Checking Fractal Component Behavior Using Behavior Protocols

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Outline

• Goals
• Introduction to behavior protocols
  ▫ Example
• Static protocol check
• JPF check
• Runtime check
• Evaluation and Conclusion
Goals

• To extend the Fractal component model (Julia) with support for behavior protocols
  ▪ Thus enable for checking for component behavior compatibility
• To implement tools that would allow for checking of component behavioral compatibility
• Provide a demo application demonstrating the results achieved

Fractal Component

• Components
  ▪ Primitive (implemented in e.g. Java)
  ▪ Composite (consisting of other components)
• Component frame
  ▪ Boundary of a component
  ▪ Set of exported (provided and required) interfaces
  ▪ Frame protocol – associated with the component frame
Behavior Protocols I.

• Regular-based expressions specifying allowed component behavior in the sense of the traffic on the component (exported) interfaces
  ▪ Consist of
    • Event tokens
      ▪ prefix interface.method suffix
      ▪ prefix: ‘!’ and ‘?’
      ▪ suffix: ‘^’ and ‘$’
    • Operators
      ▪ ‘;’, ‘+’, ‘*’, ‘|’, ‘||’
    • Parentheses
      ▪ ‘(’, ‘)’, ‘{’, ‘}’

Behavior Protocols II.

• Syntax sugar:
  ▪ ?i.m ~ ?i.m^; !i.m$
  ▪ !i.m ~ !i.m^; ?i.m$
  ▪ ?i.m \{expr\} ~ ?i.m^; expr ; !i.m$

Behavior Protocols – Example I.

Behavior Protocols – Example II.

```c
...?

?ITokenLifetimeController.Start

;

?IToken.InvalidateAndSave {

(!IAccount.AdjustAccountPrepaidTime + NULL);

!ITokenCallback.TokenInvalidated

}...```

Jan Kohori  
Fractal Workshop, ECOOP 2006, Nantes
Behavioral Compliance

- To check the compatibility, protocols are combined using special composition operator \textit{consent}
  - consent \textsimparallel \text{parallel composition capturing} three types of errors
    - Bad activity
    - No activity
    - Divergence
  - Consent composition of all subcomponents of a component on a particular level of nesting = \textbf{architecture protocol}
Compliance Types

- **Horizontal compliance** ~
  - "Do all the subcomponents on a particular level of nesting cooperate without errors?"

- **Vertical compliance** ~
  - "Do the subcomponents of a component behave in the way the component declares?"

- **Code-to-protocol compliance** ~
  - "Does the implementation behave according to the behavior protocol?"

Evaluating Compliances

- **Horizontal and vertical compliance**
  - "Static protocol check"
  - Behavior protocol checker
    - a proprietary tool
    - uses exhaustive DFS technique for exhaustive traversal of the composition state space

- **Code-to-protocol compliance**
  - "JPF check"
  - Combination of Java PathFinder and modified BP-checker
    - Only primitive components are verified
    - Problem of a suitable component environment
Runtime Check

• Additional way to compare code to protocol
  ▪ During application execution, the communication on components’ interfaces is monitored and checked against corresponding behavior protocol
  ▪ Not a verification, a test only
  ▪ Implemented via interceptors and a modified version of bp checker
  ▪ Useful when the JPF check cannot be applied

Evaluation and Conclusion

• All types of tests successfully applied on a non-trivial Fractal demo application
  ▪ Static protocol check ~ 3,5 hours
  ▪ JPF check ~ 1,5 hours
    • In several cases only naive implementation was used
  ▪ Runtime check does not slow down the execution significantly
  ▪ Information available at
    • http://kraken.cs.cas.cz/public/public_index.phtml
Questions...?