3rd UCAAT User Conference on Advanced Automated Testing

ETSI World Class Standards

Sophia Antipolis, French Riviera
20-22 October 2015

INTRODUCTION TO TTCN-3

Presented by Theofanis Vassiliou-Gioles

Testing Technologies
A Spirent Company

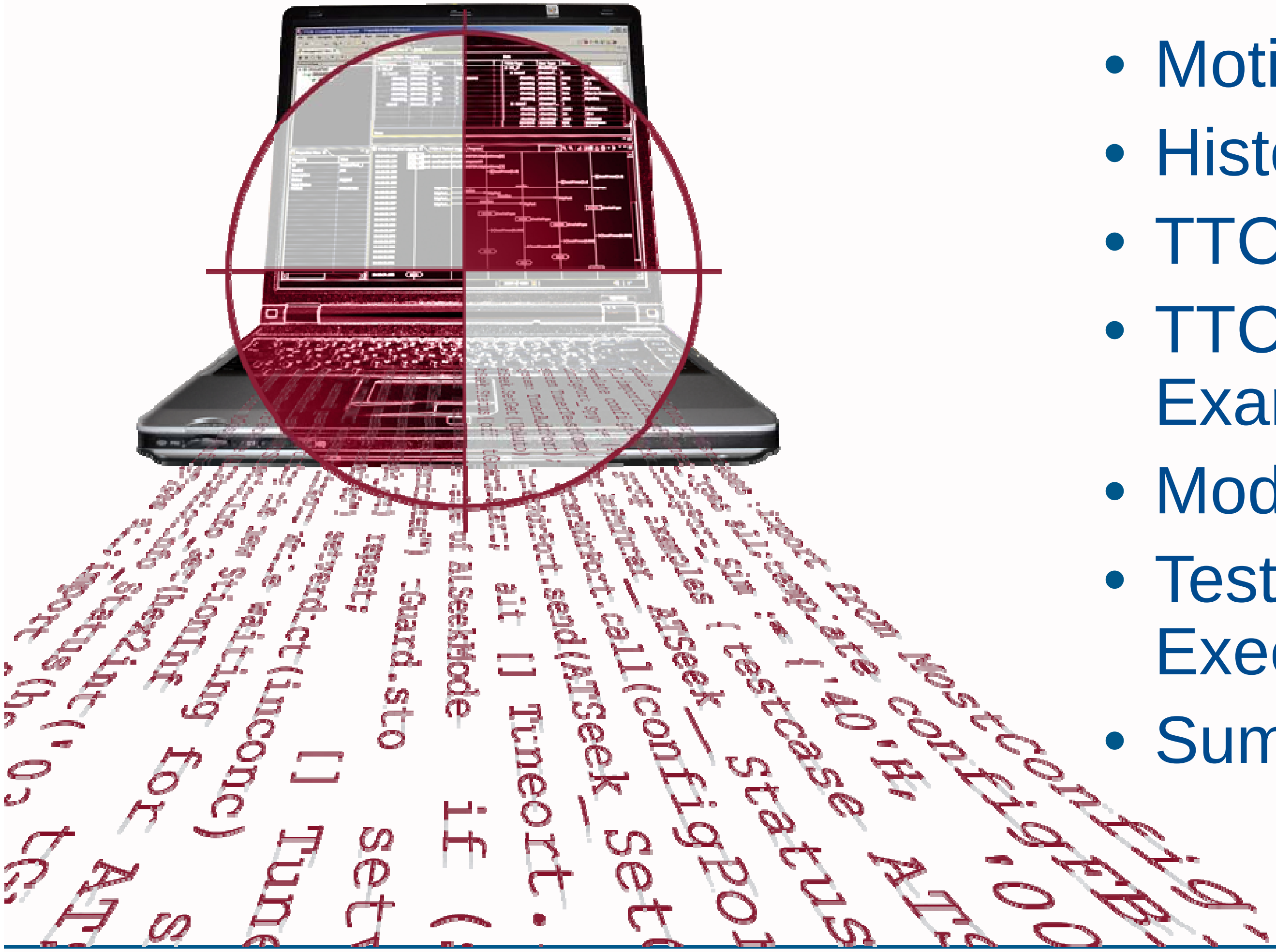
Speaker

Theofanis Vassiliou-Gioles
Founder and CEO of Testing Technologies

vassiliou@testingtech.com
www.testingtech.com

- 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
- History
- TTCN-3 Standards
- TTCN-3 by Example
- Module Definitions
- Test Case Execution
- Summary

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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

Planning Report 02-3

The Economic Impacts of Inadequate Infrastructure for Software Testing

Prepared by:
RTI
for

National Institute of Standards & Technology

Program Office
Strategic Planning and Economic Analysis Group

May 2002

NIST
U.S Department of Commerce
Technology Administration

Study by NIST, May 2002

And Today?

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

Focus on Testing is growing everywhere...

IT Budget

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 -

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

PRIMARY FOCUS

… organizations are industrializing and outsourcing their QA…

41%

of projects are done entirely in-house

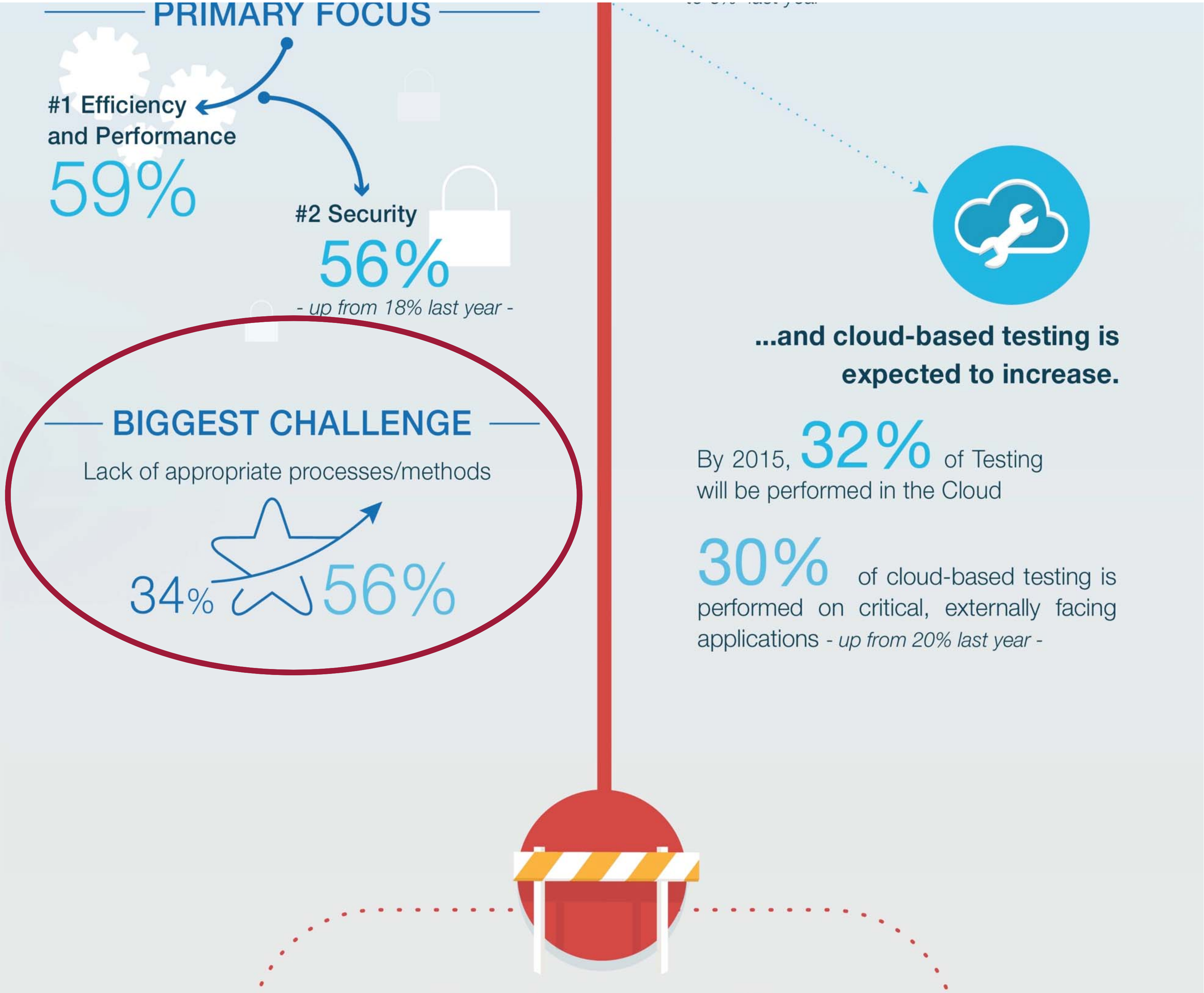
- compared to 51% last year -

26%

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

19%

of businesses have fully operational Test Centers of Excellence - *compared to 6% last year -*



to 9% last year

PRIMARY FOCUS

#1 Efficiency and Performance

59%

#2 Security

56%

- up from 18% last year -

BIGGEST CHALLENGE

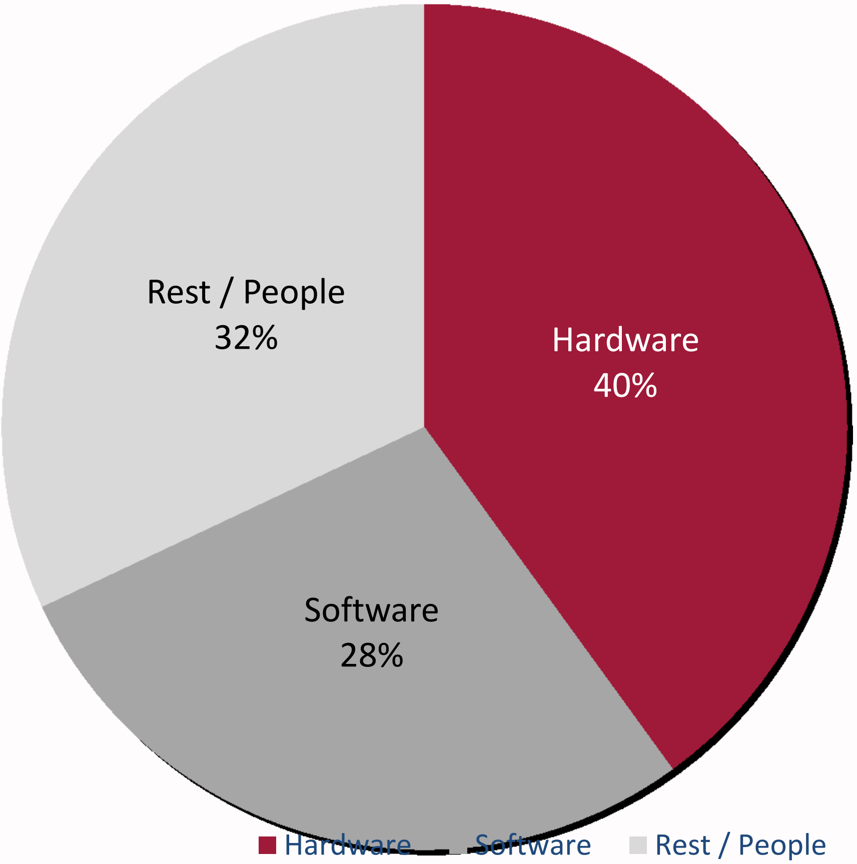
Lack of appropriate processes/methods

...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)



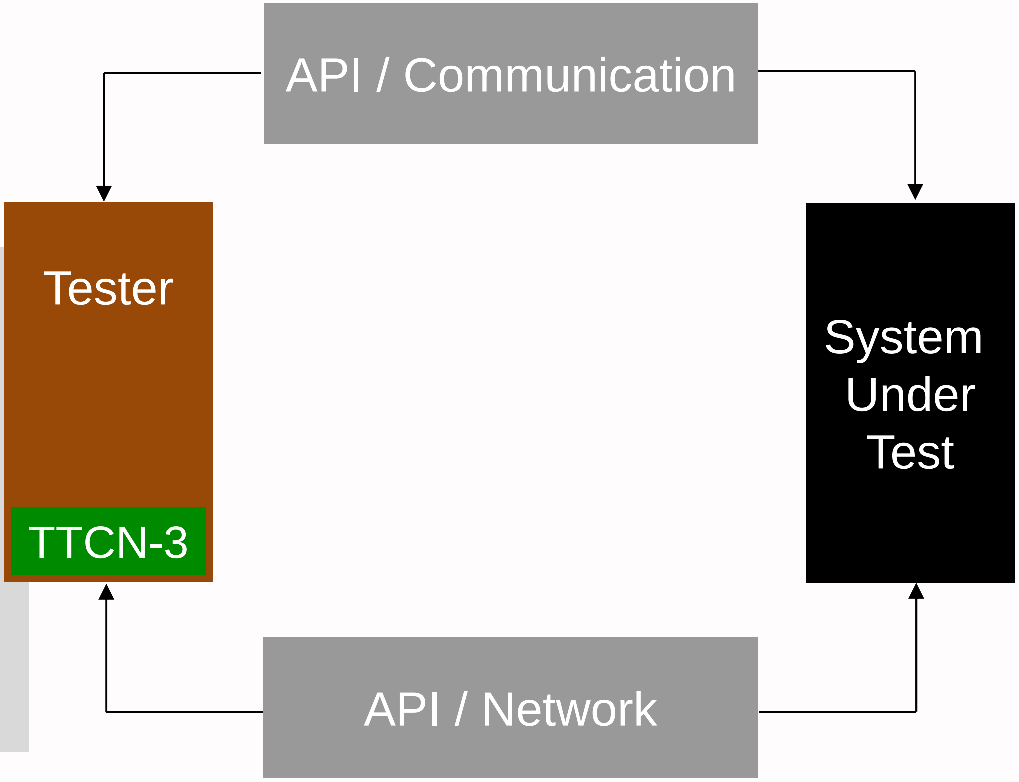
What is TTCN-3?

- Testing and Test Control Notation
- 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!

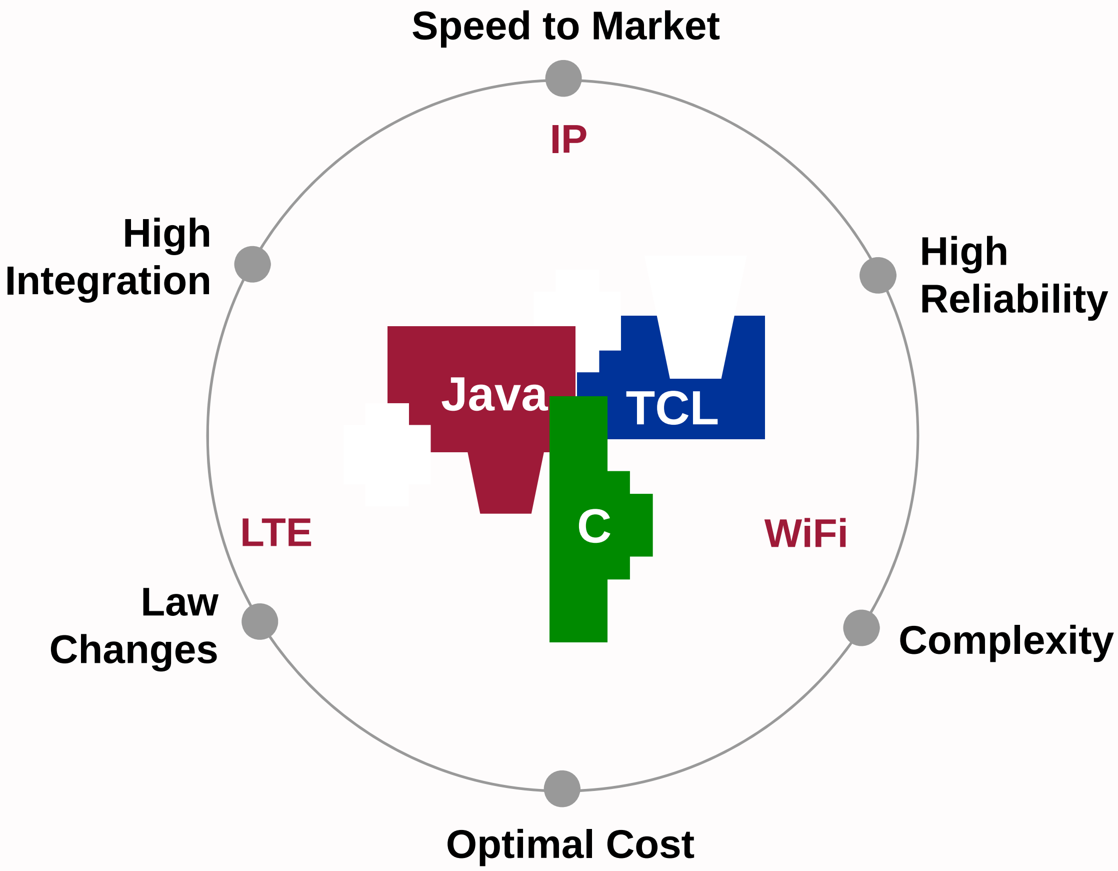
```
testcase tc_Hello_Bob () {
   p.send("How do you do?");
      alt {
         [] p.receive("Fine!"){
             setverdict( pass );}
         [else]{
             setverdict( inconc );}  //Bob asleep!
      }
}
```

TTCN-3 Execution

```
testcase tc_Hello_Bob () {
   p.send("How do you do?");
   alt {
     [] p.receive("Fine!"){
        setverdict( pass ); }
     [else]{
        setverdict( inconc ); }
   }
}
```



Why Using TTCN-3 (1)



Speed to Market

IP

High Integration

High Reliability

Java

TCL

C

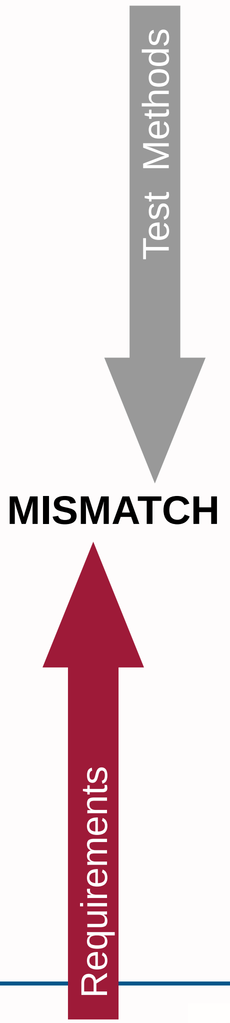
LTE

WiFi

Law Changes

Complexity

Optimal Cost

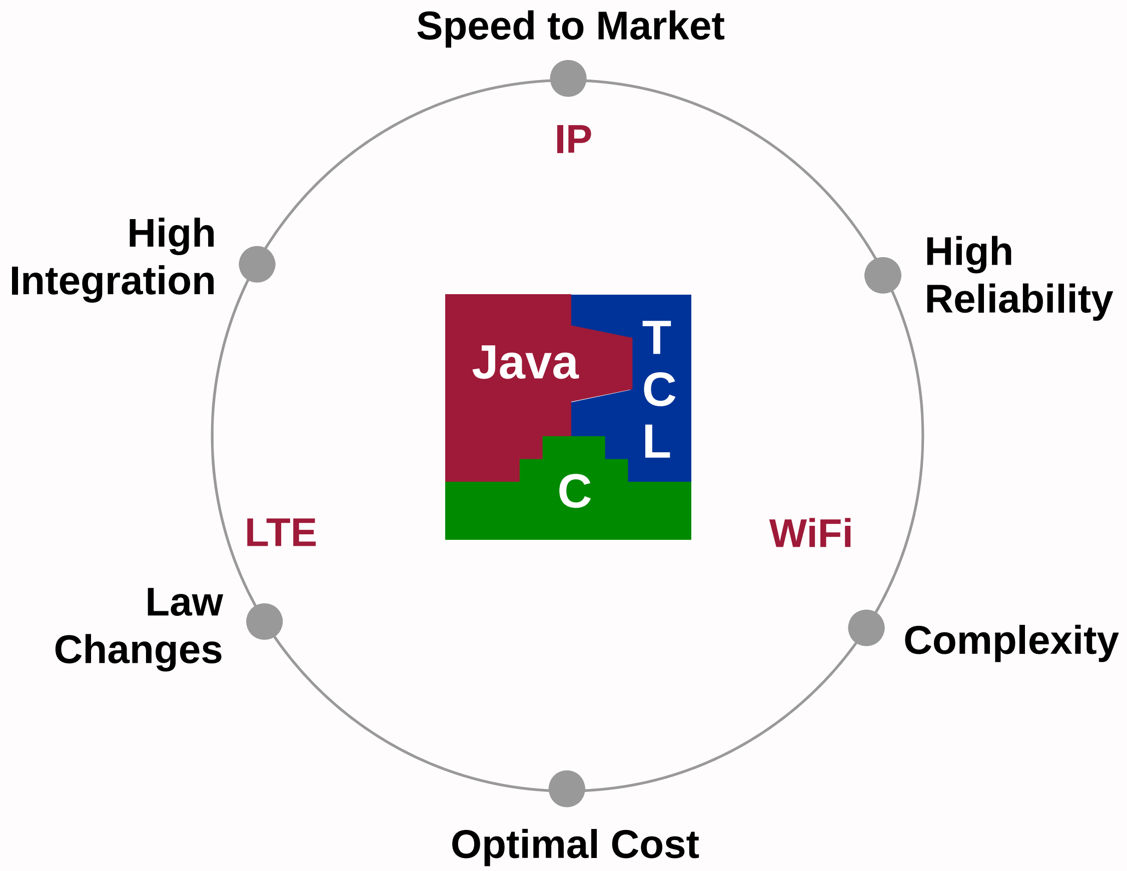


Test Methods

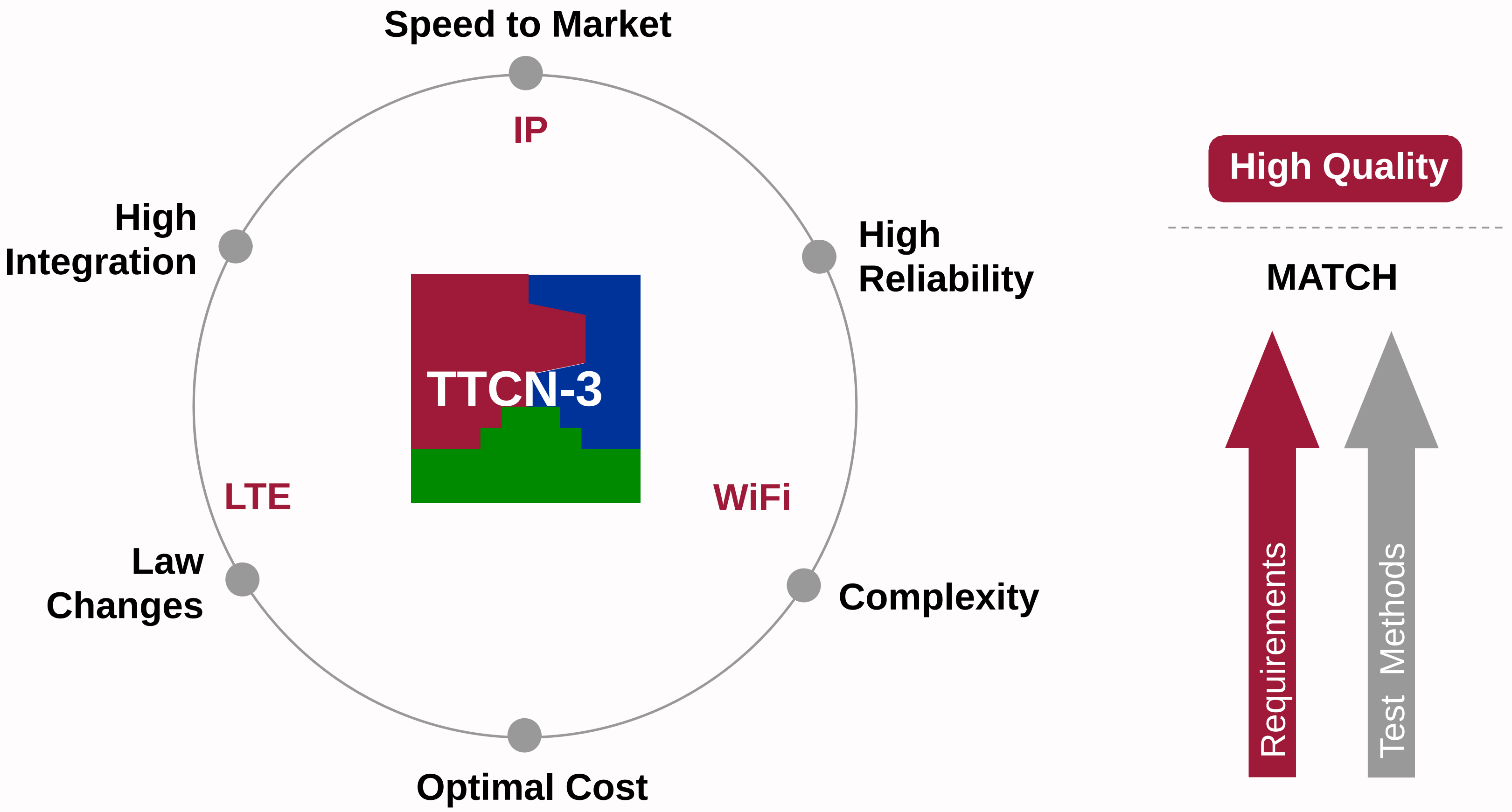
MISMATCH

Requirements

Why Using TTCN-3 (2)



Why Using TTCN-3 (3)



Speed to Market

IP

High Integration

High Reliability

TTCN-3

LTE

WiFi

Law Changes

Complexity

Optimal Cost

High Quality

MATCH

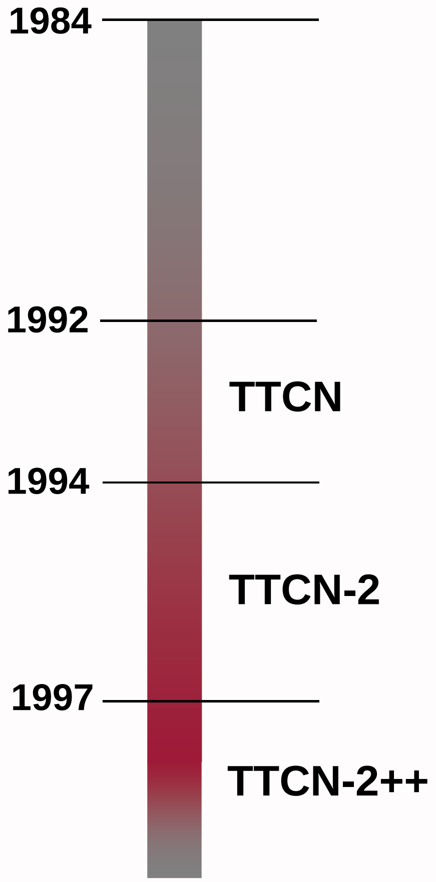
Requirements

Test Methods

INTRODUCTION TO TTCN-3

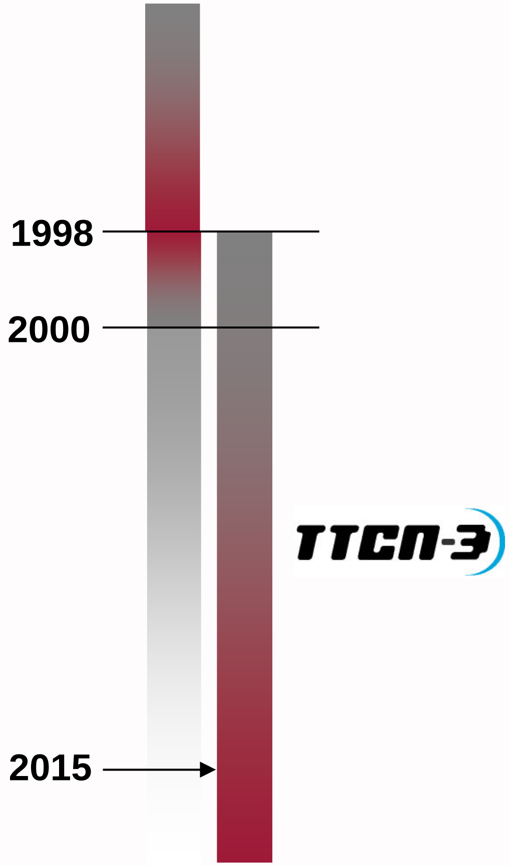
History

History (1)



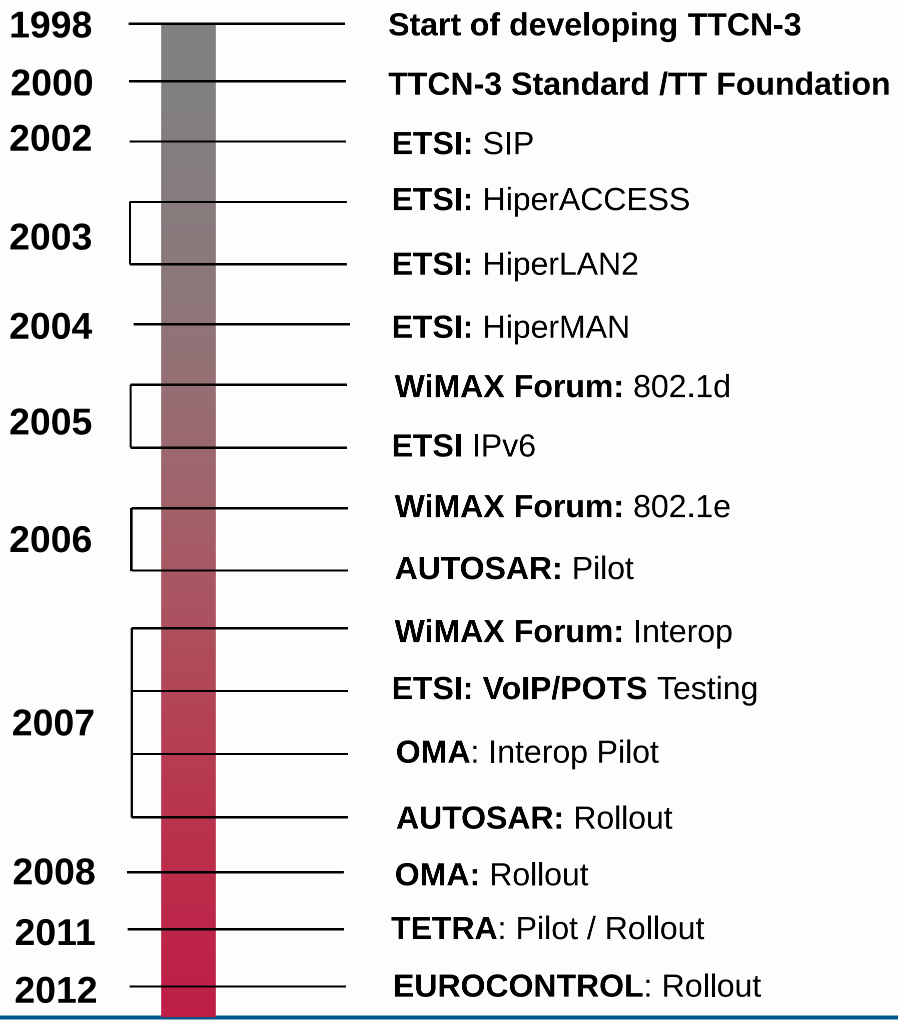
- TTCN (1992)
  - Published as an ISO standard
  - Tree and Tabular Combined Notation
  - Used for protocol testing only
    - GSM, N-ISDN, B-ISDN
- TTCN-2/2++ (1997)
  - Concurrent tests
  - Modularization
  - Manipulate external data
  - Rather for conformance testing
  - Developed by ETSI MTS

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
    - EUROCONTROL

History (3)



1998	**Start of developing TTCN-3**
2000	**TTCN-3 Standard /TT Foundation**
2002	**ETSI:** SIP
2003	**ETSI:** HiperACCESS **ETSI:** HiperLAN2
2004	**ETSI:** HiperMAN
2005	**WiMAX Forum:** 802.1d **ETSI** IPv6
2006	**WiMAX Forum:** 802.1e **AUTOSAR:** Pilot
2007	**WiMAX Forum:** Interop **ETSI: VoIP/POTS** Testing **OMA**: Interop Pilot **AUTOSAR:** Rollout
2008	**OMA:** Rollout
2011	**TETRA**: Pilot / Rollout
2012	**EUROCONTROL**: Rollout

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

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

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INTRODUCTION TO TTCN-3

TTCN-3 Standards

TTCN-3 Standards

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 4.7.1
- Also standardized by the ITU-T as ITU-T Z.16x series

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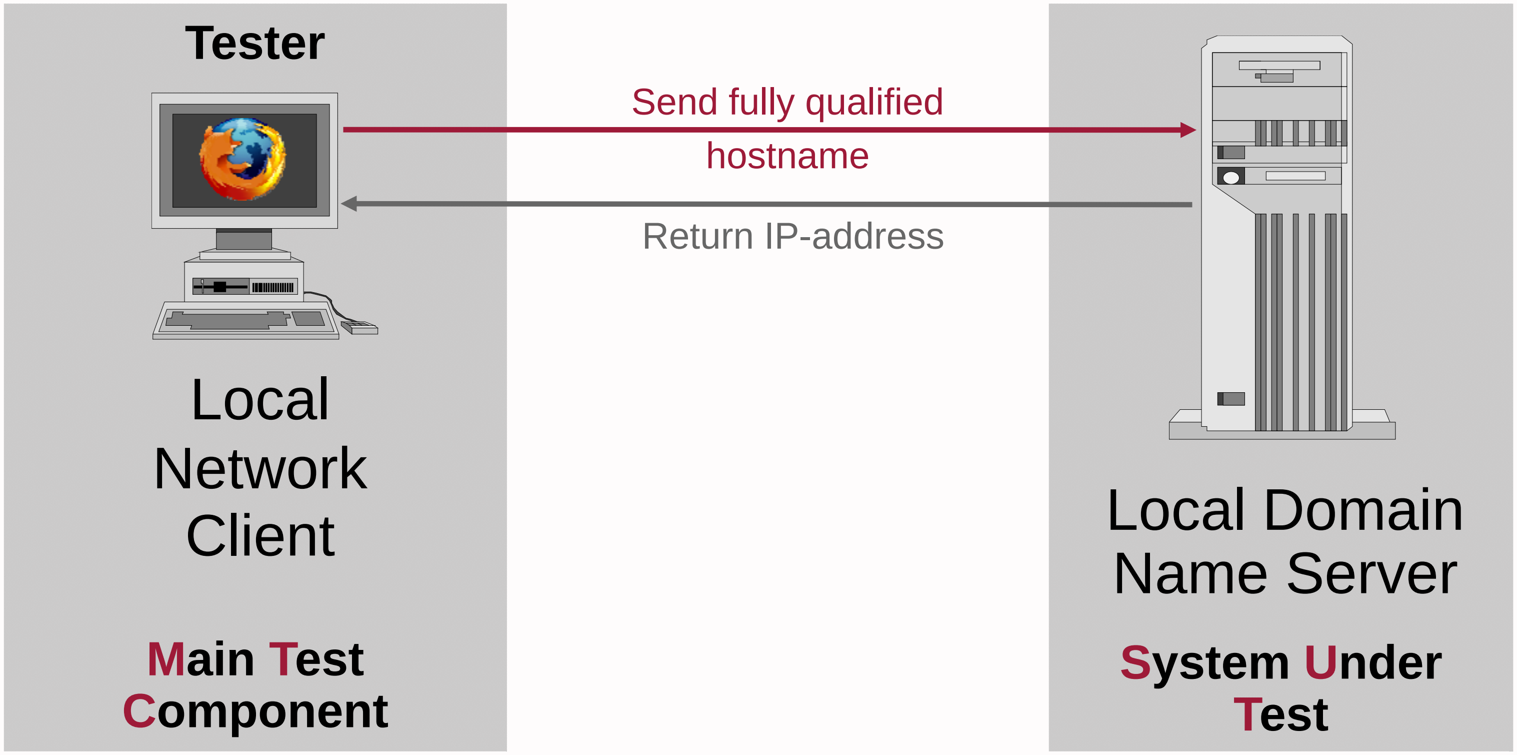
INTRODUCTION TO TTCN-3

TTCN-3 by Example

20-22/10/2015

TTCN-3 By Example



Tester

Send fully qualified hostname

Return IP-address

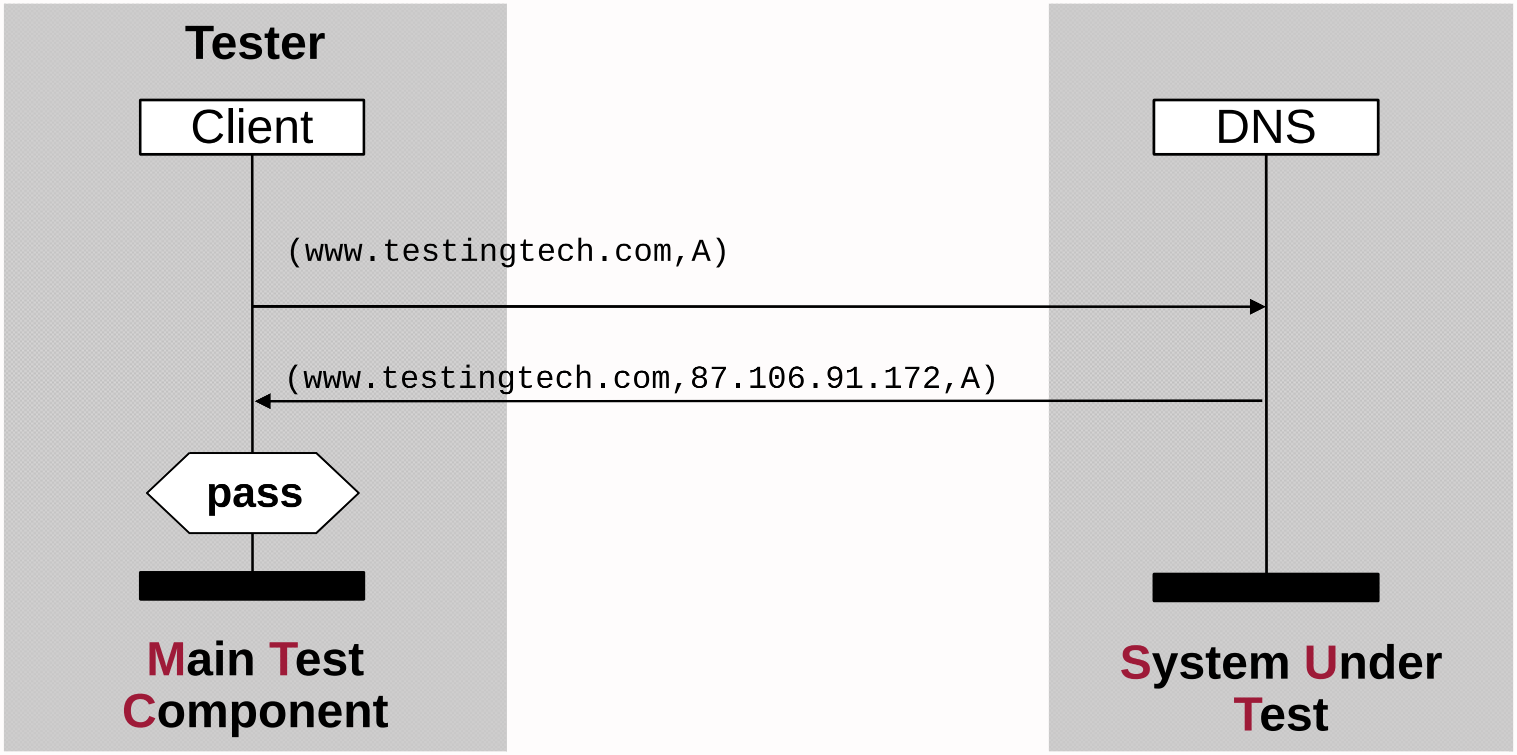
Local Network Client

Main Test Component

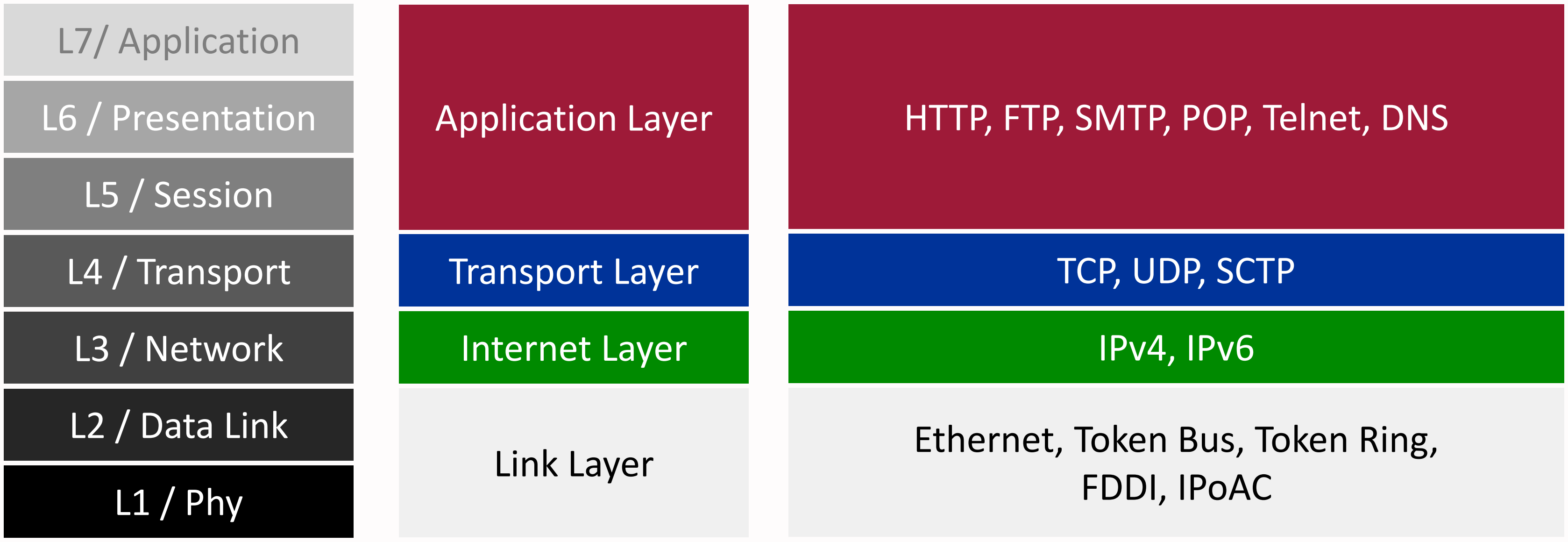
Local Domain Name Server

System Under Test

TTCN-3 By Example



Generic Protocol Architecture(s)



L7/ Application

L6 / Presentation

L5 / Session

L4 / Transport

L3 / Network

L2 / Data Link

L1 / Phy

Application Layer

Transport Layer

Internet Layer

Link Layer

HTTP, FTP, SMTP, POP, Telnet, DNS

TCP, UDP, SCTP

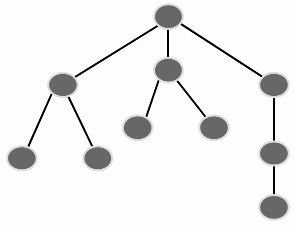
IPv4, IPv6

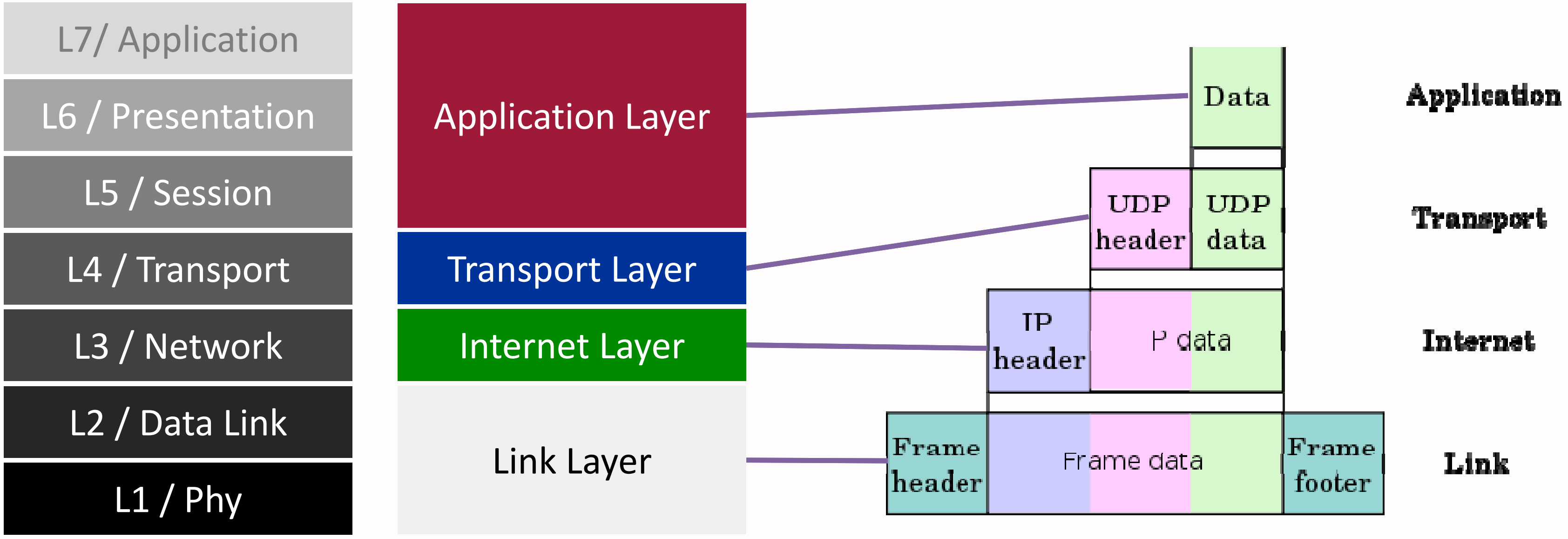
Ethernet, Token Bus, Token Ring, FDDI, IPoAC

OSI View

TCP/IP View

Generic Protocol Architecture(s)





L7/ Application

L6 / Presentation

L5 / Session

L4 / Transport

L3 / Network

L2 / Data Link

L1 / Phy

Application Layer

Transport Layer

Internet Layer

Link Layer

OSI View

TCP/IP View

INTRODUCTION TO TTCN-3

Module Definitions

TTCN-3 Modules

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

```
module DNS {

  // module definitions

  // module control (optional)

}
```

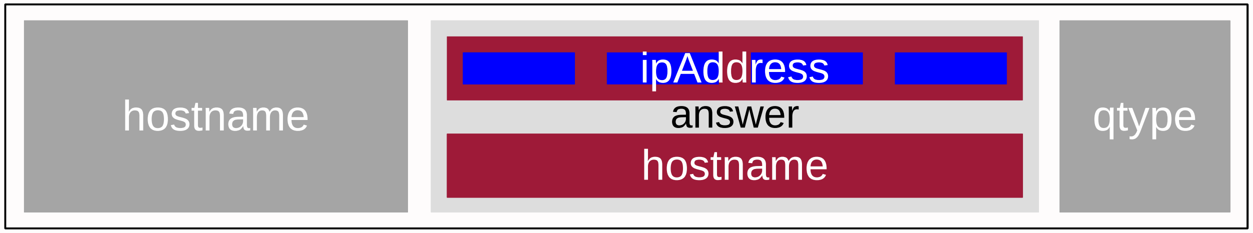
Module Definitions

- 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)

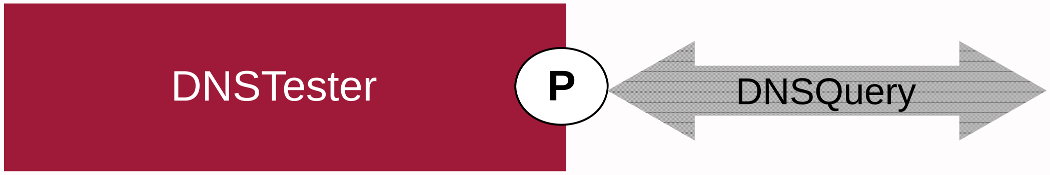
- Module definitions
  - Type definitions
  - **Port definitions**
  - **Component definitions**
  - Templates
  - Test case
- Control part
  - Controls the execution of test cases

Port definitions

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

Component definitions

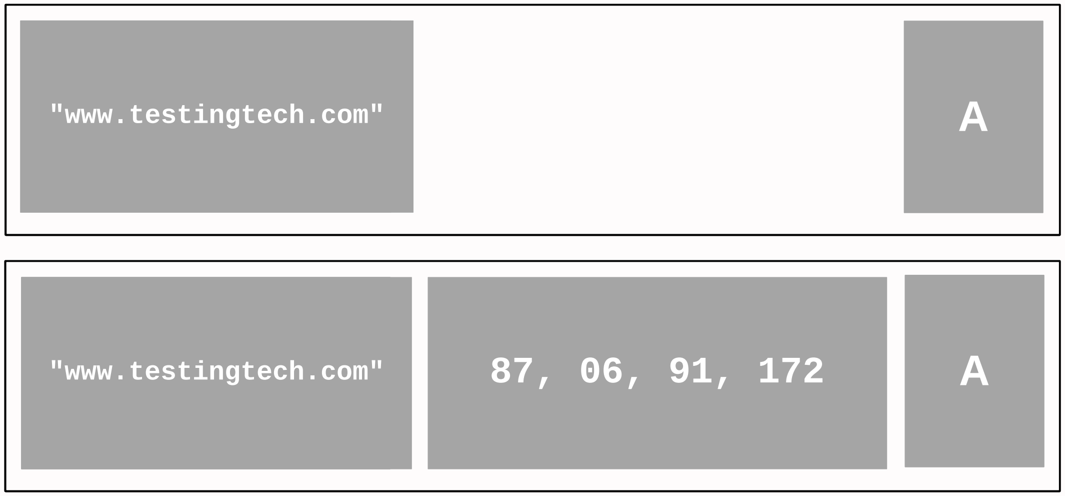
```
type component DNSTester {
   port DNSPort P;
   timer t := 3.0;
   // a component may have more than one port
}
```



Module Definitions (3)

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

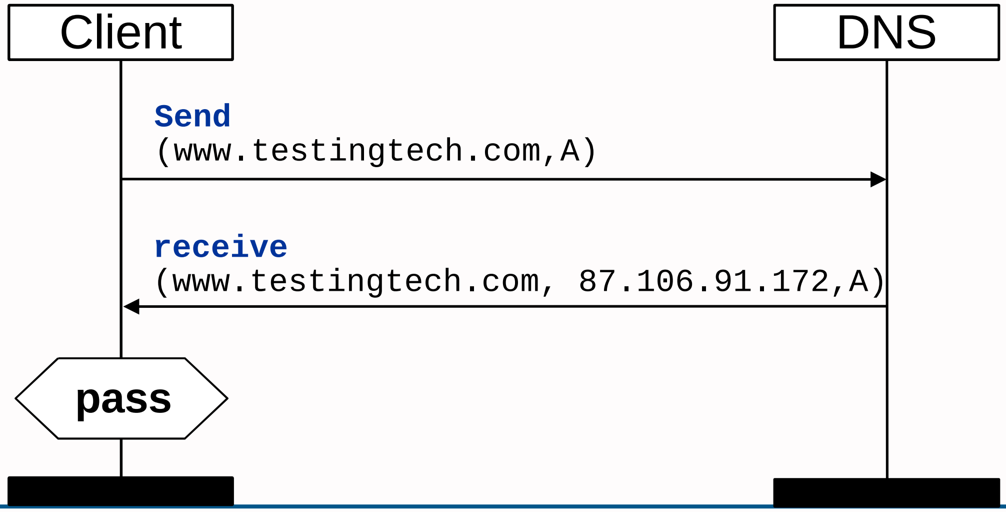
```
template DNSQuery query := {
   hostname := "www.testingtech.com",
   answer   := omit,
   qtype    := A
}
template DNSQuery reply modifies query := {
   answer := { ipAddress :=
               {87,06,91,172} }
}
```



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(query);
  P.receive(reply);
  setverdict(pass);
}

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



Module Definitions (5)

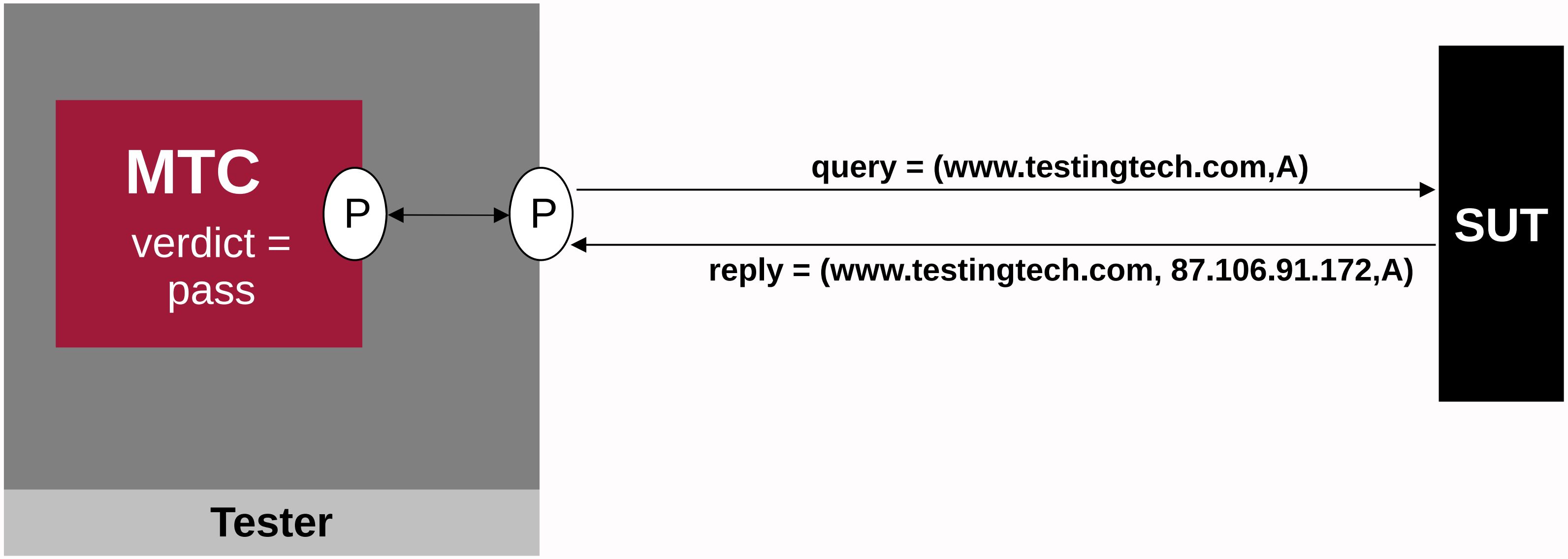
- Module definitions
  - Type definitions
  - Port definitions
  - Component definitions
  - Templates
  - Test case
- Control part
  - **Controls the execution of test cases**

```
control {

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

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

}
```

INTRODUCTION TO TTCN-3

Test Case Execution

Execution of a Test Case

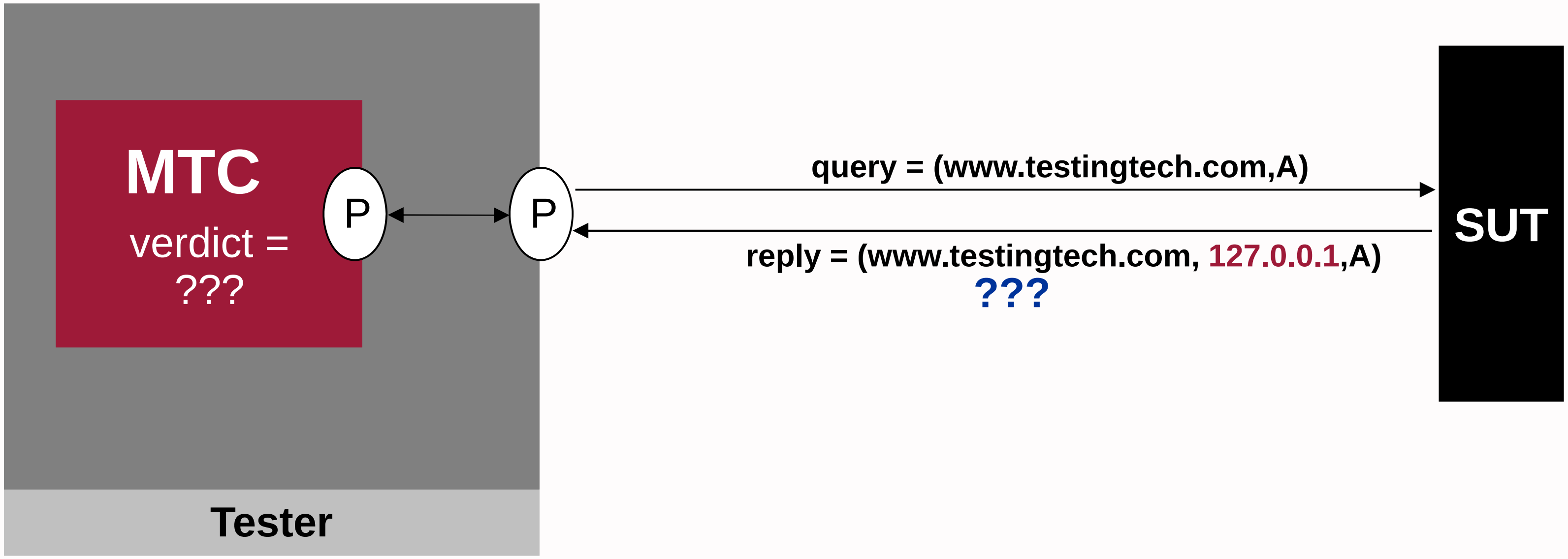

MTC
verdict = pass
P
P
query = (www.testingtech.com,A)
reply = (www.testingtech.com, 87.106.91.172,A)
SUT
Tester

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

}
```

Is this test case definition adequate?

Is this an effective test case definition?

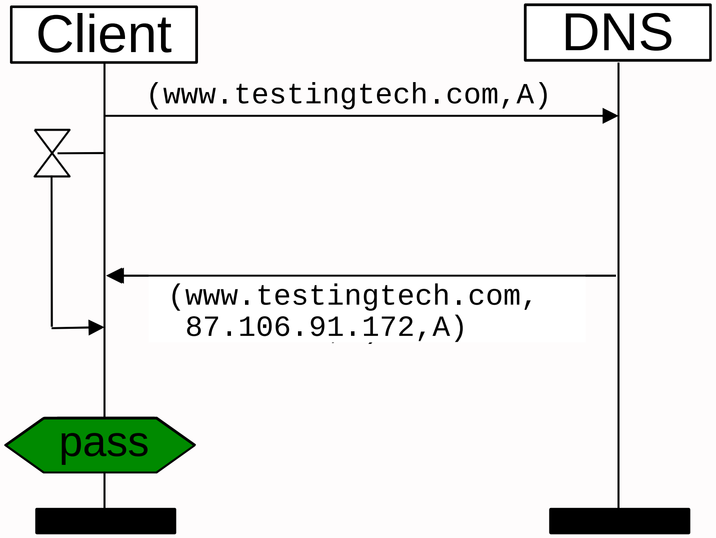
Dealing with Erroneous Behavior (1)


MTC
verdict = ???
P
P
Tester
query = (www.testingtech.com,A)
reply = (www.testingtech.com, 127.0.0.1,A)
???
SUT

- **`P.receive (reply)`** blocks until it receives a message that matches the reply
- If 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

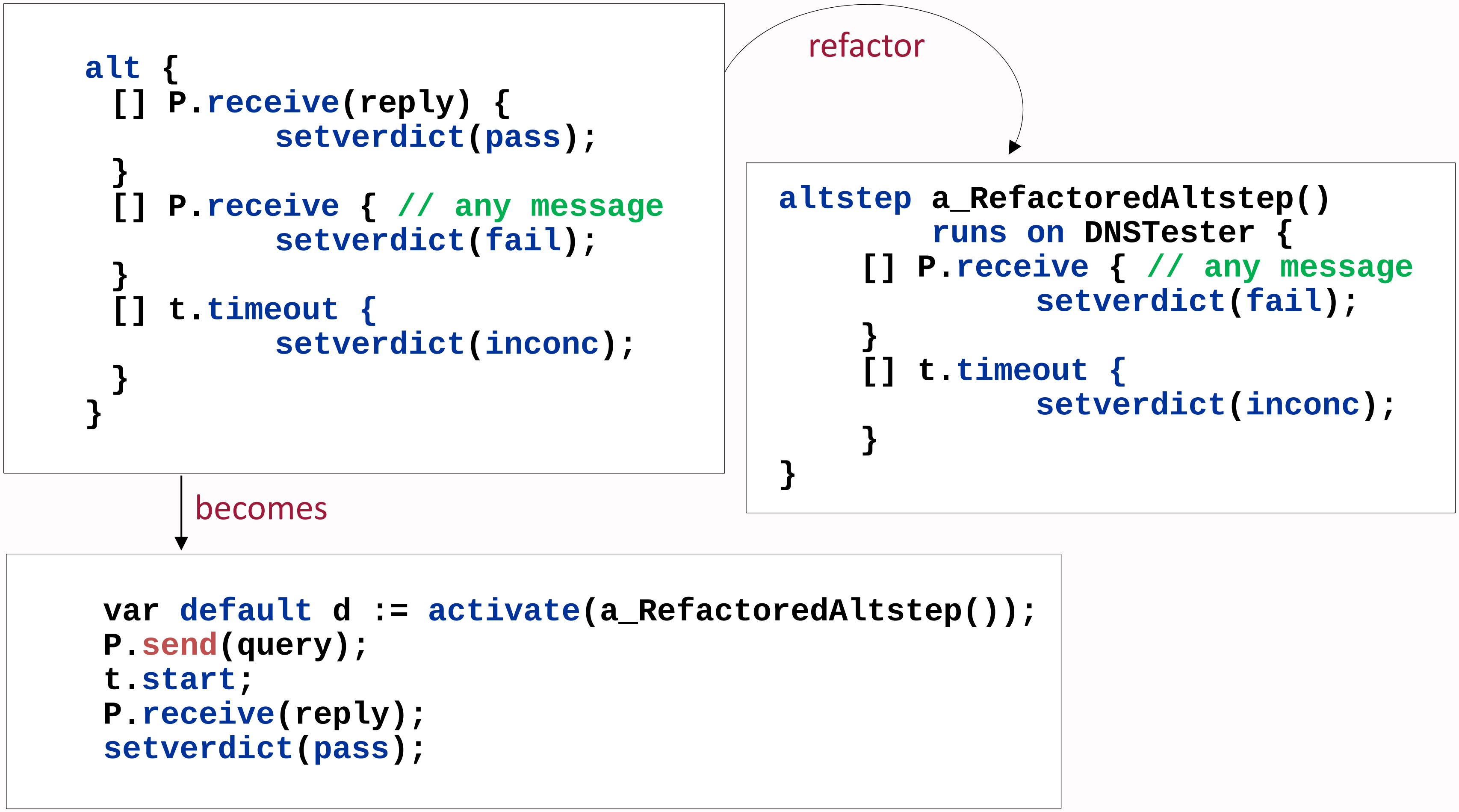
Dealing with Erroneous Behavior (2)

```
testcase tc_testcase2() runs on DNSTester {

P.send(query);

t.start;

alt {
     [] P.receive(reply) {
           setverdict(pass);
     }
     [] P.receive { // any message

           setverdict(fail);
     }
     [] t.timeout {

           setverdict(inconc);
     }
}
stop;
}
```



Is it an effective test case definition now?

Code Reusability – Altsteps and Defaults



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

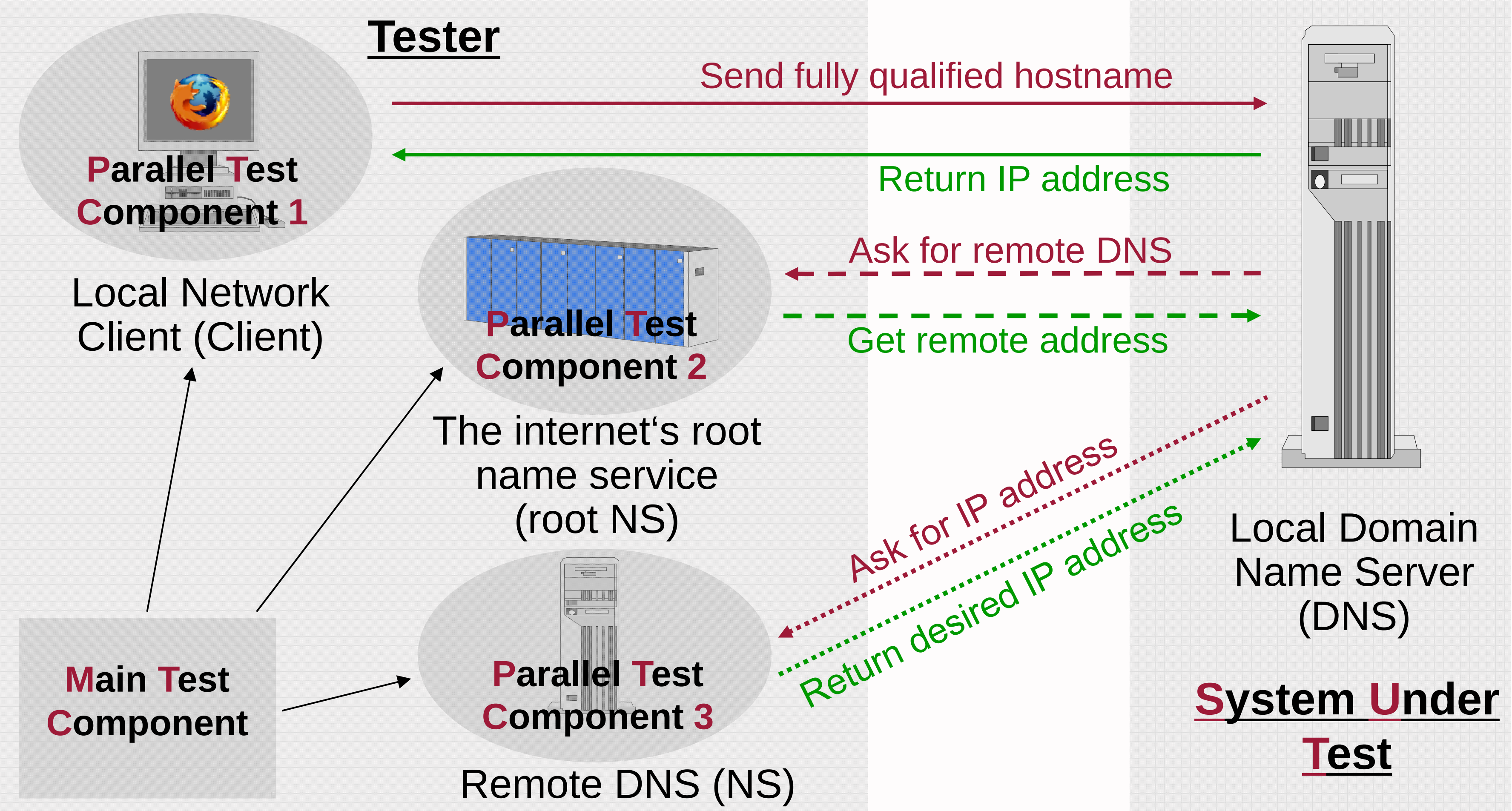
refactor

```
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(query);
t.start;
P.receive(reply);
setverdict(pass);
```

Non-Local DNS Query


Tester
Send fully qualified hostname
Return IP address
Ask for remote DNS
Get remote address
Parallel Test Component 1
Local Network Client (Client)
Parallel Test Component 2
The internet's root name service (root NS)
Ask for IP address
Return desired IP address
Main Test Component
Parallel Test Component 3
Remote DNS (NS)
Local Domain Name Server (DNS)
System Under Test

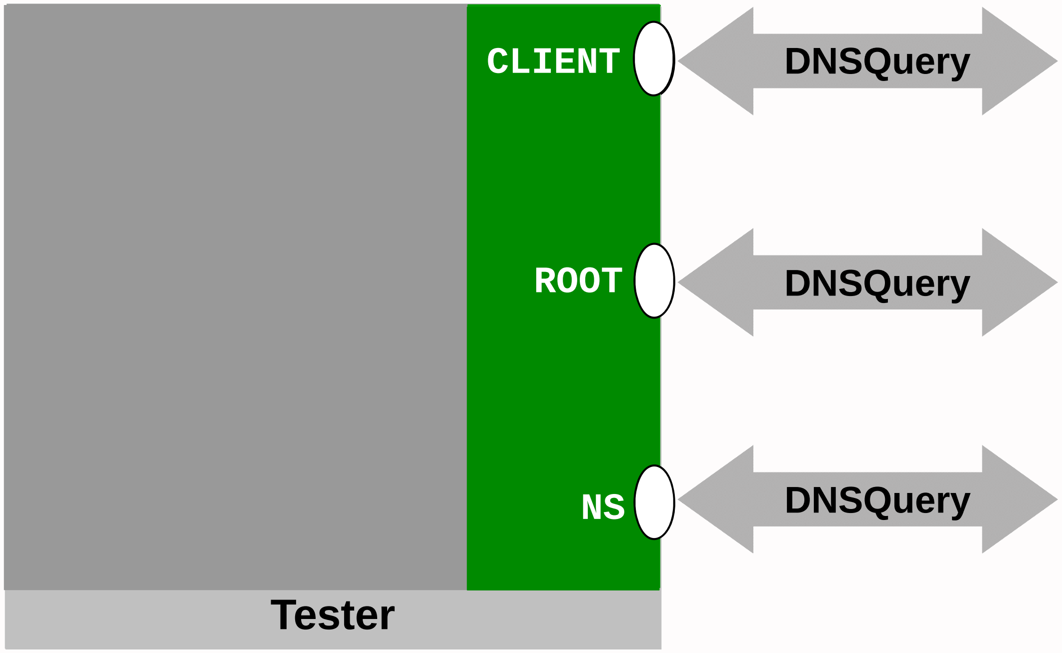
From Simple To Complex Test Scenarios

- 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 TestSystemInterface {
   port DNSPort CLIENT;
   port DNSPort ROOT;
   port DNSPort NS;
}
```



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(query);
  t.start;
  P.receive(answer);
  setverdict(pass);
  stop;
}
```

becomes

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

Additional Test Behavior

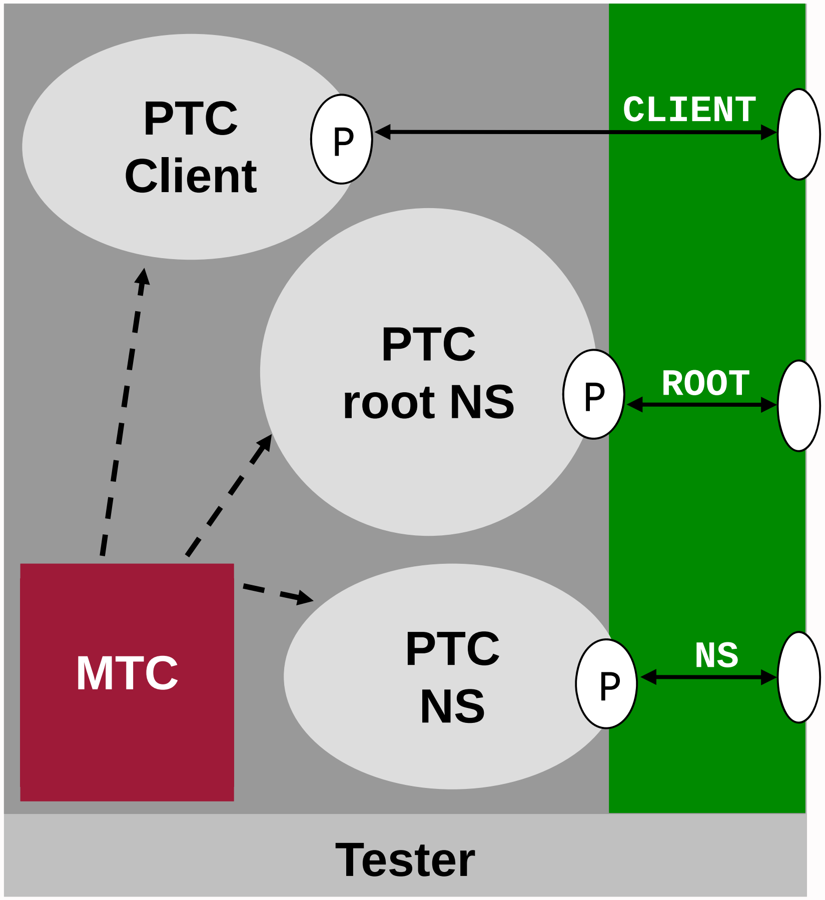
- Simple „react-on-request“ behavior

```
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);}
   }
}
```

Dynamic Configuration

```
testcase testcase3() runs on DNSTester
 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);

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

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



Some Geek Details

- Case sensitive
  - More than 130 (edition 4) keywords, all lower case
  - Identifiers
- Comments
  - Multi line comments: `/* */`
  - Single line comments: `//`
- Statements are terminated with: `;`
- Statement blocks are enclosed in: `{ }`
- Operators
  - Assignment: `:=`
  - Comparison: `!=, ==, <=, >=`

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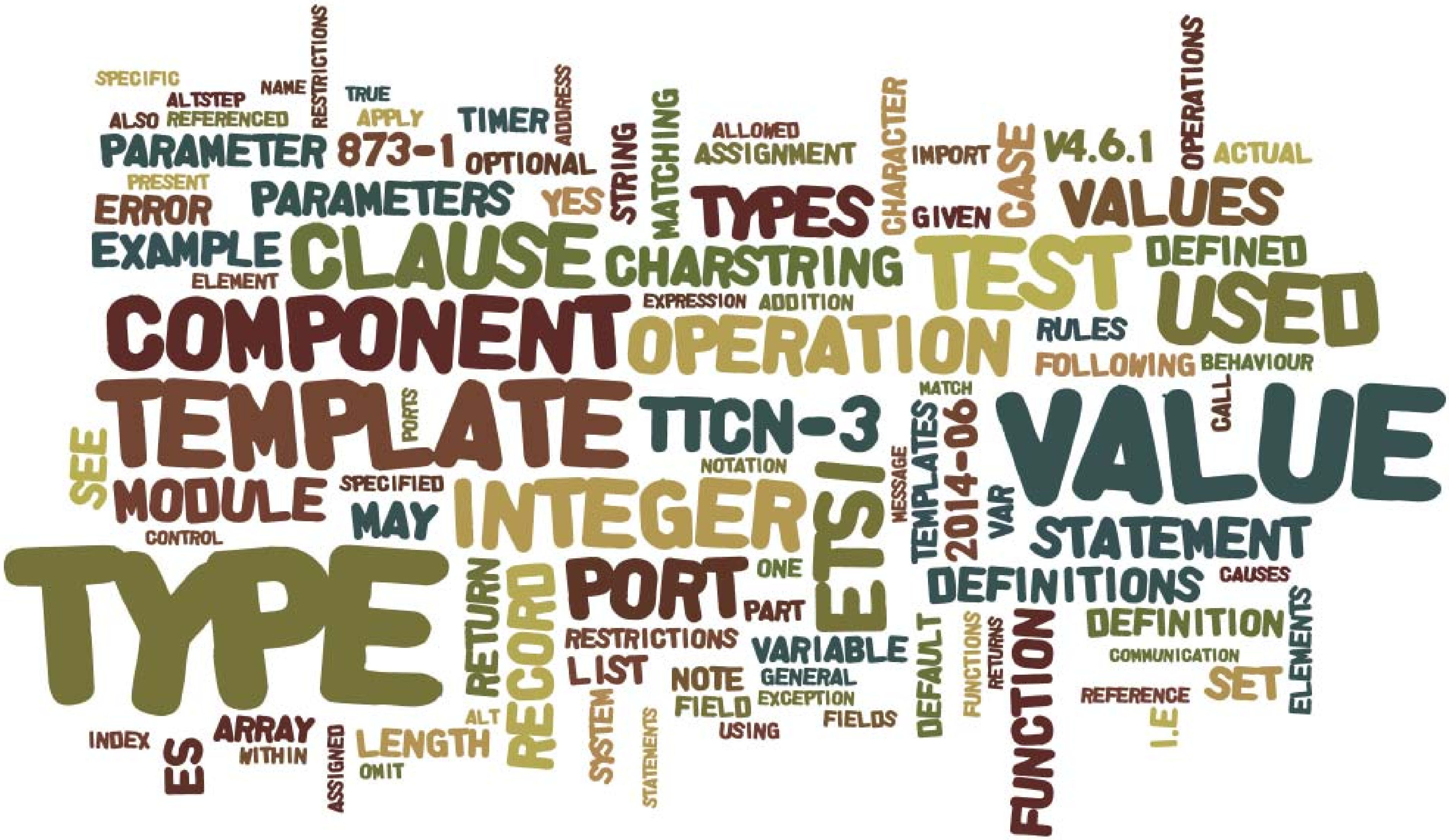
INTRODUCTION TO TTCN-3

Summary

TTCN-3 Summary



Why Should I Use TTCN-3?

- To have
  - an industrial grade
  - multi-os and
  - multi-technology
- middleware testing platform
  - to build your methods
  - to create supporting tools and tool chains
  - to be able to educate people
- in order to
  - cover the whole software development process

FAQs

- After learning about TTCN-3, what do I have to do to make it really work?
- Is TTCN-3 only for [conformance|protocol] testing?
- Can I use TTCN-3 to test embedded systems?
- Why should I use TTCN-3 instead of my [java, python, perl, …] tool?
- How complicated is it to learn TTCN-3?
- Does anybody care if I know TTCN-3?
- Where can I find more information on TTCN-3?
- What is the relation between TTCN-3 and [insert here your favorite] [
- What is the difference to my selenium test tool?
- What is the biggest TTCN-3 installation in a company?
- What is the smallest TTCN-3 installation in a company?
- I have to do GUI testing. Can you please show me how I could use TTCN-3 to accomplish this?
- And what have you learned?

Some References

- The language
  - www.ttcn-3.org
  - www.testingtech.com/ttcn3/introduction.php
  - de.wikipedia.org/wiki/TTCN-3
  - en.wikipedia.org/wiki/TTCN-3
  - t-ort.etsi.org
- TTCN-3 Training
  - www.ttcn-3.org/index.php/learn/tutorials
  - testingtech.com/services/ttcn3_training.php
- The Quick Reference Card
  - www.blukaktus.com/card.html
- Some tools
  - www.ttcn-3.org/index.php/tools/tools-com