SWAT

Advanced Metaprogramming

vadim@grammarware.net

Advanced Programming / Software Languages Team

Vadim Zaytsev, SWAT, CWI

CWI

Software is complex

- The principles of software are easy
  - just a bunch of computer instructions
  - IO, arithmetic, control, done!
  - adv: patterns, concurrency, agile/formal — still easy
- The practice of software is incomprehensible
  - too much code
  - too much diversity
  - CPU is too fast
  - too much memory

CWI

Solutions/instruments?

- Higher level programming
- Program comprehension
- IT portfolio management
- …
- Metaprogramming

CWI

Higher level programming

- Generative programming
- Domain-specific languages
- Model-driven engineering
- Metaprogramming

CWI

GP

- Obtain a collection of reusable components
- Always maximise the automation
- Aim at product lines, not at single programs
- Compose a system specification
- Generate the final system(s) from all of the above

K. Czarnecki, U. Eisenecker, , A-W 2000.

CWI

DSL

- Choose a problem domain
- Compose a dictionary of domain concepts
- Make a language with those concepts
- Define mappings to some executable language
- Program/model in your own language

M. Mernik, J. Heering, A. M. Sloane. _____. CSUR 2005.

CWI

MDE

- Investigate application domain
- Encapsulate domain knowledge in a model
- Produce software artefacts from the models
- Model-based…
  - …code generation
  - …testing
  - …architecture

J.-M. Favre, _____. Dagstuhl 2005.

CWI

Program comprehension

- Static analysis
- Dynamic analysis
- Integrated development environments
- Metaprogramming

CWI

Static program analysis

- Analyse the structure of the source code
- Control flow analysis
- Data flow analysis
- Model checking
- Abstract interpretation
- Verification of assertions in the code

CWI

Dynamic analysis

- Analyse the behaviour of the program in the runtime
- Model checking
- Testing + code coverage criteria
- Simulation

CWI

IDEs

- Source code editor
  - with syntax highlighting
  - with code completion
  - with advanced navigation
- Debugger
  - with runtime memory inspection
  - with stepwise algorithm execution
- Compiler
  - with dependency hell resolution system

CWI

IT portfolio management

- Mining software repositories
- Size & quality measurement
- Benchmarking
- Metaprogramming

CWI

Mining software repos

- Software repositories contain data on software evolution
  - versions, releases, bugfixes, documentation, discussion
- Data analysis is used to uncover
  - interesting information
  - actionable information
- E.g.
  - defect prediction
  - analysis of client satisfaction

MSR 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012

CWI

Software metrics

- Size
  - number of files? of lines of code? of languages?
- Complexity
  - number of files per artefact? lines per file?
- Performance
  - speed? bottlenecks? algorithmic complexity?

Benchmarking

Software Improvement Group

http://sig.eu

A practical model for measuring maintainability

Heitlager, Kuipers, Visser in QUATIC 2007, IEEE Press

a. Aggregate measurements into “Quality Profiles”
b. Map measurements and quality profiles to ratings for system properties
c. Map ratings for system properties to ratings for ISO/IEC 9126 quality characteristics
d. Map to overall rating of technical quality

CWI

Metaprogramming is EASY

- **Extract**
  - Fast context-free general top-down parsing
  - Pattern matching & generic traversal
- **Analyze**
  - Relational queries and comprehensions
  - Backtracking, fixed point computation, ...
- **SYnthesize**
  - String templates
  - Concrete syntax
  - Interactive visualization generator

CWI

Metaprogramming is EASY

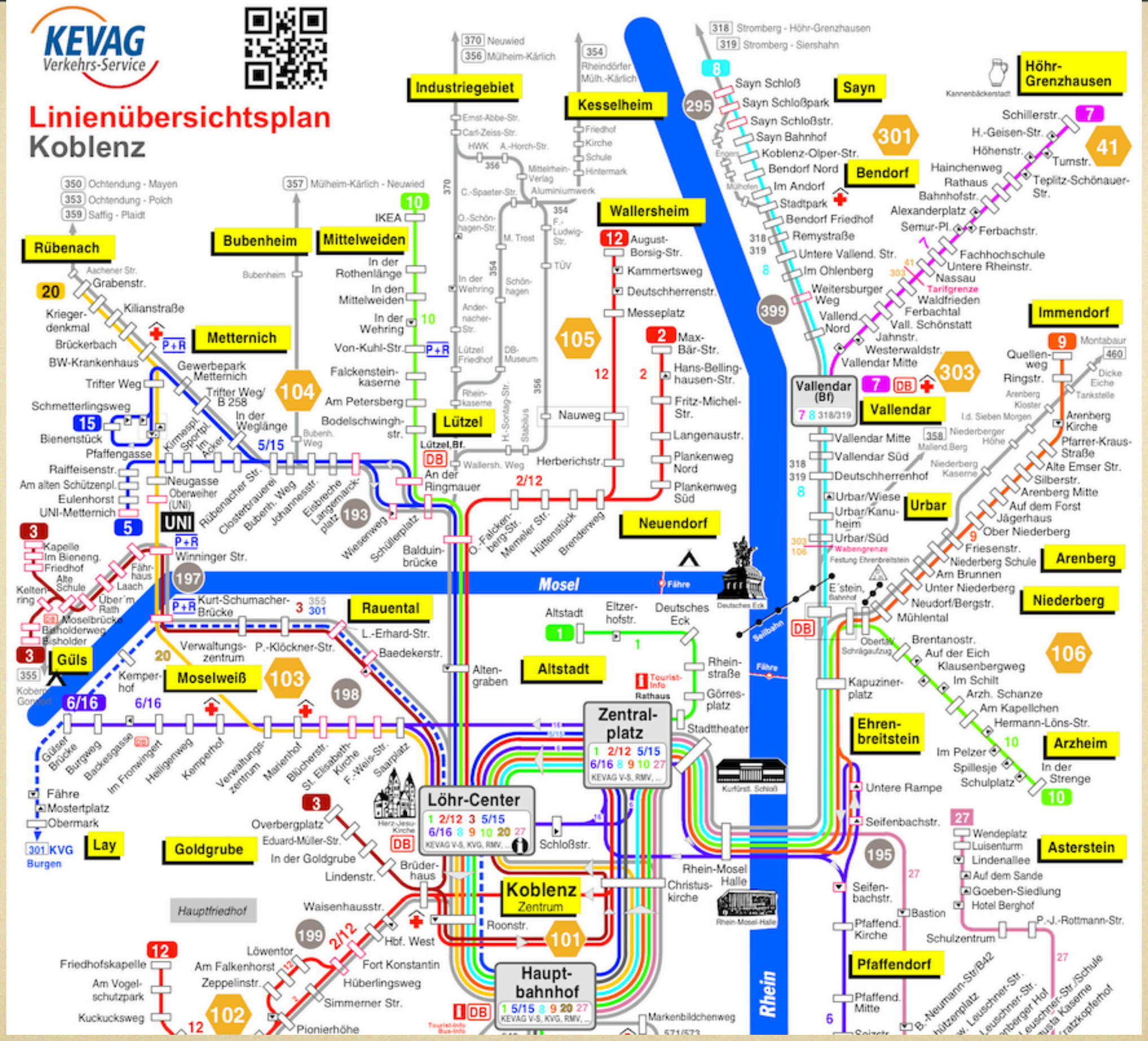
- **Extract**
  - Fast context-free general top-down parsing
  - Pattern matching & generic traversal
- **Analyze**
  - Relational queries and comprehensions
  - Backtracking, fixed point computation, ...
- **SYnthesize**
  - String templates
  - Concrete syntax
  - Interactive visualization generator

Stay tuned!

Bus lines

KEVAG Verkehrs-Service

Linienübersichtsplan Koblenz



http://www.vrminfo.de/linien-netze/liniennetzplan/koblenz

CWI

Bus lines

3: Overbergplatz, Eduard-Müller-Straße, In der Goldgrube, Lindenstraße, Brüderhaus, Roonstraße, Christuskirche, Löhr-Center, Ludwig-Erhard-Straße, Peter-Klöckner-Straße, Verwaltungszentrum, Kurt-Schumacher-Brücke, Winninger Straße.

5: Hauptbahnhof, Christuskirche, Zentralplatz, Löhr-Center, Balduinbrücke, Schüllerplatz, An der Ringmauer, Langemarckplatz, Johannesstraße, Bubenheimer Weg, Closterbrauerei, Rübenacher Straße, Im Acker, Sportplatz, Kirmesplatz, Raiffaisenstraße, Am Alten Schütenplatz, Eulenhorst, Oberweiher, Uni.

15: Hauptbahnhof, Christuskirche, Zentralplatz, Löhr-Center, Balduinbrücke, Schüllerplatz, An der Ringmauer, Langemarckplatz, Johannesstraße, Bubenheimer Weg, Closterbrauerei, In der Weglänge, Trifter Weg, Pfaffengasse, Bienenstück.

20: Hauptbahnhof, Christuskirche, Löhr-Center, Saarplatz, Franz-Weis-Straße, St-Elisabeth-Kirche, Blücherstraße, Marienhof, Verwaltungszentrum, Kurt-Schumacher-Brücke, Winninger Straße, Oberweiher.

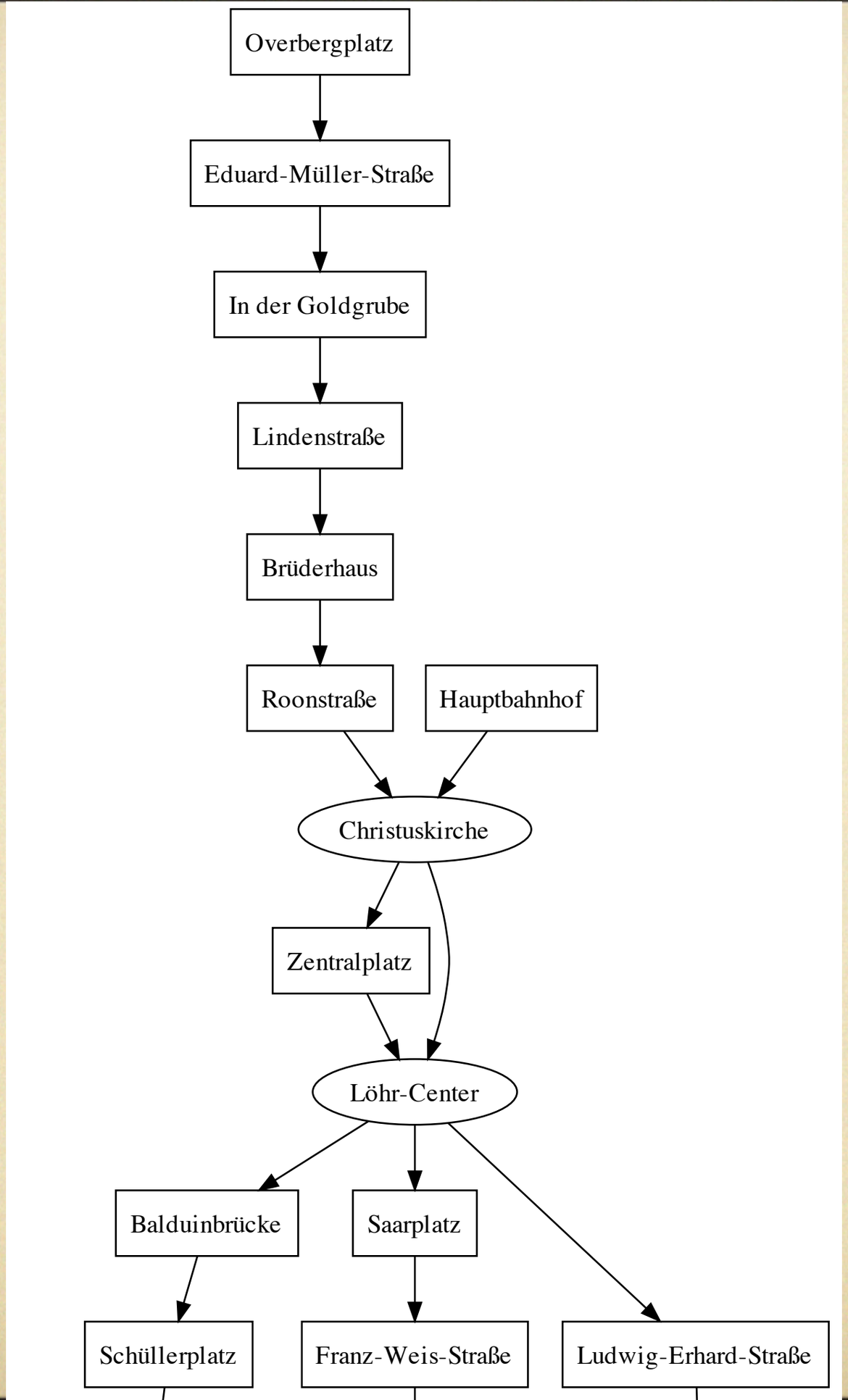
SLPS/topics/implementation/busses/Koblenz.bus

CWI

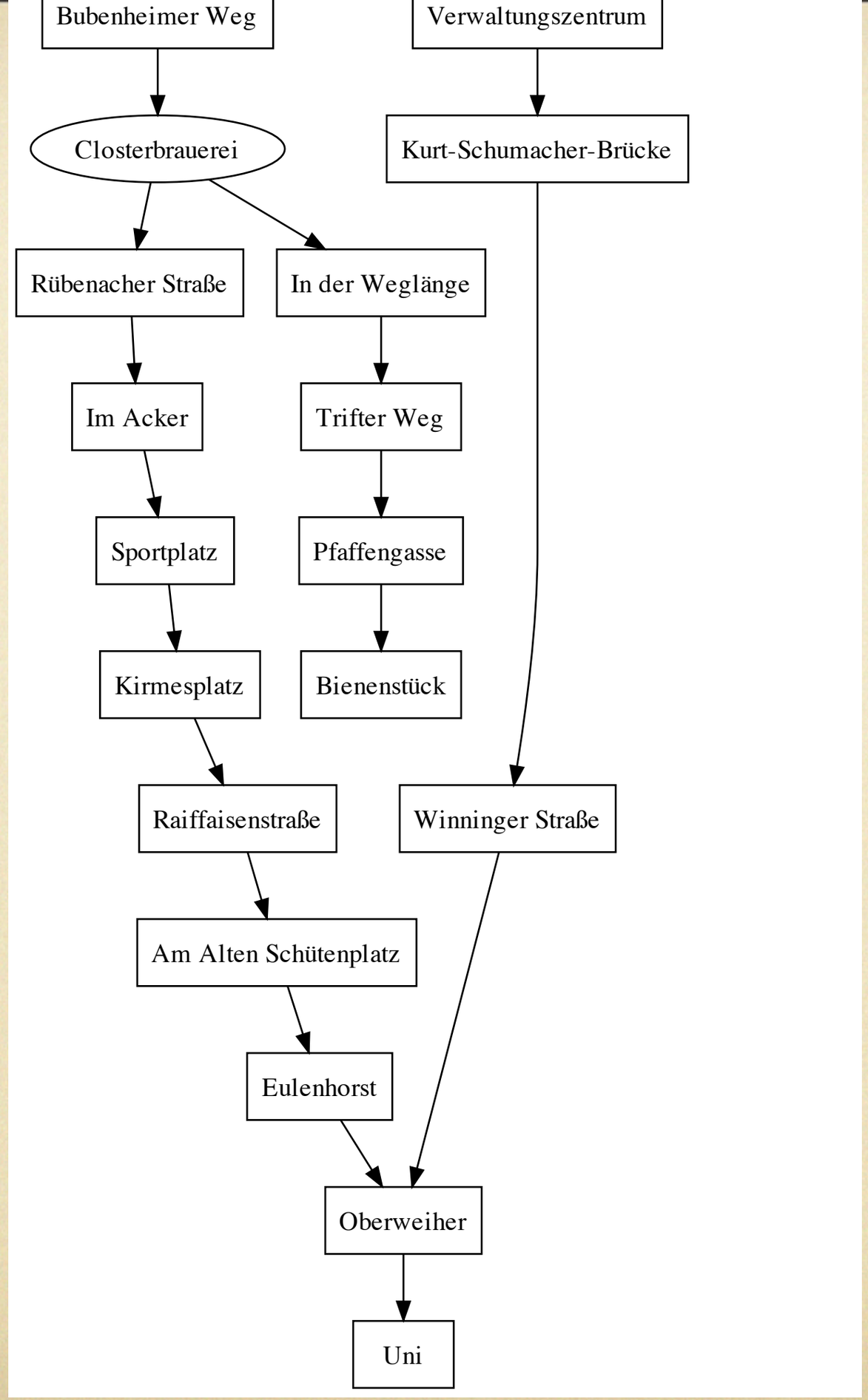
```
start syntax System = Line+;
syntax Line = Num ":" {Id ","}+ "." ;
layout WS = [\ \t\n\r]* !>> [\ \t\n\r];
lexical Id = [A-Za-z][A-Za-züäöß\-\ ]+[A-Za-z] !>> [A-Za-z];
lexical Num = [0-9]+ !>> [0-9];

rel[Id,Id] extractGraph(loc source) = {<from,to> |
/Line b := parse(#start[System],source),
(Line)`<Num _>: <{Id ","}* _>, <Id from>, <Id to>, <{Id ","}* _>.` := b};

bool umsteigen(rel[Id,Id] sys, Id hs) = size(sys[hs]) > 1;

void synthesizeDotGraph(loc source, loc target)
{rel[Id from,Id to] conn = extractGraph(source);
 writeFile(target,
      "digraph Metro { node [shape=box]
      '<for (<from, to> <- conn) {>
      ' \"<from>\" -\> \"<to>\"<}>
      '<for (st <- conn<from>, umsteigen(conn, st)){>
      ' \"<st>\" [shape=ellipse]<}>
      '}");}
```

SLPS/topics/implementation/busses/src/Busses.rsc

CWI


Overbergplatz
Eduard-Müller-Straße
In der Goldgrube
Lindenstraße
Brüderhaus
Roonstraße
Hauptbahnhof
Christuskirche
Zentralplatz
Löhr-Center
Balduinbrücke
Saarplatz
Schüllerplatz
Franz-Weis-Straße
Ludwig-Erhard-Straße

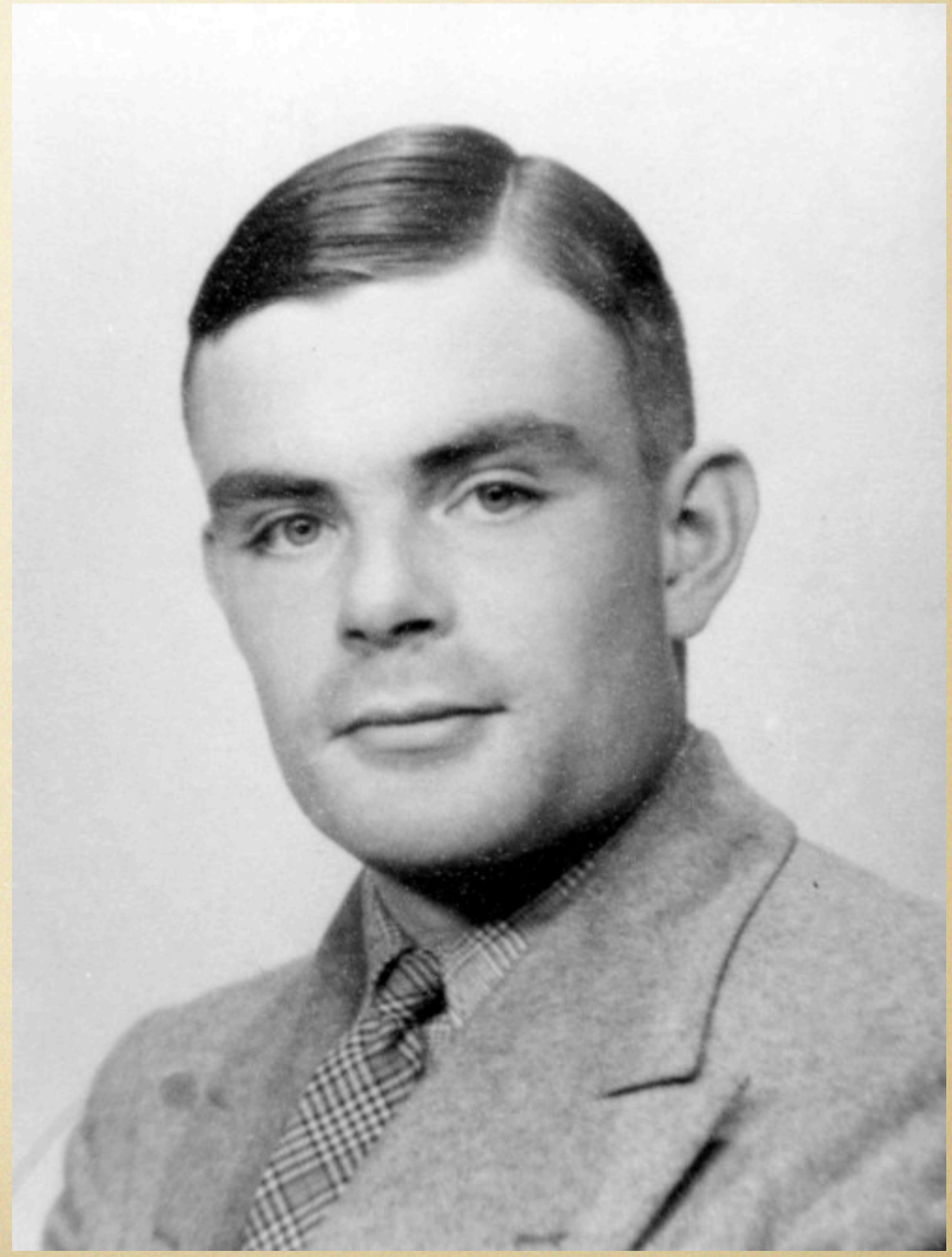
CWI


Bubenheimer Weg
Verwaltungszentrum
Closterbrauerei
Kurt-Schumacher-Brücke
Rübenacher Straße
In der Weglänge
Im Acker
Trifter Weg
Sportplatz
Pfaffengasse
Kirmesplatz
Bienenstück
Raiffaisenstraße
Winninger Straße
Am Alten Schützenplatz
Eulenhorst
Oberweiher
Uni

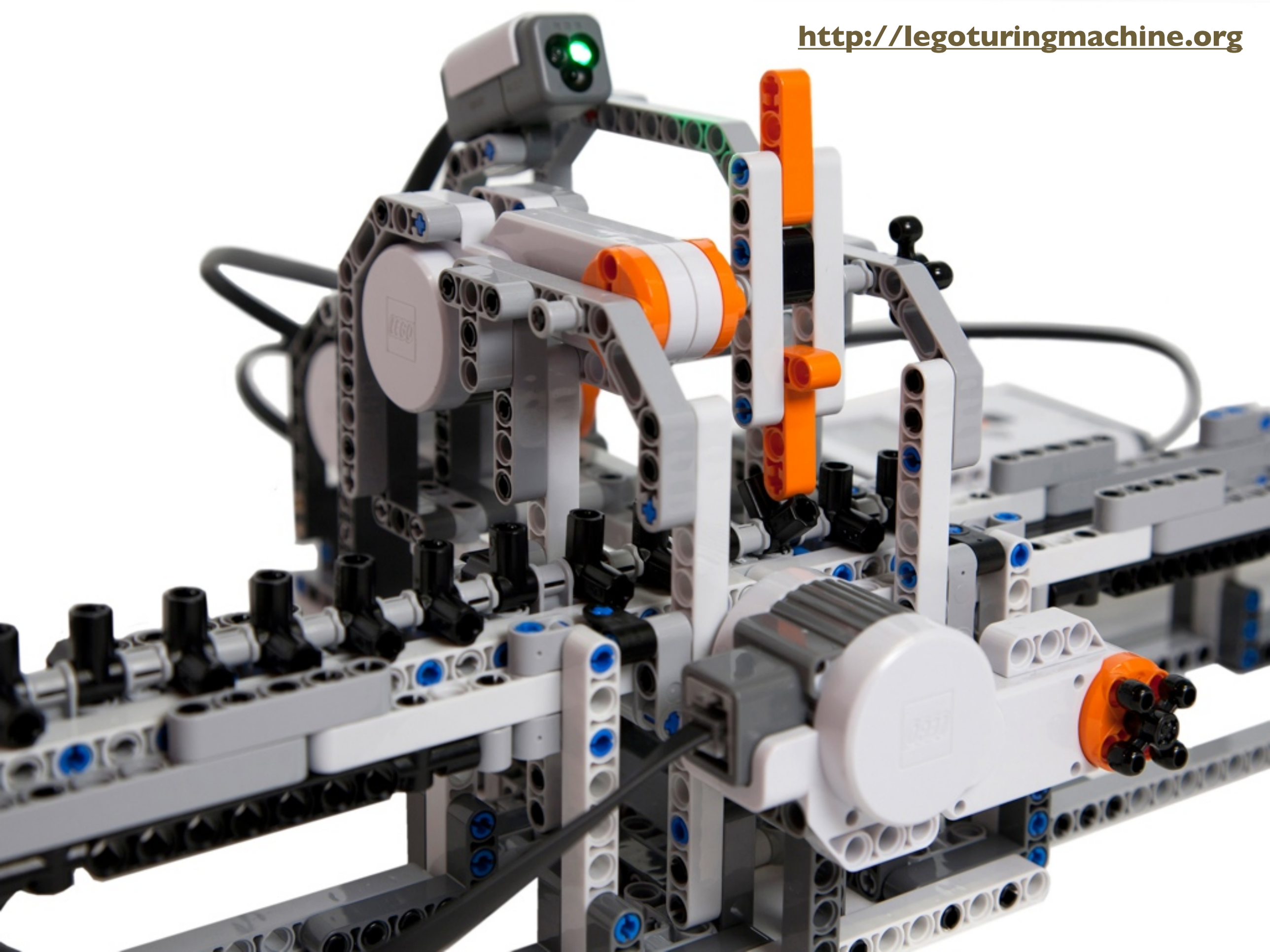
CWI

Alan Turing

- Alan Turing (1912–1954)
- Programming pioneer
- Defined “algorithm”
- Defined “computability”
- Defined “intelligent”
- Cracked Enigma with Bombe
- …
- RTFM



http://legoturingmachine.org



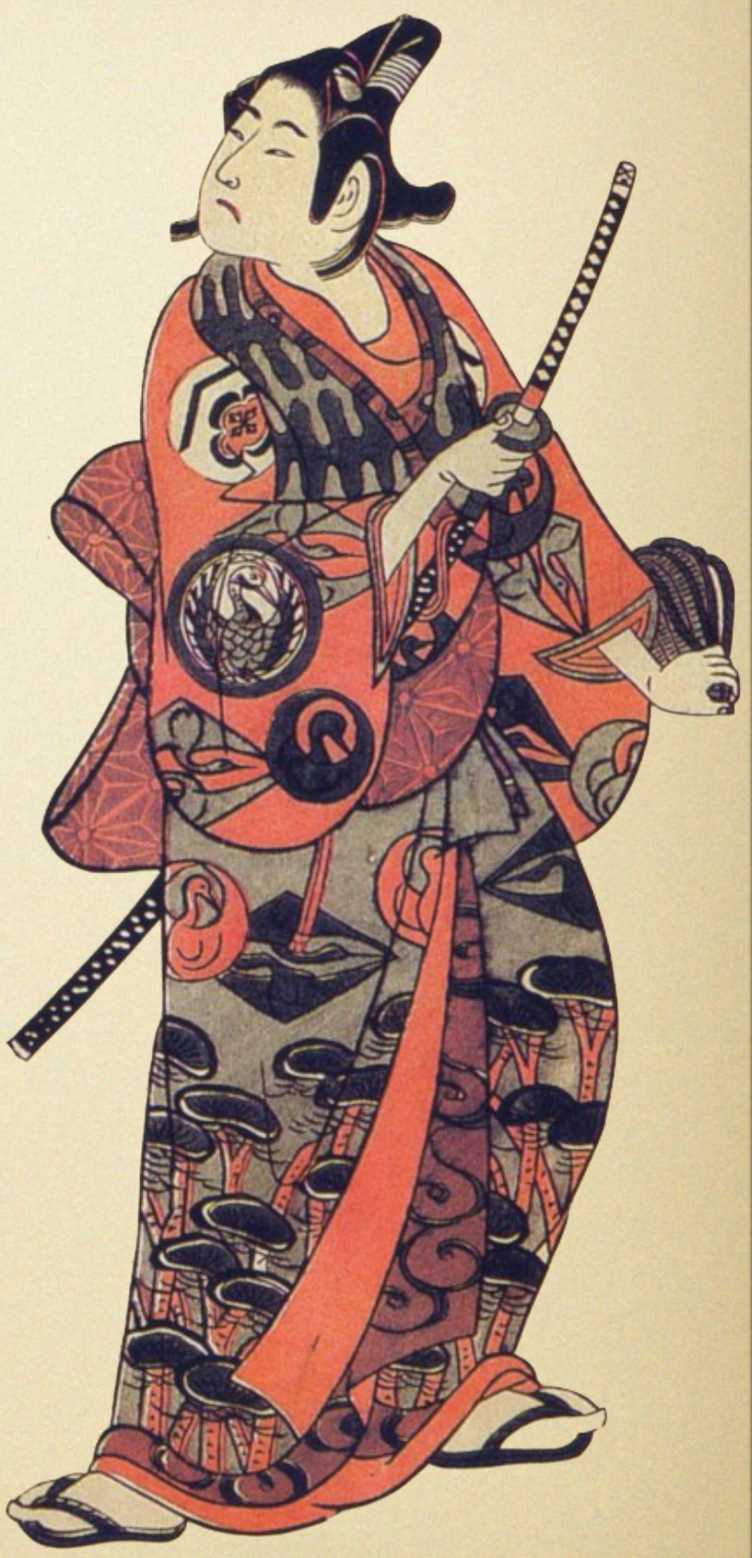
CWI

Grammars…

CWI

To summarise

- Software is complex
- Metaprogramming helps
- Rascal
  - no magic, no boilerplate
  - works across languages
- Rapid prototyping
- Rapid tool development
- ⇒ http://rascal-mpl.org



http://commons.wikimedia.org/wiki/File:Torii_kiyoshige_bando_hikosaburo_ii.jpg

Q?

vadim@grammarware.net