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

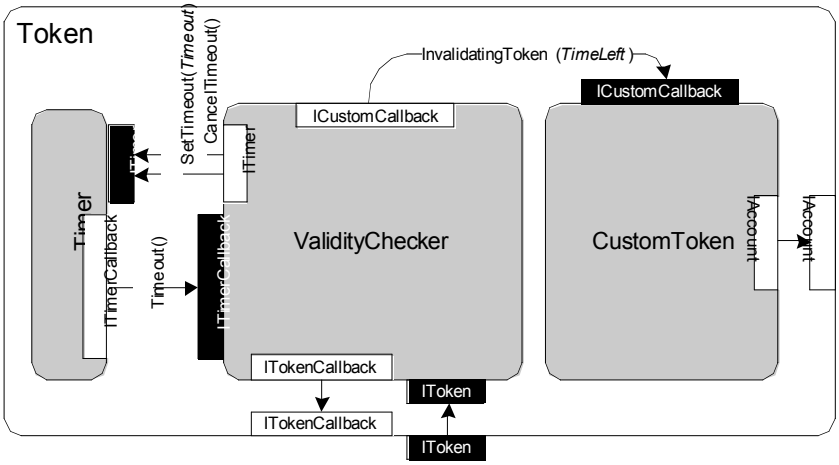
Behavior Protocols I.

- 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.

```
...
?ITokenLifetimeController.Start
;
(
?IToken.InvalidateAndSave {
   (!IAccount.AdjustAccountPrepaidTime + NULL);
   !ITokenCallback.TokenInvalidated
}*...
```

Behavior Protocols – Example III.

```
...
?IToken.InvalidateAndSave {
      !ITimer.CancelTimeouts;
      (!ICustomCallback.InvalidatingToken + NULL);
      !ITokenCallback.TokenInvalidated
}*
...
```


Behavioral Compliance

- To check the compatibility, protocols are combined using special composition operator **consent**
  - consent ~ 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 =
    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

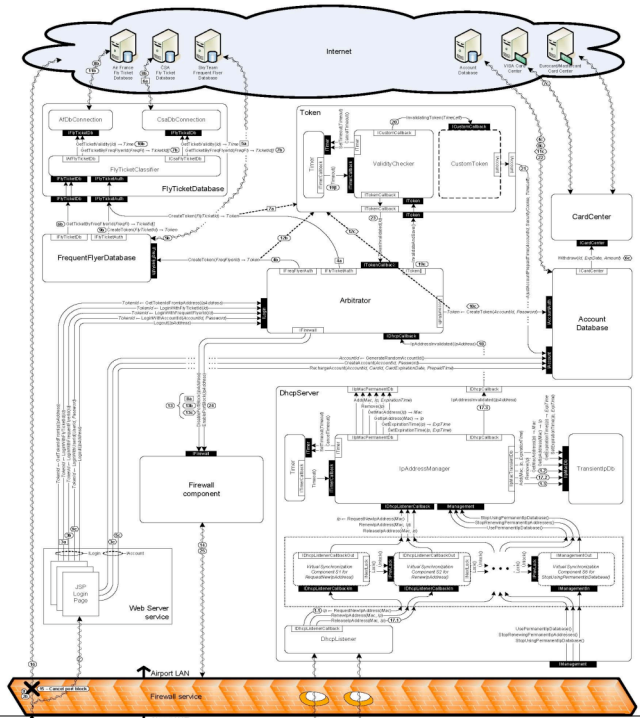
- Horizontal and vertical compliance
  - "Static protocol check"
  - Behavior protocol checker
    - a proprietary tool
    - uses exhaustive DFS technique for exhaustive traversal of the composition state space
- Code-to-protocol compliance
  - "JPF check"
  - Combination of Java PathFinder and modified 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


Internet
ATDbConnection
CsaDbConnection
FlyTicketClassifier
FlyTicketDatabase
Token
Validity Checker
CustomToken
CardCenter
FrequentFlyerDatabase
Arbitrator
Account Database
DhcpServer
IpAddressManager
TransientIpDb
Firewall component
Web Server service
JSP Login Page
Airport LAN
Firewall service

Questions...?