Compiler Construction

Introduction

Guido Wachsmuth

Overview

today's lecture

What is this course about?

- software languages
- modern compilers
- compiler construction

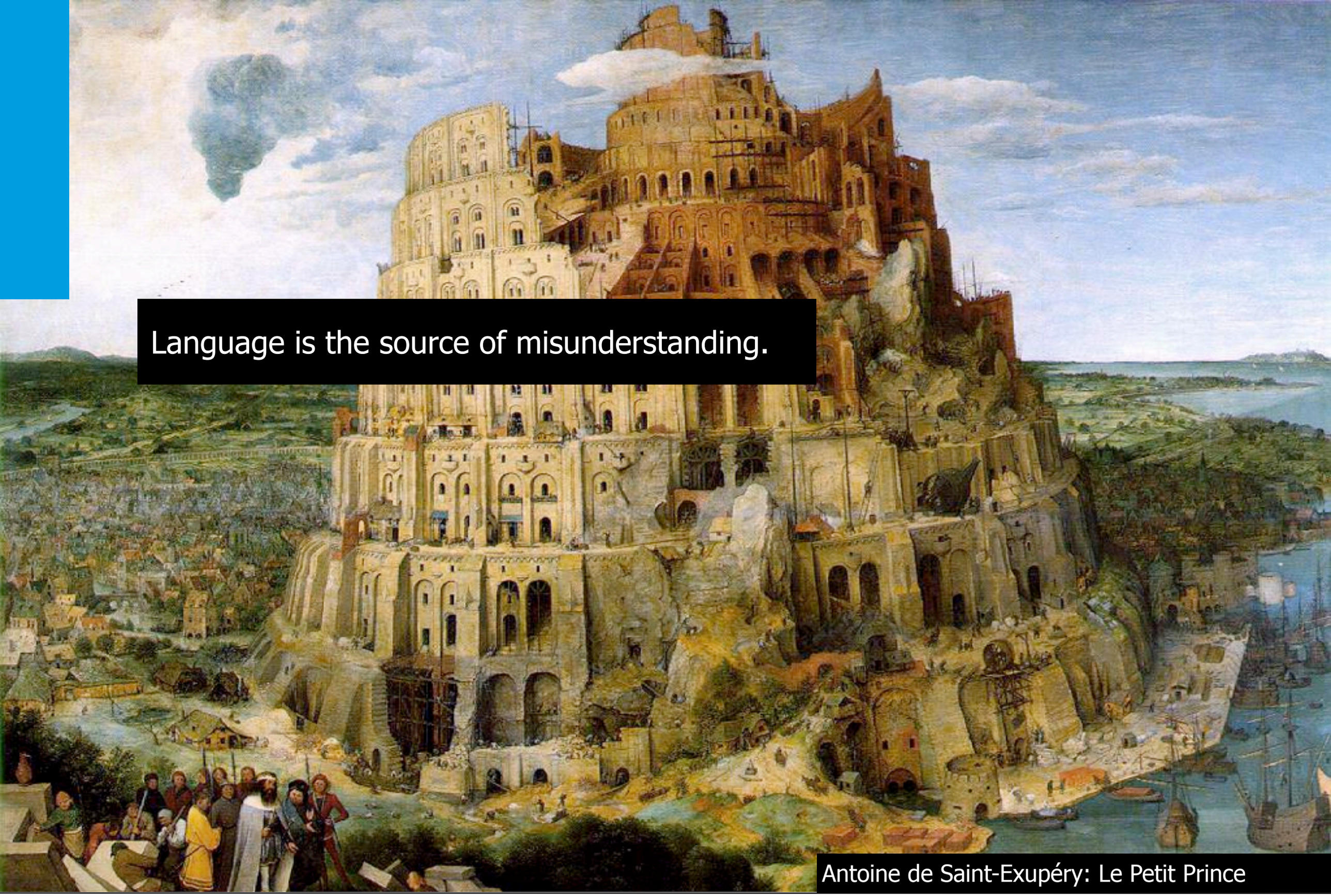
How is this course organised?

- lectures
- assignments
- resources

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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ideas, emotions, and desires

by means of a **system**

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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

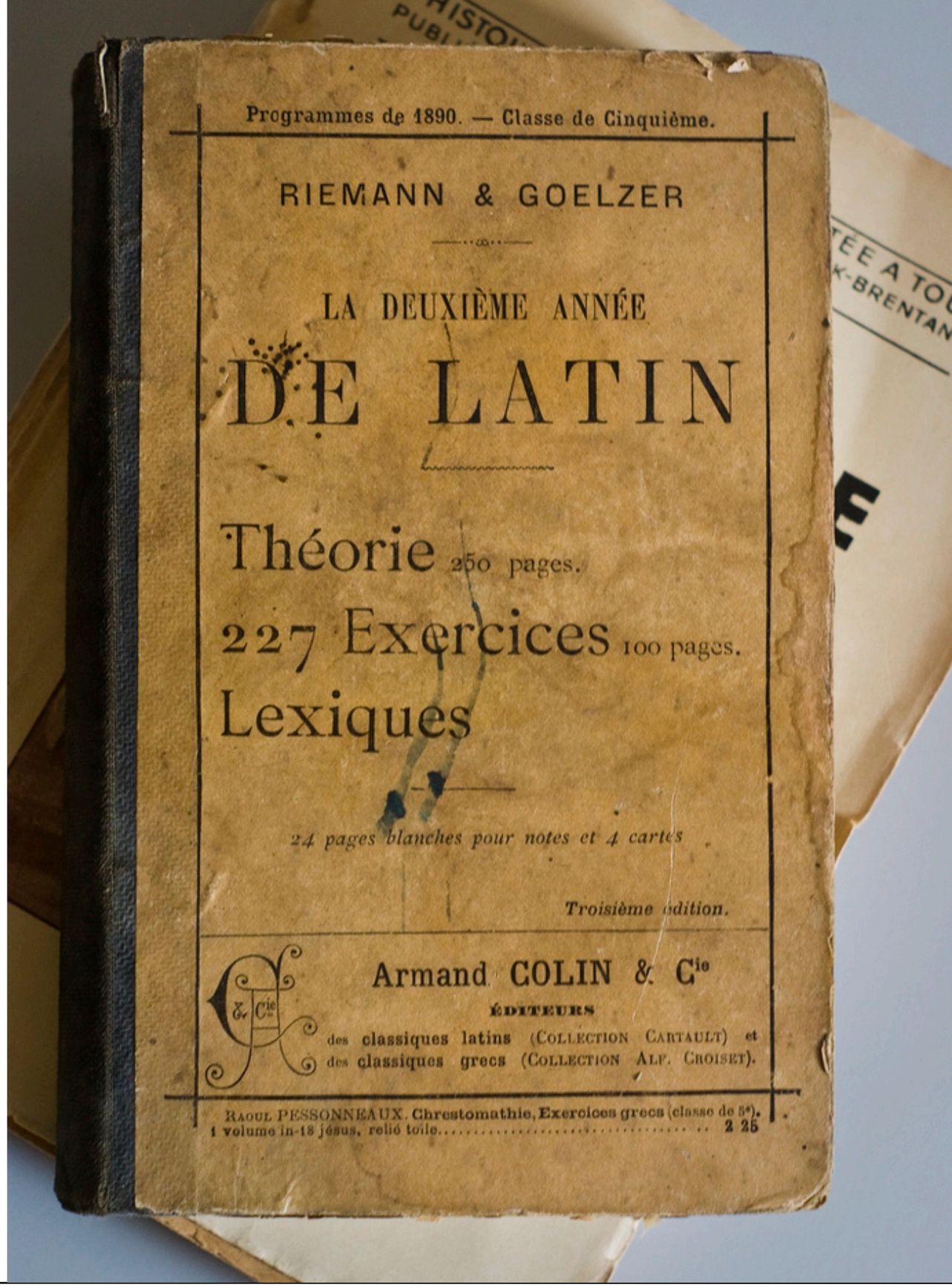
symbolic

Language
properties

arbitrary

symbolic

systematic



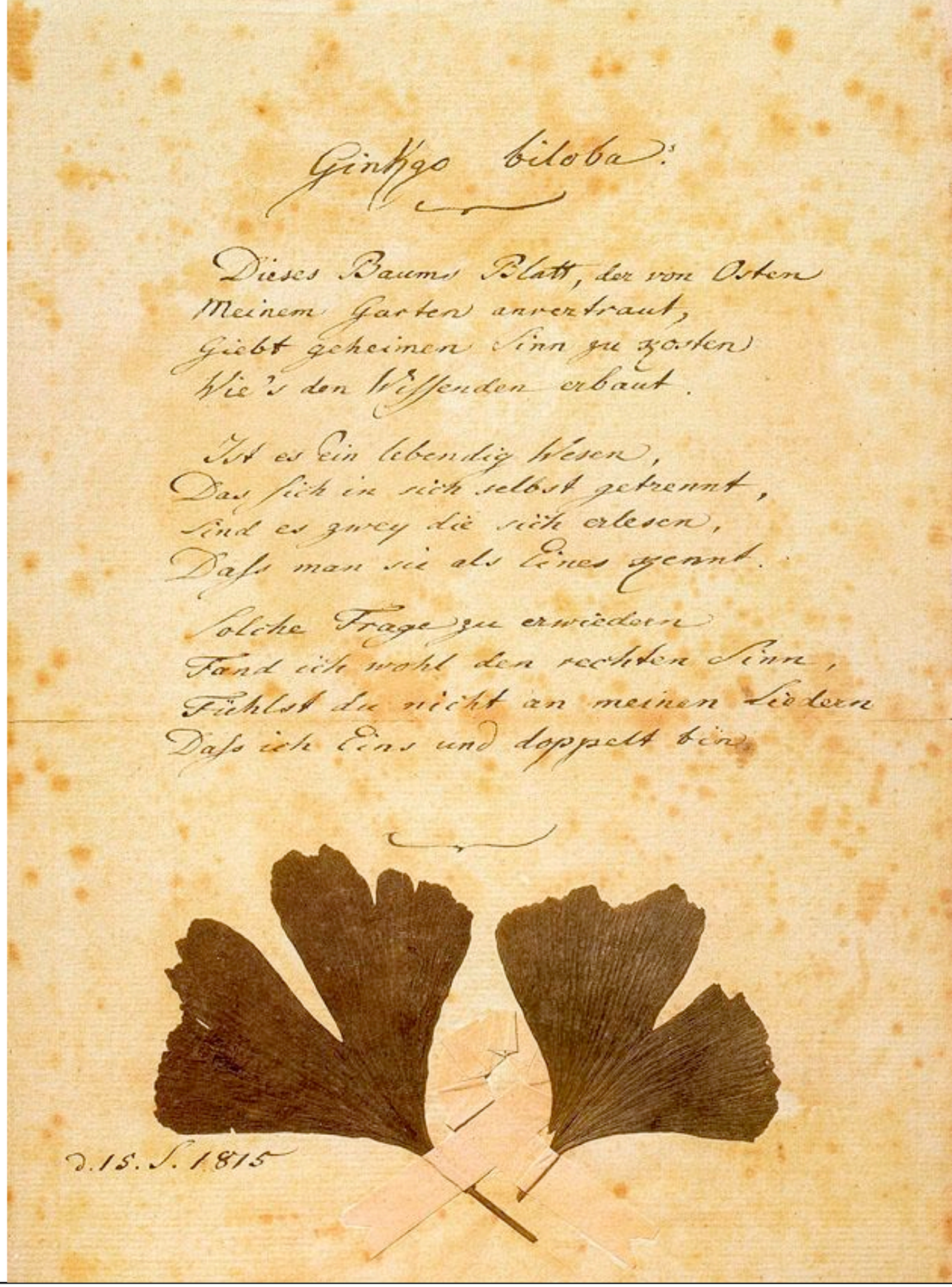
Language
properties

arbitrary

symbolic

systematic

productive



Language
properties

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symbolic

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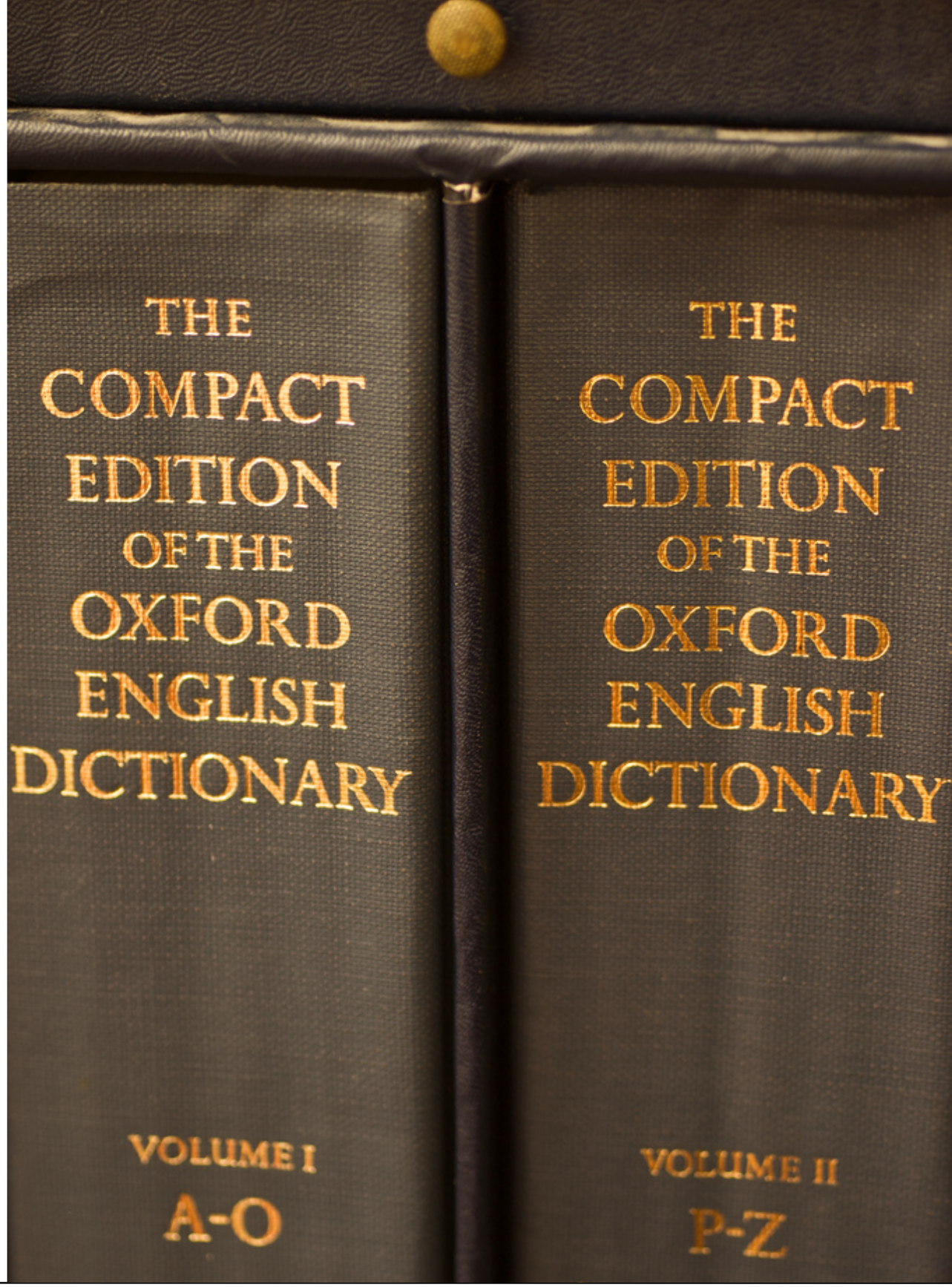
productive

non-instinctive



Language
properties

arbitrary

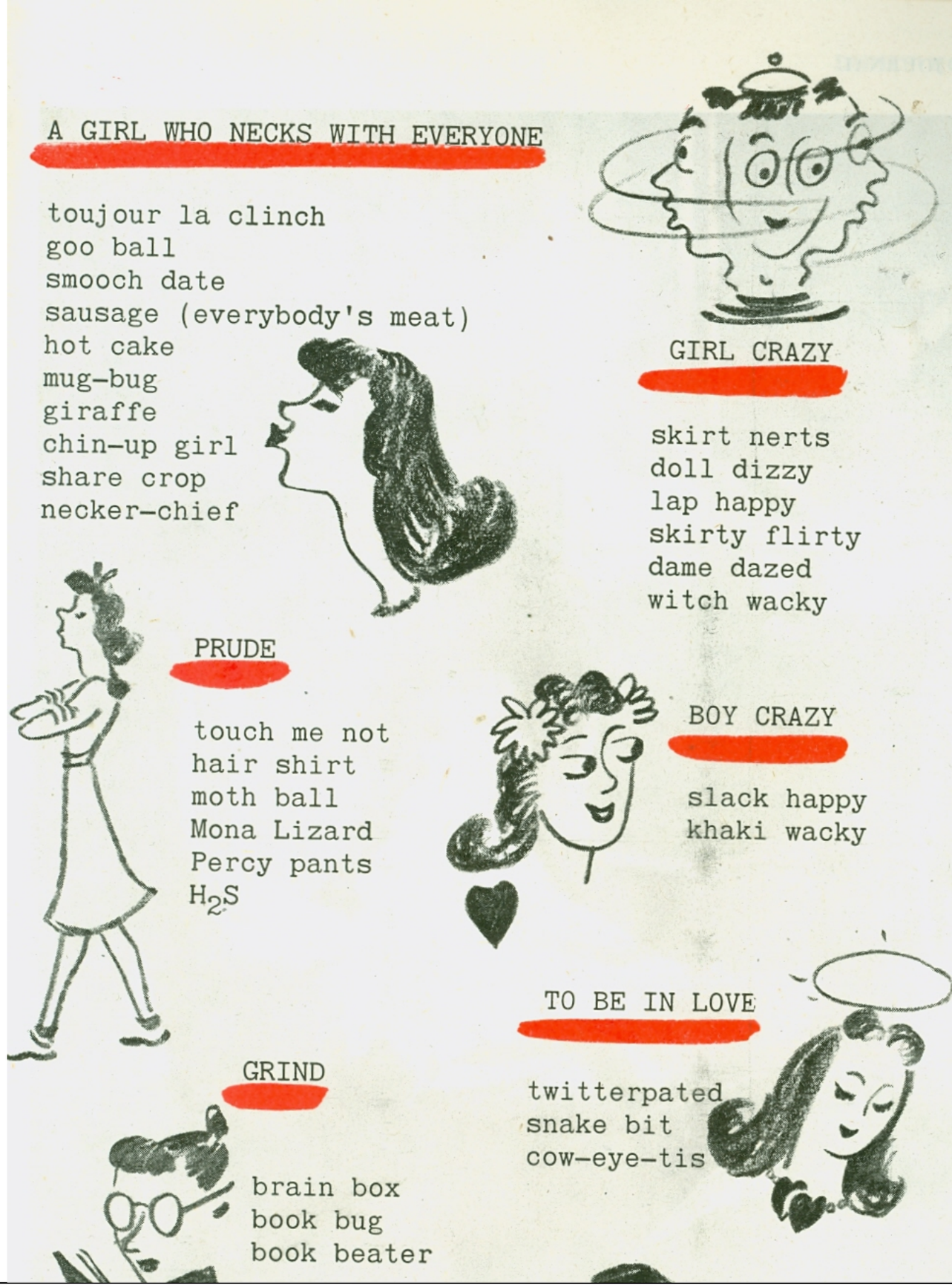
symbolic

systematic

productive

non-instinctive

conventional



Language
properties

arbitrary

symbolic

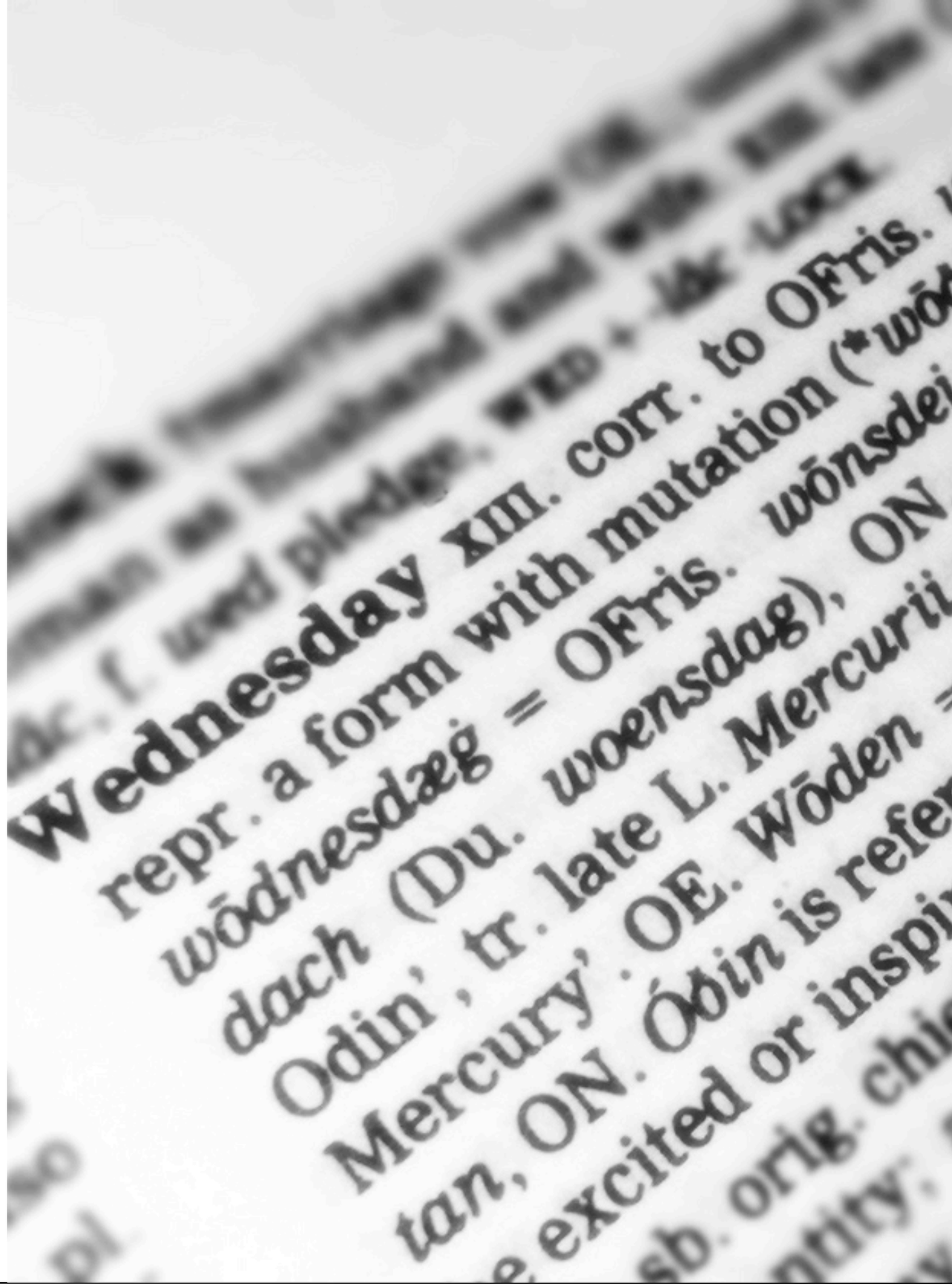
systematic

productive

non-instinctive

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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- semantics

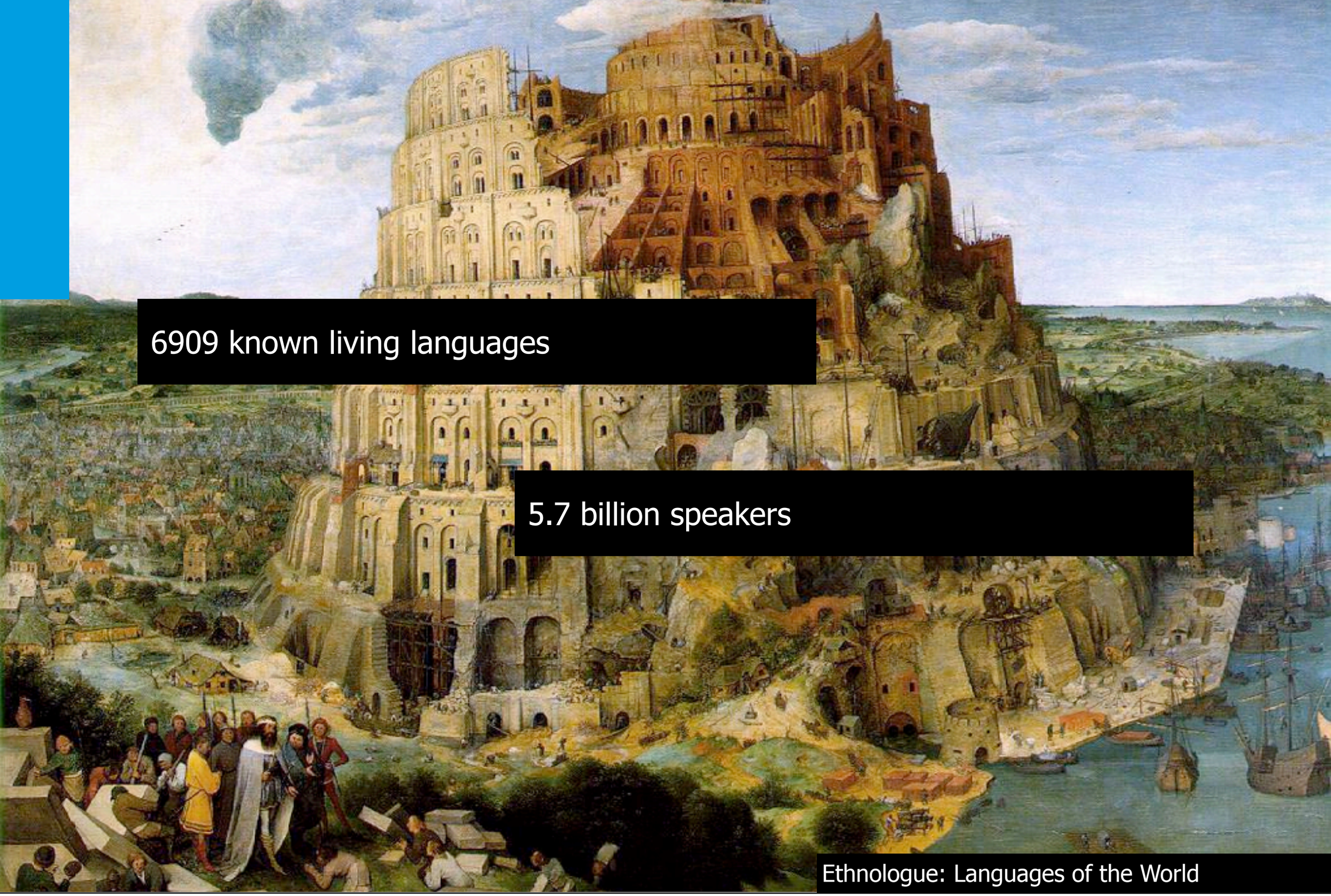
interdisciplinary

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

What is a language?

A language is a dialect with an army and navy.

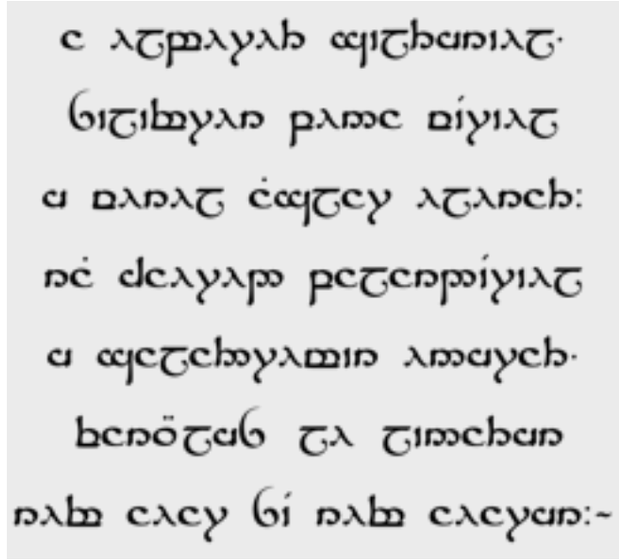
Max Weinreich: YIVO Bletter 25(1)

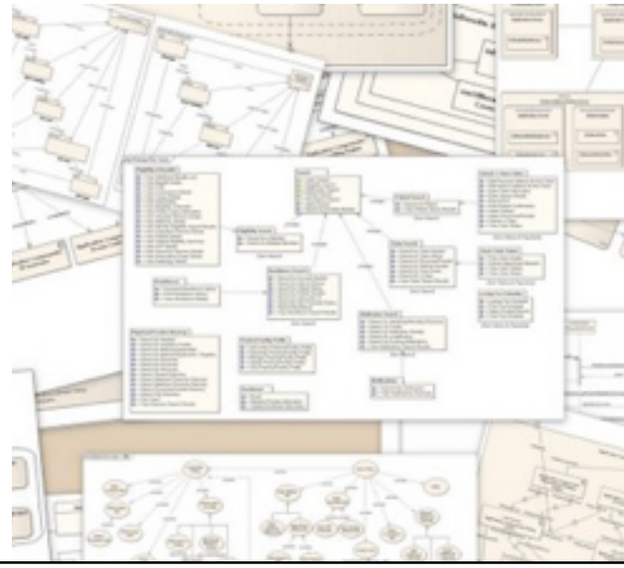

6909 known living languages
5.7 billion speakers
Ethnologue: Languages of the World

Language Control

towards artificial languages

Sanskrit Duden Simplified English





Language Control

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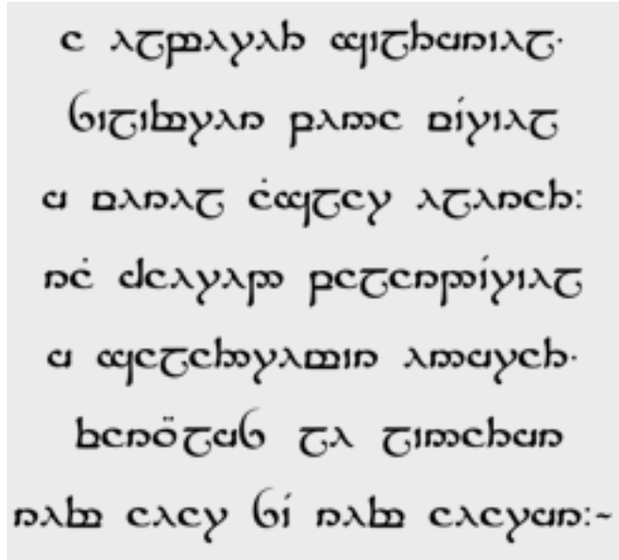
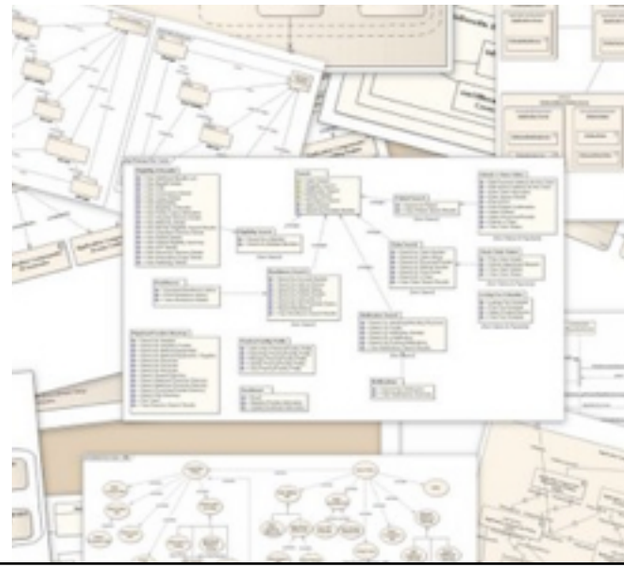
Sanskrit Duden Simplified English

Esperanto Ido Interlingua





Language Control
towards artificial languages

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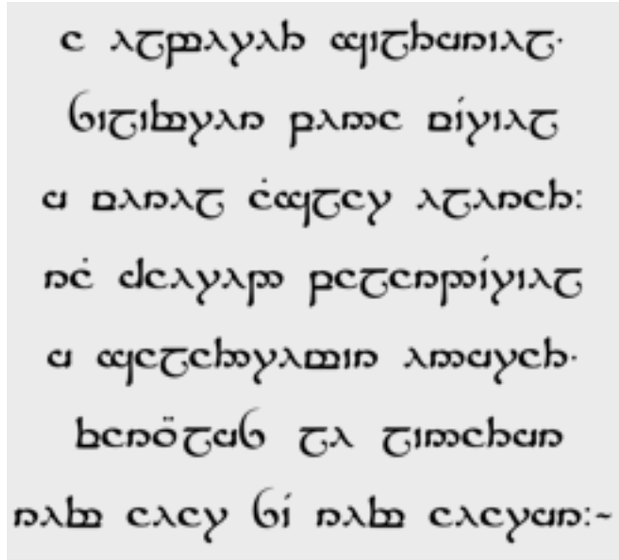
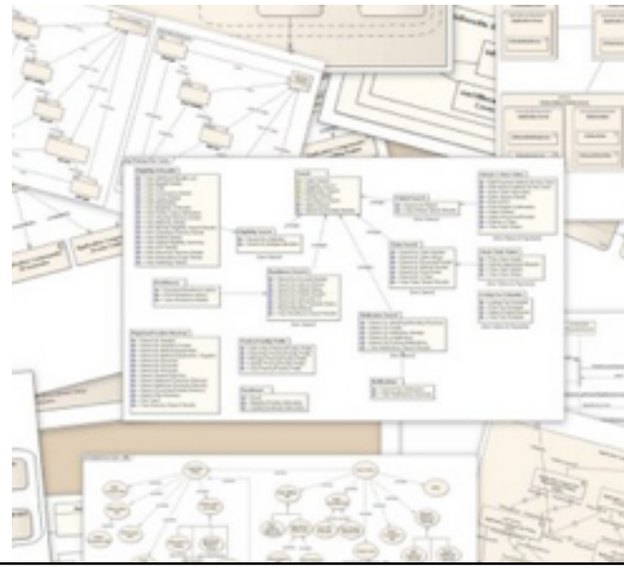
Esperanto Ido Interlingua

Quenya Klingon Na’vi





Language Control

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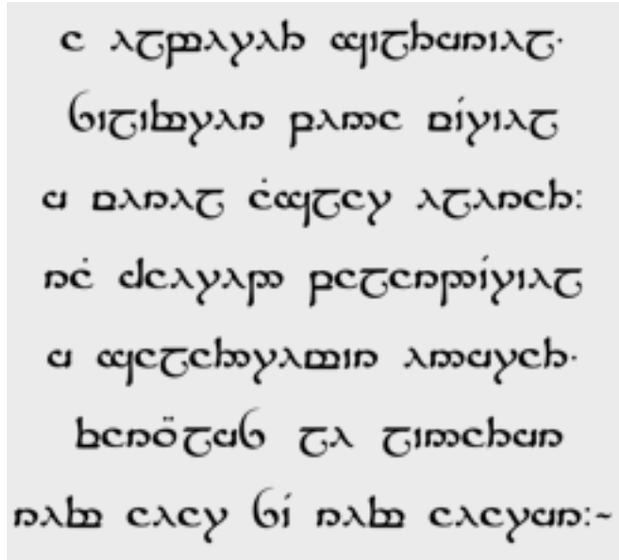
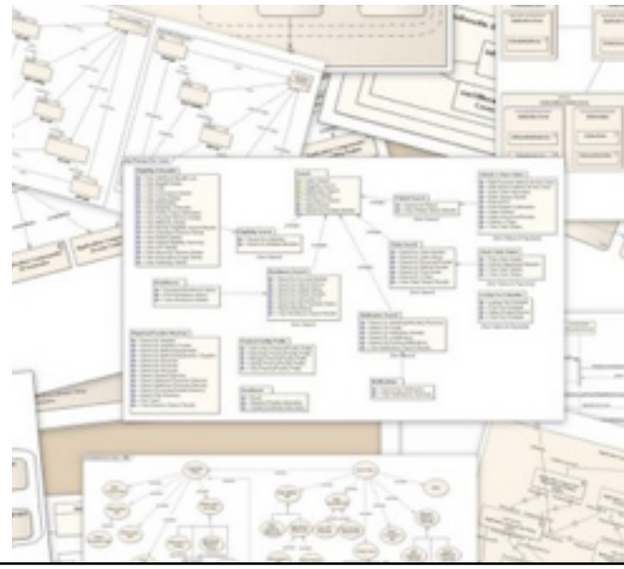
Sanskrit Duden Simplified English

Esperanto Ido Interlingua

Quenya Klingon Na’vi

International Algebraic Language





Language Control

towards artificial languages

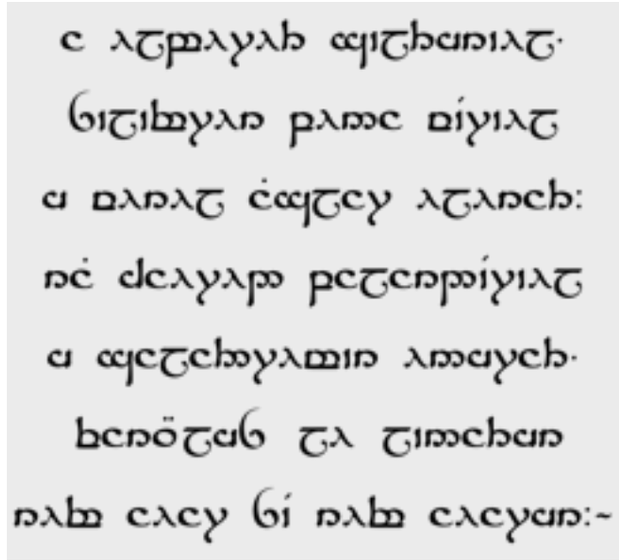
Sanskrit Duden Simplified English

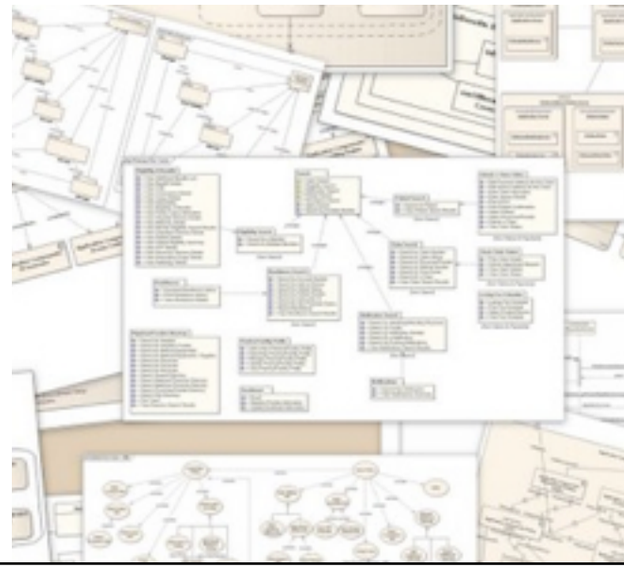
Esperanto Ido Interlingua

Quenya Klingon Na’vi

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** …

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

Software Languages

languages to engineer software

8512 software languages
15.2 million developers worldwide
Encyclopedia of Computer Languages
Evans Data report 2009

Study of Language

linguistics and friends

philosophy

linguistics

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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
```

MiniJava

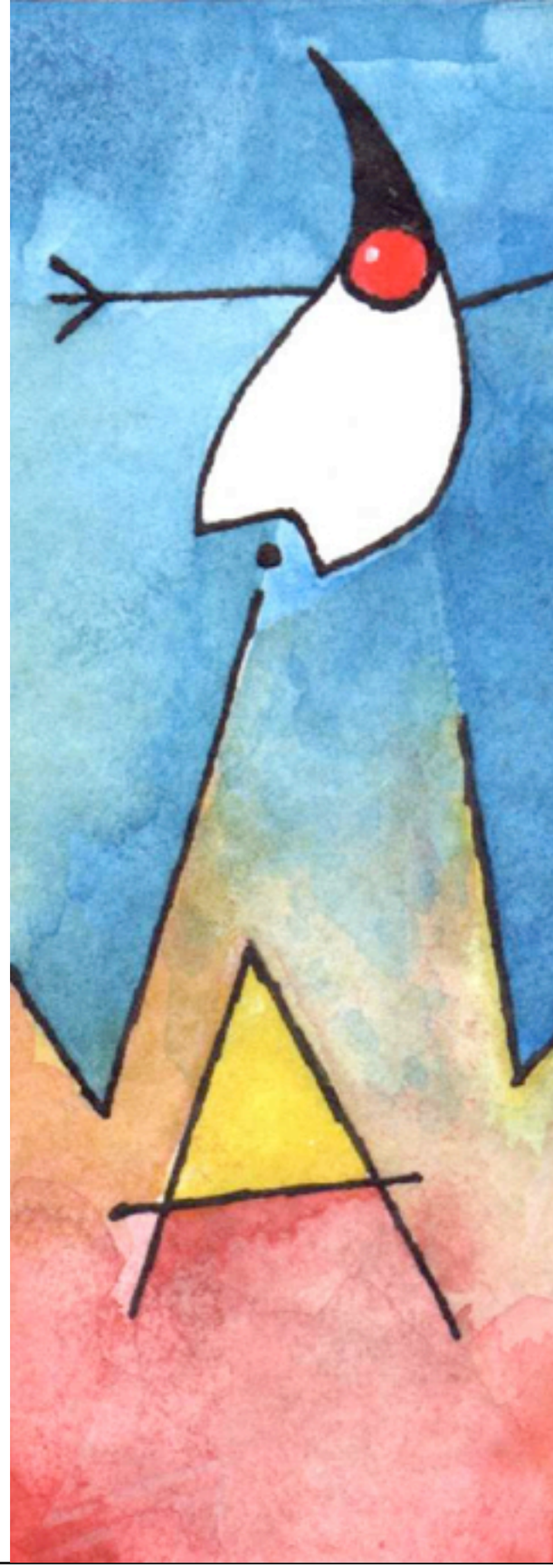
the lab language

```
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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To provide a means for realising a stated process on a variety of **machines** …

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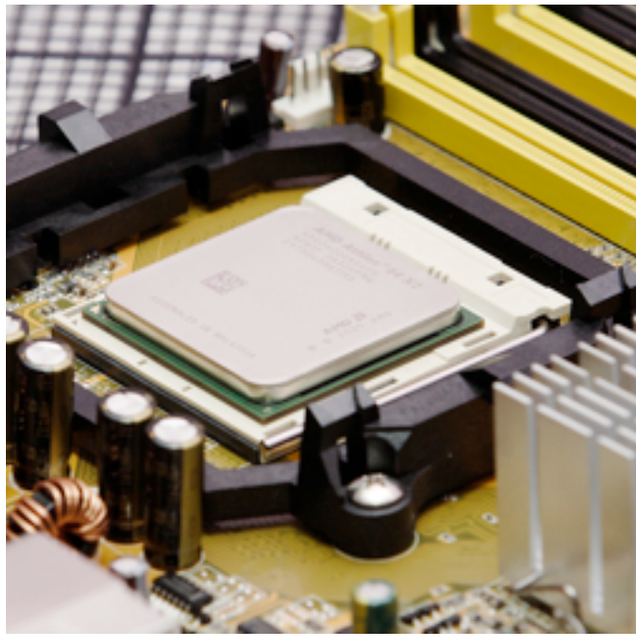
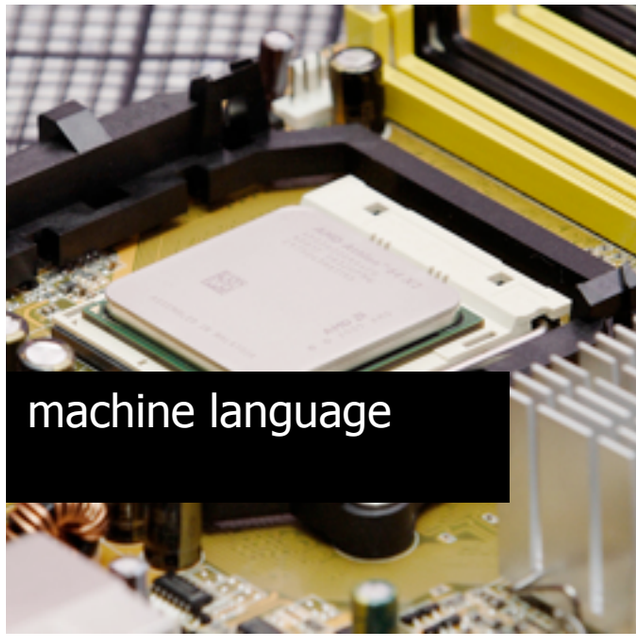
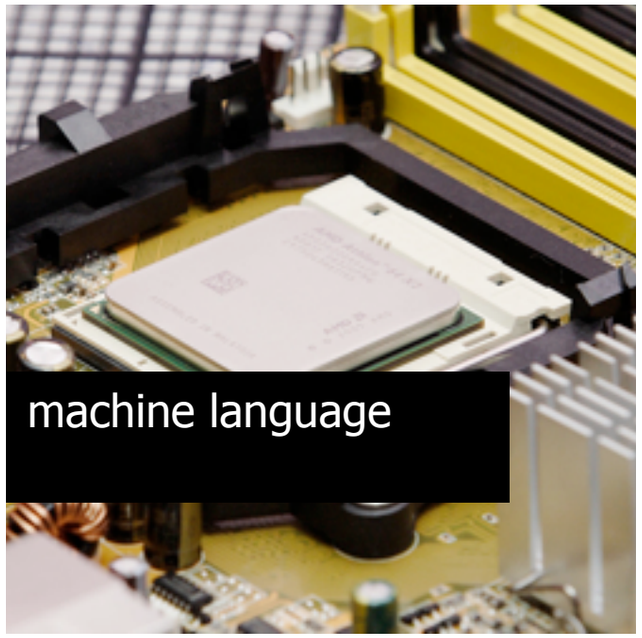
Compilers



Compilers

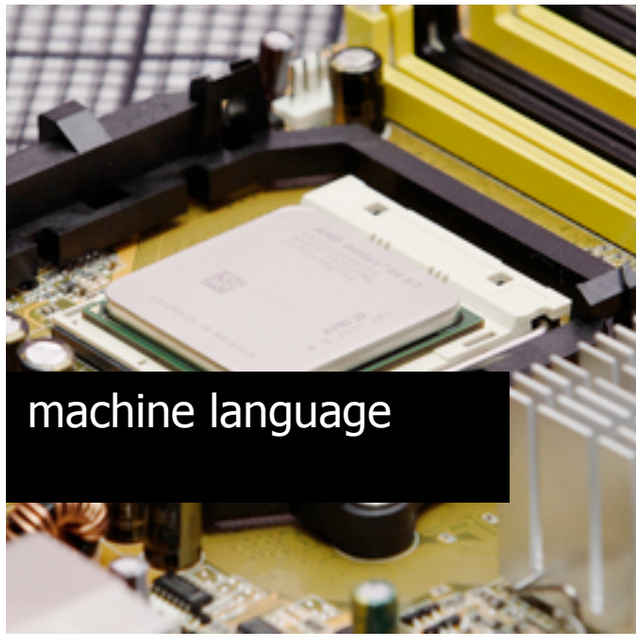


Compilers



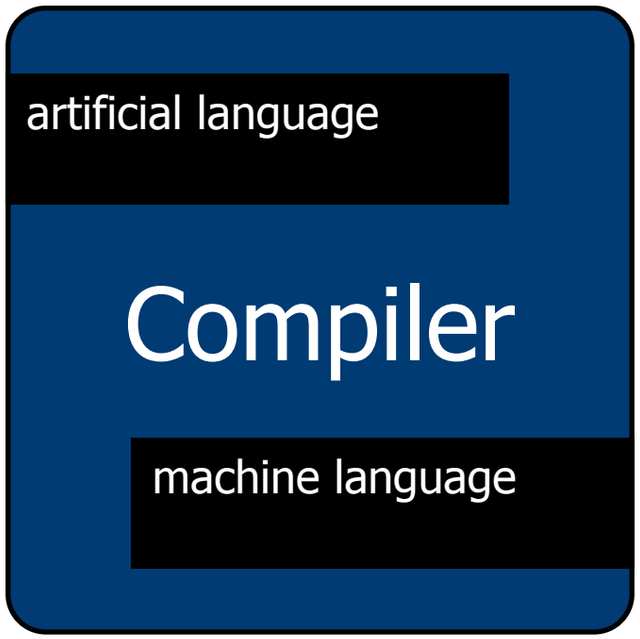
Compilers

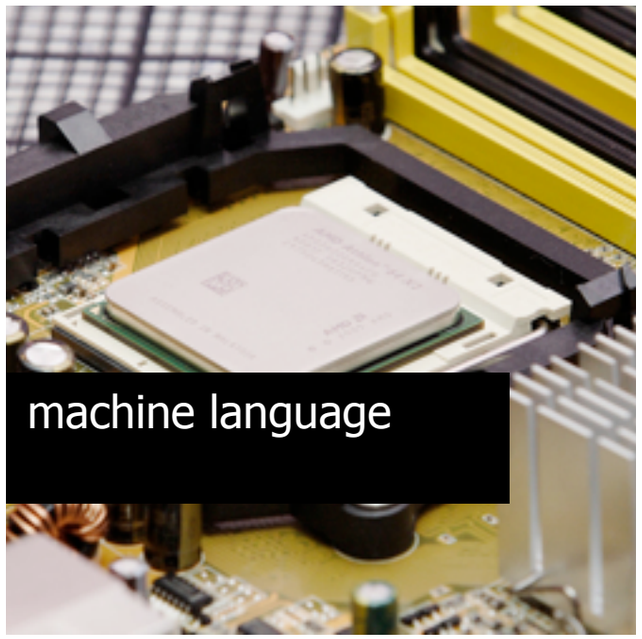
Compiler



Compilers

artificial language


artificial language
Compiler
machine language


machine language

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

example

ls

```
Course.java
```

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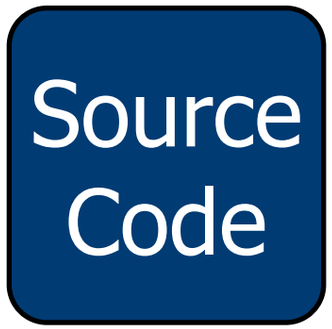
ls

```
Course.class    Course.java
```

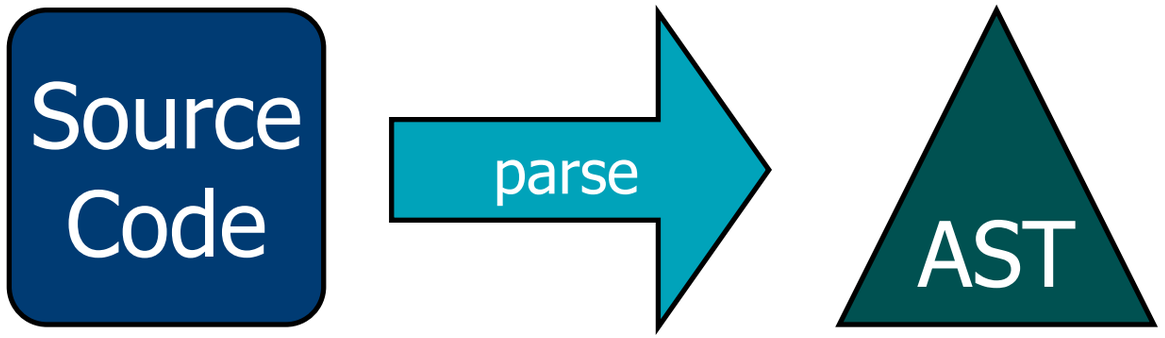
Traditional Compilers

architecture



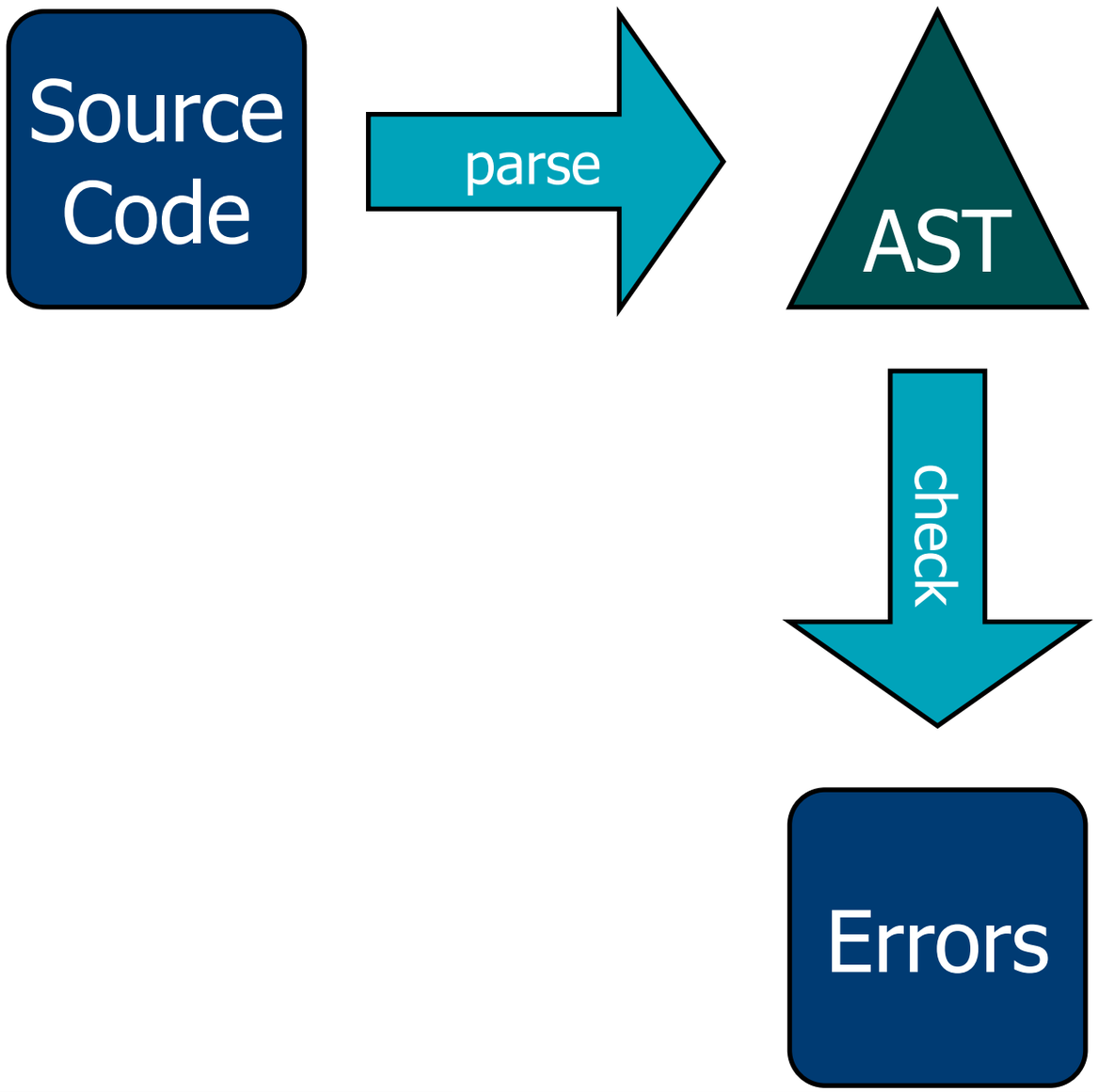
Traditional Compilers

architecture



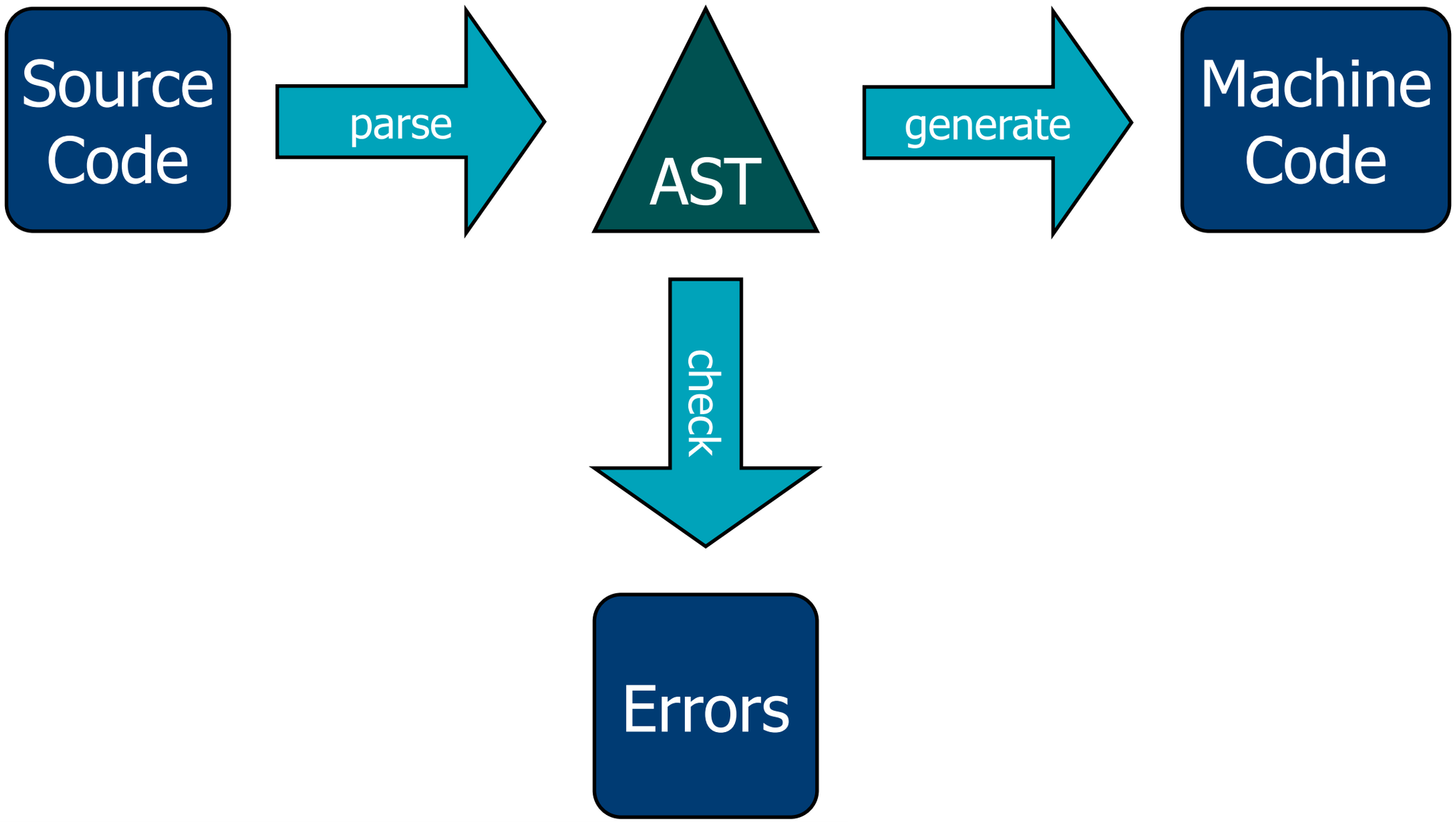
Traditional Compilers

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

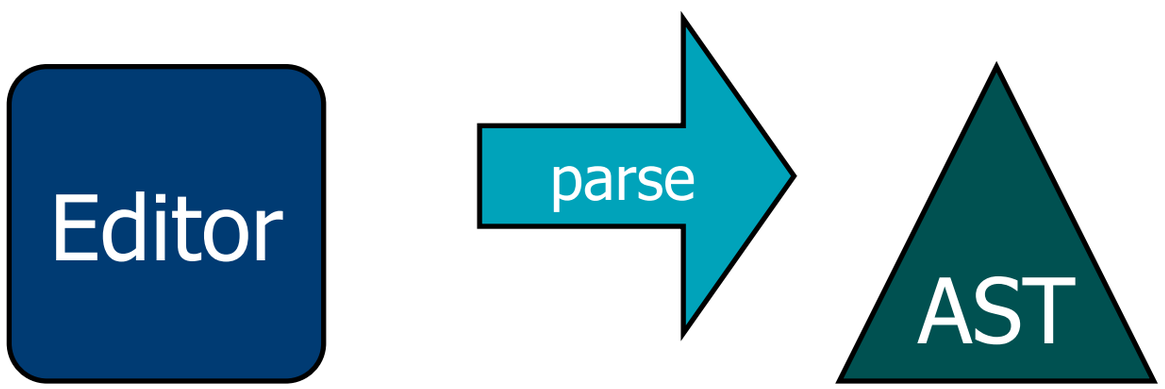
- error checking
- reference resolving
- hover help
- code completion
- refactoring

Modern Compilers in IDEs

architecture

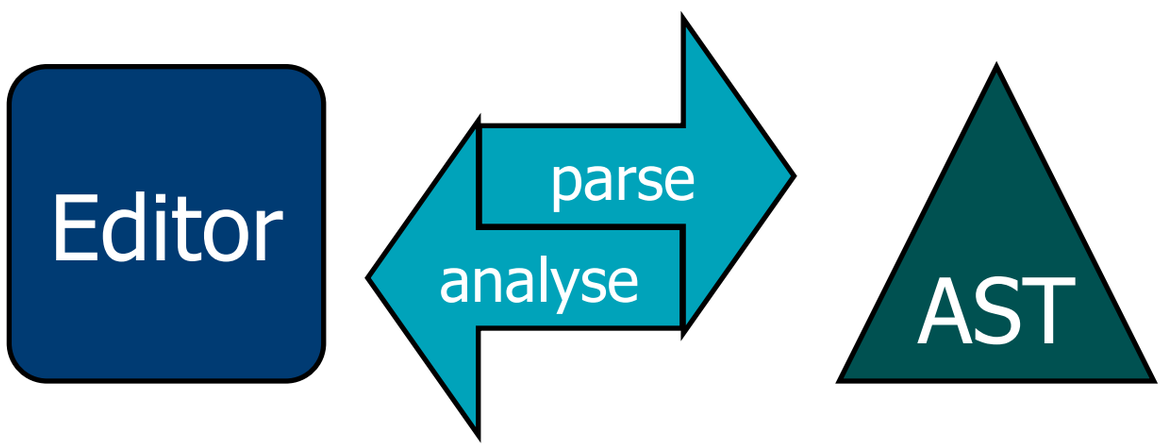
Modern Compilers in IDEs

architecture



Modern Compilers in IDEs

architecture



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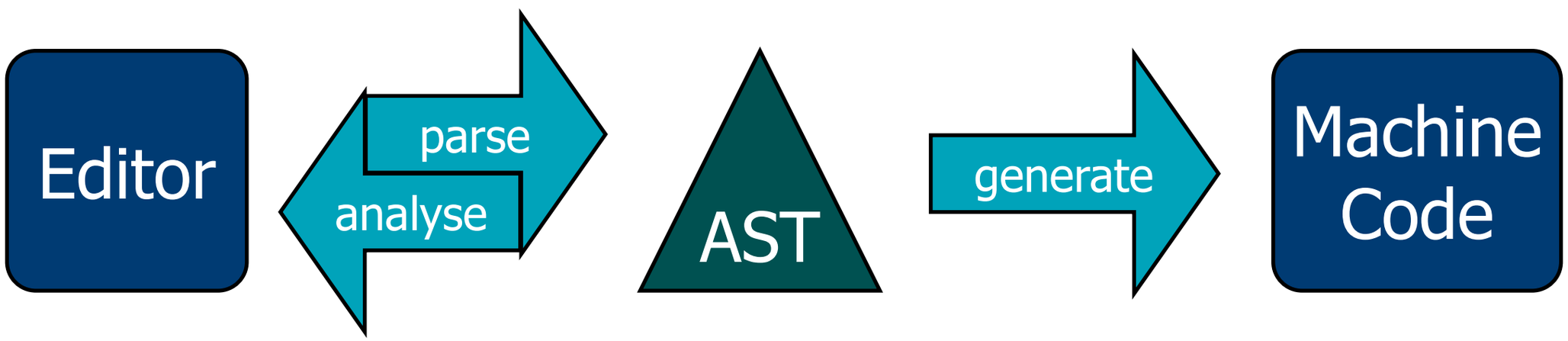
architecture



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

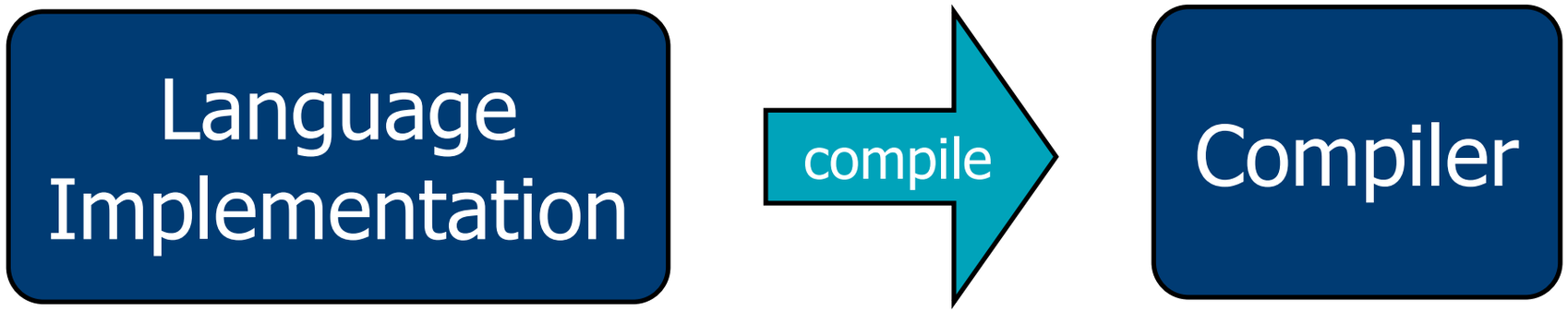
III

compiler construction

metalanguage facility

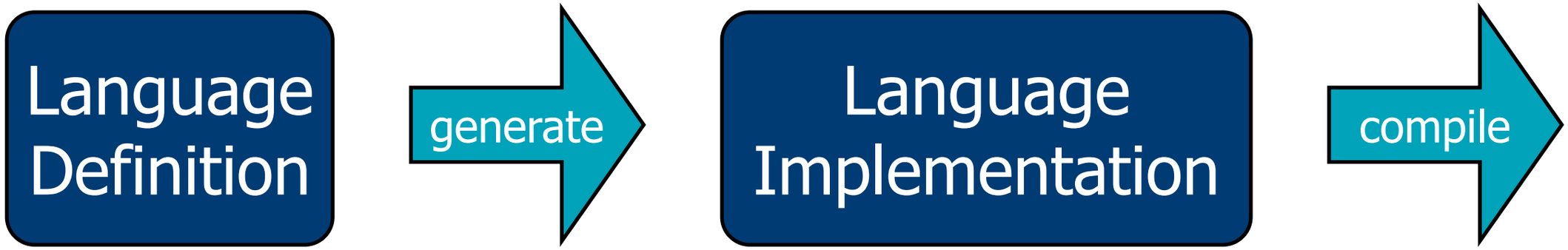
Traditional Compiler Compilers

manual implementation



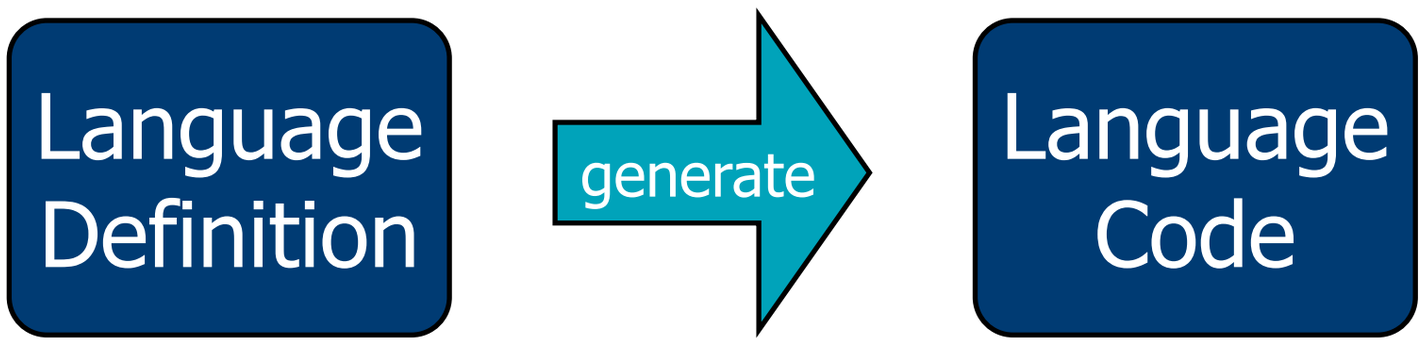
Traditional Compiler Compilers

generation + generation



Traditional Compiler Compilers

generation + interpretation



Language Definition
components

syntax definition

- concrete syntax
- abstract syntax

static semantics

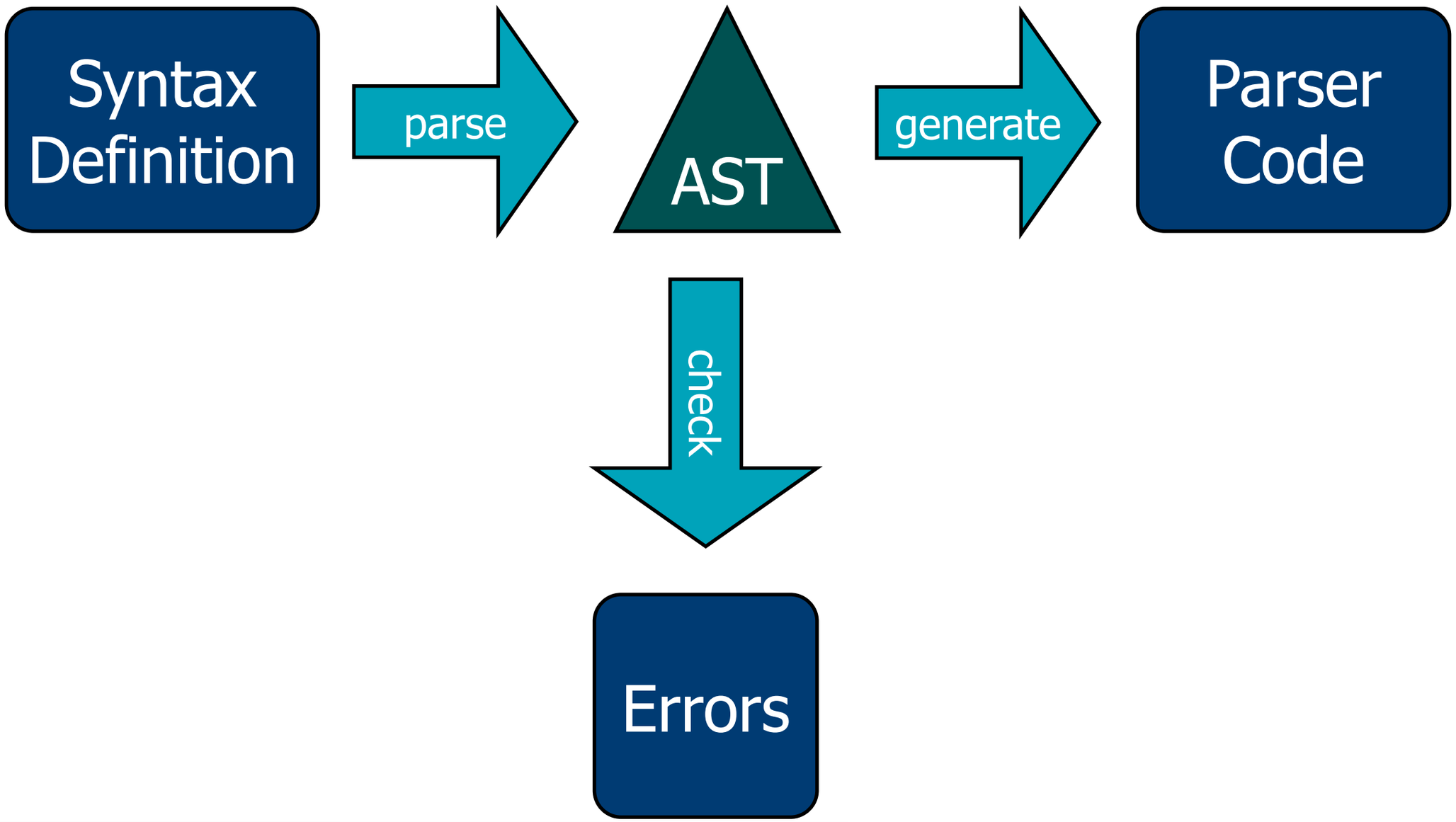
- name bindings
- type analysis

dynamic semantics

- translation
- interpretation

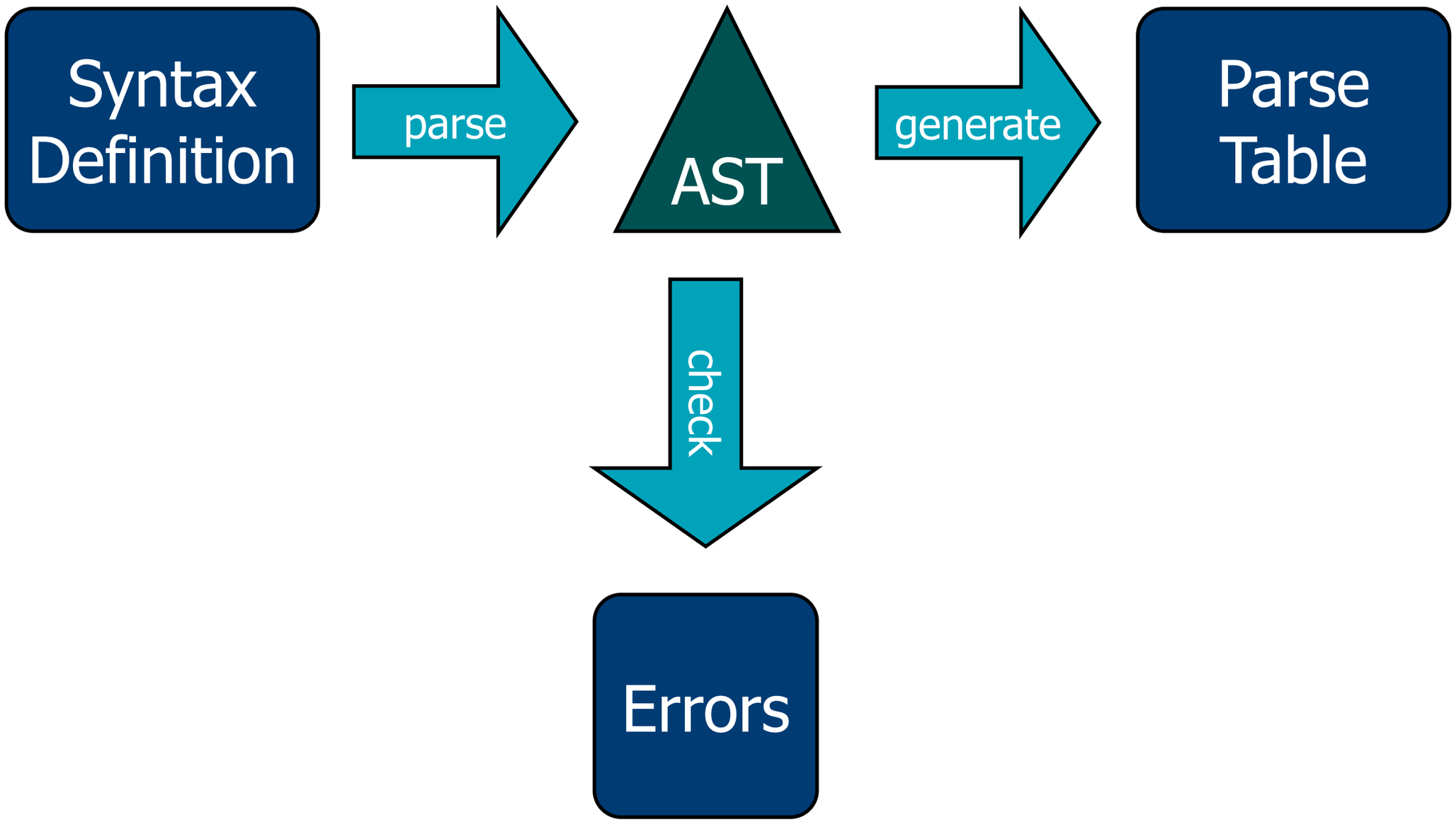
Traditional Compiler Compilers

generation + generation



Traditional Compiler Compilers

generation + 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

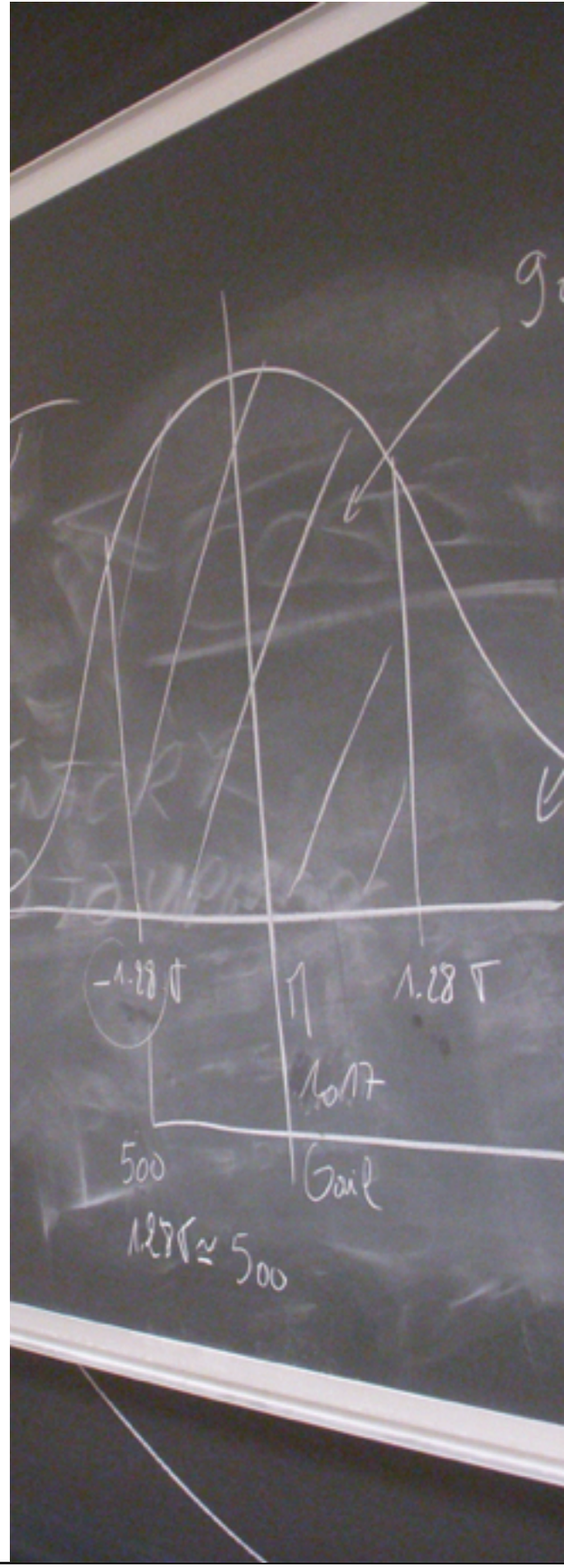
http://blackboard.tudelft.nl

course

- 15 lectures
- 14 lab sessions

assessment

- weekly lab assignments
- written exam Jan 29



Organisation
contact

lectures & lab sessions

office

HB 08.040, Mekelweg 4

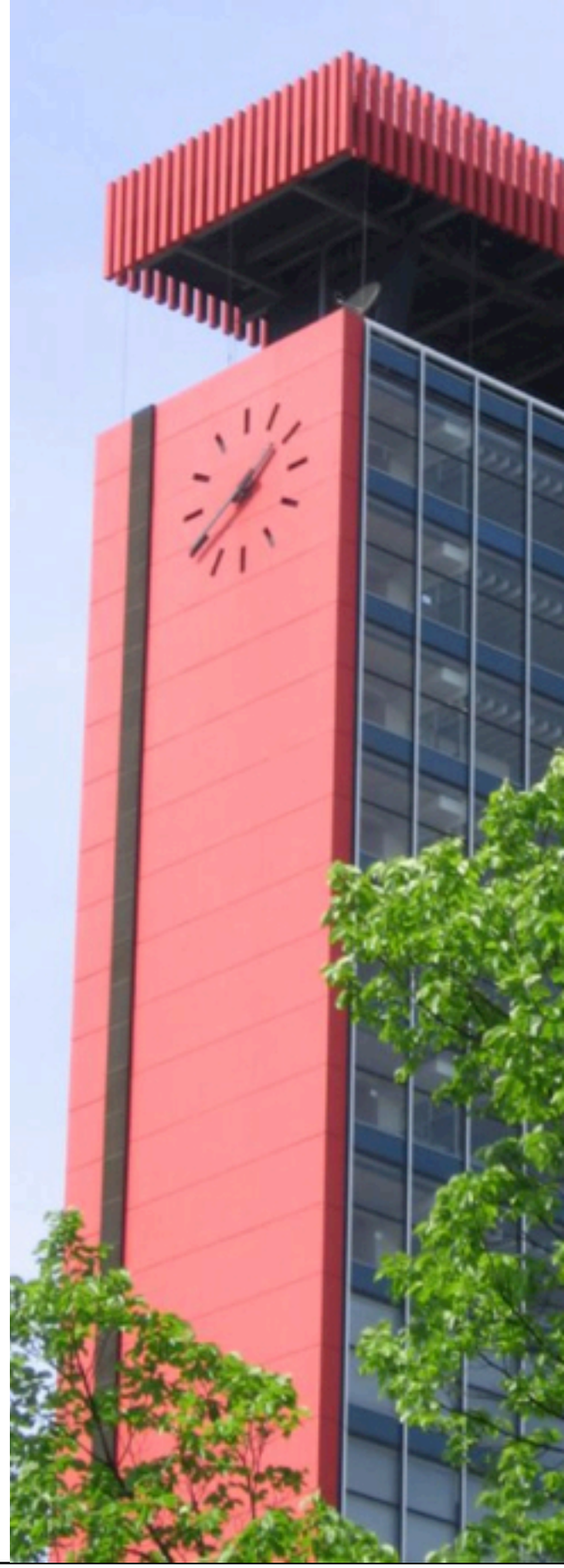
e-mail

G.H.Wachsmuth@tudelft.nl

twitter

http://twitter.com/IN4303

http://twitter.com/guwac



Organisation
lectures

lectures

- 1 + 7 + 6 + 1 lectures
- starting Sep 11

parts

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

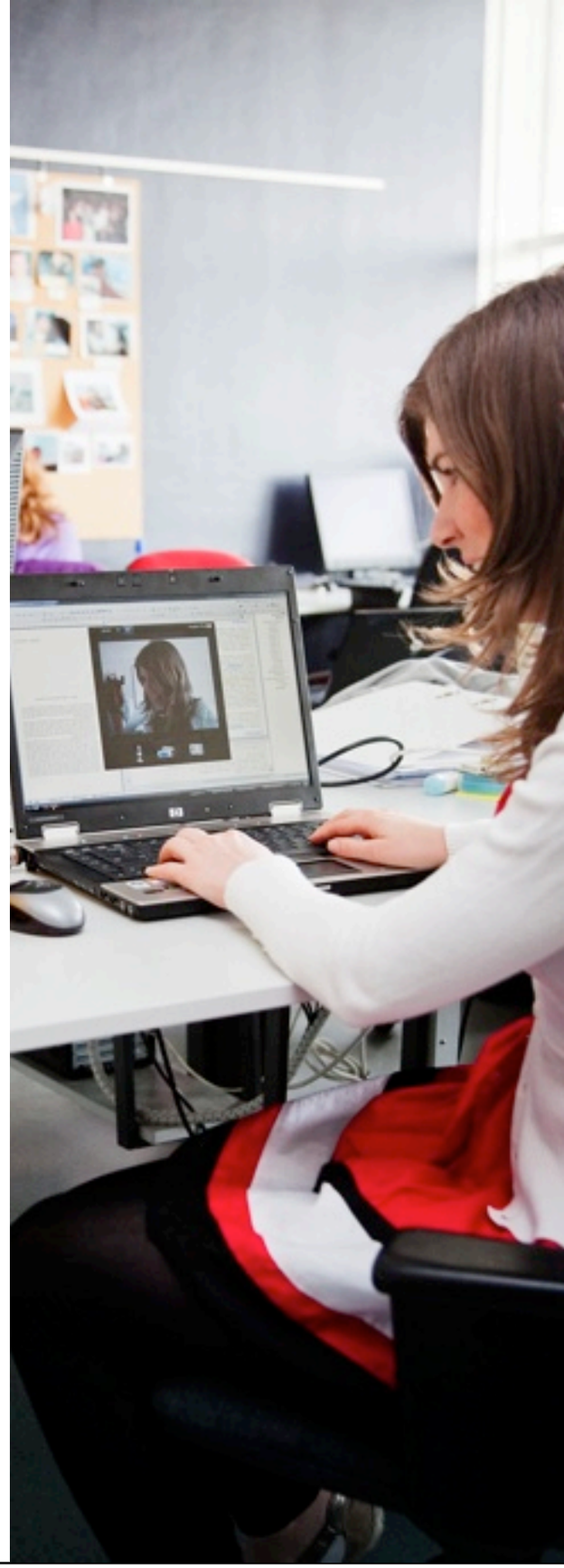
Organisation
assignments

practical work

- 1 + 6 + 7 lab sessions
- starting Sep 13

milestones

- editor (3 labs)
- name + type analysis + error checking (3)
- code generator (4)
- free style (3)



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

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

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How is this course organised?

Literature

learn more

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language

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

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

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Andrew W. Appel: Modern Compiler Implementation in ML.

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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 13

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

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