XOTcl– an Object-Oriented Scripting Language

Gustaf Neumann
Department of Information Systems
Vienna University of Economics
Vienna, Austria
gustaf.neumann@wu-wien.ac.at

Uwe Zdun
Specification of Software Systems
University of Essen
Essen, Germany
uwe.zdun@uni-essen.de

First European Tcl/Tk User Meeting, 15/16th June 2000

Overview

- **XOTcl = Extended Object Tcl**

- **XOTcl is freely available from:**

  http://nestroy.wi-inf.uni-essen.de/xotcl

- **Outline:**

  - Scripting and object-orientation,
  - XOTcl high-level language constructs,
  - Example: design pattern-based design of an XML interpreter,
  - xoComm HTTP implementation: performance comparison with Apache.

Gustaf Neumann, Uwe Zdun
University of Essen

Tcl-Strengths

Important Ideas in Tcl:

- **Fast & high-quality development through component-based approach**
- **2 levels: "System Language" and "Glue Language"**
- **Flexibility through . . .**
  - dynamic extensibility,
  - read/write introspection,
  - automatic type conversion.
- **Component-Interface through Tcl-Commands**
- **Scripting language for glueing**

Motivation for XOTcl

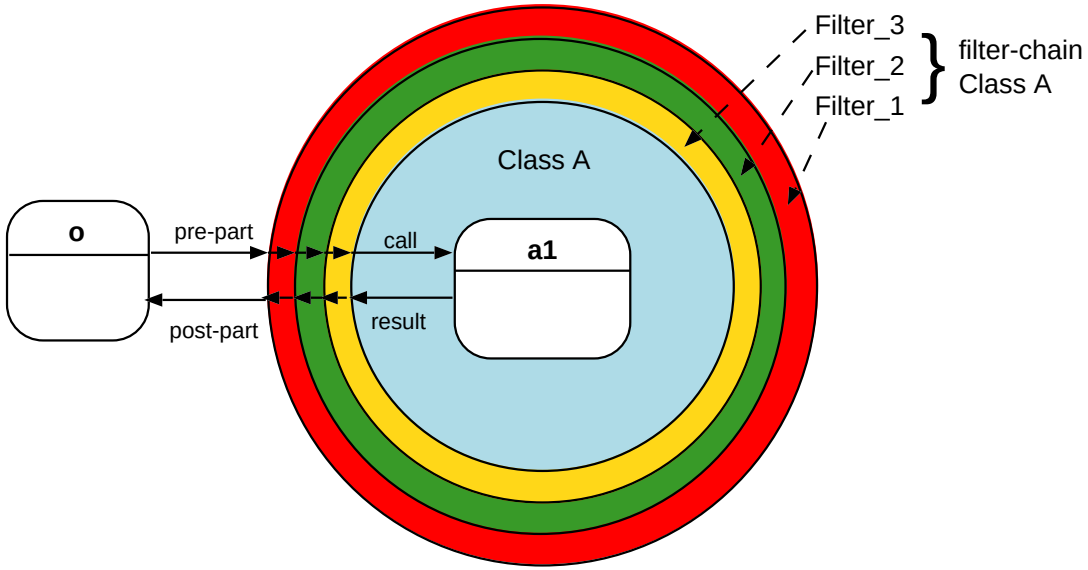
- **Extend the Tcl-Ideas to the OO-level.**
- **Just "glueing" is not enough! Goals are . . .**
  - Architectural support
  - Support for design patterns (e.g. adaptations, observers, facades, . . .)
  - Support for composition (and decomposition)
- **Provide flexibility rather than protection:**
  - Introspection for all OO concepts
  - All object-class and class-class relationships are dynamically changeable
  - Structural (de)-composition through *Dynamic Aggregation*
  - Language support for high-level constructs through powerful interceptors (*Filters* and *Per-Object Mixins*)

Filters

- **A filter is a special instance method registered for a class C. Every time an object of class C receives a message, the filter is invoked automatically.**

- **Three parts, each optional:**
  - pre-part,
  - call to `next`, invokes:
    - filter-chain,
    - actual called method.
  - post-part.

- **Filter-inheritance.**



Example: Simple Filter

```
Class A                                    ;# Class Definition
A a1                                       ;# Instance a1 of A

A instproc Filter-1 args {                 ;# Filter instance method
  puts "pre-part of Filter-1"
  next
  puts "post-part of Filter-1"
}

A filter Filter-1                          ;# Filter registration

a1 set x 1                                 ;# Method invocation
```

Applications: Trace facility, Composite Pattern, Proxy Pattern, Observers . . .

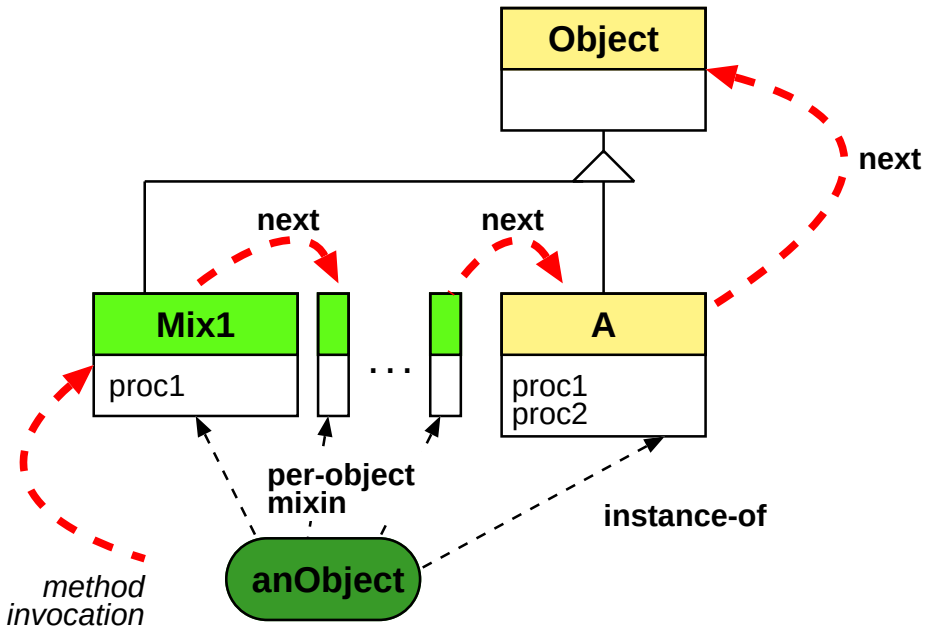
Per-Object Mixins

- **A per-object mixin is a class which is mixed into the precedence order of an object in front of the precedence order implied by the class hierarchy.**

Motivation:

- **Model behavior of individual objects (decorator).**
- **Handle orthogonal aspects not only through multiple inheritance.**
- **Intrinsic vs. extrinsic behavior, similar to roles.**

Applications: timing, statistics, persistence, life-cycle, chain of responsibility, adapter



Example Code for Per-Object Mixins

```
Class A                                ;# Class definition
A instproc proc1 {} {                  ;# Method definition
  puts [self class]; next
}
A instproc proc2 {} {                  ;# Method definition
  puts [self class]; next
}
Class Mix1                             ;# Class definition
Mix1 instproc proc1 {} {               ;# Method definition
  puts [self class]; next
}
A anObject                             ;# Instantiation of class A
anObject mixin Mix1                    ;# Mixin registration

anObject proc1                         ;# -> results in output "::Mix1 ::A"
anObject proc2                         ;# -> results in output "::A"
```

Dynamic Object Aggregations and Nested Classes

- **Nesting though namespaces: Classes and objects in XOTcl can contain other classes/objects.**

→ **Dynamic Object Aggregation resembles Part-of relationship in a dynamic and introspective fashion.**

→ **Nested Classes reduce interference of independently developed program structures.**

- **Class nesting and aggregation semantics are handled through XOTcl object system (including built-in methods for deep copy and deep move).**

Example Code: Nested Classes/Dynamic Object Aggregation

```
Class Agent                                    ;# Class definition
Class Agent::Head                              ;# Nested classes
Class Agent::Body

Agent instproc init args {                     ;# Constructor aggregates two
  ::Agent::Head [self]::head                   ;# objects dynamically
  ::Agent::Body [self]::body
}

Agent myAgent                                  ;# Object creation

puts "Children: [myAgent info children]"       ;# Output: head body

myAgent::head destroy                          ;# Agent looses his head

puts "Children: [myAgent info children]"       ;# Output: body
```

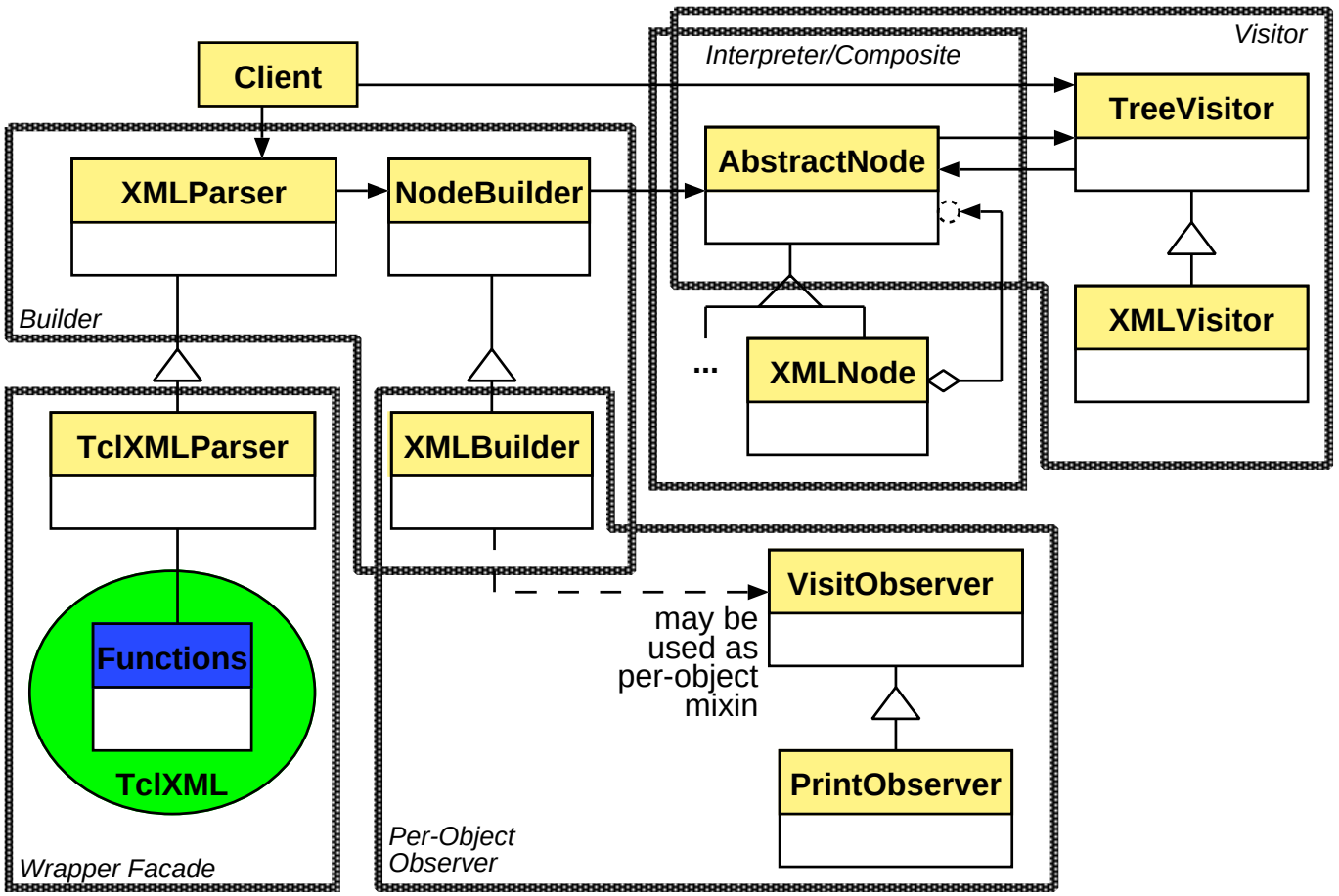
Further Functionalities provided in XOTcl

- **Assertions reduce interface and reliability problems caused by dynamic typing:**
  - Design by contract: invariants and pre-/post-conditions for methods,
  - per-class and object-specific assertions.
- **Meta-Data enhances self-documentation of objects and classes.**
- **Automatic Name Creation with `autoname`.**
- **Abstract Classes,**
- **Parameters.**

Example: XML Parser/Interpreter

- **Constructs a composite object structure from XML documents**
- **OO-implementation using design patterns, based on TclXML, around 120 lines (including example visitors and reusable pattern)**
- **Changeability and Adaptability through:**
  - dynamics,
  - introspection,
  - patterns in hot spots,
  - interceptors per-object and filter,
- **Patterns:** Wrapper Facade, Builder, Composite, Interpreter, Visitor, Observer, ...
- **Extensibility through new visitors, observers**

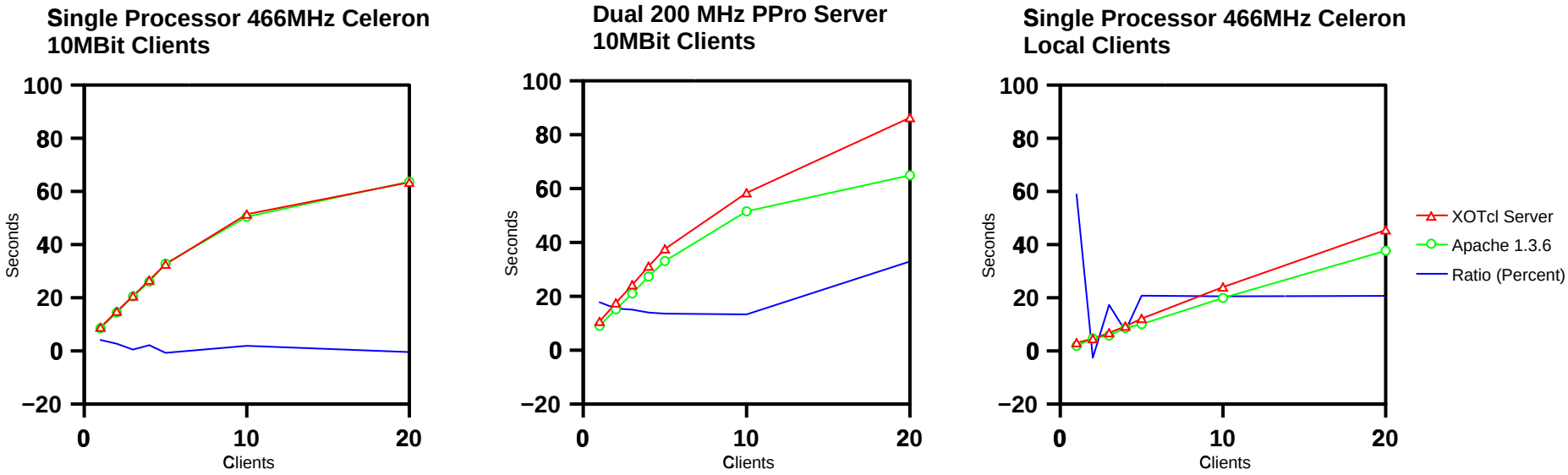
Partial Design of the XML Parser/Interpreter



Assessments

- **size 73 lines (including two more visitors),**
- **+ 22 lines for the Wrapper Facade and 25 lines for the Composite,**
- **Reuseable Composite implementation and reuseable TclXML wrapper,**
- **Changeability and Adaptability through:**
  - dynamics,
  - introspection,
  - patterns in hot spots,
  - interceptors per-object and filter,
- **Extensibility through new visitors.**

Speed Comparison: XOTcl based HTTP Server vs. Apache



- Basic functionality of HTTP/1.1 in around 250-400 lines of XOTcl code
- 1-20 simultanoues client sessions issuing each 76 HTTP requests.

→ Modern CPUs are fast enough to execute even complex applications in object-oriented scripting language with sufficient speed.

Summary and Conclusions

- **XOTcl provides high-level language constructs for software composition,**
- **tailored for the use with scripting applications:**
  - dynamics,
  - (read/write) introspection,
  - flexible glueing of (preexisting) components.
- **Combination of: scripting, object-orientation, and high-level language constructs**

  ⇒ Flexible composition of software systems.
  ⇒ Coping with changes at runtime/design time.

More XOTcl Material

- Gustaf Neumann, Uwe Zdun: *Filters as a Language Support for Design Patterns in Object-Oriented Scripting Languages*, Proceedings of the 5th Conference on Object-Oriented Technologies and Systems (COOTS´99), San Diego, May 3-9, 1999.

- Gustaf Neumann, Uwe Zdun: *Enhancing Object-Based System Composition through Per-Object Mixins*, Proceedings of Asia-Pacific Software Engineering Conference (APSEC‘99), Takamatsu, Japan, December 6-10, 1999.

- Gustaf Neumann, Uwe Zdun: *Towards the Usage of Dynamic Object Aggregations as a Form of Composition*, Proceedings of Symposium of Applied Computing (SAC‘00), Como, Italy, March 19-21, 2000.

- Gustaf Neumann, Uwe Zdun: *High-Level Design and Architecture of an HTTP-Based Infrastructure for Web Applications*, Word Wide Web Journal, Baltzer, early 2000.

- More on `http://www.xotcl.org`, `http://nestroy.wi-inf.uni-essen.de/xotcl`