Marktoberdorf 2004

Towards Trusted Components

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Lesson 1: Focusing on reuse

Working hypothesis

For progress in software, focus on high-quality components

A definition

Trusted component

A reusable software element accompanied by a guarantee of quality

Four lessons

Lesson 1: Focusing on reuse

Lesson 2: Proving classes: the overall pointer structure

Lesson 3: The Current Calculus

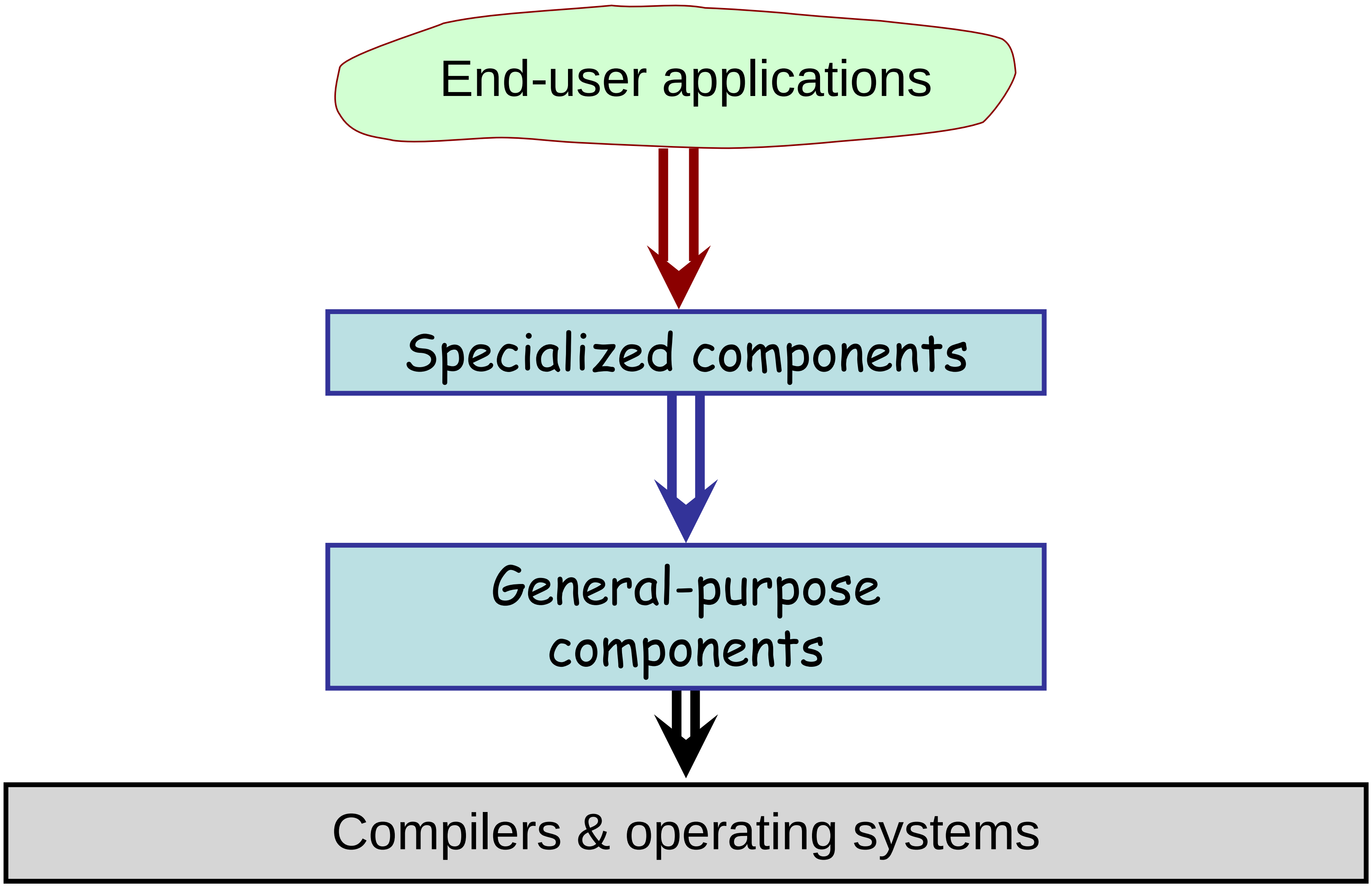
Lesson 4: Doing proofs

Working hypothesis

Where to focus effort for progress in software?

- Tools?
  A priori, a posteriori
- Languages?
- Methods, education?
- High quality components

Levels involved



What is a software component?

Program element with the following properties:

- Can be used by other program elements ("clients")

- Has an official description sufficient for client authors to use it

  (information hiding)

- Component authors do not need to know who are the client authors

The two aspects of reuse and their benefits

The consumer view

- Less software to develop: gain productivity
- Facilitate maintenance
- Gain on quality (?): Reliability, efficiency…
- Learn from models, standardize practices

The producer view

- Improve interoperability
- Turn know-how into capital

Today's software is often good enough

Overall:

- Works most of the time
- Doesn't kill too many people
- Negative effects, esp. financial, are diffuse

Significant improvements since early years:

- Better languages
- Better tools
- Better practices

Beyond good enough?

Stable economic system:

- Sum of individual optima = Global optimum

Traditional, non-component-based development:

- Individual optimum: Good Enough
- To make software better: consumer is responsible!

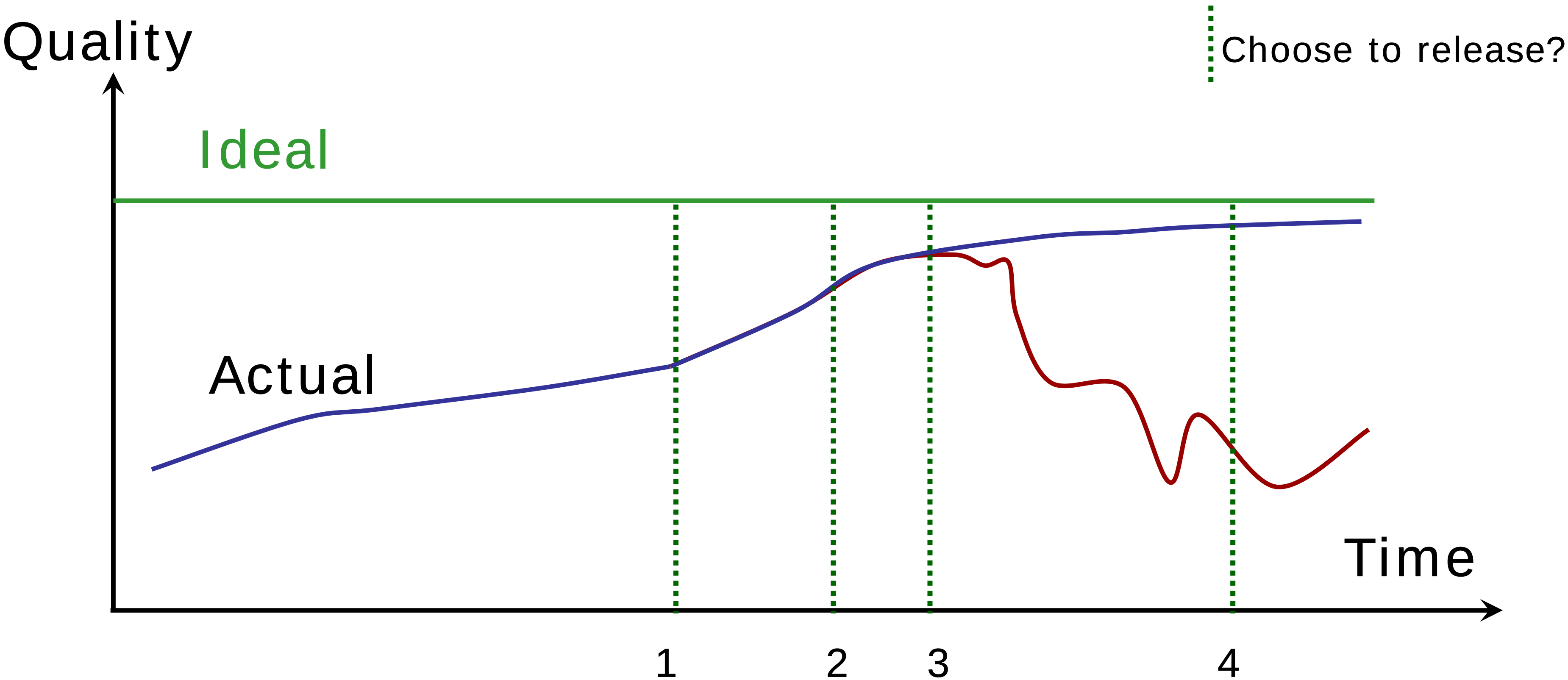
Component-based development:

- Consumer & producer both want better components
- Improvements: Producer does the job

From "good enough" to good?

Beyond "good enough", quality is economically bad

He who perfects, dies



Components and quality

The good news:

Reuse scales up everything

Components and quality

The good news:

Reuse scales up everything

The bad news:

Reuse scales up everything

The opportunity to do things right?

In ordinary development (the construction of applications), programmer perfectionism is often considered a nuisance

In component development, perfectionism is good

"*Formula-1 racing*" of software engineering

Eiffel library experience

EiffelBase (collection classes), EiffelVision (portable graphics), EiffelNet, EiffelStore, EiffelMath, EiffelLex, EiffelParse

- Strong consistency principles, strict interface & design rules
- Systematic use of Eiffel techniques (genericity, multiple inheritance, inheritance machinery)
- Design by Contract throughout
- Strict design discipline: command-query separation, operand-option separation, taxonomy, uniform access...
- Extensively reused in practice

Trusted Components: how to get there

High road:

- Proofs of correctness
- Assumes source code
- In fact, assumes we write the components ourselves

Low road:

- Focused on commercial components
- Component Certification
- Component Quality Model

The following lessons...

… will focus on the "high road" (building proven classes)

So let's talk a bit about the low road for the rest of today.

Towards a Component Quality Model

A: Acceptance

B: Behavior

C: Constraints

D: Design

E: Extension

Towards a Component Quality Model

A: Acceptance

B: Behavior

C: Constraints

D: Design

E: Extension

A.1 Some reuse attested
A.2 Producer reputation
A.3 Published evaluations

Towards a Component Quality Model

A: Acceptance

B: Behavior

- B.1 Examples
- B.2 Usage documentation
- B.3 Preconditioned
- B.4 Some postconditions
- B.5 Full postconditions
- B.6 Observable invariants

C: Constraints

D: Design

E: Extension

Towards a Component Quality Model

A: Acceptance

B: Behavior

C: Constraints

- C.1 Platform spec
- C.2 Ease of use
- C.3 Response time
- C.4 Memory occupation
- C.5 Bandwidth
- C.6 Availability
- C.7 Security

D: Design

E: Extension

Towards a Component Quality Model

A: Acceptance

B: Behavior

C: Constraints

D: Design

- D.1 Precise dependency doc
- D.2 Consistent API rules
- D.3 Strict design rules
- D.4 Extensive test cases
- D.5 Some proved properties
- D.6 Proofs of preconditions, postconditions & invariants

E: Extension

Towards a Component Quality Model

A: Acceptance

B: Behavior

C: Constraints

D: Design

E: Extension

E.1 Portable across platforms
E.2 Mechanisms for addition
E.3 Mechanisms for redefinition
E.4 User action pluggability

The culture of reuse

From consumer to producer

Management support is essential, including financial

The key step: generalization

A reuse policy

The two principal elements:

- Focus on producer side
- Build policy around a library

Library team, funded by Reuse Tax

Library may include both external and internal components

Define and enforce strict admission criteria

The context

Seamless, reversible development as supported in the Eiffel method

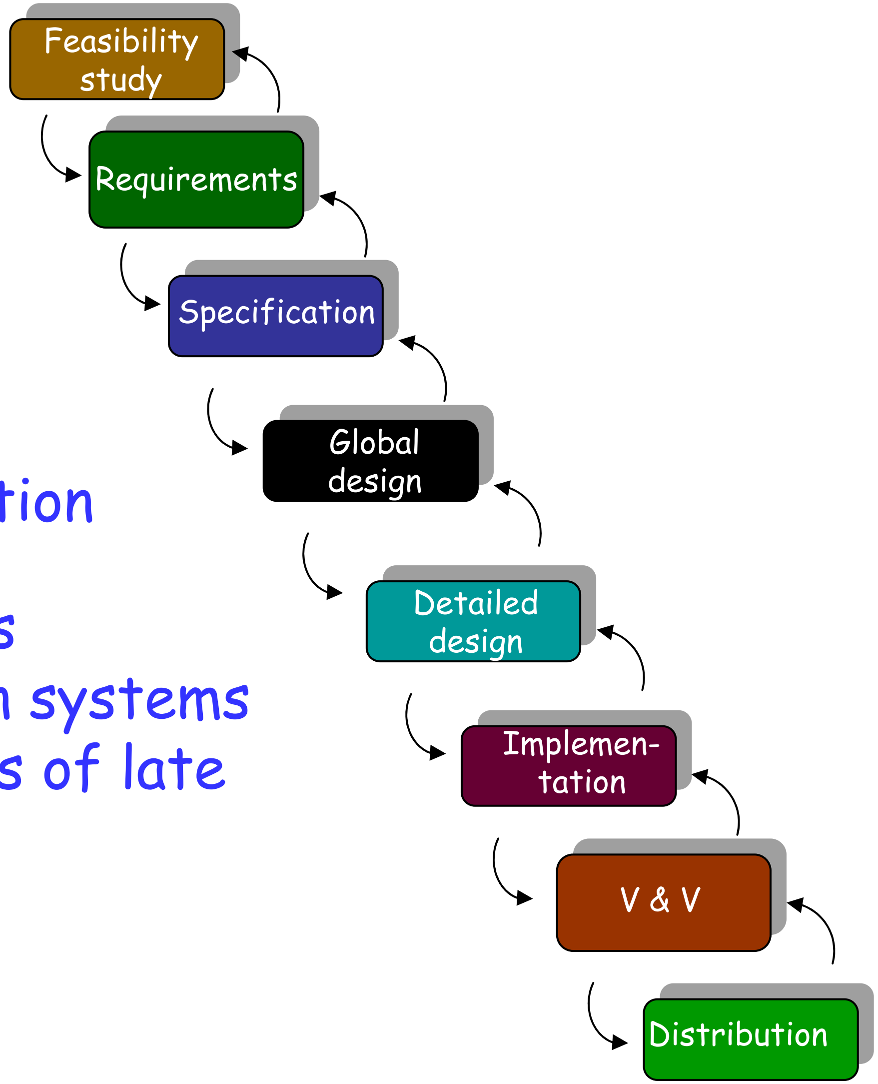
The traditional model

Separate tools:

- Programming environment
- Analysis & design tools, e.g. UML

Consequences:

- Hard to keep model, implementation, documentation consistent
- Constantly reconciling views
- Inflexible, hard to maintain systems
- Hard to accommodate bouts of late wisdom
- Wastes efforts
- Damages quality



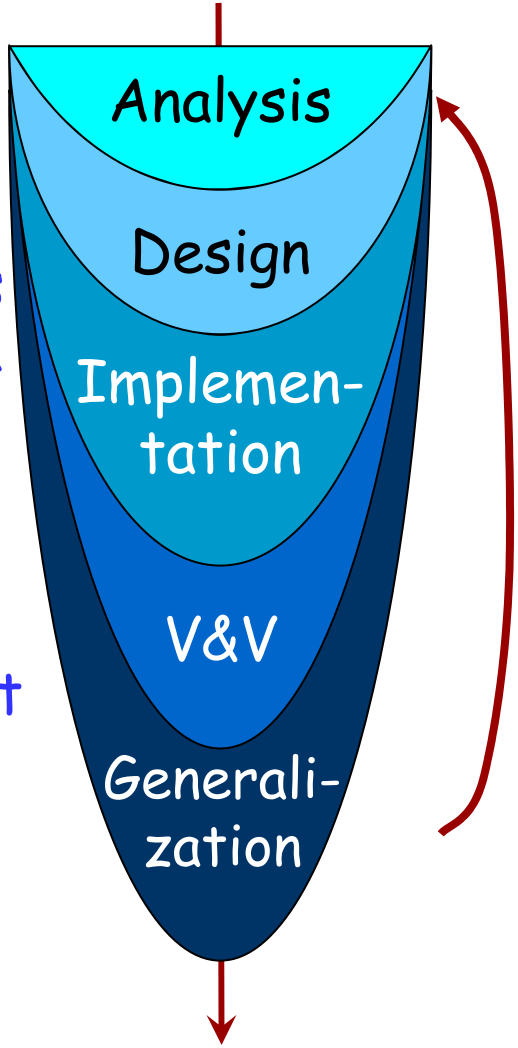
The Eiffel model

Seamless development:

- Single notation, tools, concepts, principles throughout
- Eiffel is as much for analysis & design as implementation & maintenance
- Continuous, incremental development
- Keep model, implementation and documentation consistent

Reversibility: go back and forth

- Saves money: invest in single set of tools
- Boosts quality



Example classes:

PLANE, ACCOUNT, TRANSACTION…

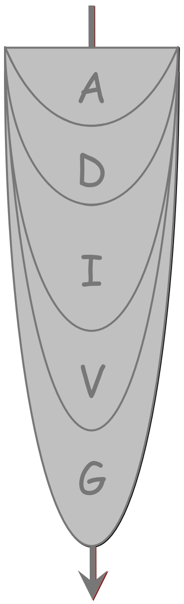
STATE, COMMAND…

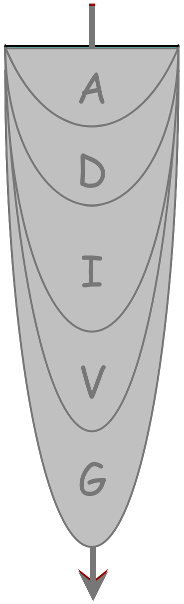
HASH_TABLE…

TEST_DRIVER…

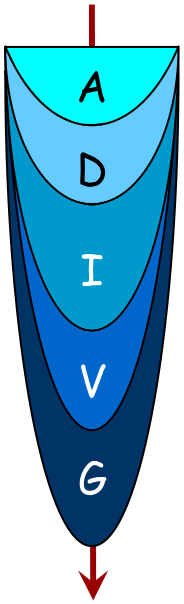
TABLE…

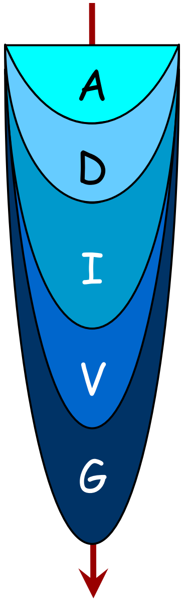
The cluster model





Mix of sequential and concurrent engineering





Permits dynamic reconfiguration

Levels of reusability for a software element

0 - Usable in some program

1 - Usable by programs written by the same author

2 - Usable within a group or company

3 - Usable within a community

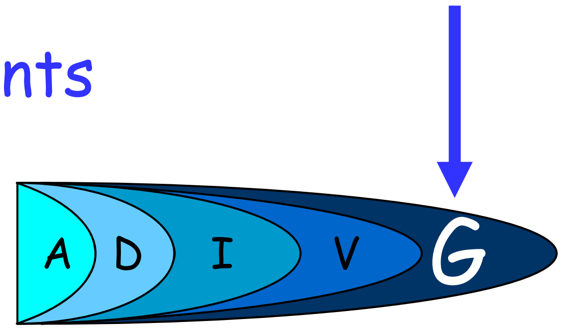
4 - Usable by anyone

Nature or nurture?

Two modes:

- Build and distribute libraries of reusable components (business model is not clear)

- Generalize out of program elements



(Basic distinction:

Program element --- Software component)

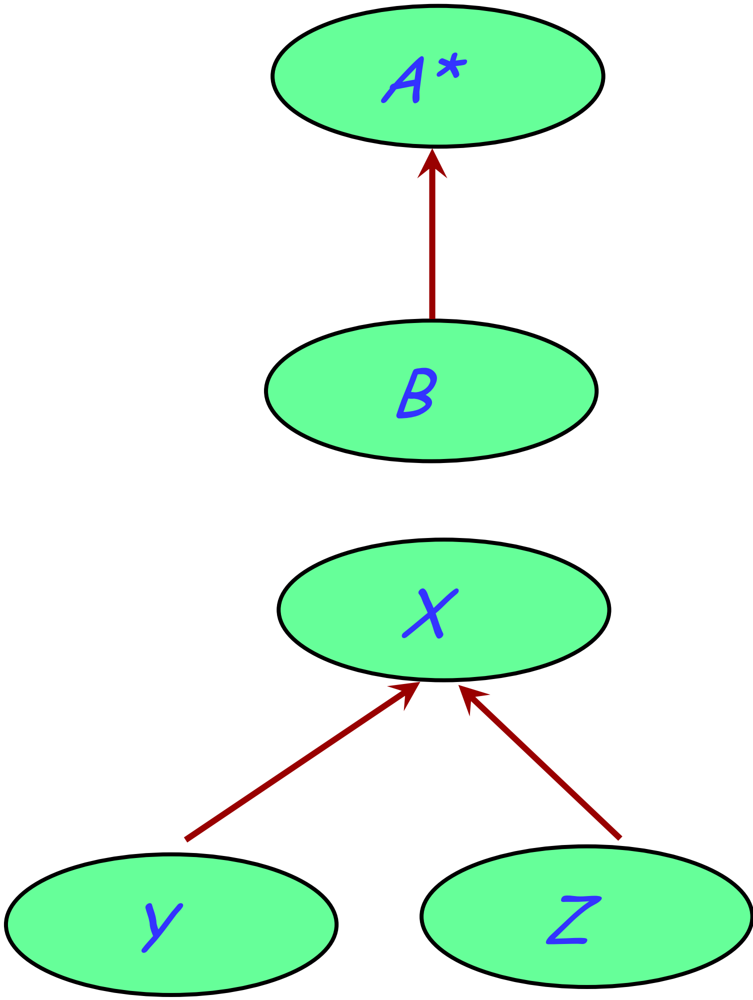
ETH Software Engineering

Generalization

Prepare for reuse. For example:

- Remove built-in limits
- Remove dependencies on specifics of project
- Improve documentation, contracts...
- Abstract
- Extract commonalities and revamp inheritance hierarchy

Few companies have the guts to provide the budget for this



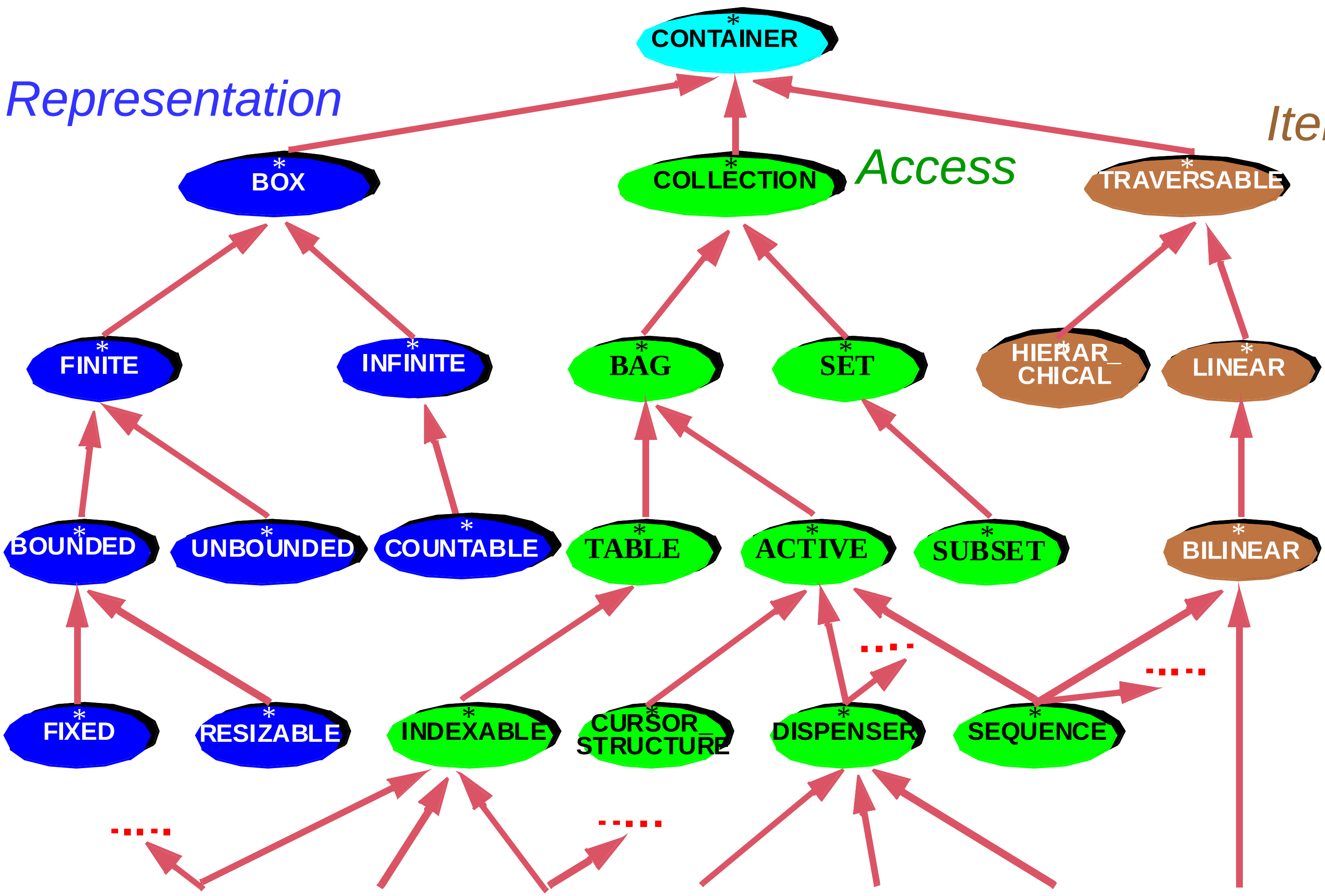
Two keys to component development success

Substance: Rely on a theory of the application domain

Form: Obsess over consistency

- High-level: design principles
- Low-level: style

Eiffelbase hierarchy



Old and old names for EiffelBase classes

Class	Features		
ARRAY	*put* *enter*	*item* *entry*	
STACK	*put* *push*	*item* *top*	*remove*
QUEUE	*put* *add*	*item* *oldest*	*remove* *remove_oldest*
HASH_TABLE	*put* *insert*	*item* *value*	*remove* *delete*

Design principles in the Eiffel method

Object technology: Module $\equiv$ Type

Design by Contract

Command-Query Separation

Uniform Access

Operand-Option Separation

Inheritance for subtyping, reuse, many variants

Bottom-Up Development

Design for reuse and extension

Style matters

Typical API in a traditional library (NAG)

```
nonlinear_ode
        (equation_count: in INTEGER
         epsilon: in out DOUBLE
         func: procedure
                (eq_count: INTEGER; a: DOUBLE
                 eps: DOUBLE; b: ARRAY [DOUBLE]
                 cm: pointer Libtype);
         left_count, coupled_count: INTEGER ...)
```

[And so on. Altogether 19 arguments, including:

- 4 in out values;
- 3 arrays, used both as input and output;
- 6 functions, each with 6 or 7 arguments, of which 2 or 3 arrays!]

The EiffelMath approach

e: *ORDINARY_DIFFERENTIAL_EQUATION*

create *e.make* ("...values ...")

e.solve

-- Answer available in *e.x* and *e.status* ...

Style rules

No routine without header comments

Preconditions always fully expressed

Counter-example!

Postconditions and invariants: the more the better

Redundancy OK in class invariants (axioms *and* theorems)

Standardized layout

Queries never use verbs!

Class *ACCOUNT*:
balance, not *get_balance*

Systematic naming conventions

No exceptions; rules strictly enforced

Feature categories: keeping a class in order

```
class
    C
inherit
    ...
feature -- Category 1
    ... Feature declarations ...
feature -- Category 2
    ... Feature declarations ...
feature -- Category n
    ... Feature declarations ...
invariant
    ...
end
```

Feature categories

Standard categories (the only ones in EiffelBase):

- Initialization

Creation

- Access
- Measurement
- Comparison
- Status report

Basic queries

- Status setting
- Cursor movement
- Element change
- Removal
- Resizing
- Transformation

Basic commands

- Conversion
- Duplication
- Basic operations

Transformations

- Inapplicable
- Implementation
- Miscellaneous

Internal

Summary of lesson 1

My conjecture: reuse-based development holds the key to substantial progress in software engineering

Reuse is a culture, and requires management commitment ("buy in")

The process model can support reuse

Generalization turns program elements into software components

A good reusable library proceeds from systematic design principles and an obsession with consistency