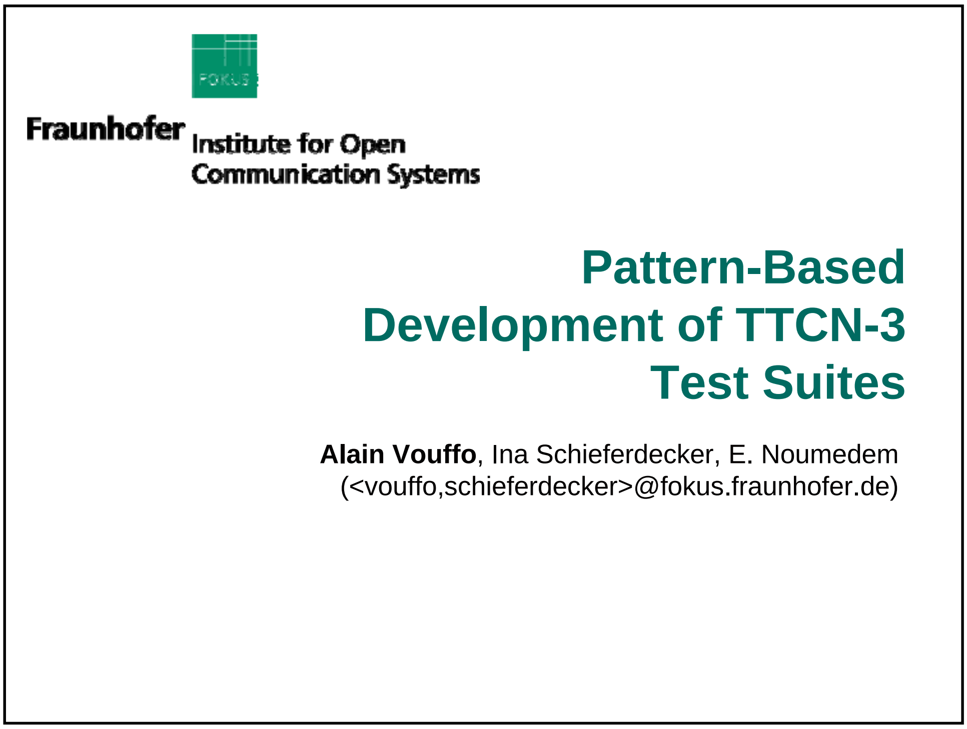

Fraunhofer Institute for Open Communication Systems

Pattern-Based Development of TTCN-3 Test Suites

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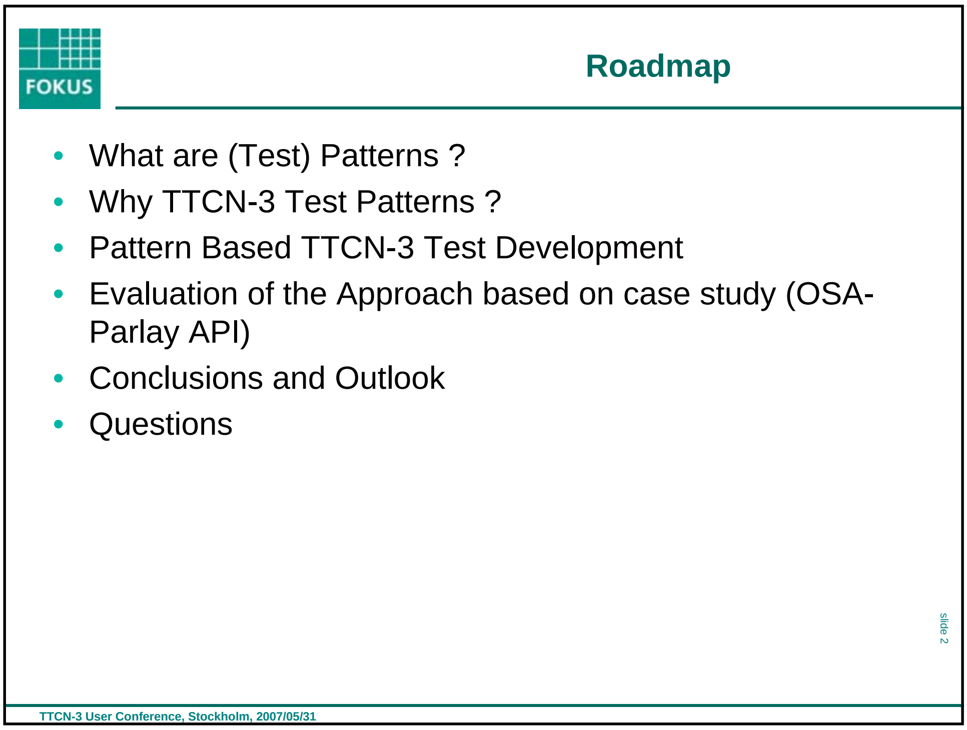


Roadmap

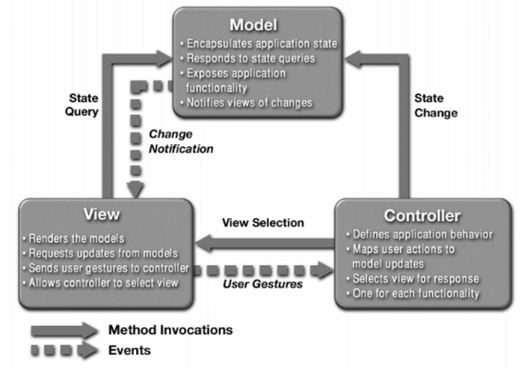
- What are (Test) Patterns ?
- Why TTCN-3 Test Patterns ?
- Pattern Based TTCN-3 Test Development
- Evaluation of the Approach based on case study (OSA-Parlay API)
- Conclusions and Outlook
- Questions

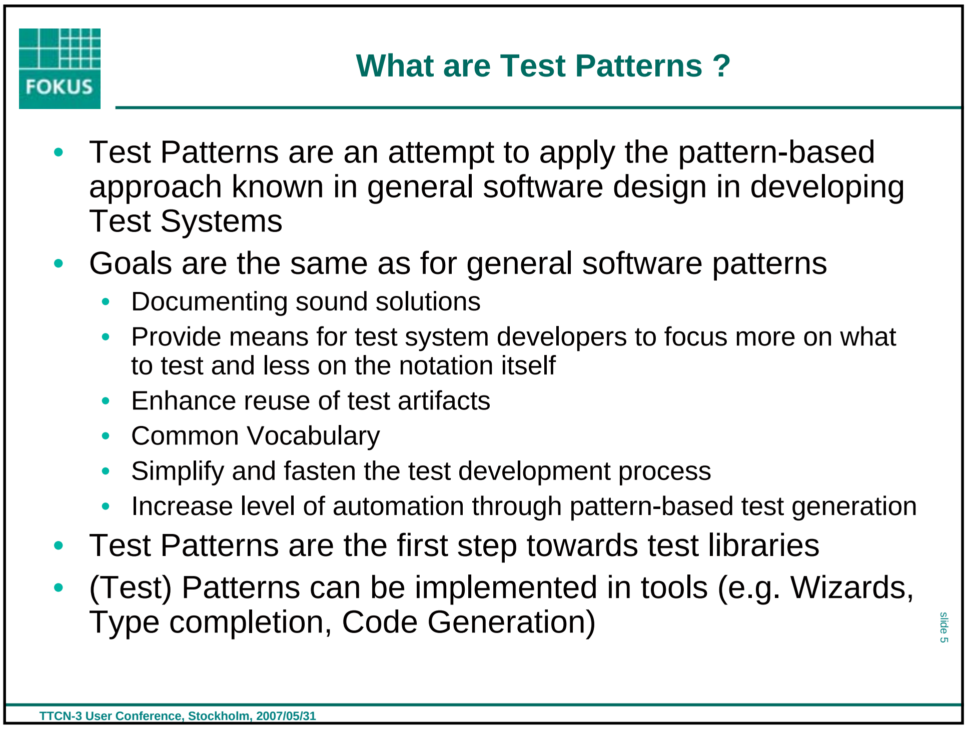
Patterns Characteristics

- **Identify and specify abstractions** above level of single instances or components in a software system
- **Document** existing well proven design **experiences**, software **architectures** and **guidelines**
- Provide a **common vocabulary** and understanding for design principles
- Address **functional** as well as **non-functional requirements** for software systems.
- Can provide **support for building software** with defined properties.
- Always **come from practical use**, although they are themselves abstract.

Example Software Design Patterns

- Software Design Patterns
  - Model-View-Controller
  - Proxy
  - Proactor
  - Visitor
  - Adapter
  - Singleton
  - Observer
  - Facade


Model
• Encapsulates application state
• Responds to state queries
• Exposes application functionality
• Notifies views of changes
State Query
State Change
Change Notification
View
• Renders the models
• Requests updates from models
• Sends user gestures to controller
• Allows controller to select view
View Selection
User Gestures
Controller
• Defines application behavior
• Maps user actions to model updates
• Selects view for response
• One for each functionality
Method Invocations
Events



What are Test Patterns ?

- Test Patterns are an attempt to apply the pattern-based approach known in general software design in developing Test Systems
- Goals are the same as for general software patterns
  - Documenting sound solutions
  - Provide means for test system developers to focus more on what to test and less on the notation itself
  - Enhance reuse of test artifacts
  - Common Vocabulary
  - Simplify and fasten the test development process
  - Increase level of automation through pattern-based test generation
- Test Patterns are the first step towards test libraries
- (Test) Patterns can be implemented in tools (e.g. Wizards, Type completion, Code Generation)

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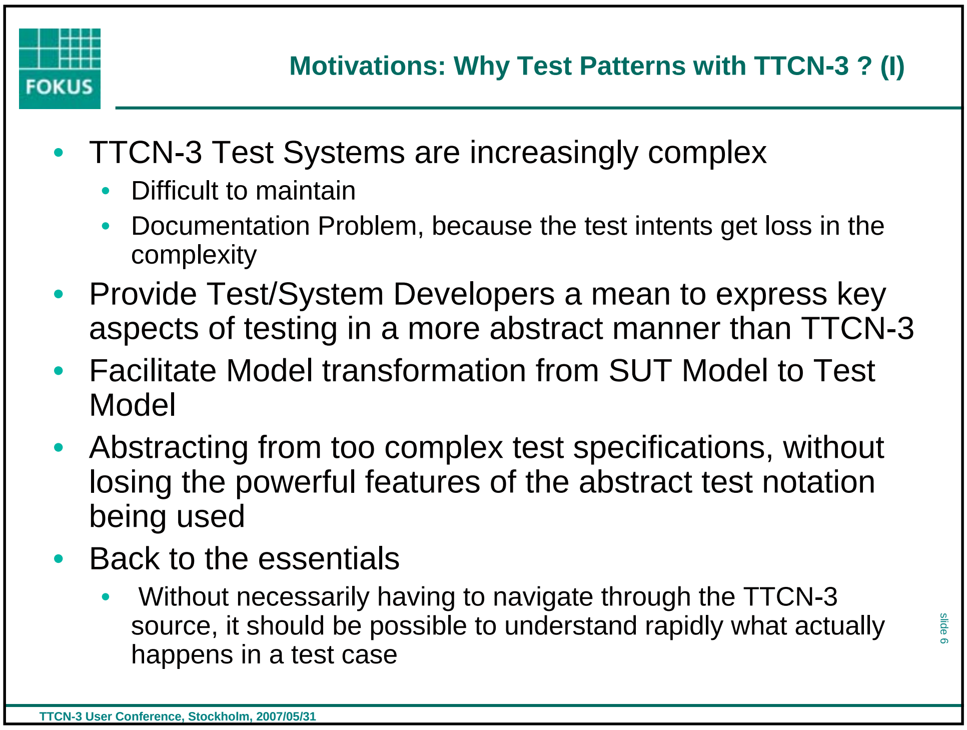

Motivations: Why Test Patterns with TTCN-3 ? (I)

- TTCN-3 Test Systems are increasingly complex
  - Difficult to maintain
  - Documentation Problem, because the test intents get loss in the complexity
- Provide Test/System Developers a mean to express key aspects of testing in a more abstract manner than TTCN-3
- Facilitate Model transformation from SUT Model to Test Model
- Abstracting from too complex test specifications, without losing the powerful features of the abstract test notation being used
- Back to the essentials
  - Without necessarily having to navigate through the TTCN-3 source, it should be possible to understand rapidly what actually happens in a test case

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Motivations: Why Test Patterns With TTCN-3 ? (II)

- Growing complexity of the SUTs => growing complexity of the ATS
  - ***E.g.*** Middleware or Telecommunication Systems with several different components providing and using ***several interfaces*** at the same time (IMS, OSA-Parlay)
  - The complexity of the Test System rises dramatically for performance and load testing involving ***concurrent behaviour*** among the test components
  - Less Readability of ATS
  - Less Reusability => Maintenability => Costs
- ***Question***: How to ensure that the test system, while coping with the SUT's complexity, does not also turn into a programming nightmare ? (Avoiding the „Who test the tester" dilemma).
- ***The Answer***: ***Focus on the essential aspects => Test Patterns***

Motivations: TTCN-3 Test Development Process

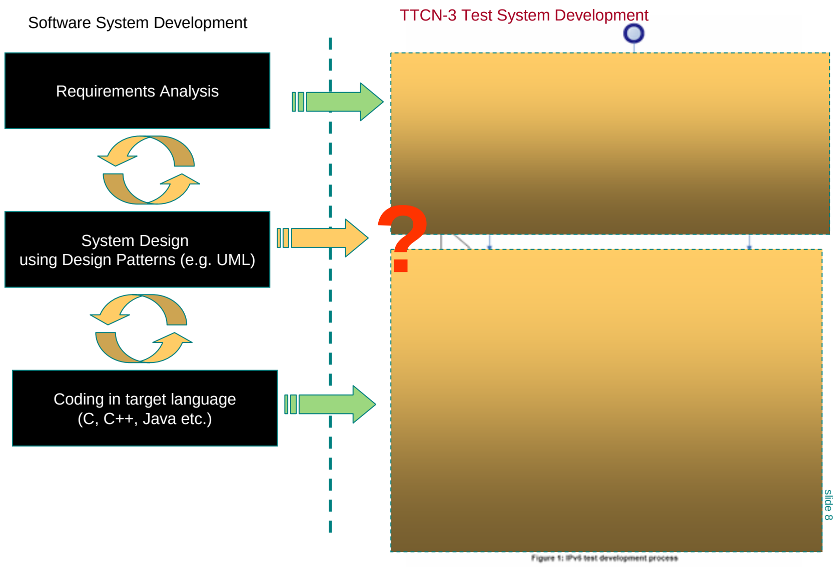

Software System Development
TTCN-3 Test System Development
Requirements Analysis
System Design
using Design Patterns (e.g. UML)
Coding in target language
(C, C++, Java etc.)
?

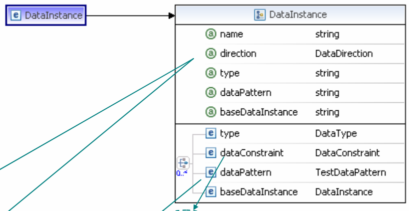
Figure 1: IPv6 test development process

Classification of TTCN-3 Patterns

- Test data patterns
  - Test Data (TTCN-3 Templates) are defined for certain test purposes or to fullfil certain constraints
  - Incoming/Outgoing data (wildcards, optional fields)
- Behavioral test patterns
  - Send – Receive
  - Send – Discard
  - Trigger – Receive
  - Exception handling
  - …
- Architectural test patterns
  - Configurations
  - Coordination and synchronization of Test Components

Test Data Patterns: Examples

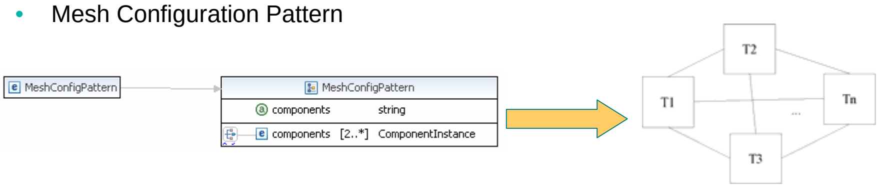
- Data Pattern Kinds
  - Domain Partition
  - Default Value
  - Boundary Value
  - Random Value



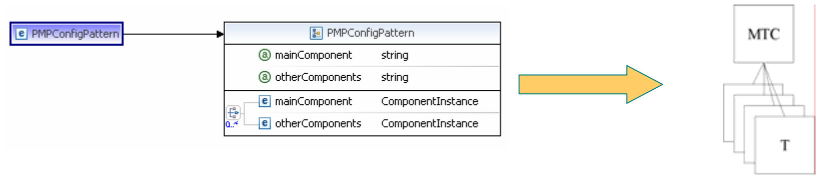
```
template EchoRequest m_echoRequest_extHdr_data ( …) := {}

template EchoRequest mw_echoRequest (… ) := {
    ipv6Hdr := mw_ipHdr_nextHdr_srcDst(c_icmpHdr, p_src, p_dst),
    extHdrList := *,
    icmpType:= c_echoRequest,
    icmpCode:= c_icmpCode0,
    checksum:= ?,
    identifier:= ?,
    sequenceNumber:= ?,
    data:= *
}
```

Architectural Patterns: Examples

- Mesh Configuration Pattern



- PMP Pattern



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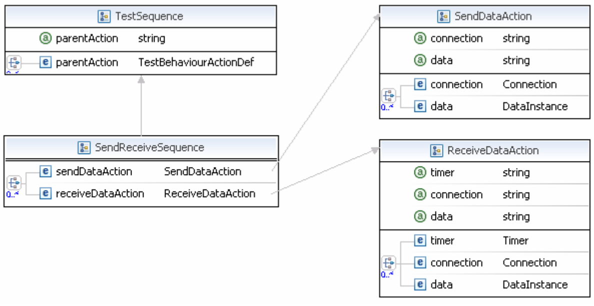
TTCN-3 Behavior Patterns: Examples



```
function <SendAndReceive> (template <T> to_send,
    (template <T> to_receive)+)
    {
        <send to_send>
        <activate defaults>
        (
        <start guard timer>
        <receive to_receive>
        <stop guard timer>
        <deactivate defaults>
        )+
    }
```

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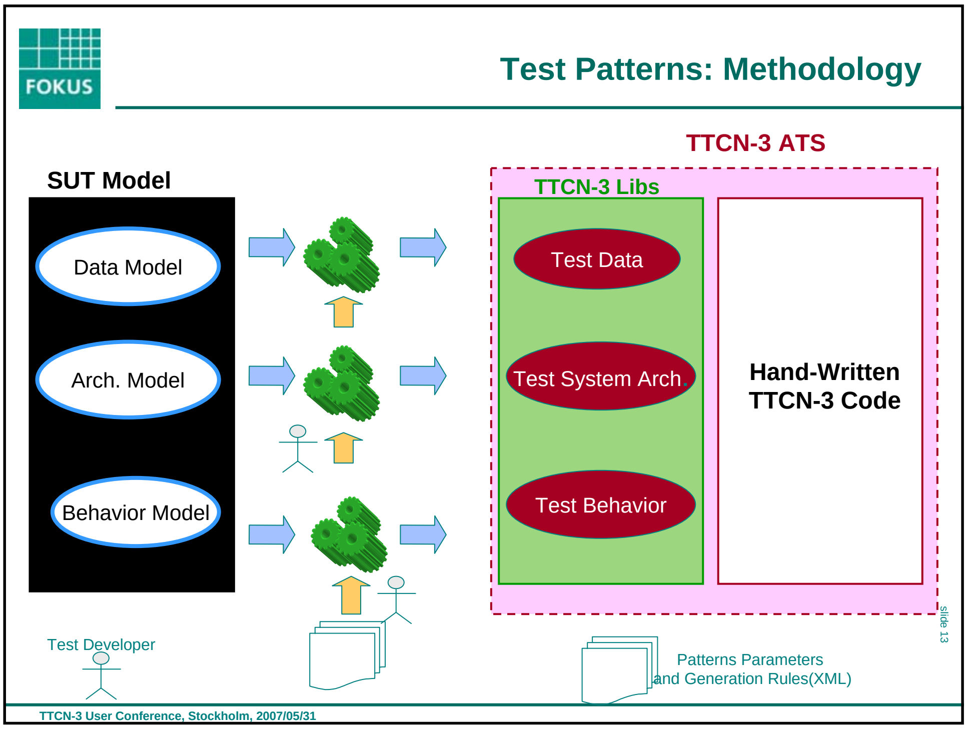
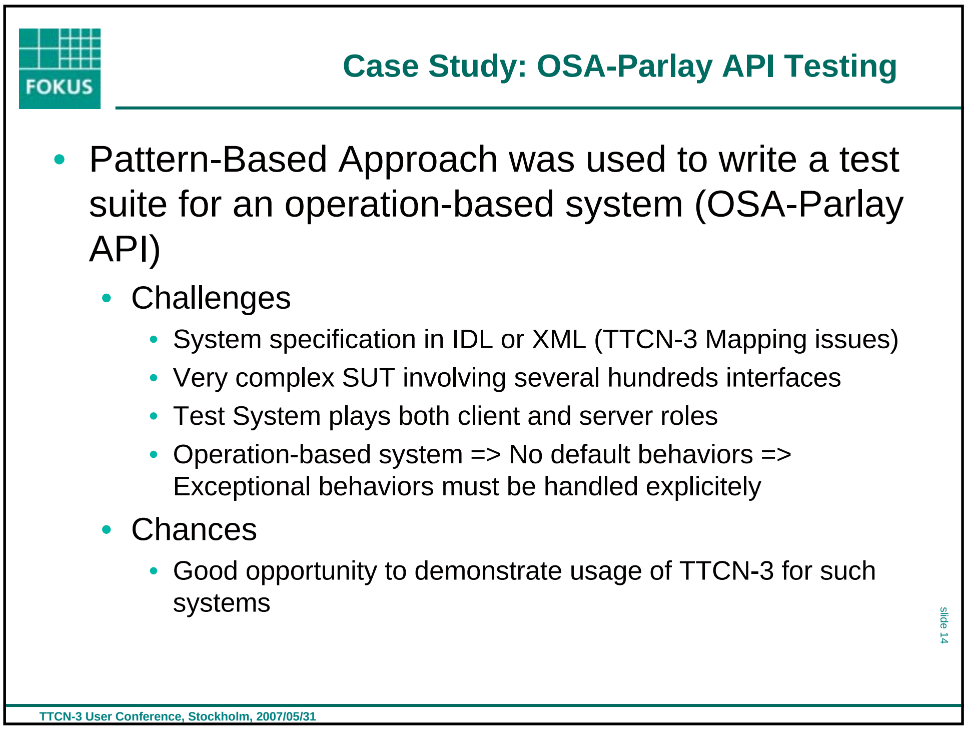


Test Patterns: Methodology

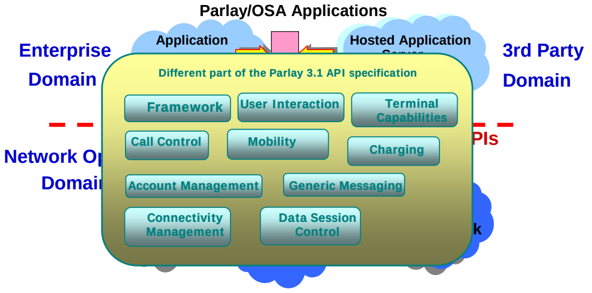


Case Study: OSA-Parlay API Testing

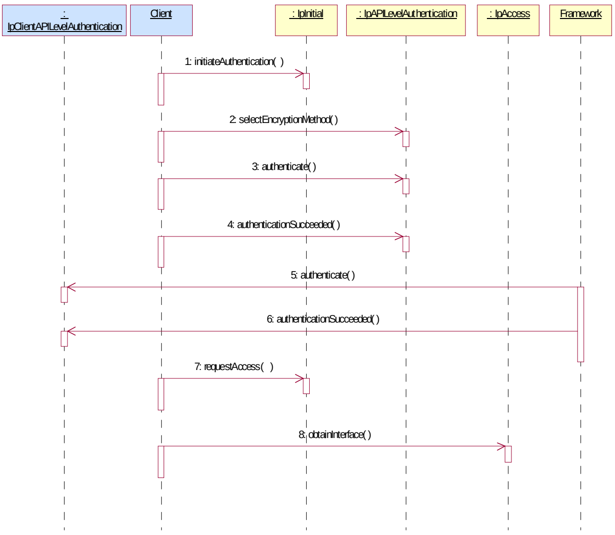
- Pattern-Based Approach was used to write a test suite for an operation-based system (OSA-Parlay API)
  - Challenges
    - System specification in IDL or XML (TTCN-3 Mapping issues)
    - Very complex SUT involving several hundreds interfaces
    - Test System plays both client and server roles
    - Operation-based system => No default behaviors => Exceptional behaviors must be handled explicitely
  - Chances
    - Good opportunity to demonstrate usage of TTCN-3 for such systems

Background and work presentation (I)

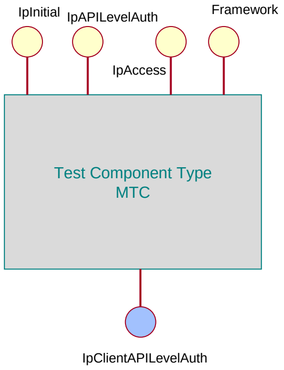
- **Background: OSA-Parlay Architecture**
  - Open API specified by 3GPP,ETSI and Parlay Group.
  - The aims are to enable Operator and 3rd party Applications developer to use networks functionality independently of the underlying networks.
  - Parlay/OSA APIs are specified in CORBA/IDL and XML/SOAP and define three types of component: Framework, services capability server and Applications Interface
  - Current version of parlay is 6.0 whereas release 4 of 3rd version has been use in this work. It is grouped on the following parts.



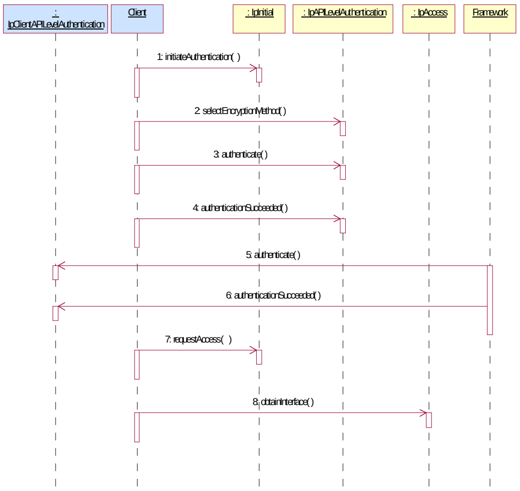
From SUT Specification to ATS (I): Test Configuration


: IpClientAPILevelAuthentication
Client
: IpInitial
: IpAPILevelAuthentication
: IpAccess
Framework
1: initiateAuthentication( )
2: selectEncryptionMethod( )
3: authenticate( )
4: authenticationSucceeded( )
5: authenticate( )
6: authenticationSucceeded( )
7: requestAccess( )
8: obtainInterface( )

Generated TTCN-3 Component Types & Configuration



From SUT Specification to ATS (II): Behavior Functions


:
IpClientAPILevelAuthentication
Client
: IpInitial
: IpAPILevelAuthentication
: IpAccess
Framework
1: initiateAuthentication( )
2: selectEncryptionMethod( )
3: authenticate( )
4: authenticationSucceeded( )
5: authenticate( )
6: authenticationSucceeded( )
7: requestAccess( )
8: obtainInterface( )

- **Behavior functions are generated**:
  - Call_InitiateAuthentication()
  - Call_SelectEncryptionMetho()
  - Call_Authenticate()
  - Call_AuthenticationSucceeded()
  - GetCall_Authenticate()
  - GetCall_AuthenticatedSucceeded()
  - Call_RequestAccess()
  - Call_ObtainInterface()

Case Study: Generated TTCN-3 Code Snippet

```
function call_viaPort_IpInitial__initiateAuthentication(
        inout IpInitial port_p,
        in org__csapi__fw.TpAuthDomain
        IpInitial__clientDomain_p,
        in charstring IpInitial__authType_p,
        in template org__csapi__fw
        .TpAuthDomain rtn_templ_p) runs on IpInitial_Tester
        return org__csapi__fw.TpAuthDomain {
        var org__csapi__fw.TpAuthDomain rtnValue := …;
```

The highlighted part of the code snippet represents the core test behaviour. Everything else is implicit, but still required => Could be hidden away from the user based on predefined rule/pattern

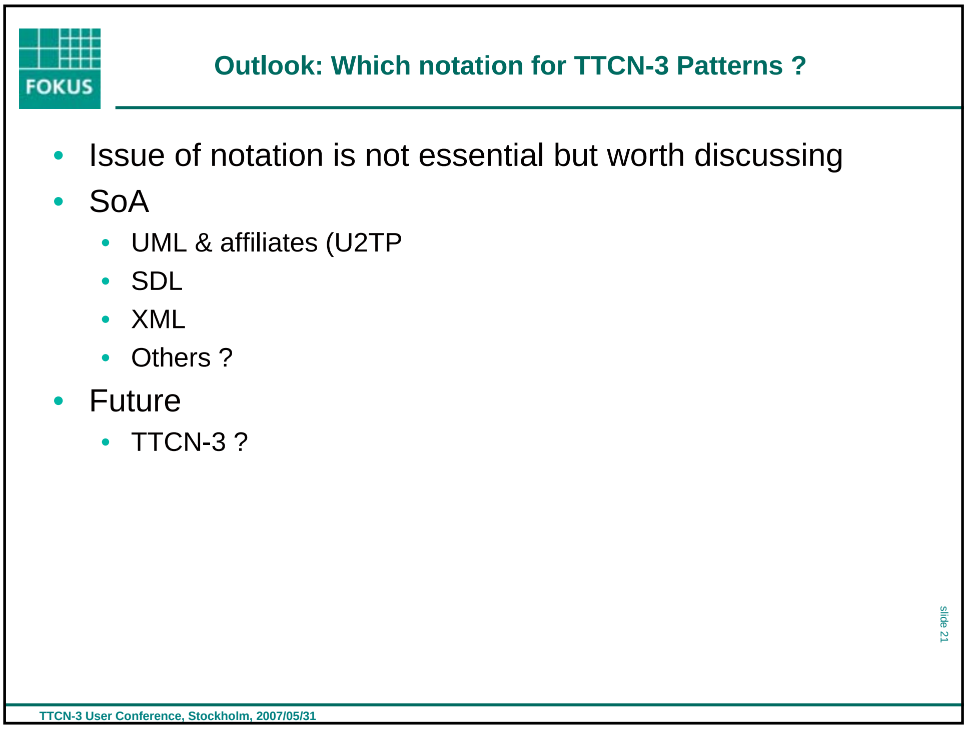
```
port_p.call (IpInitial__initiateAuthentication: {
IpInitial__clientDomain_p, IpInitial__authType_p
}, T_CLIENT) {
[] port_p.getreply (
IpInitial__initiateAuthentication_r_0 value rtn_templ_p) -> value
        rtnValue {
log ("Method IpInitial__initiateAuthentication invoked successfully");
}
[] port_p.catch (
IpInitial__initiateAuthentication, org__csapi.TpCommonExceptions: ?)
        {
        setverdict (inconc);
 }
…
[] port_p.getreply {
        setverdict (fail);
}
[] port_p.catch {
        setverdict (fail);
}
[] port_p.catch (timeout) {
        setverdict (fail);
}
}
return rtnValue;
}
```

OSA Parlay Case Study: Results and Findings

- TTCN-3 Library for OSA-Parlay successfully generated
  - Very helpful in speeding up development process
- Tests successfully executed against real-life implementations
- Brute force not efficient
  - Too much potentially unused code generated
- Human intervention is required for selecting relevant SUT interfaces and messages for more efficient code generation
- Approach applicable for Asynchronous (Message-based) communication as well, however
  - Refinements of behaviour model required
  - More convenient Approach for patterns definition and code generation rules required (currently hard-coded in XML)

Conclusions and Outlook

- Pattern-oriented Test Development has been used successfully in testing operation-based systems with TTCN-3
- Approach is also applicable for message-based systems (e.g. protocol stacks).
- A mean for expressing test patterns is required to decouple from the complexity of the systems to be tested
- Test Patterns can effectively fill the gap between system specification and test specification => facilitate test automation



Outlook: Which notation for TTCN-3 Patterns ?

- Issue of notation is not essential but worth discussing
- SoA
  - UML & affiliates (U2TP
  - SDL
  - XML
  - Others ?
- Future
  - TTCN-3 ?