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Persistent Contextual Values as Inter-process Layers

Markus Raab

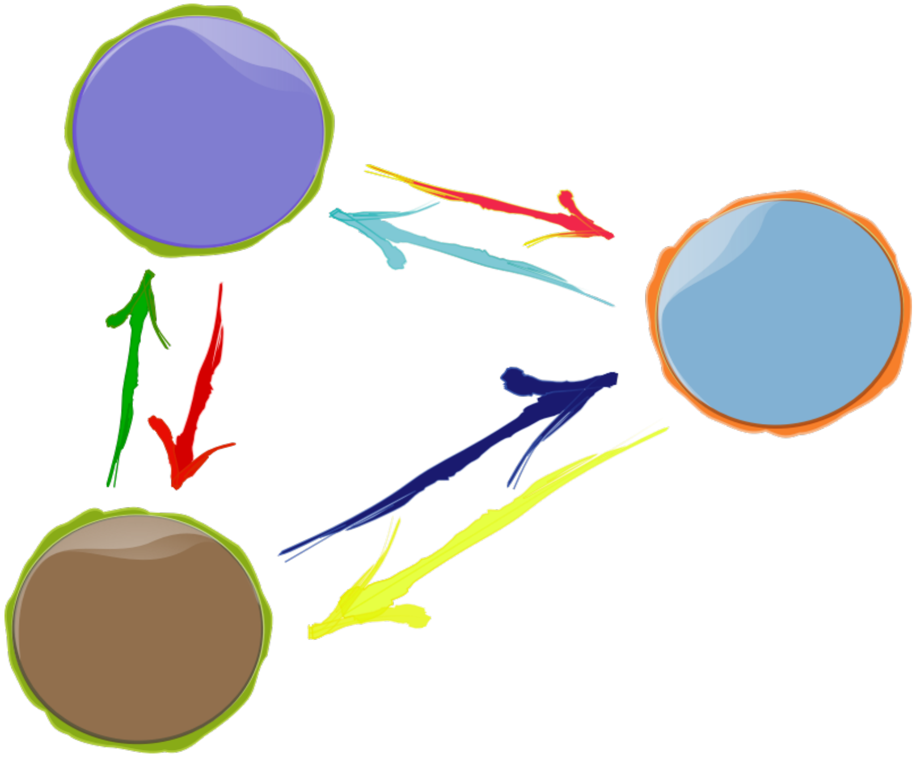
Vienna University of Technology

Institute of Computer Languages, Austria

Email: markus.raab@complang.tuwien.ac.at

Goals

- Context-aware
  - e.g. battery status
- Customizable
  - adapt to user
- Mobile
  - consistent context changes across apps
  - performance/battery life



Context-Oriented Programming

- originates from object-oriented programming
- layers represents context
- can be activated anywhere in the program
  - dynamic scope

many layers can be active

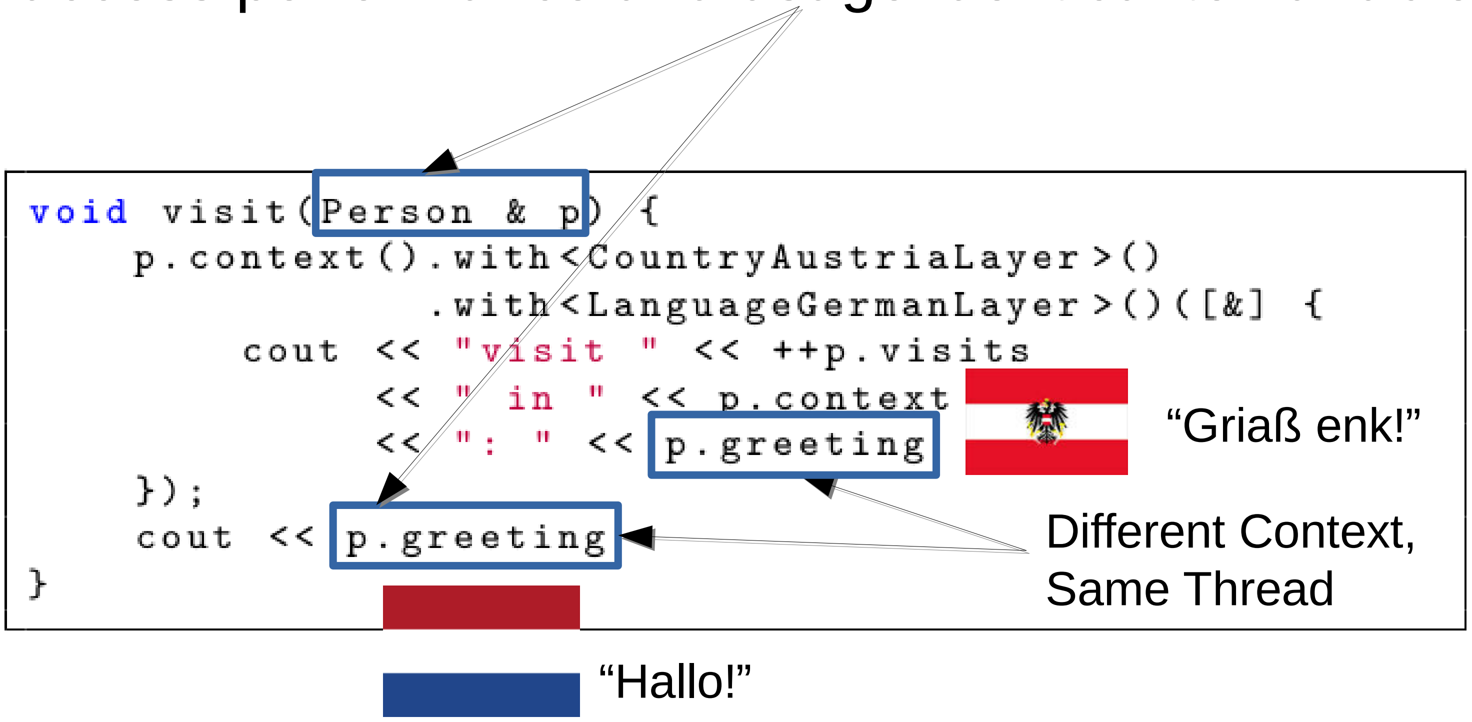
name of layer

```
void rcvPhoneCall () {
    e.context().with()<PhoneCall>()([&]{
        vibrate();
    });
}
```

Part of dynamic Scope

Contextual Values

- “Trivial generalization of thread-local values”
- layers and dynamic scoping as in context-oriented programming
- access performance and usage identical to variables



```
void visit(Person & p) {
    p.context().with<CountryAustriaLayer>()
               .with<LanguageGermanLayer>()([&] {
        cout << "visit " << ++p.visits
             << " in " << p.context
             << ": " << p.greeting
    });
    cout << p.greeting
}
```

Program Execution Environment

- consists of: Configuration Files, Commandline Arguments, ...
- Program Execution Env. is defined using a specification

```
[/%language%/%country%/%dialect%/person/greeting]
  type=String
[/%country%/person/visits]
  type=Integer
  default=0
[/%location%/country]
  type=String
```

  - `/`: denotes hierarchy of contextual values
  - `%`: placeholders for layers
- needed for **customization**
  - initialize and persist every contextual value

Problem

- no synchronization between processes
- dependencies between activations
- implementation of layer tedious

```
class PhoneCall
{ ??? };
```

```
void rcvPhoneCall () {
    e.context().with()<PhoneCall>()([&]{
        vibrate();
    });
    // vibrate();
}
```

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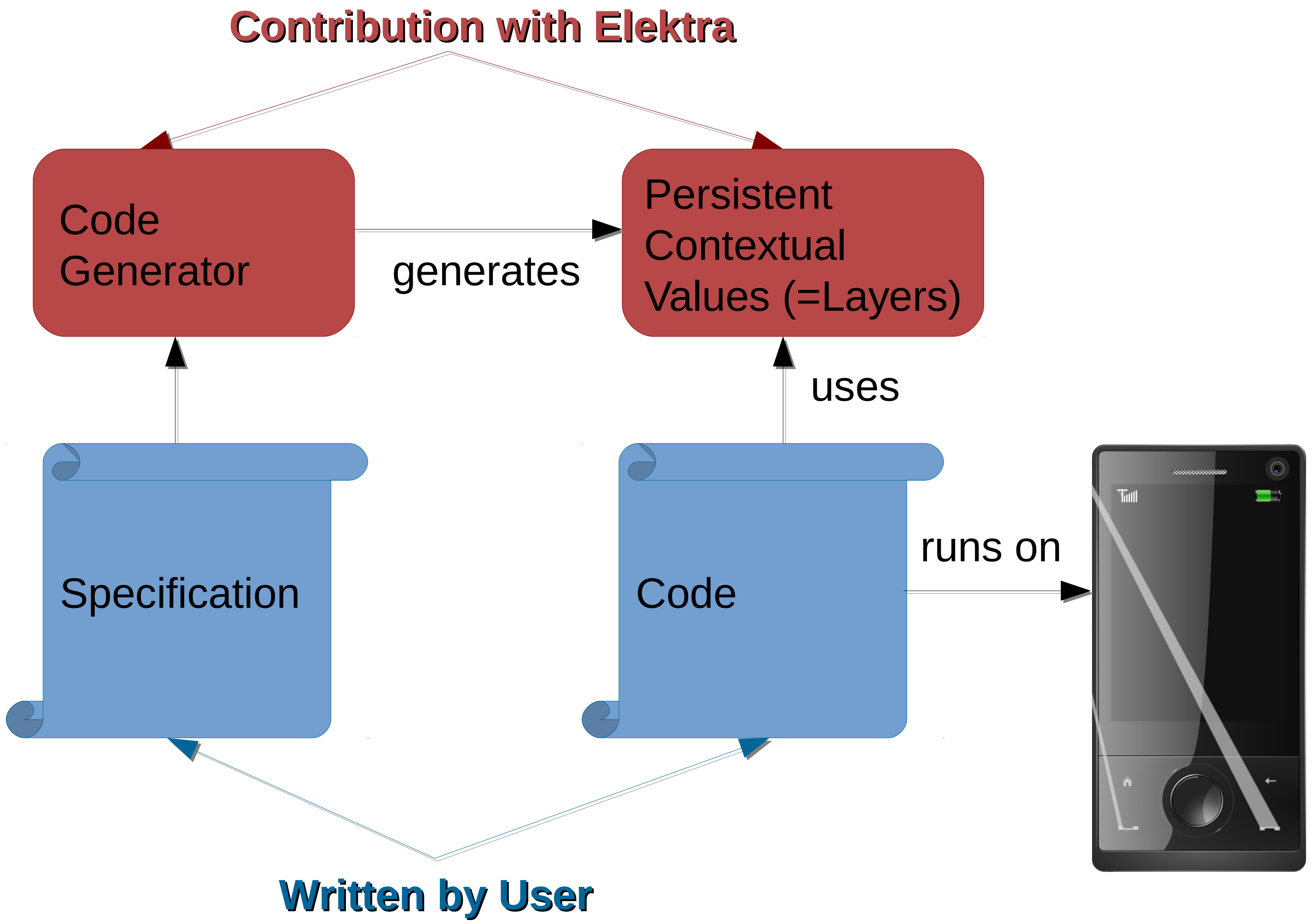
Elektra

Usage


Contribution with Elektra
Code Generator
generates
Persistent Contextual Values (=Layers)
uses
Specification
Code
runs on
Written by User

Solution

- directly activate CVs (every CV works as layer!)

```
void greet (Person & p,Country & country,
            Location & location) {
  p.activate(country);
  p.activate(location);
  cout << p.greeting << endl;
}
```

- **sync** CVs between processes

```
void userInteraction(Accuracy const& a) {
  a.context().sync(); // a might change
  for (long i=0; i<a; ++i) {
  /* a does not change here */ }
}
```

Activation via Assignment

- **assignments** on CVs trigger layer activations
- **sync** triggers all necessary assignments
- implication: we do not need extra layers anymore

```
void assignLanguage(Language & lang) {
  lang.context().activate(lang);
  lang = "";
  // layer lang deactivated
  lang = "spanish";
  // layer switch to spanish
  lang.context().deactivate(lang);
  lang = "english";
  // layer still deactivated
}
```

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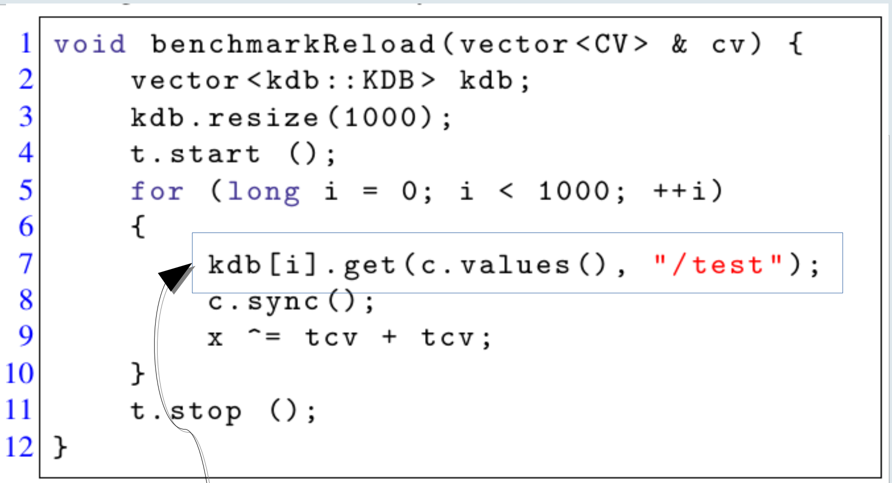
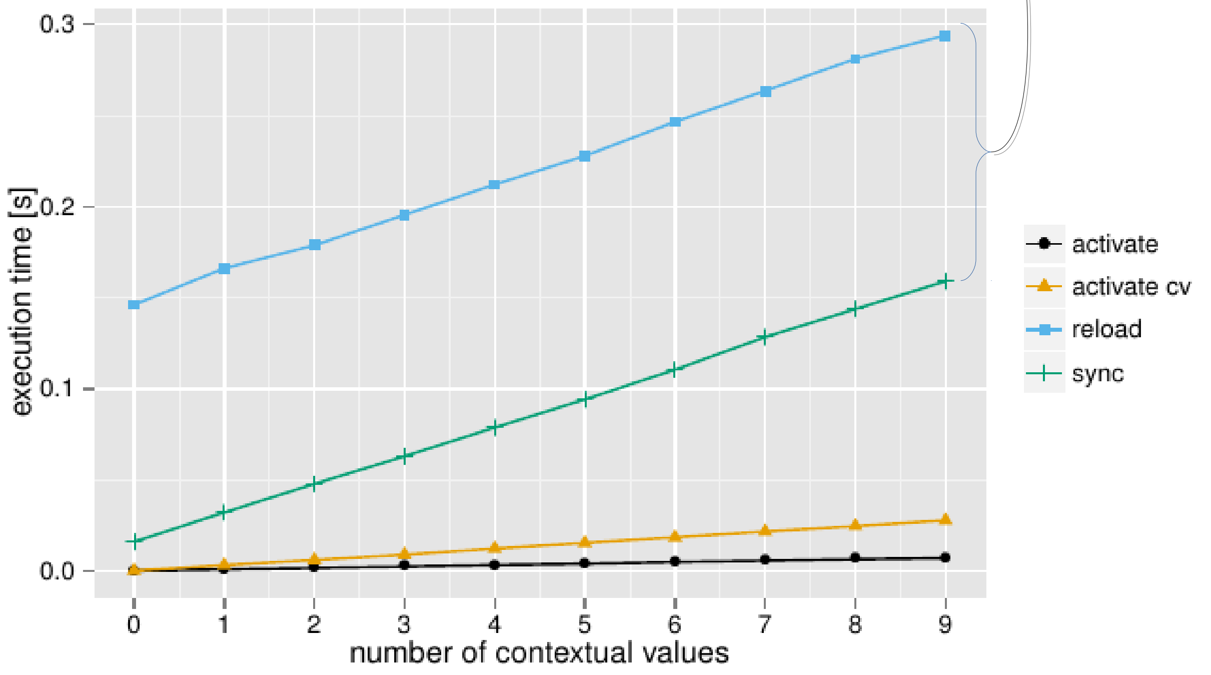
Evaluation

Benchmark

- access: no overhead
- 4 benchmarks

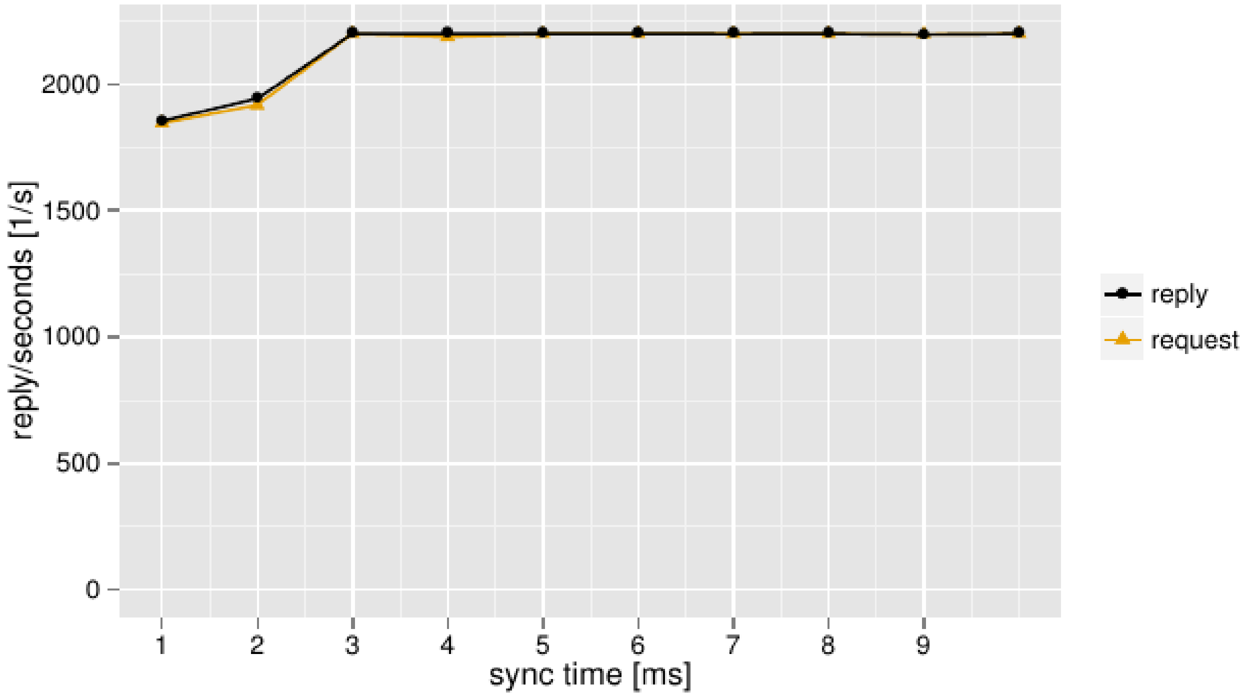


```
void benchmarkReload(vector<CV> & cv) {
      vector<kdb::KDB> kdb;
      kdb.resize(1000);
      t.start ();
      for (long i = 0; i < 1000; ++i)
      {
            kdb[i].get(c.values(), "/test");
            c.sync();
            x ^= tcv + tcv;
      }
      t.stop ();
}
```



Case Study Webserver

```
httperf --hog --timeout=1 --num-conn=50000
--rate=2200 --num-call=1 --server=127.0.0.1
```



Source Code

- Source Code released as free software within Elektra
  - >70 predefined plugins
  - support for hundreds kinds of configuration files
  - integrate standard software
  - specification is configuration (e.g. in XML, JSON)
- http://www.libelektra.org
  - version 0.8.18 released at 2016-09-16

Conclusion

- combination of performance, context awareness and customization
- CVs with code generation in multi-threaded and multi-process applications
- CVs can be **shared** across applications
- implementation is **free software** and can be downloaded from http://www.libelektra.org
- supports mobile development in C++, Java, and more
- **benchmark**: overhead increases linearly with CVs
- **case study**: only with dominant layer activations performance decreases

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Thank you for your attention!

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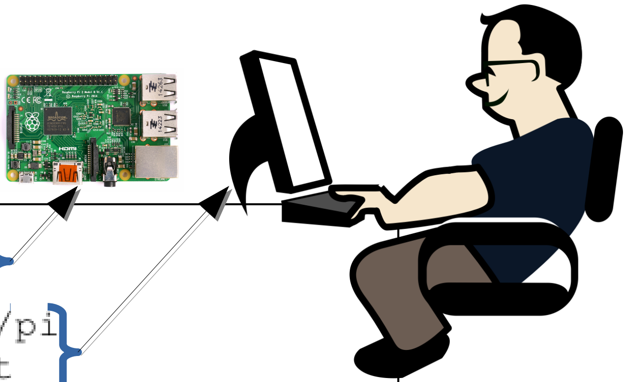
Example: Hardware Abstraction

- hardware as context



```
/hw/pi/pi/gpio/folder = /sys/class/gpio/
/hw/pi/pi/gpio/tamper = gpio7
/hw/pi/elitebook/gpio/folder = ~/context/pi
/hw/pi/elitebook/gpio/tamper = tamper.txt
```

(this is a configuration file, not a specification!
But they are both part of Program Execution Environment)

- layer activations for sensor states

```
select(fd+1, 0, 0, &fds, 0);
t.c().activate<Tamper>();
```

```
t.c().syncLayers();
if (t) out<< "tamper!!!";
```

Benchmark Setup

- hp ® EliteBook 8570w ™
  - CPU Intel ® Core i7-3740QM @ 2.70GHz
  - 7939 MB Ram
- GNU/Linux Debian Jessy 8.4
- gcc compiler Debian 4.9.2-10
  - with the options -std=c++11, -O2
- measured the time using **`gettimeofday`**
- median of eleven executions

Some Related Work

context variables (check on every usage)
M. von Löwis, M. Denker, and O. Nierstrasz, “Context-oriented programming: Beyond layers,” in Proceedings of the 2007 International Conference on Dynamic Languages

ensure-active-layers (global layer activation)
P. Costanza, R. Hirschfeld, and W. De Meuter, “Efficient layer activation for switching context-dependent behavior,” in Modular Programming Languages

partial evaluation avoids usage of libxml2
M. Jung, R. Laue, and S. A. Huss, “A case study on partial evaluation in embedded software design,” in SEUS 2005

hybrid mediator-observer pattern
O. Riva, C. di Flora, S. Russo, and K. Raatikainen, “Unearthing design patterns to support context-awareness,” in Pervasive Computing and Communications Workshops

Example: Battery low

```
c1.activate<BatteryLow>();
```

```
c2.syncLayers();
// BatteryLow active
```

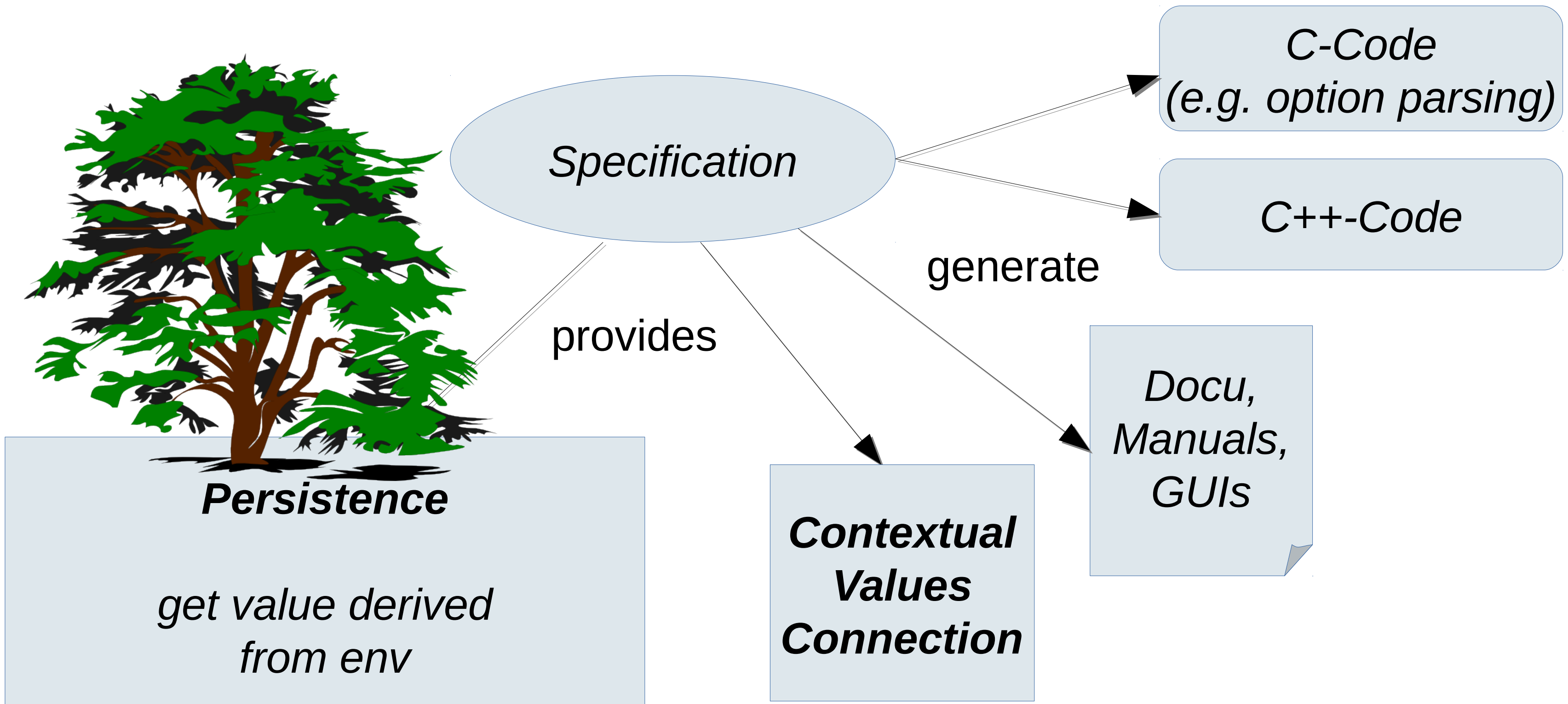
```
c1.deactivate<BatteryLow>();

// Security unchanged
```

```
c2.activate<Security>(cv);
// BatteryLow inactive
```

Thread 1

Thread 2

Big Picture


Specification
provides
generate
C-Code (e.g. option parsing)
C++-Code
Docu, Manuals, GUIs
Contextual Values Connection
Persistence
get value derived from env

- *Runtime Checks*
- *Validation*
- *Upgrades*
- *Integration*

```
/%/%/%/person/greeting=Hi!
/German/%/%/person/greeting=Guten Tag!
/German/Austria/%/person/greeting=Servus!
/German/Austria/t/person/greeting=Griaß enk!
```