Testing Technologies

ETSI‘s User Conference on Advanced Automated Testing

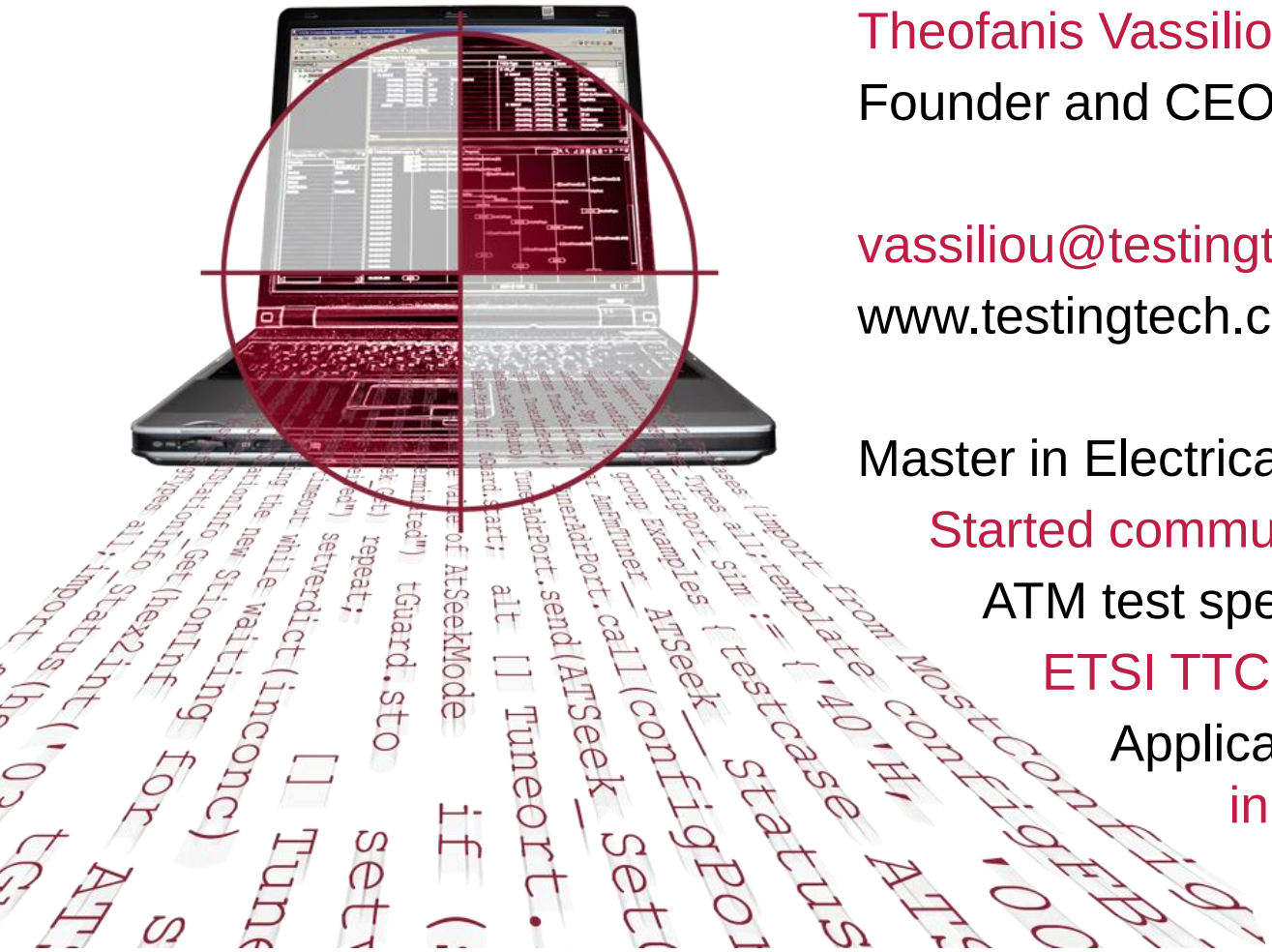
Testing Technologies

1st User Conference on Advanced Automated Testing

Introduction to TTCN-3

Paris, October 2013

Speaker



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Founder and CEO of Testing Technologies

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Master in Electrical Engineering

Started communication testing 1996

ATM test specification Standardization

ETSI TTCN-3 Standardization

Application of test automation in new domains

Agenda

- Motivation
- Introduction to TTCN-3 – TTCN-3 by Example

Testing Technologies

The TTCN-3 Language

Introduction to TTCN-3

Motivation

How Much Does Testing Cost?

„ ... the national annual cost estimates of an inadequate infrastructure for software testing are estimated to be **$59.5 billion**.
The potential cost reduction from feasible infrastructure improvements is **$22.2 billion**.“

The Economic Impacts of Inadequate Infrastructure for Software Testing

Study by NIST, May 2002

And today?

Testing Technologies

World Quality Report 2013-14

As consumers demand high performance, error-free applications, organizations are increasing their QA budgets and more testing functions are centralized

A higher share of the IT budget is invested in Testing ...

23%

of the IT budget is spent on QA & Testing

- compared to 18% last year -

46%

of QA budget is spent on "transformational projects"

- compared to 41% last year -

... organizations are industrializing and outsourcing their QA...

41%

of projects are done entirely in-house

- compared to 51% last year -

26%

of organizations have a centralized testing function - *up from 8% in 2012 -*

19%

of businesses have fully operational Test Centers of Excellence - *compared*

...and as mobile applications increase, mobile testing gains traction...

PRIMARY FOCUS

#1 Efficiency and Performance

59%

#2 Security

56%

- up from 18% last year -

BIGGEST CHALLENGE

Lack of appropriate processes/methods

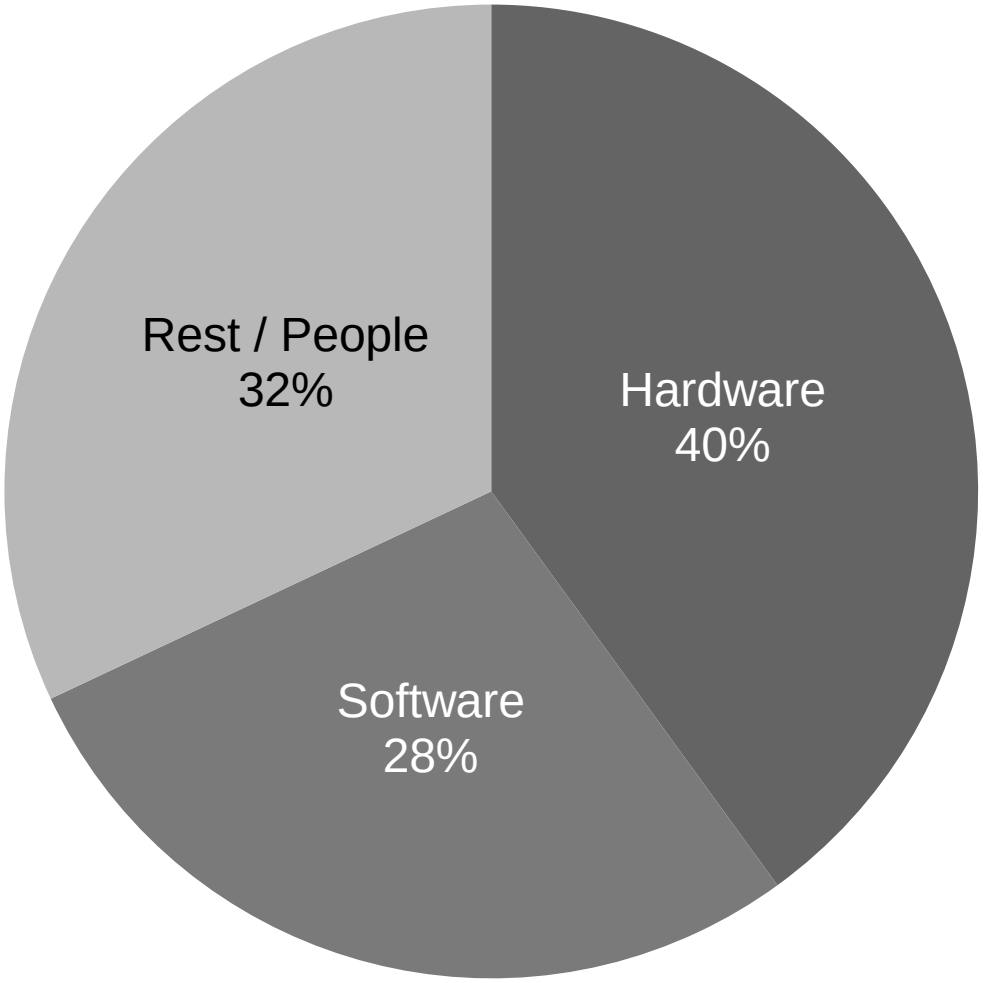
34% 56%

...and cloud-based testing is expected to increase.

By 2015, 32% of Testing will be performed in the Cloud

30% of cloud-based testing is performed on critical, externally facing applications *- up from 20% last year -*

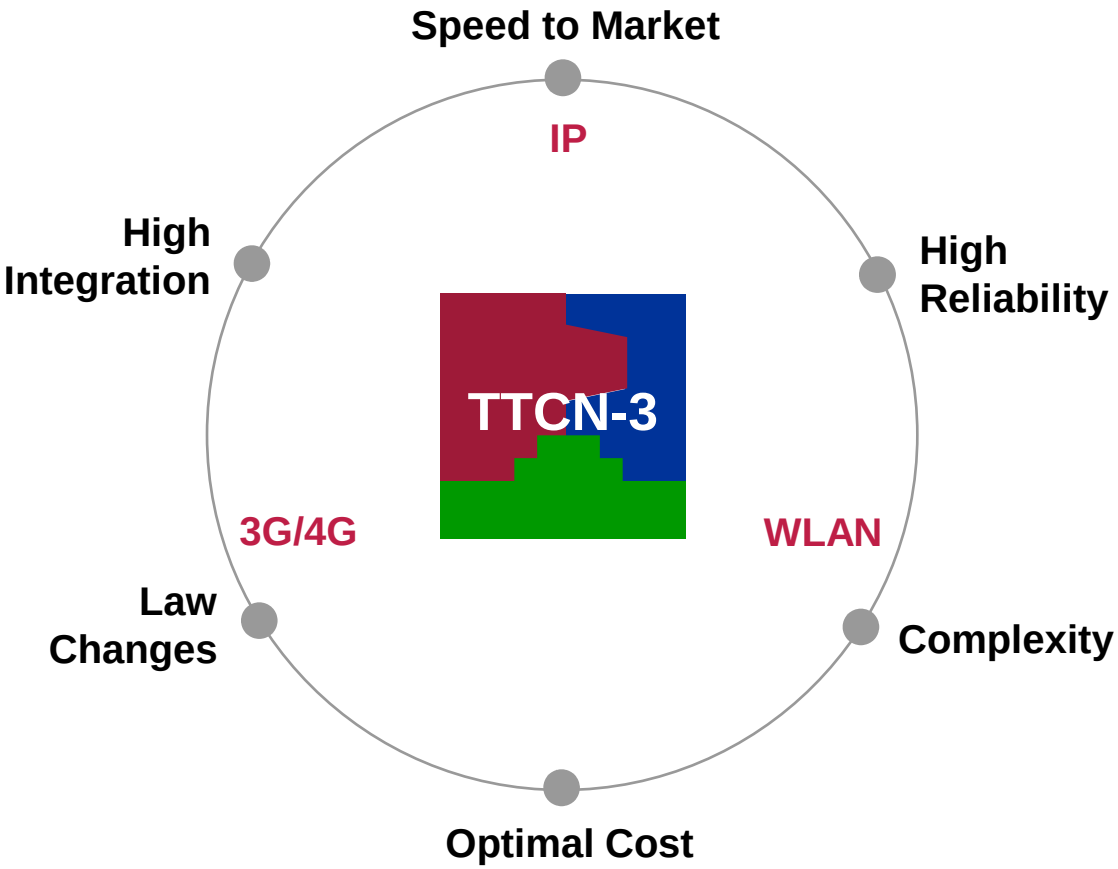
Spendings in Testing (WQR 2013)



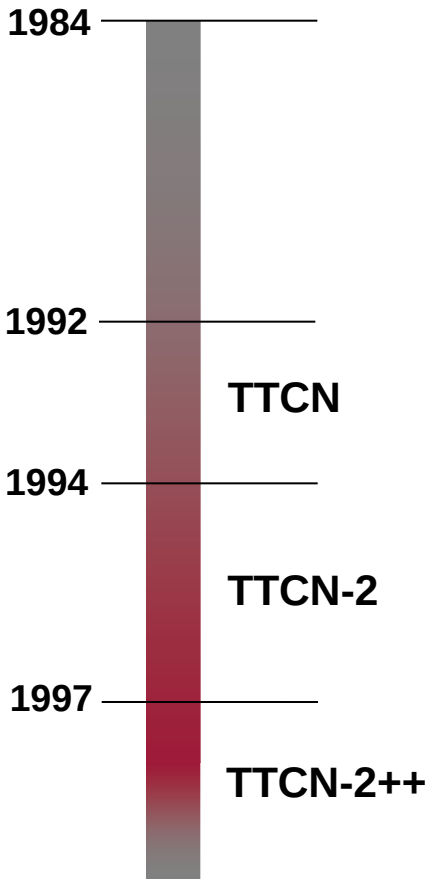
Testing Today

- Is
  - Important
  - Expensive
  - Time critical
- But
  - Only rarely practiced as a strategic component
  - Unsystematic throughout the organization
  - Performed by hand
  - Error-prone
  - Uncool („If you are a bad programmer you might be a tester.“)
  - Unconstructive

Why Using TTCN-3 (2)

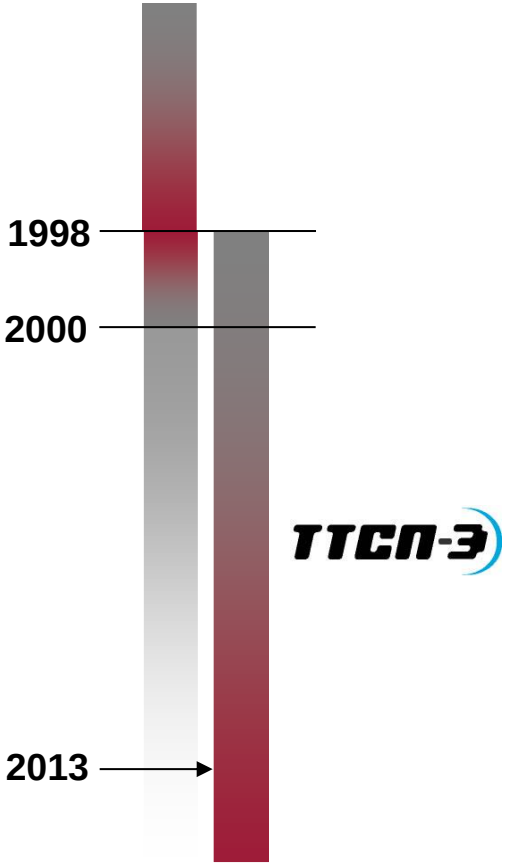


History (1)



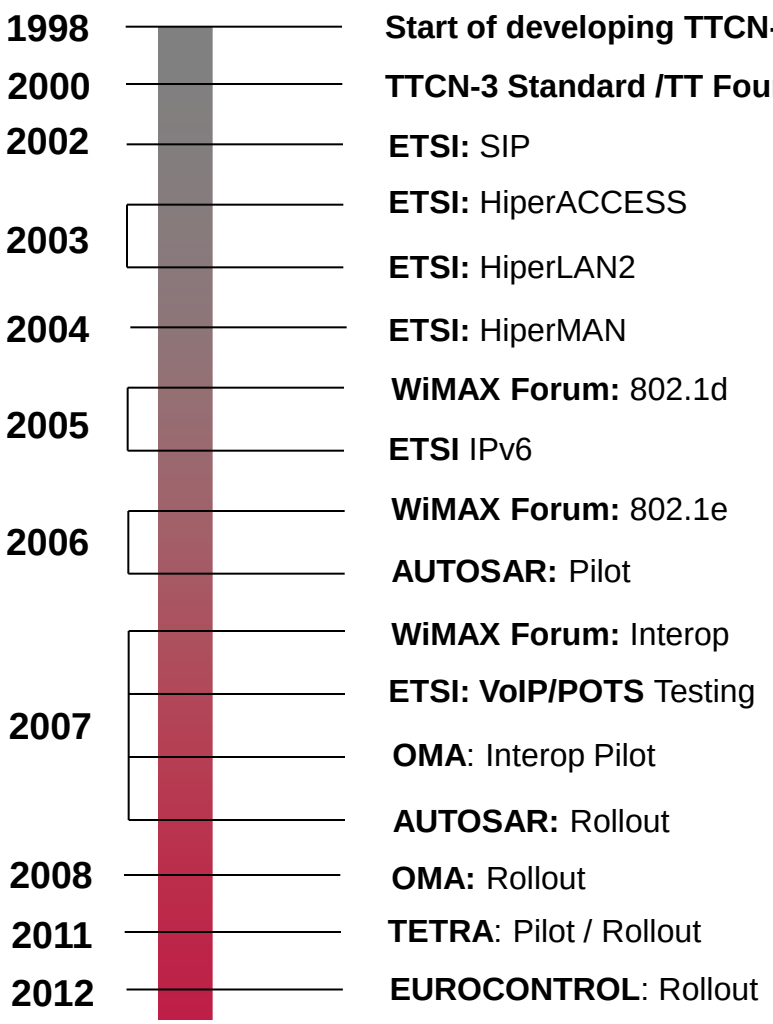
- TTCN (1992)
  - Published as an ISO standard
  - Tree and Tabular Combined Notation
  - Used for protocol testing only
    - GSM, N-ISDN, B-ISDN
- TTCN-2/2++ (1997)
  - Concurrent tests
  - Modularization
  - Manipulate external data
  - Rather for conformance testing
  - Developed by ETSI MTS

History (2)



- TTCN-3 (2000)
  - Testing and Test Control Notation
  - Developed by ETSI MTS
  - Standard language
    - Well defined syntax and semantics
  - Enhanced communication, configuration and control
  - Standard test specification
    - SIP, SCTP, M3UA, IPv6
    - HiperLan, HiperAccess, Wimax
    - 3GPP LTE, OMA
    - TETRA
    - MOST, AUTOSAR

History (3)



- Since 2002 standard bodies using TTCN-3 to define test specifications
  - ETSI 3GPP
  - WiMAX Forum
  - OMA
  - TETRA
  - AUTOSAR
  - MOST

Maintenance of TTCN-3

- Standard is constantly maintained
  - Through Change Requests (CRs)
  - Extension proposals
  - Active contributions in the TTCN-3 community
    - TTCN-3 mailing list, TTCN-3 users conference
- ETSI STFs (Specialist Task Force)
- Change requests result in new editions of the standard
  - 2000: Edition 1
  - 2003: Edition 2
  - 2005: Edition 3
  - 2010: Edition 4.2.1
  - 2011: Edition 4.3.1
  - 2012: Edition 4.4.1
  - 2013: Edition 4.5.1
- Resources: http://portal.etsi.org http://www.ttcn-3.org

Testing is

- a technical process
- performed by experimenting with a software product
- in a controlled environment
- following a specified procedure
- with the intent of observing one or more characteristics of the product
- by demonstrating the deviation of the product's actual status from the required status/specification

Testing Today‘s Systems

- Component-based
  - Test-components contribute to SUT functionality and performance
- Distributed
  - Not only local, but also distributed test setups
- Dynamic in terms of behavior and configuration
  - Testing of static and dynamic aspects; dynamic creation of test components
- Use various type systems to exchange data
  - Open to all type systems
- Service is essential
  - Concentration on service-oriented black-box testing

Design Principles of TTCN-3

- One test technology for different kind of testing
  - Distributed, platform-independent testing
  - Integrated graphical test development, -documentation and -analysis
  - Adaptable, open test environment
- One test technology for distributed IT and telco systems and beyond

Main Aspects of TTCN-3

- Triple C
  - **C**onfiguration: Dynamic concurrent test configurations with test components
  - **C**ommunication: Various communication mechanisms (message-based, procedure-based)
  - **C**ontrol: Test case execution and selection mechanisms
- Features
  - Well-defined syntax, static and operational semantics
  - Different presentation formats
  - Module concept
  - Extendibility via attributes, external function, external data
  - Harmonization with ASN.1, integration of XML, IDL, …

TTCN-3 Standards

Testing Technologies

ETSI ES 201 873-1	TTCN-3 Core Language (CL)
ETSI ES 201 873-2	TTCN-3 Tabular Presentation Format (TFT)
ETSI ES 201 873-3	TTCN-3 Graphical Presentation Format (GFT)
ETSI ES 201 873-4	TTCN-3 Operational Semantics
ETSI ES 201 873-5	TTCN-3 Runtime Interface (TRI)
ETSI ES 201 873-6	TTCN-3 Control Interfaces (TCI)
ETSI ES 201 873-7	Integration of ASN.1
ETSI ES 201 873-8	Integration of IDL
ETSI ES 201 873-9	Integration of XML
ETSI ES 201 873-10	T3Doc
ETSI ES 202 781	TTCN-3 Extension: Configuration And Deployment Supp
ETSI ES 202 782	TTCN-3 Extension: Performance & Real-Time Testing
ETSI ES 202 784	TTCN-3 Extension: Advanced Parametrization
ETSI ES 202 785	TTCN-3 Extension: Behaviour Types
ETSI ES 202 786	TTCN-3 Extension: Continuous Signals
ETSI ES 202 789	TTCN-3 Extension: Extended TRI

- Maintenance on the basis of change requests by ETSI
- Standard available for download at http://www.etsi.org
- Testing Tech tools support Edition 4.5.1
- Also standardized by the ITU-T as ITU-T Z.140 series

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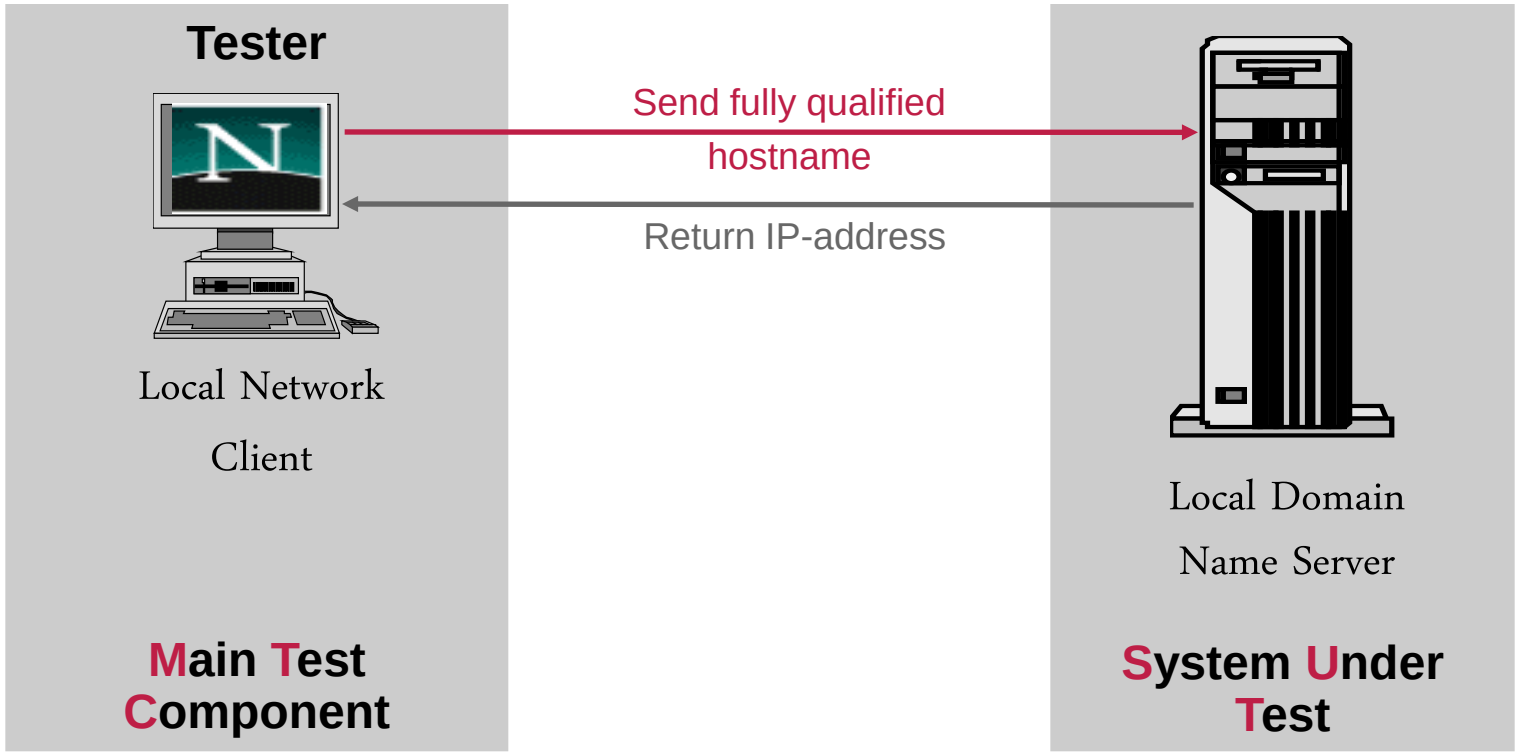
The TTCN-3 Language

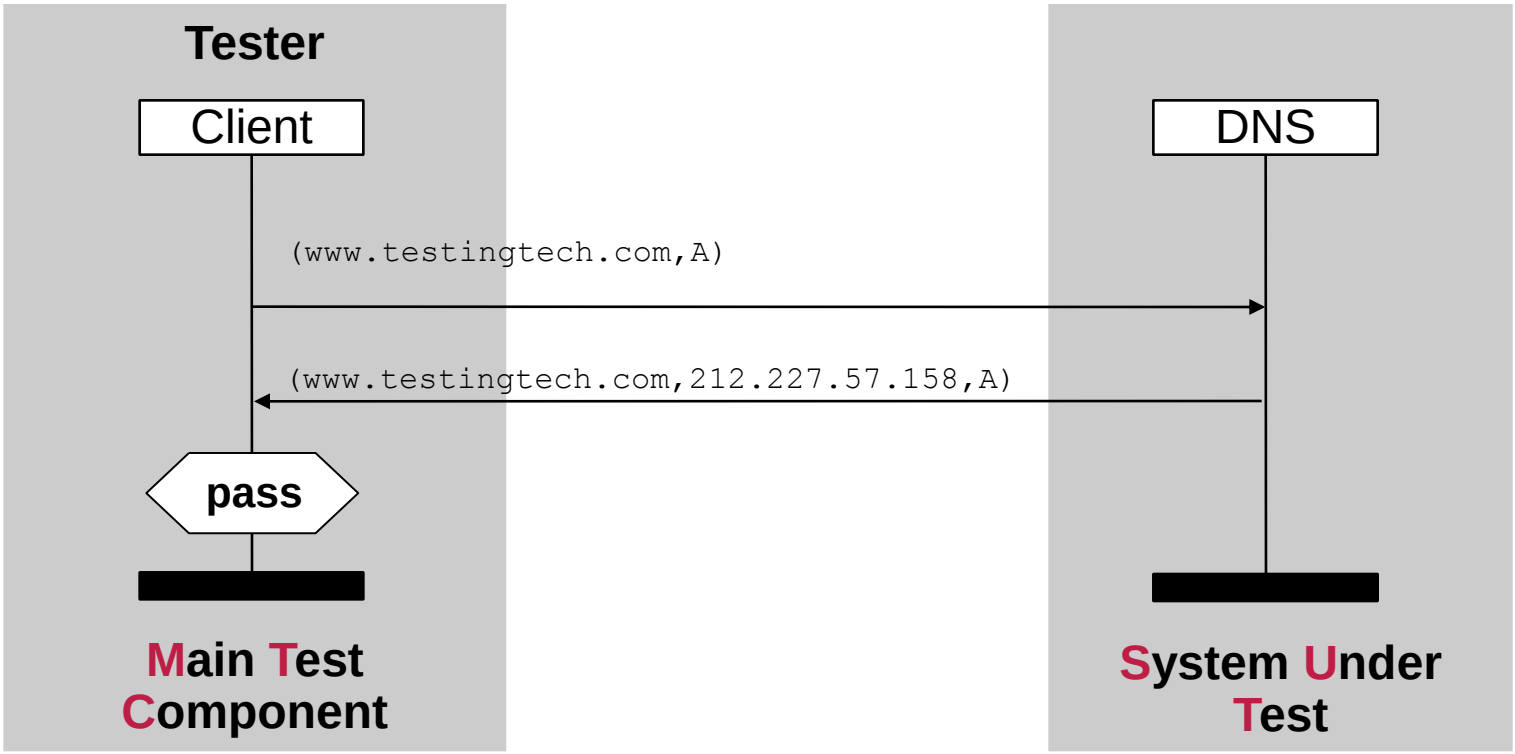
Introduction to TTCN-3

TTCN-3 by Example

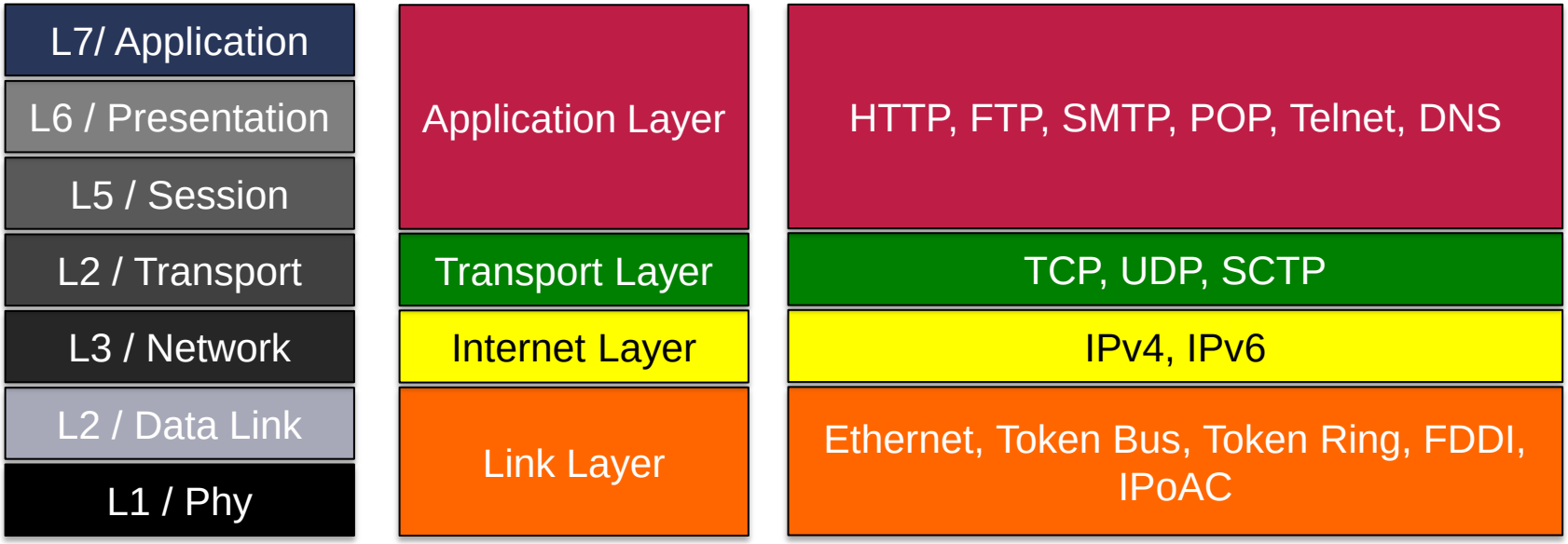
TTCN-3 By Example



TTCN-3 By Example



Generic Protocol Architecture(s)



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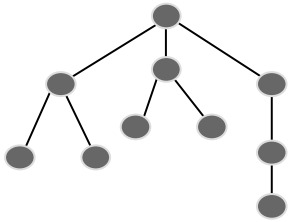
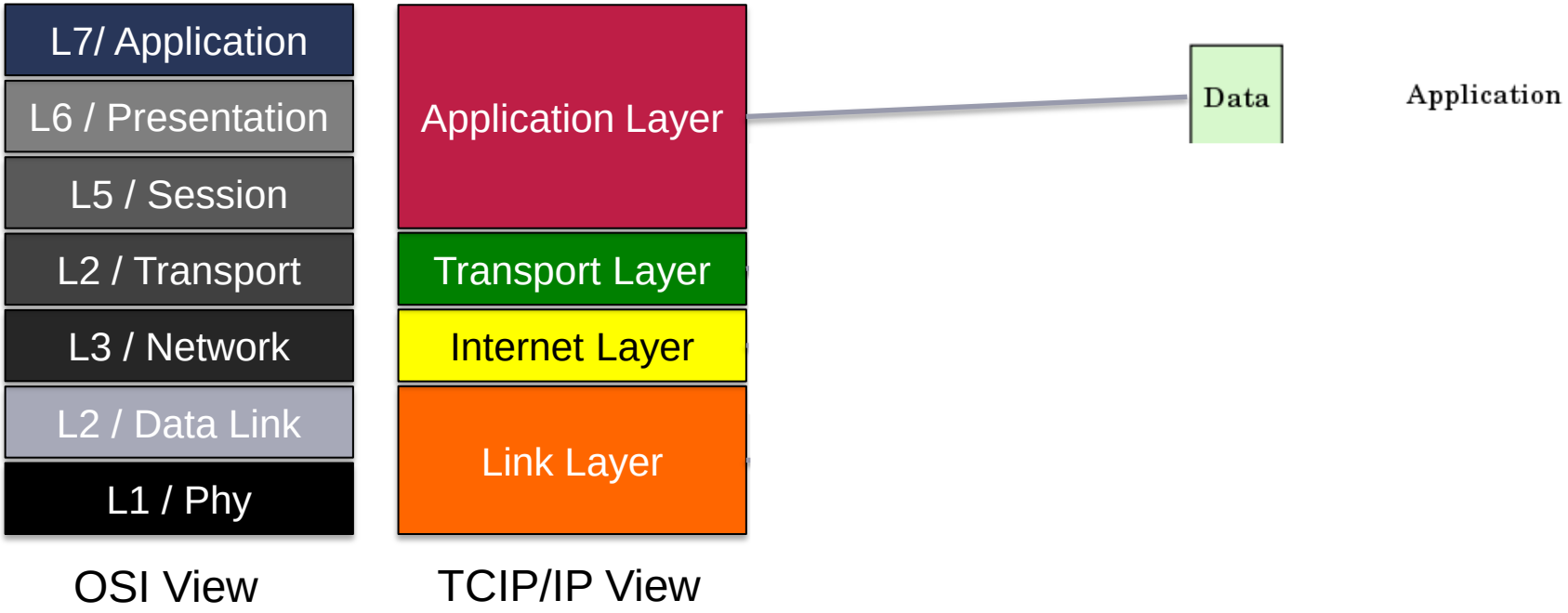
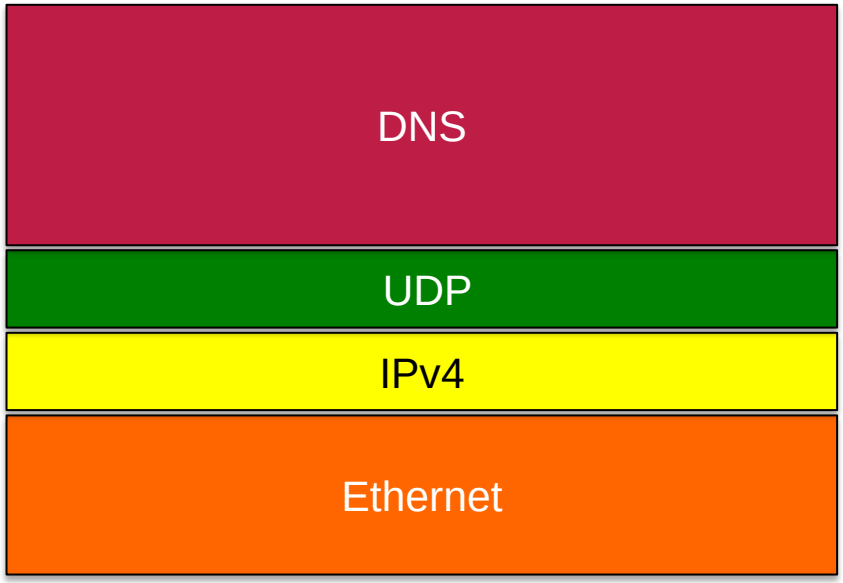




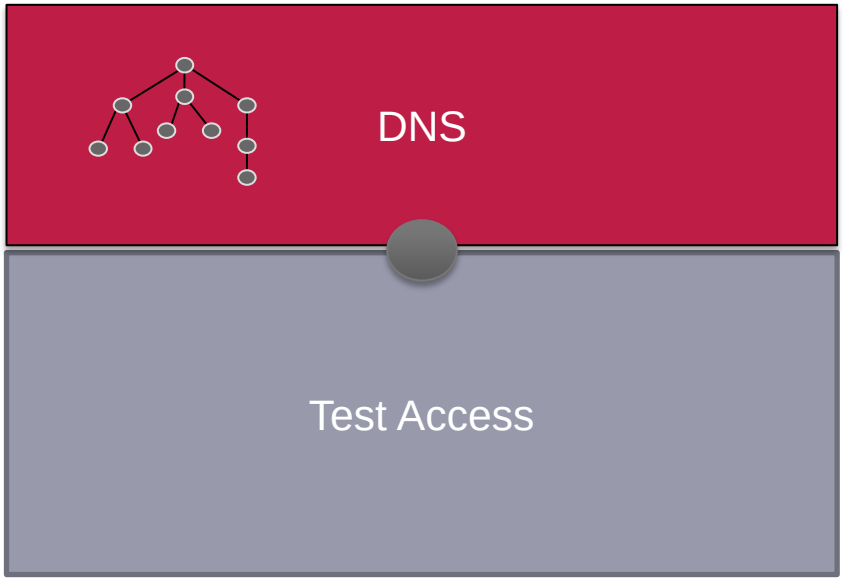
When we test we ...

- Select the **protocol** or **application** to test
  → DNS
- Select the **test access**
  → UDP, IPv4, Ethernet



When we test we would like to ...

- **Concentrate** on the protocol (application) on an **abstract** level
- **Do not care** for the concrete technical details like test access

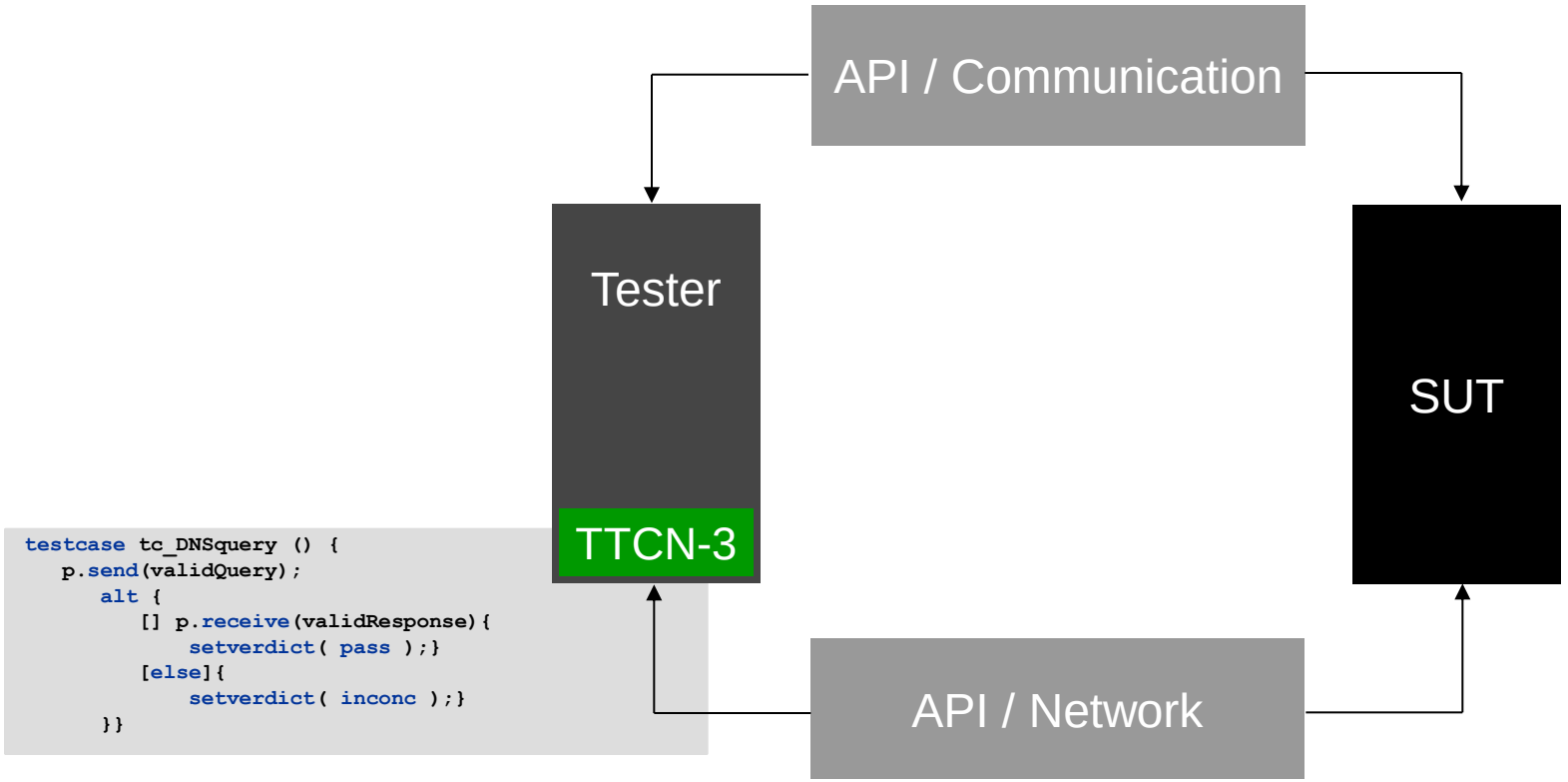


What is TTCN-3?

- **T**esting and **T**est **C**ontrol **N**otation
- Internationally standardized testing language for formally defining test scenarios. Designed purely for testing
- In its essence it can be considered as a kind of scripting language that includes tons of testing specific features!

```
testcase tc_DNSquery () {
   p.send(validQuery);
      alt {
         [] p.receive(validResponse){
             setverdict( pass );}
         [else]{
             setverdict( inconc );}
      }
}
```

TTCN-3 Execution



TTCN-3 Modules

- Main building block of TTCN-3 is a module
  - Unit of compilation
  - Contains definitions
  - Plus optional control part

```
module DNS {

  // module definitions

  // module control (optional)

}
```

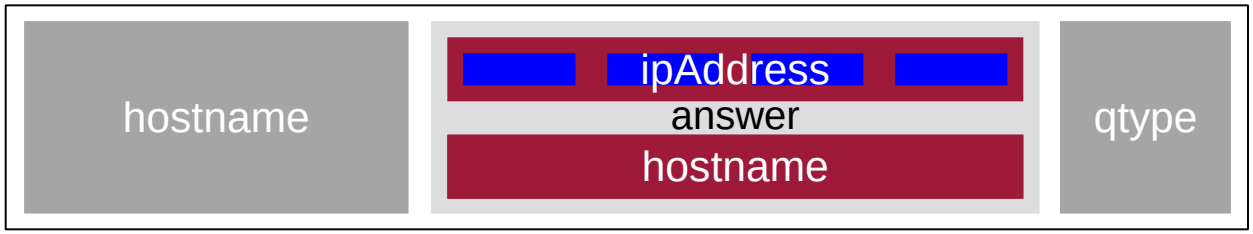
Module Definitions

- Contains descriptions for
  - What type of data the System Under Test understands
  - How the System Under Tests can be accessed and what environment a test component needs
  - When to communicate what with the SUT and why
  - Dependencies between test cases, if any

Module Definitions (1)

- Module definitions
  - **Type definitions**
  - Port definitions
  - Component definitions
  - Templates
  - Test case
- Control part
  - Controls the execution of test cases

```
type record DNSQuery {
   charstring hostname,
   AnswerType answer optional,
   QueryType qtype
}
type union AnswerType {
   Byte ipAddress[4],
   charstring hostname
}
type integer Byte (0 .. 255);
type enumerated QueryType {
   A, NS, CNAME, MX
}
```



Module Definitions (2)

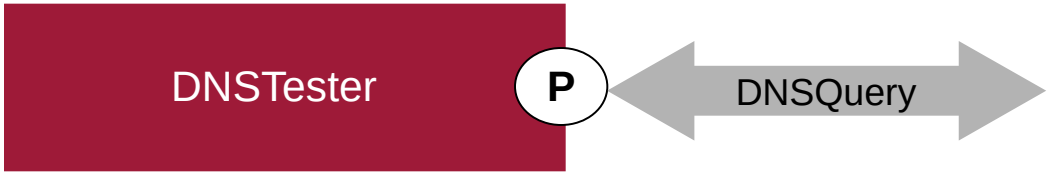
- Module definitions
  - Type definitions
  - **Port definitions**
  - **Component definitions**
  - Templates
  - Test case
- Control part
  - Controls the execution of test cases

Port definitions

```
type port DNSPort message {
   inout DNSQuery;
   // a port may send/receive messages
   // of more than one type
}
```

Component definitions

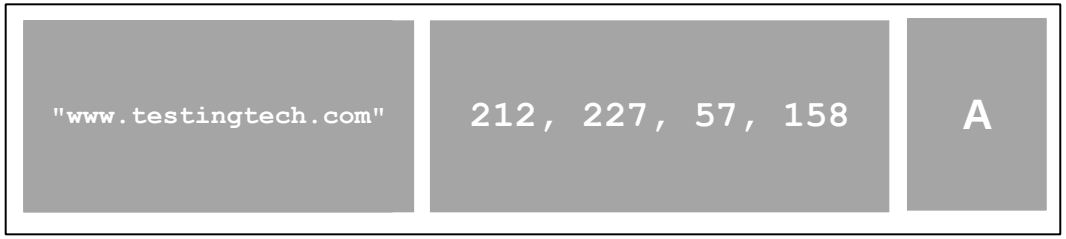
```
type component DNSTester {
   port DNSPort P;
   timer t := 3.0;
   // a component may have more than one port
}
```



Module Definitions (3)

- Module definitions
  - Type definitions
  - Port definitions
  - Component definitions
  - **Templates**
  - Test case
- Control part
  - Controls the execution of test cases

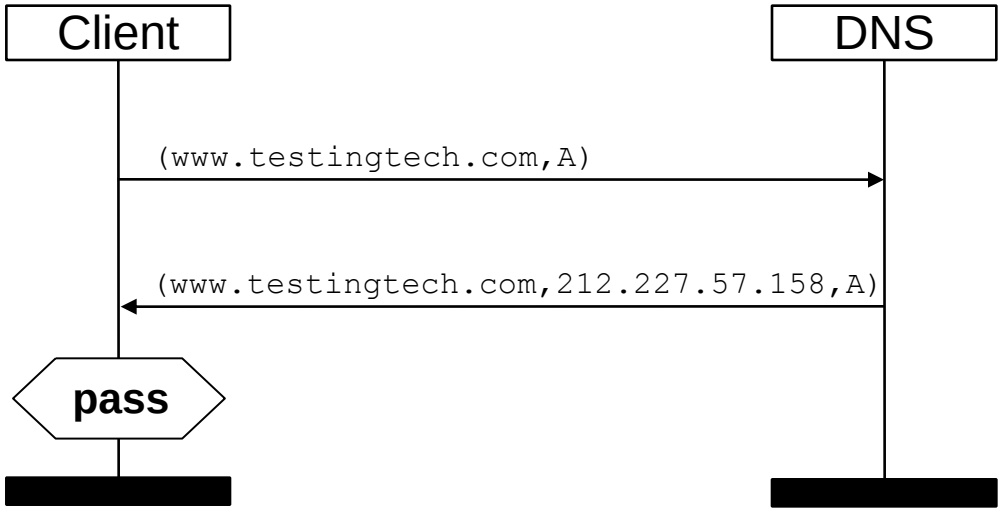
```
template DNSQuery validQuery := {
   hostname := "www.testingtech.com",
   answer   := omit,
   qtype    := A
}
template DNSQuery validReply modifies query := {
   answer := { ipAddress :=
               {212,227,57,158} }
}
```



Module Definitions (4)

- Module definitions
  - Type definitions
  - Port definitions
  - Component definitions
  - Templates
  - **Test case**
- Control part
  - Controls the execution of test cases

```
testcase tc_testcase1() runs on DNSTester {
  P.send(validQuery);
  P.receive(validReply);
  setverdict(pass);
}

// there may be more than one in a module
```

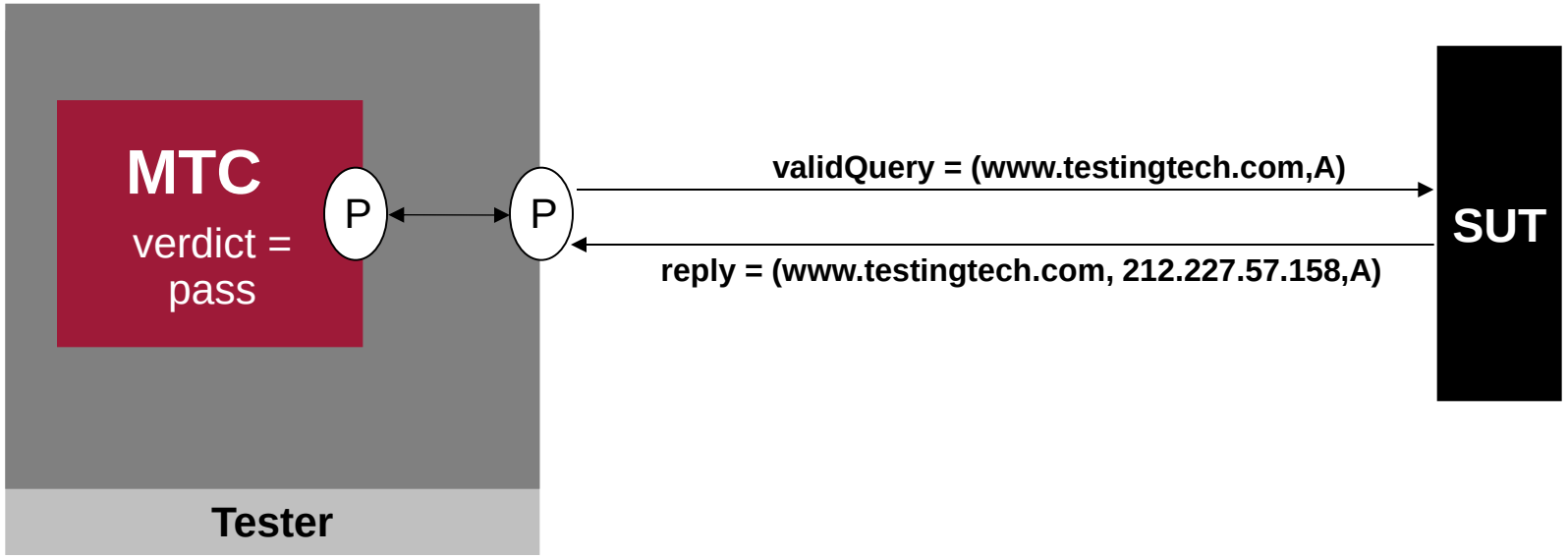


Module Definitions (5)

- Module definitions
  - Type definitions
  - Port definitions
  - Component definitions
  - Templates
  - Test case
- Control part
  - **Controls the execution of test cases**

```
control {

   execute(tc_testcase1(), 5.0);
   while( /* condition */) { };

   // more testcases might follow
   // C-like control structures available

}
```

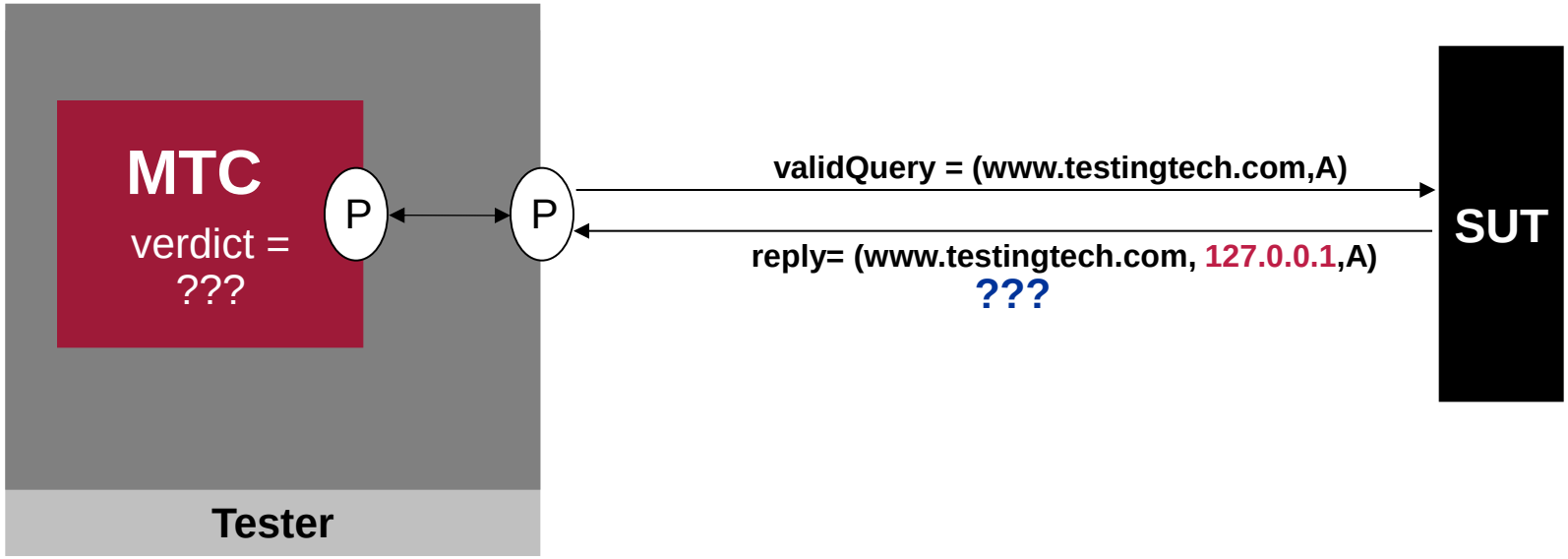
Execution of a Test Case




```
testcase tc_testcase1() runs on DNSTester {
  P.send(validQuery);
  P.receive(validReply);
  setverdict(pass);

}
```

Is this test case definition adequate?

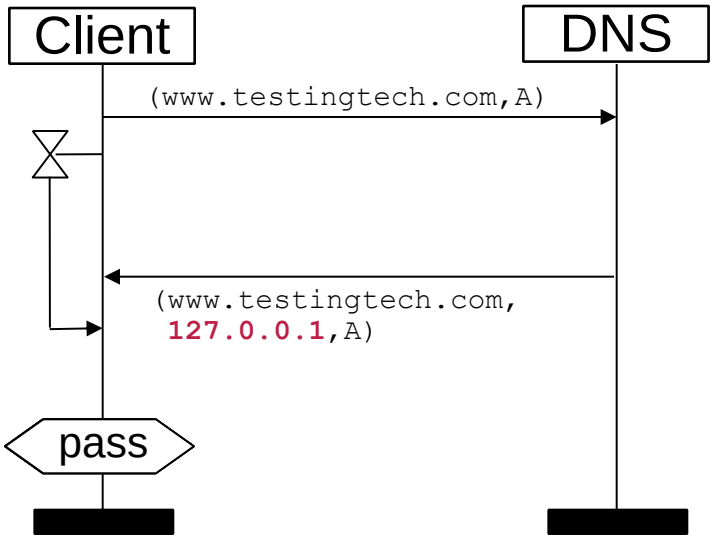
Dealing with Erroneous Behavior (1)



- `P.receive (validReply)` blocks until it receives a message that matches the reply
- If an unexpected message is received, any other correct message does not unblock the tester, which then blocks forever
- If no message is received, the tester will also block forever

Dealing with Erroneous Behavior (2)

```
testcase tc_testcase2() runs on DNSTester {

P.send(validQuery);

t.start;

alt {
     [] P.receive(validReply) {
          setverdict(pass);
     }
     [] P.receive { // any message
          setverdict(fail);
     }
     [] t.timeout {
          setverdict(inconc);
     }
}
stop;
}
```



Code Reusability – Altsteps and Defaults

```
alt {
  [] P.receive(validReply) {
          setverdict(pass);
  }
  [] P.receive { // any message
          setverdict(fail);
  }
  [] t.timeout {
          setverdict(inconc);
  }
}
```

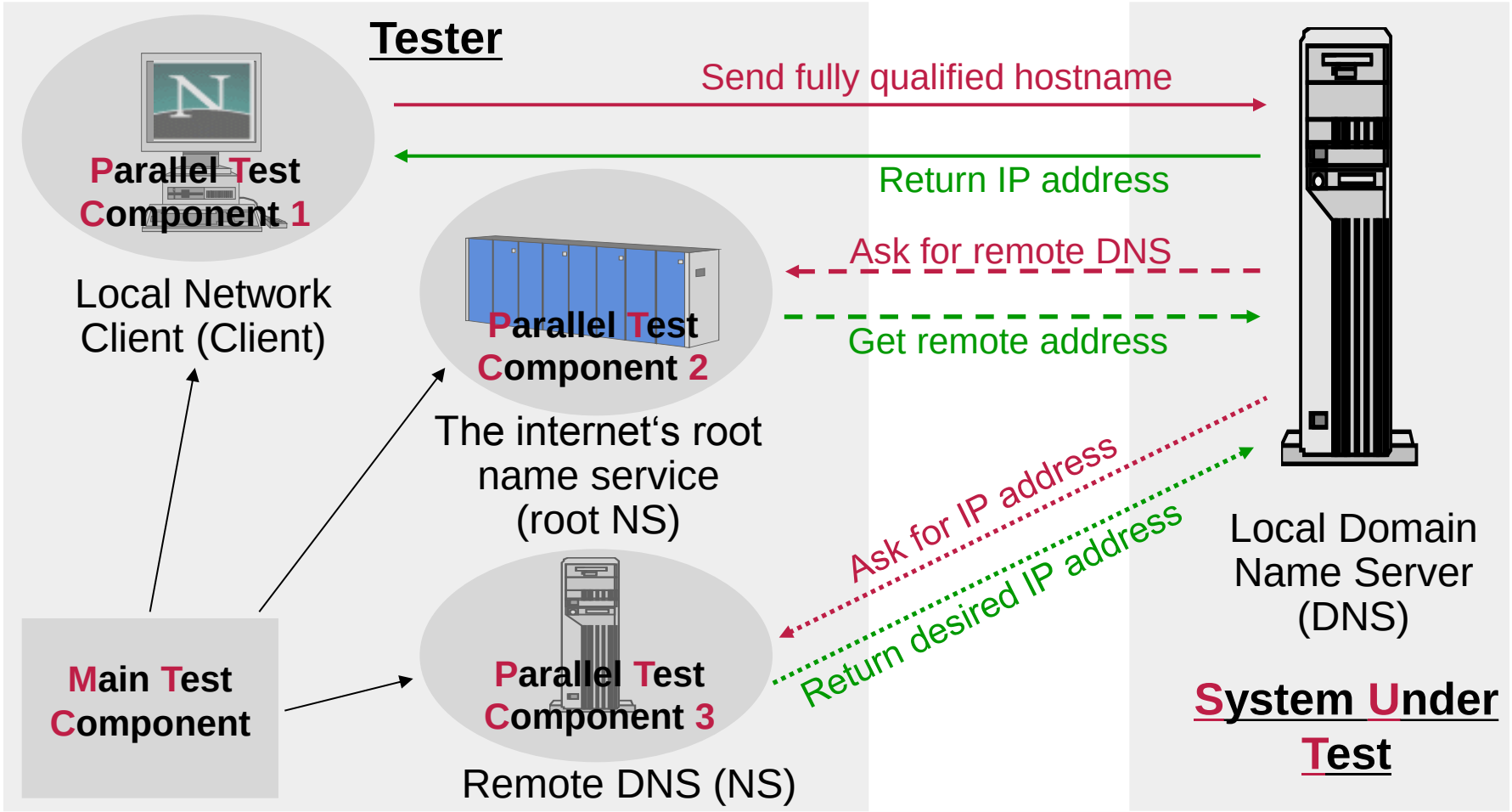
refactor

```
altstep a_RefactoredAltstep()
        runs on DNSTester {
    [] P.receive { // any message
            setverdict(fail);
    }
    [] t.timeout {
            setverdict(inconc);
    }
}
```

becomes

```
var default d := activate(a_RefactoredAltstep());
P.send(validQuery);
t.start;
P.receive(validReply);
setverdict(pass);
```

Non-Local DNS Query (1)



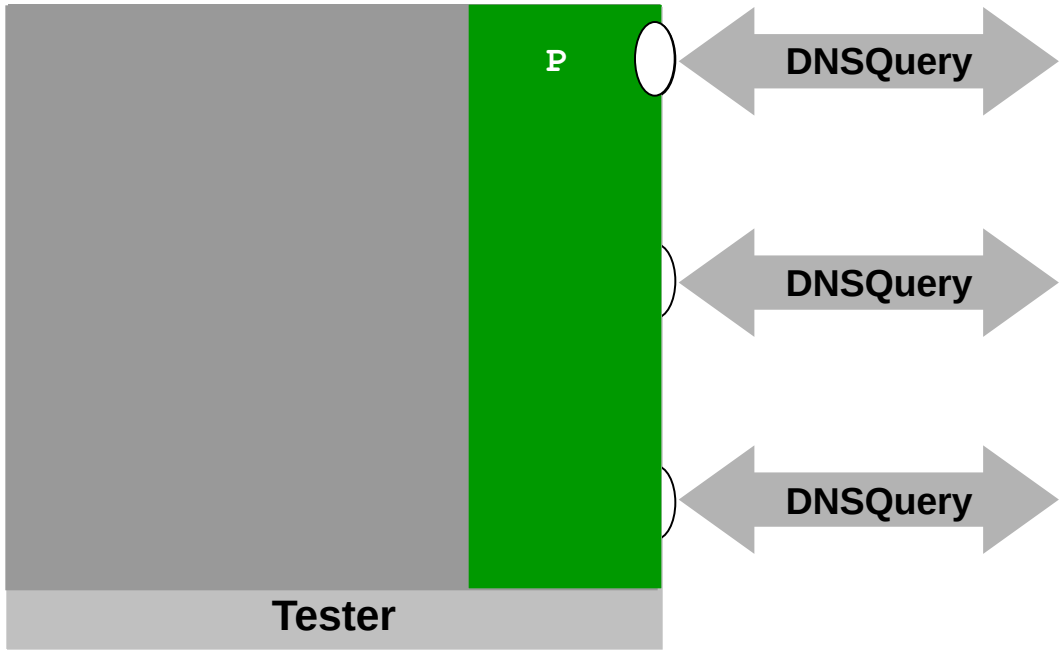
From Simple To Complex Test Scenarios

- Test system needs more interfaces
  - Test System Interface has to be extended
- Test behavior required at additional test interfaces
  - Behavior of Local Network Client already covered in `tc_testcase2`
  - Behavior of RootNS and NS required
- Test case that combines all parts

Parallel Test Components

- Test system interface

```
type component DNSTestSystemInterface {
   port DNSPort CLIENT;
   port DNSPort ROOT;
   port DNSPort NS;
   // a component may have more than one port
}
```



From Test Case to Behavior Function

- Functions can be used to define the behavior of the parallel test components

```
testcase tc_testcase2() runs on DNSTester {
  var default d := activate(a_refactoredAltstep());
  P.send(validQuery);
  t.start;
  P.receive(validReply);
  setverdict(pass);
  stop;
}
```

becomes

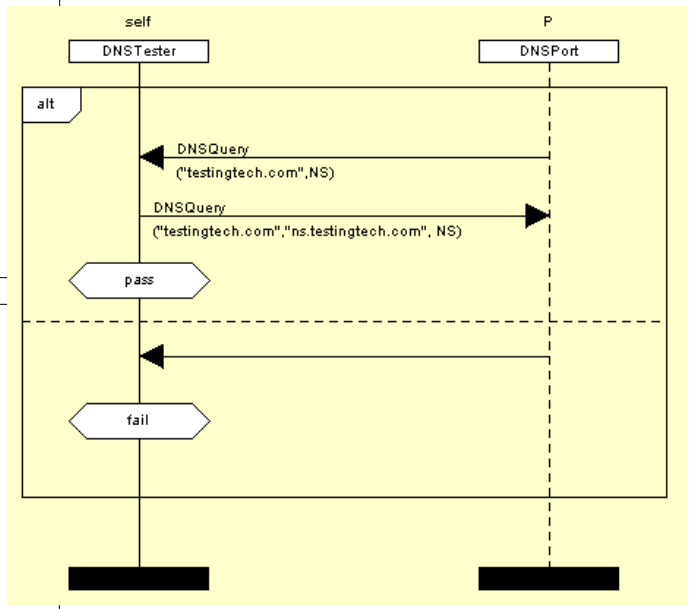
```
function f_clientBehavior() runs on DNSTester {
  var default d := activate(a_refactoredAltstep());
  P.send(validQuery);
  t.start;
  P.receive(validReply);
  setverdict(pass);
  stop;
}
```

Additional Test Behavior

- Simple „react-on-request“ behavior

```
function f_rootBehavior() runs on DNSTester {
   alt {
      [] P.receive(rootQuery) {
          P.send(rootAnswer);
          setverdict(pass);}
      [] P.receive {
          setverdict(fail);}
   }
}
```

```
function f_nSBehavior() runs on DNSTester {
   alt {
      [] P.receive(nsQuery) {
          P.send(nsAnswer);
          setverdict(pass);}
      [] P.receive {
          setverdict(fail);}
   }
}
```

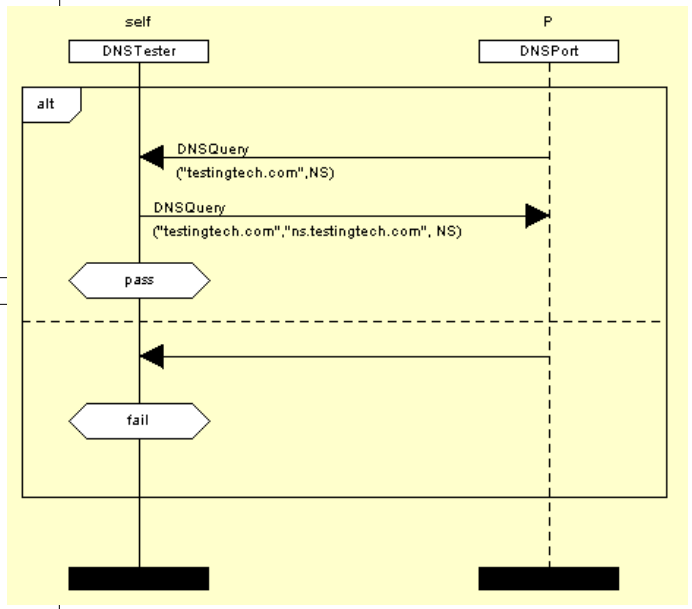


Additional Test Behavior

- Simple „react-on-request“ behavior

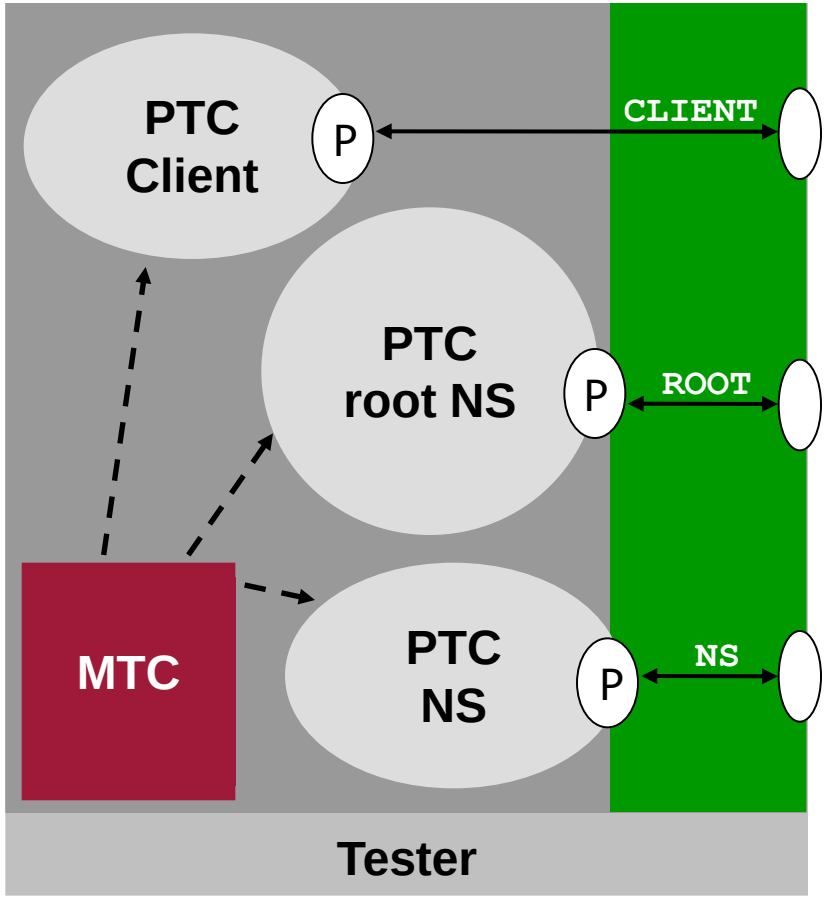
```
function f_rootBehavior() runs on DNSTester {
   alt {
      [] P.receive(rootQuery) {
          P.send(rootAnswer);
          setverdict(pass);}
      [] P.receive {
          setverdict(fail);}
   }
}
```

```
function f_nSBehavior() runs on DNSTester {
   alt {
      [] P.receive(nsQuery) {
          P.send(nsAnswer);
          setverdict(pass);}
      [] P.receive {
          setverdict(fail);}
   }
}
```



Dynamic Configuration

```
testcase tc_testcase3() runs on MTC
       system TestSystemInterface {

  var DNSTester ClientComp, RootComp,
      NSComp;

  ClientComp := DNSTester.create;
  RootComp   := DNSTester.create;
  NSComp     := DNSTester.create;

  map(ClientComp:P, system:CLIENT);
  map(RootComp:P,   system:ROOT);
  map(NSComp:P,     system:NS);

  RootComp.start  (f_rootBehavior());
  NSComp.start    (f_nSBehavior());
  ClientComp.start(f_clientBehavior());

  ClientComp.done;
  // block until ClientComp is done
  stop;
  }
```



- Re-configuration during run time is possible

A Little Bit on Syntax

Testing Technologies

- Case sensitive
  - More than 146 (edition 4.5) keywords, all lower case
  - Identifiers
- Comments
  - Multi line comments: `/* */`
  - Single line comments: `//`
- Statements are terminated with: `;`
- Statement blocks are enclosed in: `{ }`
- Operators
  - Assignment: `:=`
  - Comparison: `==, !=, <=, >=`

Some References

- The language
  - www.ttcn-3.org
  - www.testingtech.com/ttcn3/introduction.php
  - de.wikipedia.org/wiki/TTCN-3
  - en.wikipedia.org/wiki/TCN-3
  - t-ort.etsi.org
- The TTCN-3 Certificate
  - www.german-testing-board.info/en/ttcn3_certificate.shtm
- The Quick Reference Card
  - www.blukaktus.com/card.html
- Some tools
  - www.ttcn-3.org/commercialtools.htm