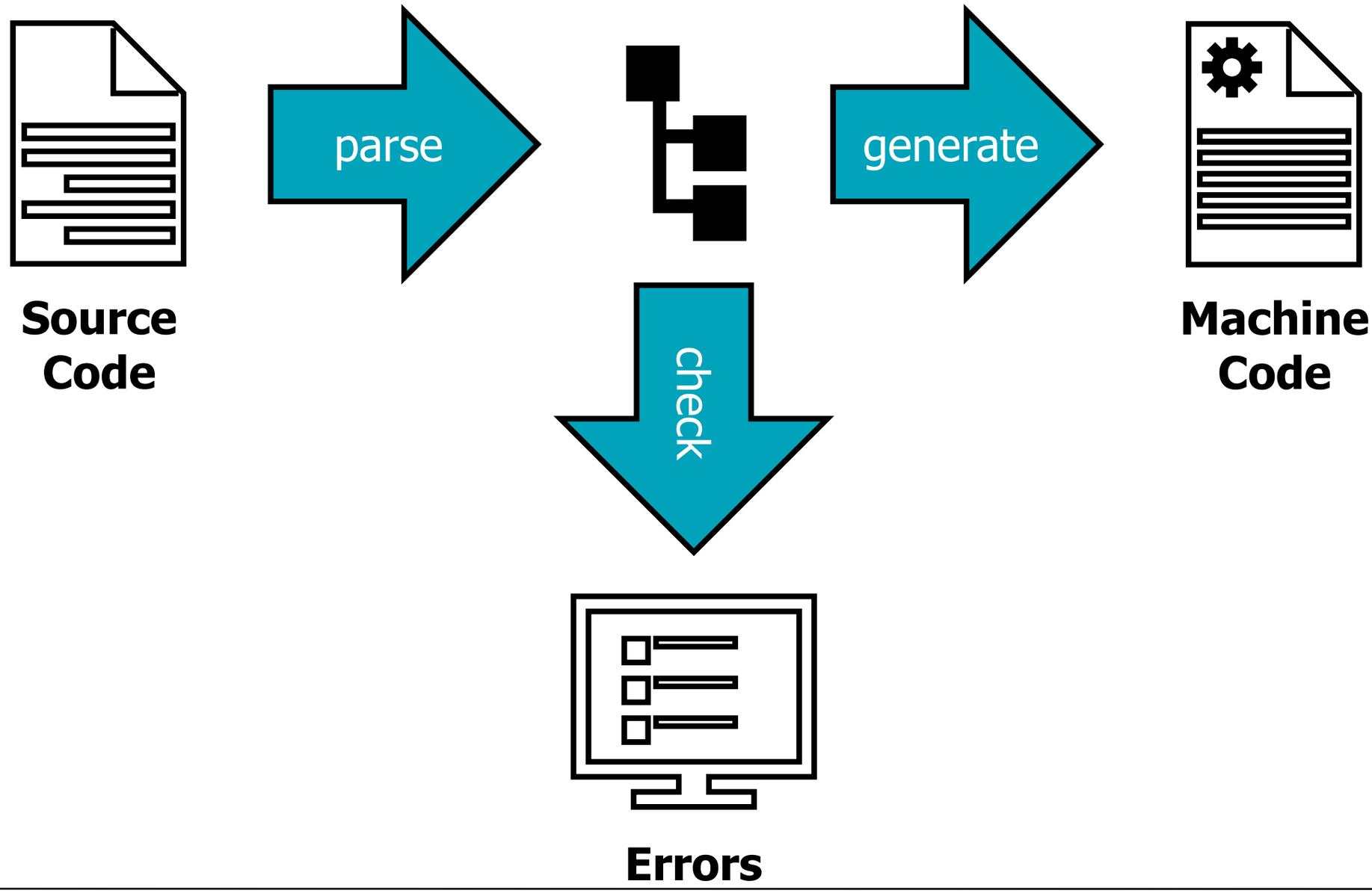
Traditional Compilers

architecture



Traditional Compilers

architecture



Modern Compilers in IDEs

example

Modern Compilers in IDEs

features

syntactic editor services

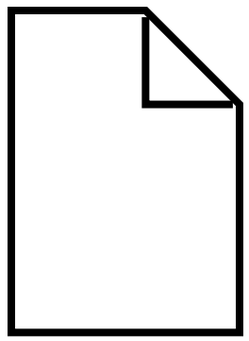
- syntax checking
- syntax highlighting
- outline view
- code folding
- bracket matching

semantic editor services

- error checking
- reference resolving
- hover help
- code completion
- refactoring

Modern Compilers in IDEs

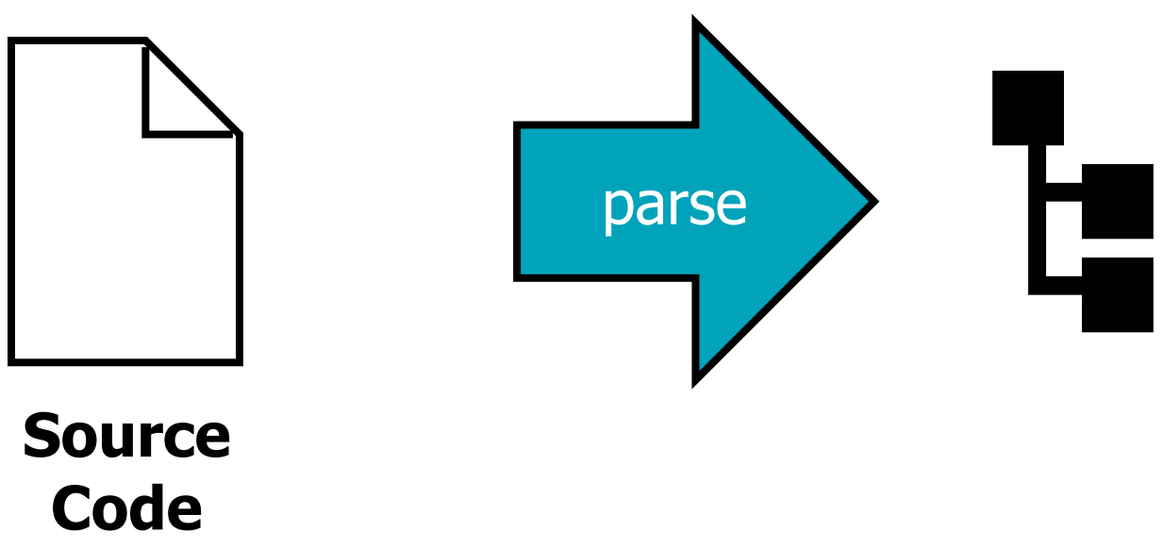
architecture



Source Code

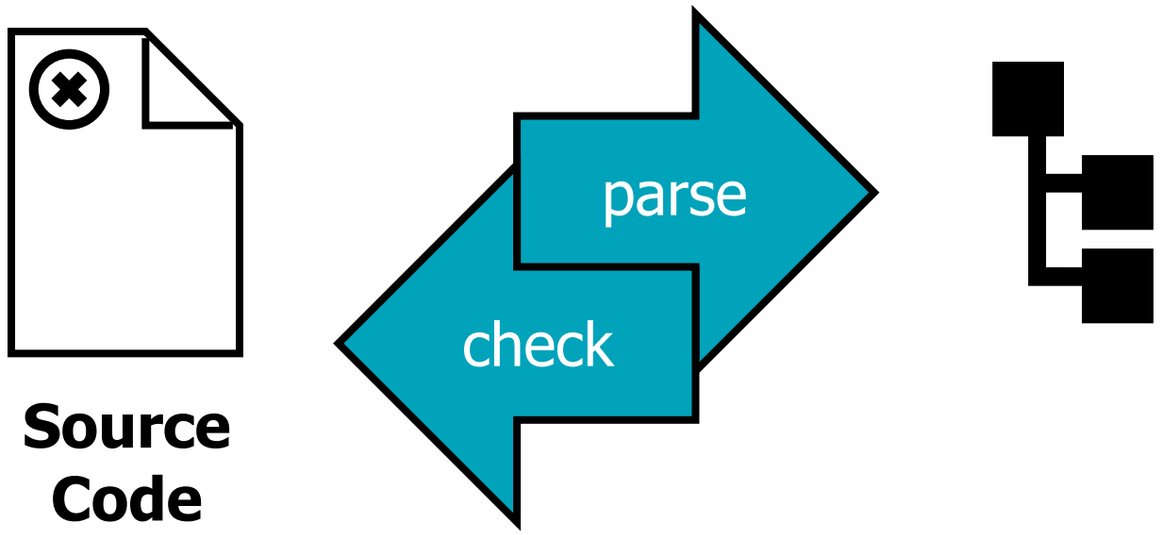
Modern Compilers in IDEs

architecture



Modern Compilers in IDEs

architecture



Modern Compilers in IDEs

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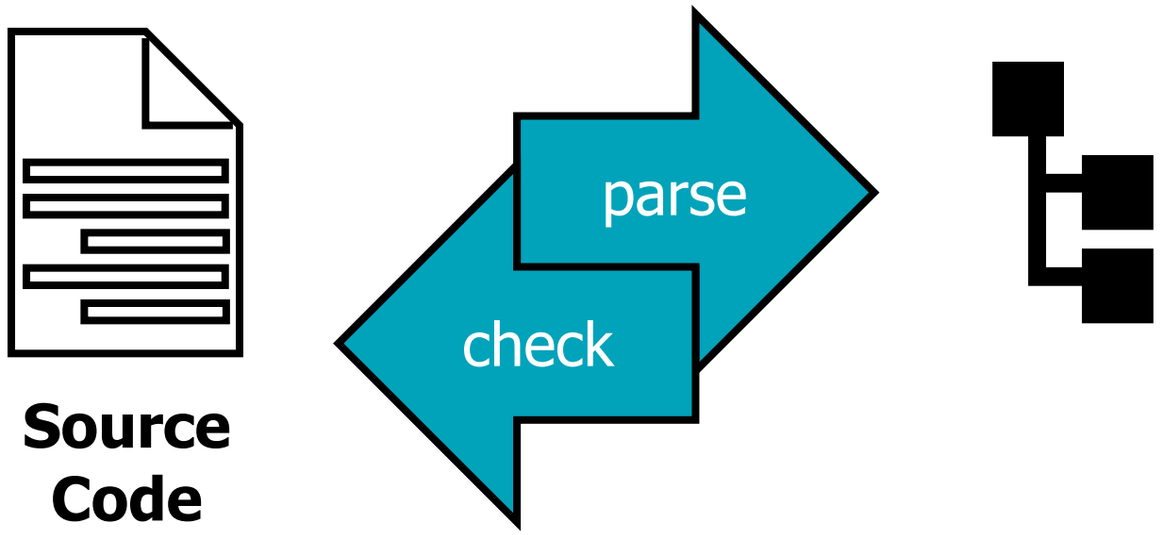
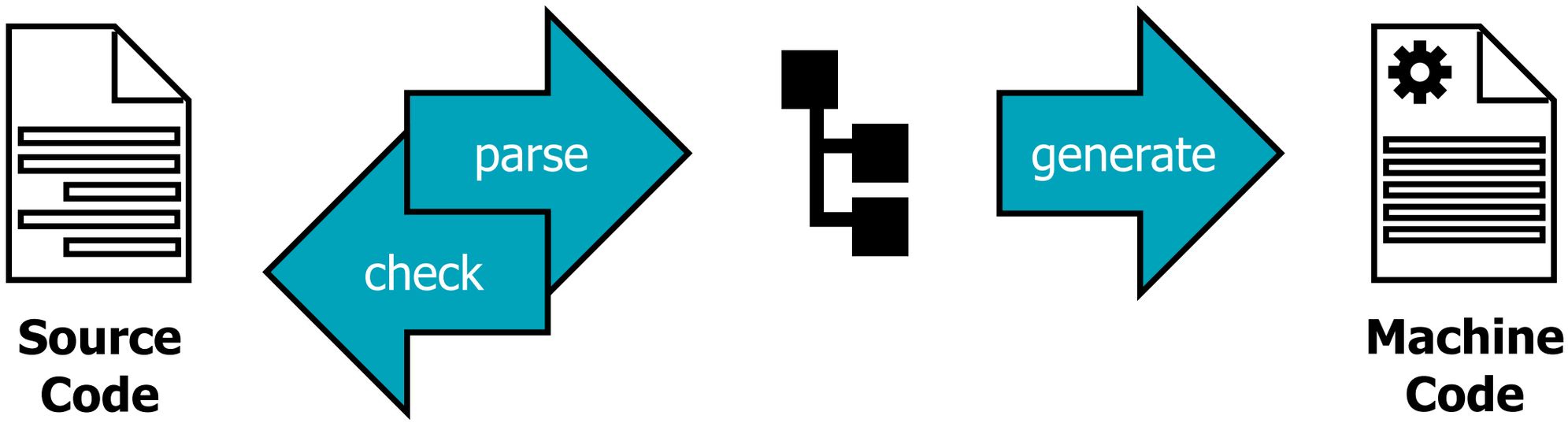


Modern Compilers in IDEs

architecture



Language Processors
beyond compilation

syntax

- scanners
- parsers
- pretty-printers
- syntax-directed editors

semantics

- type checker
- analysis tools
- optimisers
- refactoring tools
- renovation tools
- interpreters
- code generators
- debuggers

Software Languages

languages to engineer **software**

pieces of **software** themselves

coffee break

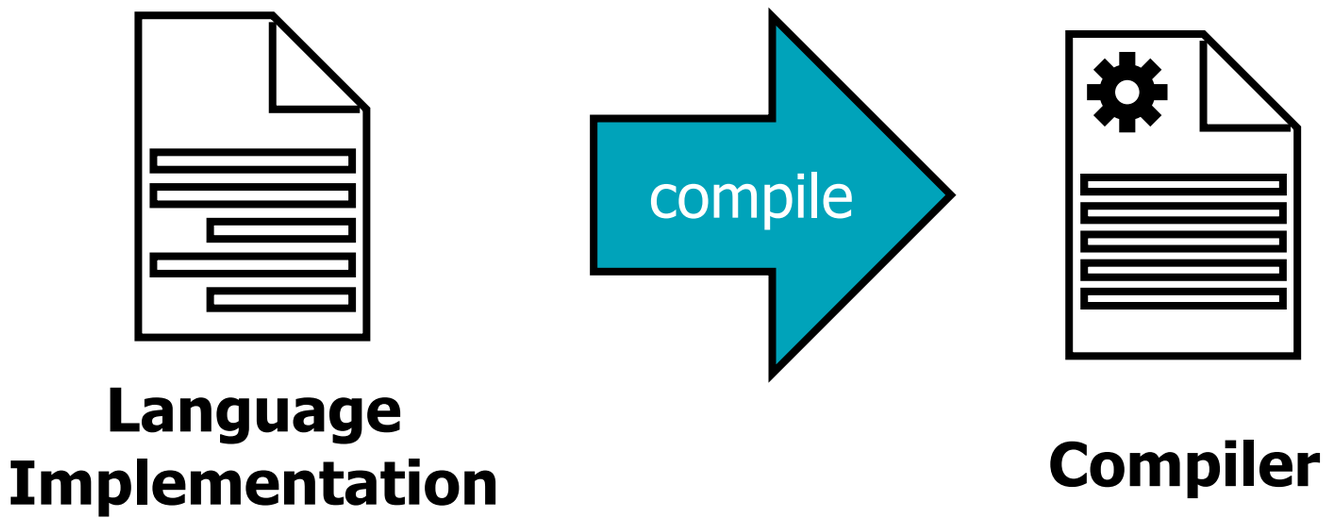
III

compiler construction

metalanguage facility

Traditional Compiler Compilers

manual implementation

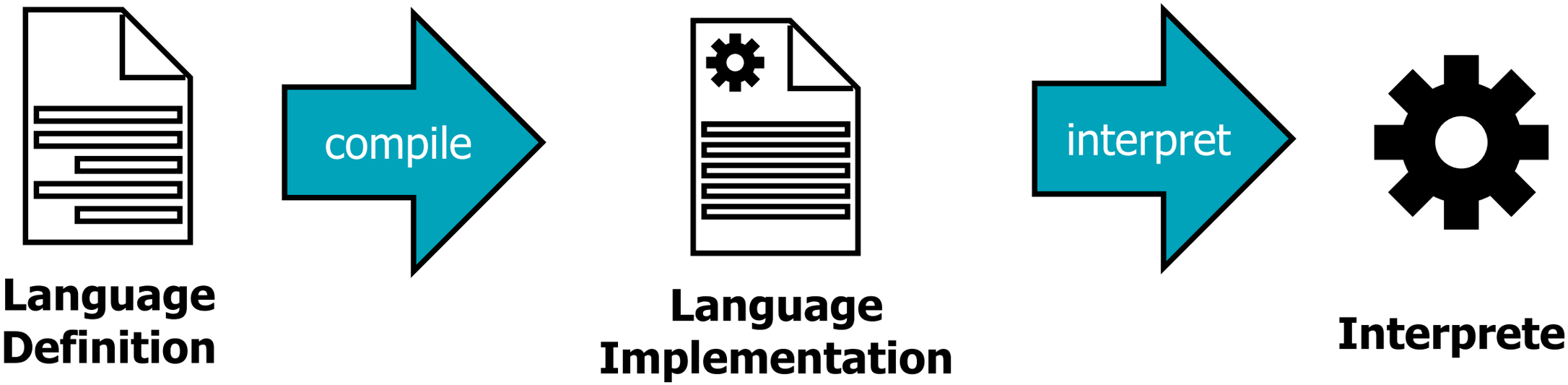


Traditional Compiler Compilers

compilation + compilation

Traditional Compiler Compilers

compilation + interpretation



Language Definition
components

syntax definition

- concrete syntax
- abstract syntax

static semantics

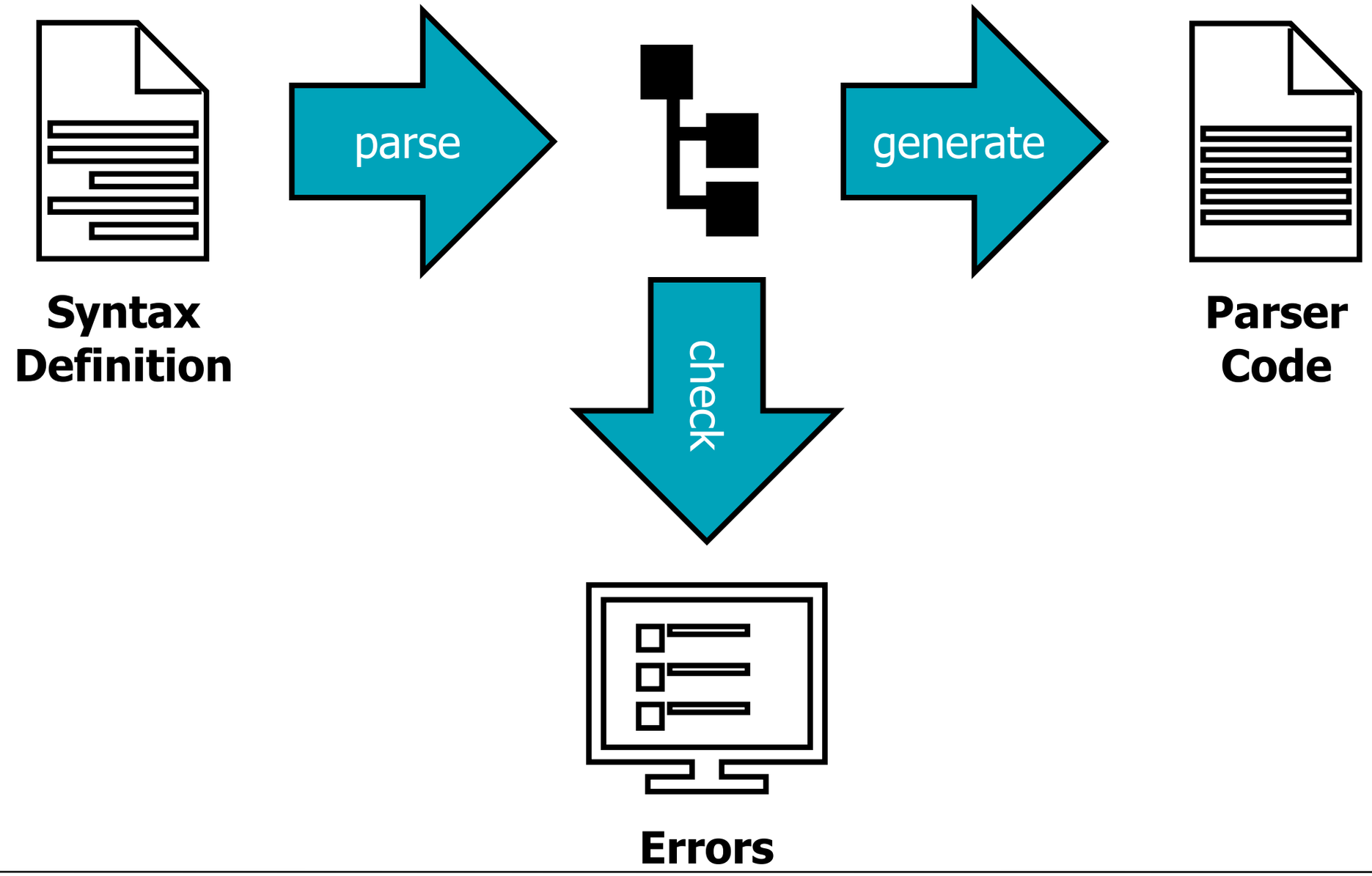
- name bindings
- type analysis

dynamic semantics

- translation
- interpretation

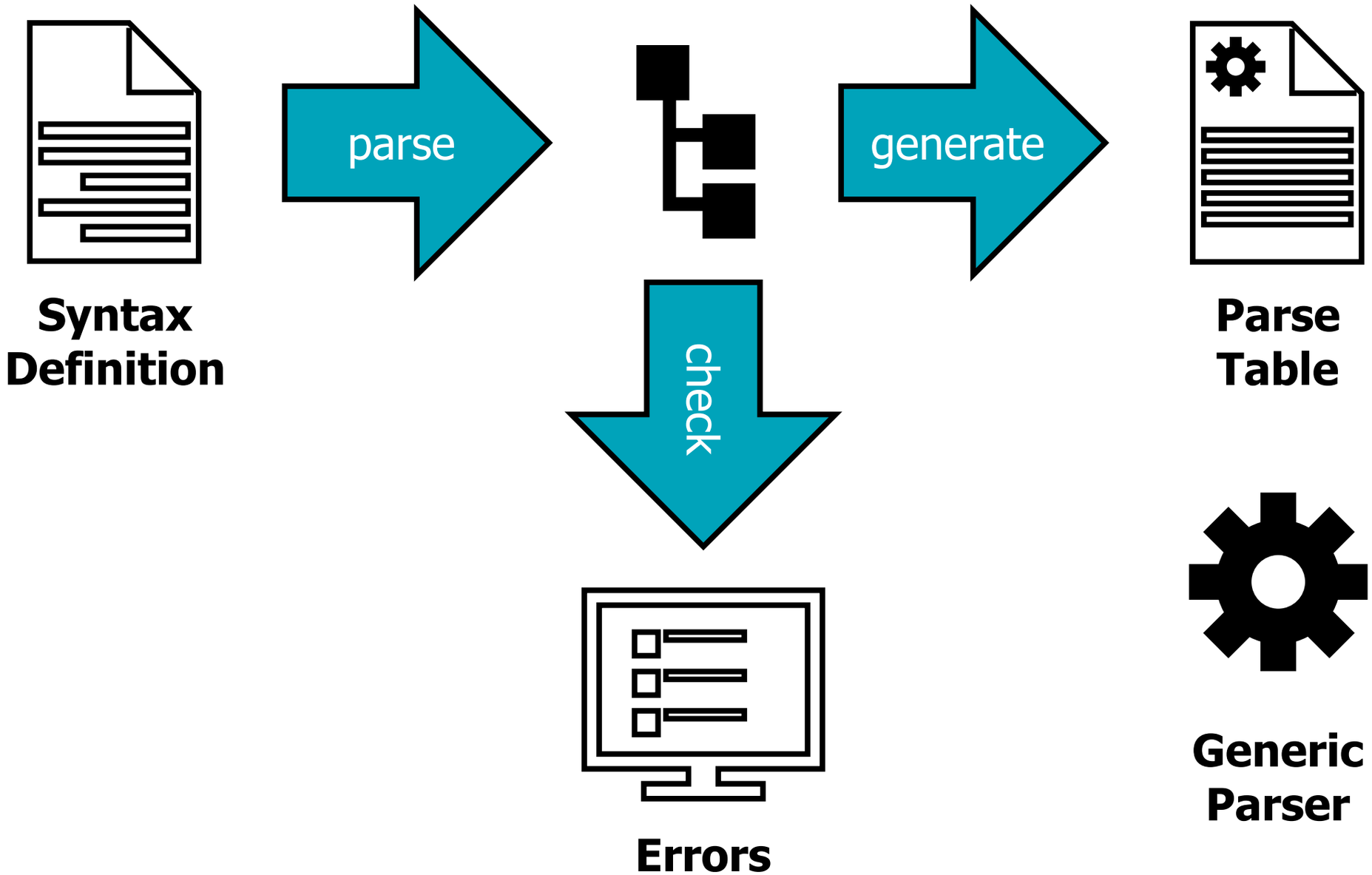
Traditional Compiler Compilers

compilation + compilation

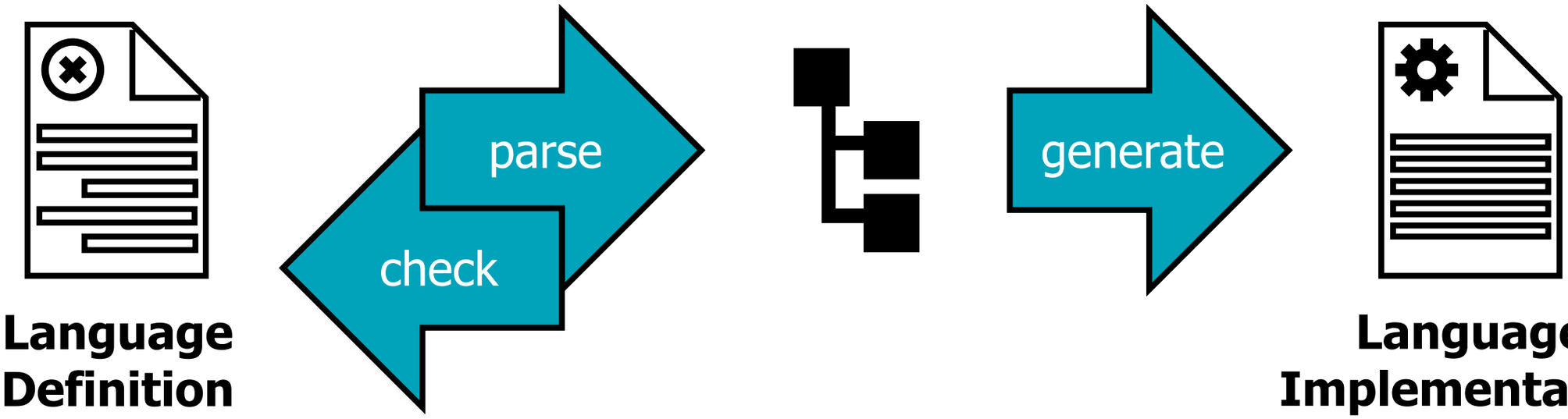


Traditional Compiler Compilers

compilation + interpretation



Language Workbenches
architecture



Spoofax

the lecture & lab language workbench

based on IMP framework by IBM Research

syntax definition

- declarative meta-languages
- modular syntax definitions

semantics

- declarative transformation languages
- operating on ASTs
- rewrite rules, strategies

editor services

- declarative configuration languages

IV

organisation

Organisation

overview

Blackboard

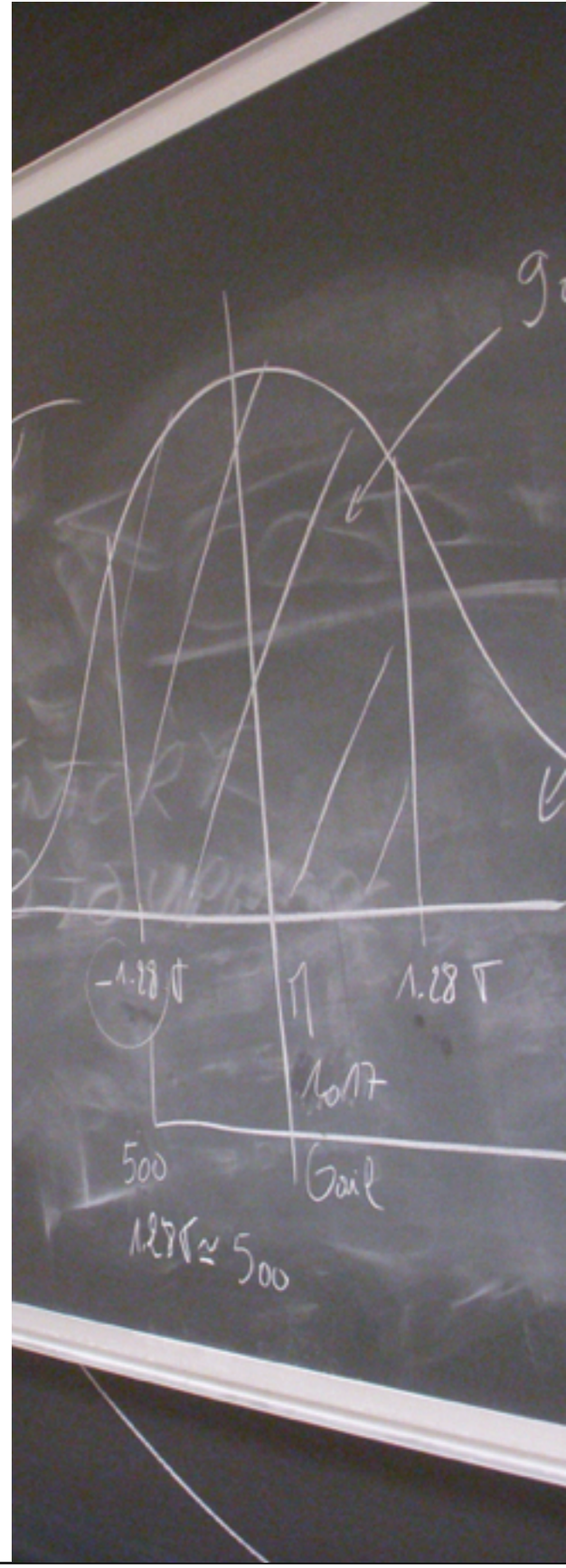
http://blackboard.tudelft.nl

course

- 15 lectures
- 14 lab sessions

assessment

- weekly lab assignments
- written exam Jan 28



Organisation

contact

lectures & lab sessions

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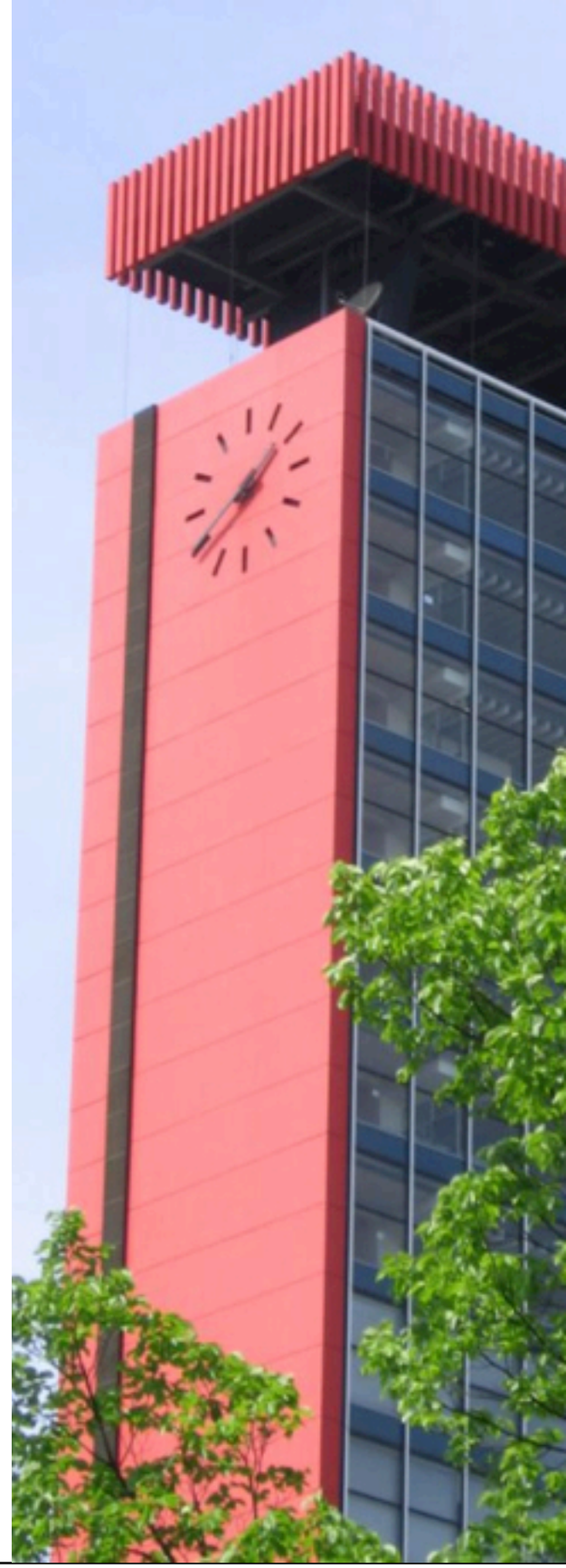
G.H.Wachsmuth@tudelft.nl

twitter

http://twitter.com/IN4303

http://twitter.com/guwac



Organisation
lectures

lectures

- 1 + 8 + 5 + 1 lectures
- starting Sep 9

parts

- introduction (2 lectures)
- declarative language definition (6)
- implementing imperative and object-oriented languages (4)
- compiler components and their generators (3)

Organisation
assignments

practical work

- 1 + 6 + 7 lab sessions
- starting Sep 12

milestones

- editor (3 labs)
- name + type analysis + error checking (5)
- code generator (5)

Organisation

resources

text book

Andrew W. Appel, Jens Palsberg: Modern Compiler Implementation in Java, 2nd Edition. Cambridge University Press, 2002

papers

http://researchr.org/bibliography/compiler-construction

software

http://eclipse.org

http://spoofax.org

http://strategoxt.org

V

summary

Summary
lessons learned

Summary
lessons learned

What are software languages?

- computer-processable artificial languages used in software eng.
- pieces of software

Summary
lessons learned

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What is a compiler?

- piece of software translating high-level code to low-level code
- traditional compilers vs. compilers in IDEs

Summary
lessons learned

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- pieces of software

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How can we construct compilers?

- manual implementation vs. generation
- language workbenches

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lessons learned

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How can we construct compilers?

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How is this course organised?

Literature

learn more

Literature

learn more

language

Edward Sapir. Language. An Introduction to the Study of Speech. 1921

M. Paul Lewis, editor. Ethnologue: Languages of the World. 2009

Literature

learn more

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MiniJava and Tiger

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Andrew W. Appel: Modern Compiler Implementation in ML.

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MiniJava and Tiger

Andrew W. Appel, Jens Palsberg: Modern Compiler Implementation in Java. Cambridge University Press

Andrew W. Appel: Modern Compiler Implementation in ML.

Spoofax

Lennart C. L. Kats, Eelco Visser. The Spoofax Language Workbench. Rules for Declarative Specification of Languages and IDEs. OOPSLA 2010

Outlook
coming next

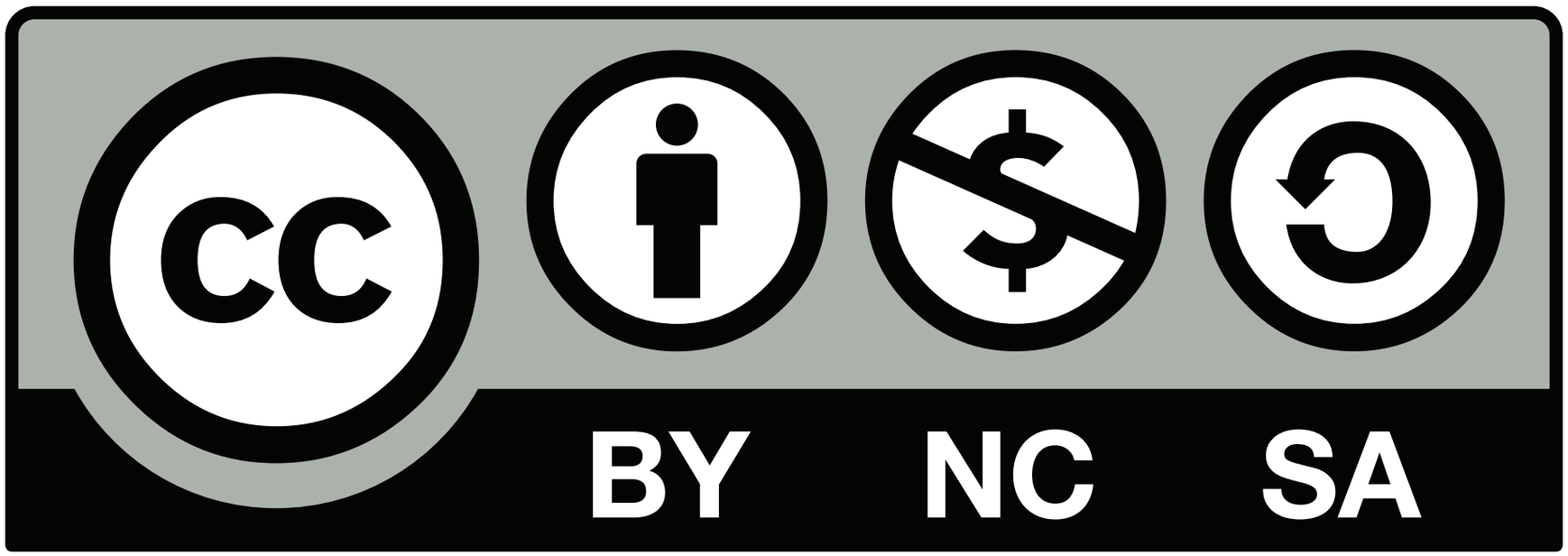
imperative & OO programming languages

declarative language definition

- Lecture 1: Grammars and Trees
- Lecture 2: SDF and ATerms
- Lecture 3: Term Rewriting
- Lecture 4: Static Analysis and Error Checking
- Lecture 5: Code Generation

Lab Sep 12

- get used to Eclipse, Spoofax, and MiniJava
- explore an Spoofax project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