

Fully Automated Network Testing

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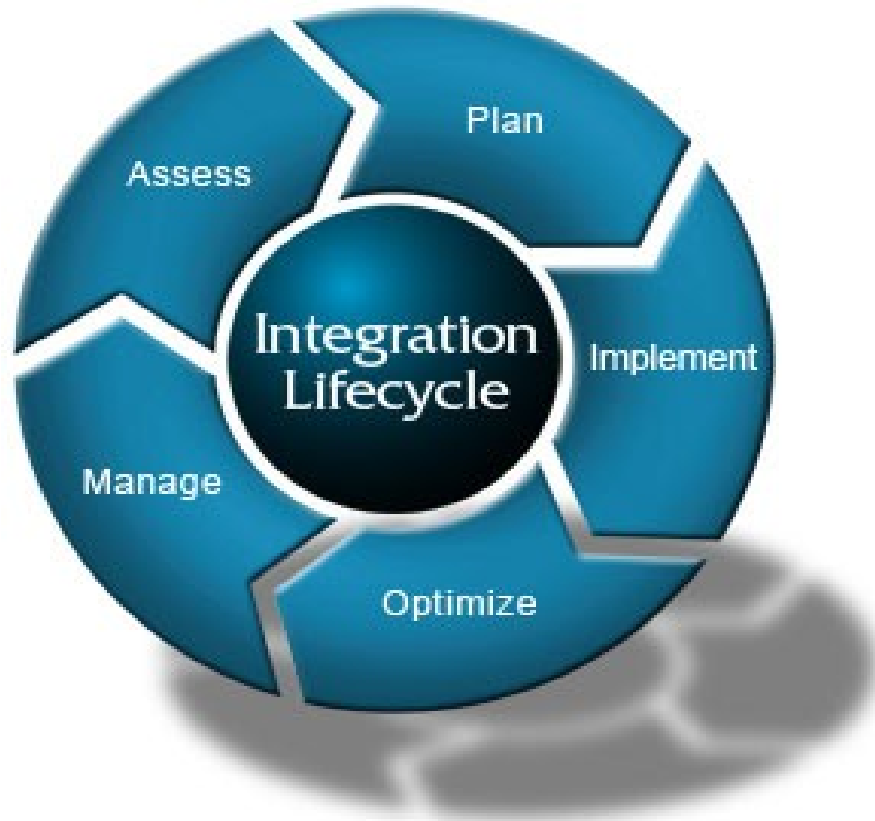
*Qualità dei Servizi di Rete
a.a. 2009/2010*

Outline

- Introduction
- State of the Art
 - Common practice
 - Limitations
- Fully Automated Network Testing
 - Goals
 - Main idea
 - Some details
 - The vision
- Projects

Computer Networks Lifecycle

Assume the perspective of an enterprise network administrator

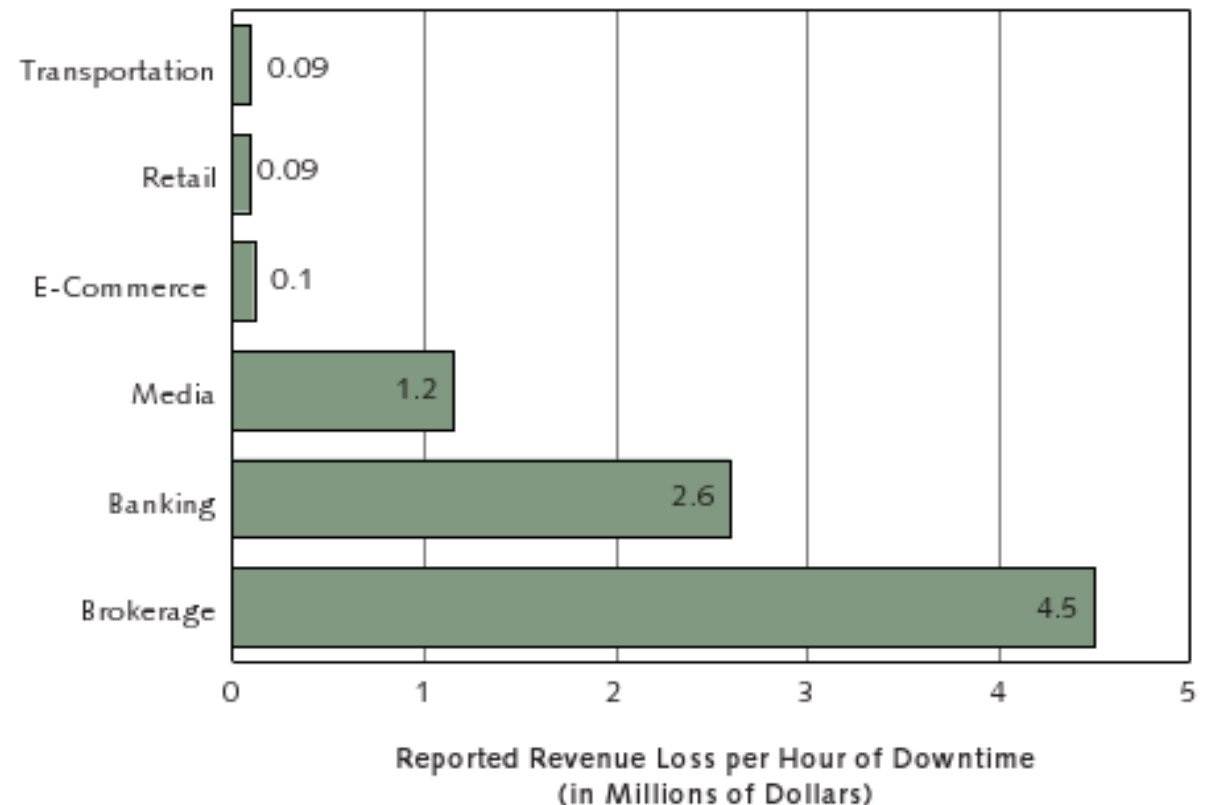


- Networking is not only design a new network starting from scratch...
- Rather the most common case is to deal with (at least partially) deployed networks
- Network management and integration are very important activities

Network Management

Management is an important (long) phase in the network lifecycle

- Recent surveys [Kerravala04] report that 80% of the IT budget is spent for management
- This is motivated by the high costs of network downtime

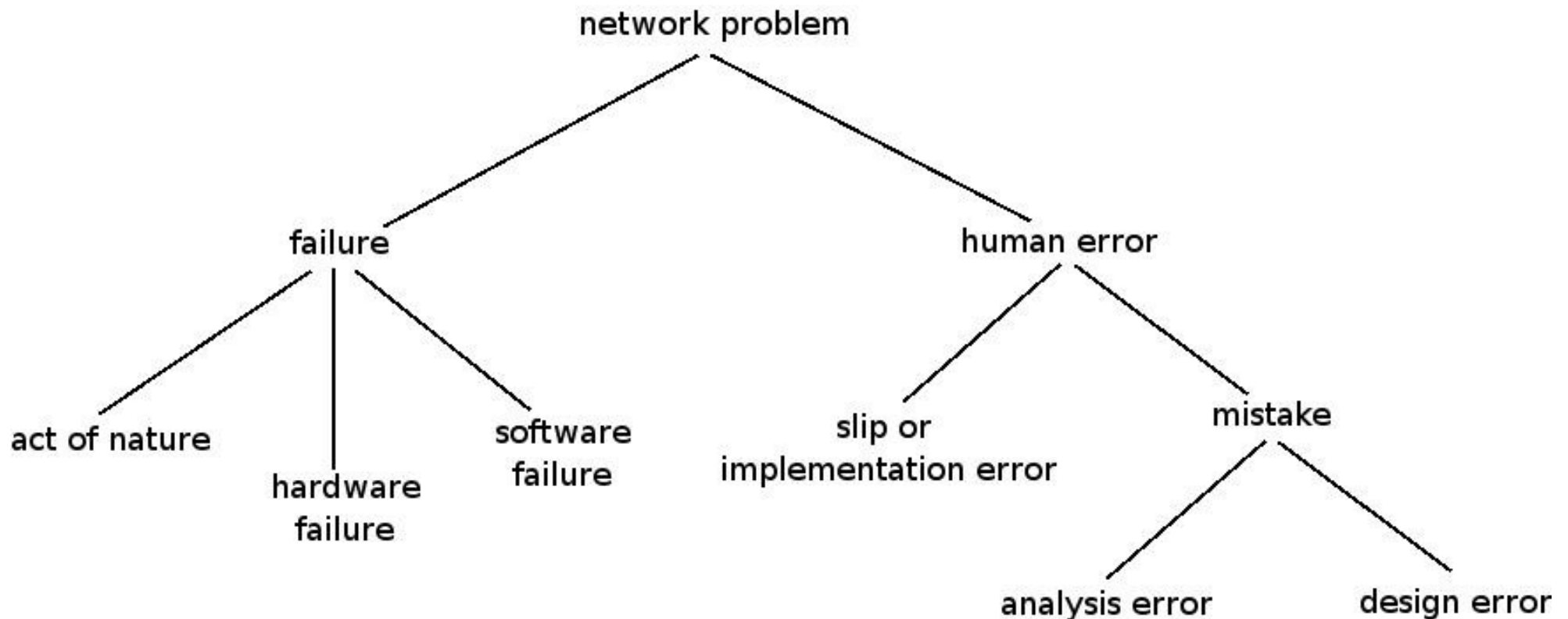


Management Encompass Testing

- The main goal of network management is to prevent, detect and recover from network problems (errors, faults, disruptions, ...)
 - This implies that *network testing is necessary*
- Network problems are caused by different factors and can not be entirely avoided: faults are unpredictable and errors can be widespread and latent
 - This makes *network testing challenging*

Network Problems

- We can define a problem as a misbehavior of the network with respect to requirements
 - > A network is correct if satisfies all its requirements



Different Strategies

- Verification: formal verification of the correctness of a network
 - > Theorem proving and model checking based approaches
 - > Not possible for all the requirements
- Testing: the activity of checking a network for its correct behavior
 - > Check that the network shows specific properties or desirable qualities
- Troubleshooting: the activity of understanding the cause of an observable misbehavior
 - > Also called root cause analysis or diagnosis
- Recovery: the ability of restoring a correct behavior

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Current Testing Practice

Most known methodologies prescribe to

- Follow **best practices** for design and implementation
- Verify most relevant design choices using **testbeds**
- Periodically check correct operation of links, devices and machines through **monitoring** tools
- **Troubleshoot** when a problem arises

Current practice typically attains to these guidelines.

Best Practices

- Best practices aim at avoiding that problems arise
 - The adoption of best practices can be categorized as a proactive approach
- However, not all the network problems can be anticipated or prevented by design
 - A *strong on-the-field strategy is needed* to complement the adoption of best practices

Testbeds

Testbeds are **protected environment** used to safely perform tests, normally before deployment

- The use of testbeds aim at emulating production networks, in a smaller and safer environment, so that actual ***user traffic can not be affected***
- Tests are typically designed and executed by network administrators, which can exploit several testing tools

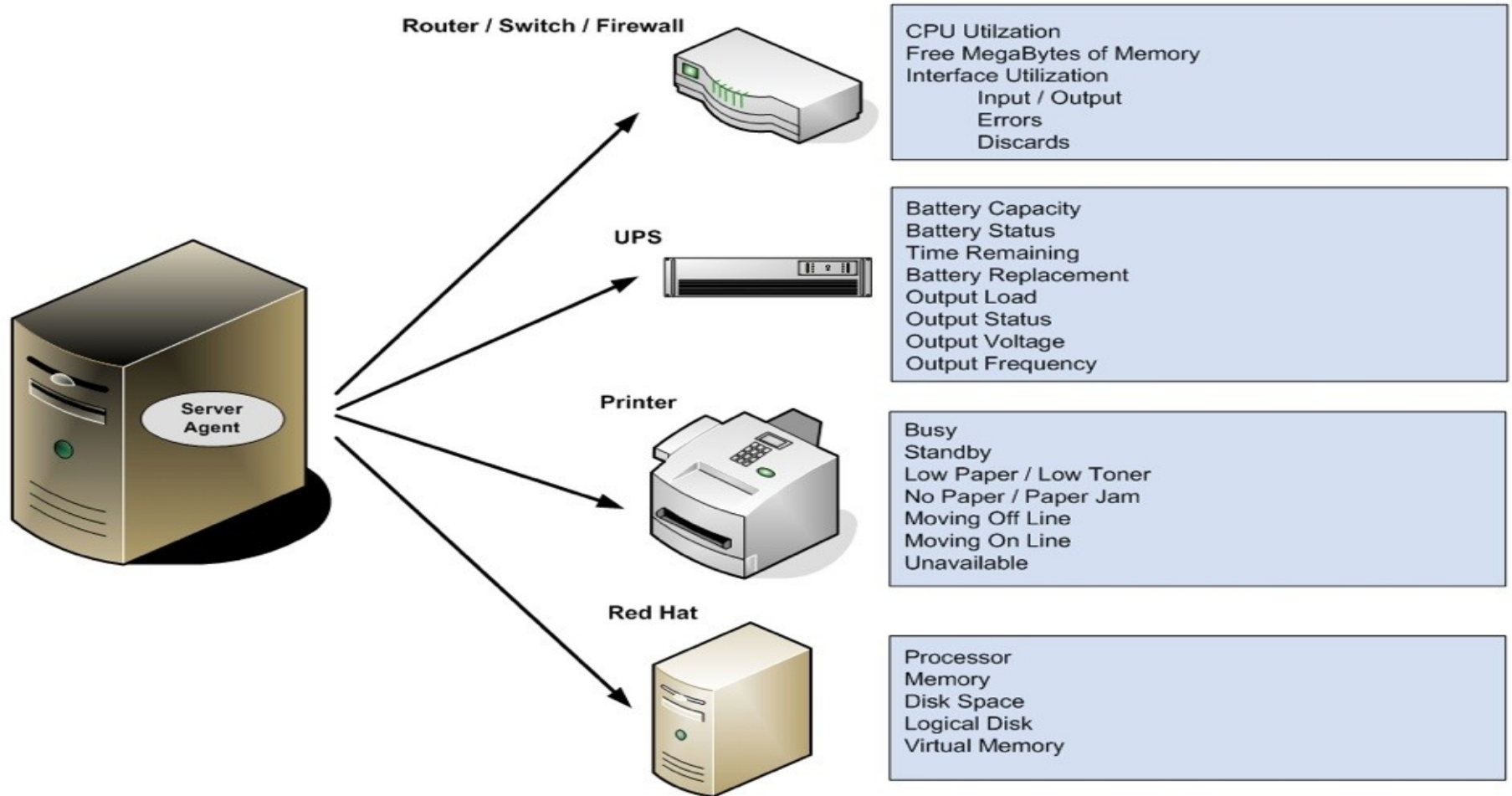


Where Testbeds Fall Short?

- **Costs**: Setting up a testbed can be very expensive
- **Documentation**: As a side effect, high costs force an extensive use of written documentation (*test plan*)
- **Reliability**: Testbeds should behave as the corresponding production networks (under test) but this is difficult to enforce
- **Alignment**: Testbeds should be maintained aligned to the corresponding production networks if they are exploited for testing during the management phase

Monitoring

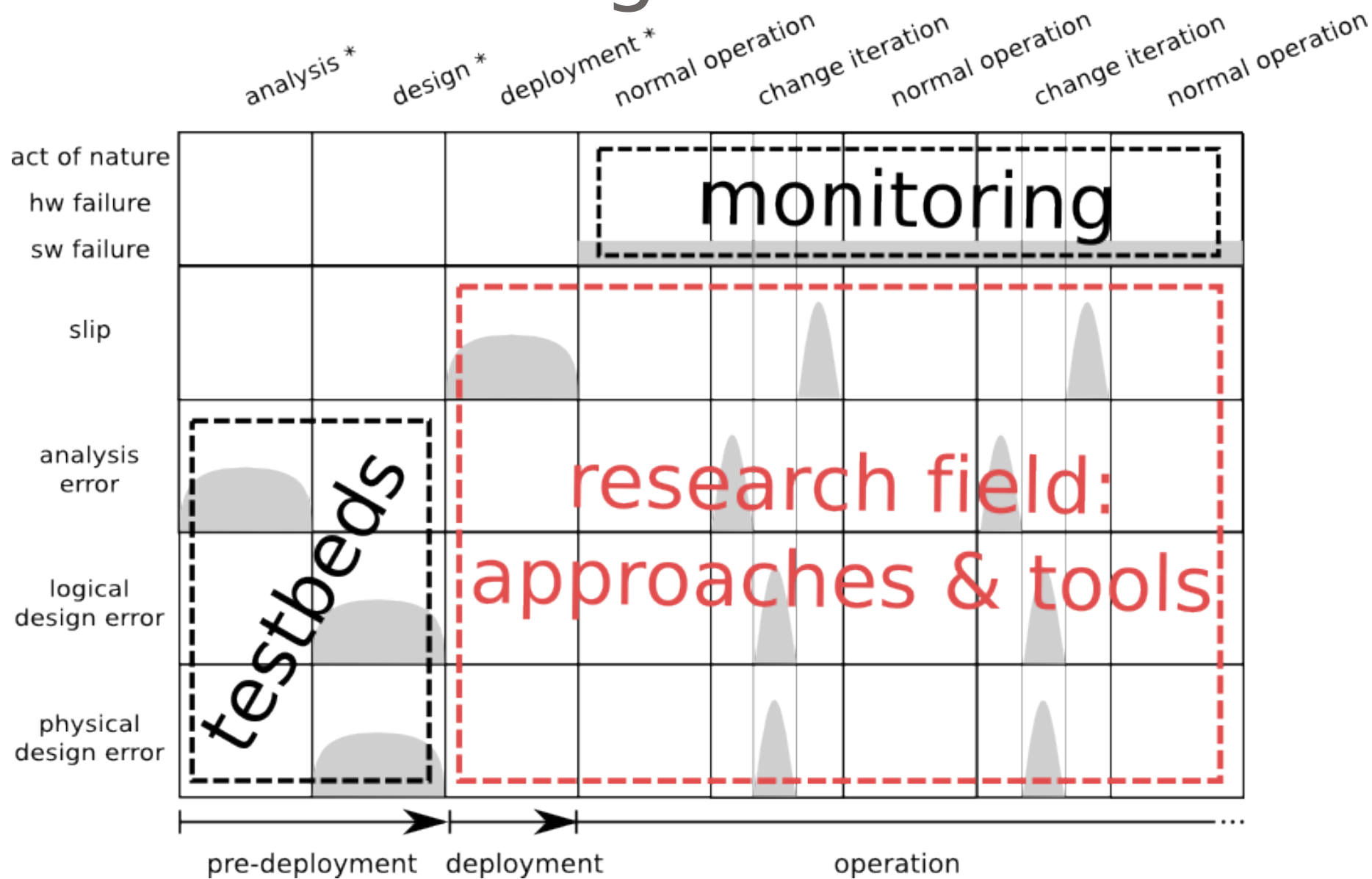
Network Monitoring



Discussion on Monitoring

- Monitoring is a **lightweight** testing approach to check (typically simple) properties during normal operation
 - Its main goal is to highlight link or node failures
 - Monitoring activity can result in generating alerts to network administrators in case of potentially troublesome situations (e.g., high CPU frequency on a server machine)
- A variety of **tools** can be used for monitoring
 - Open source, like Nagios, Zabbix, Munin, ...
 - Commercial tools, e.g., IBM Tivoli, TestDirector, HP OpenView. ..

Better Testing is Possible



Outline

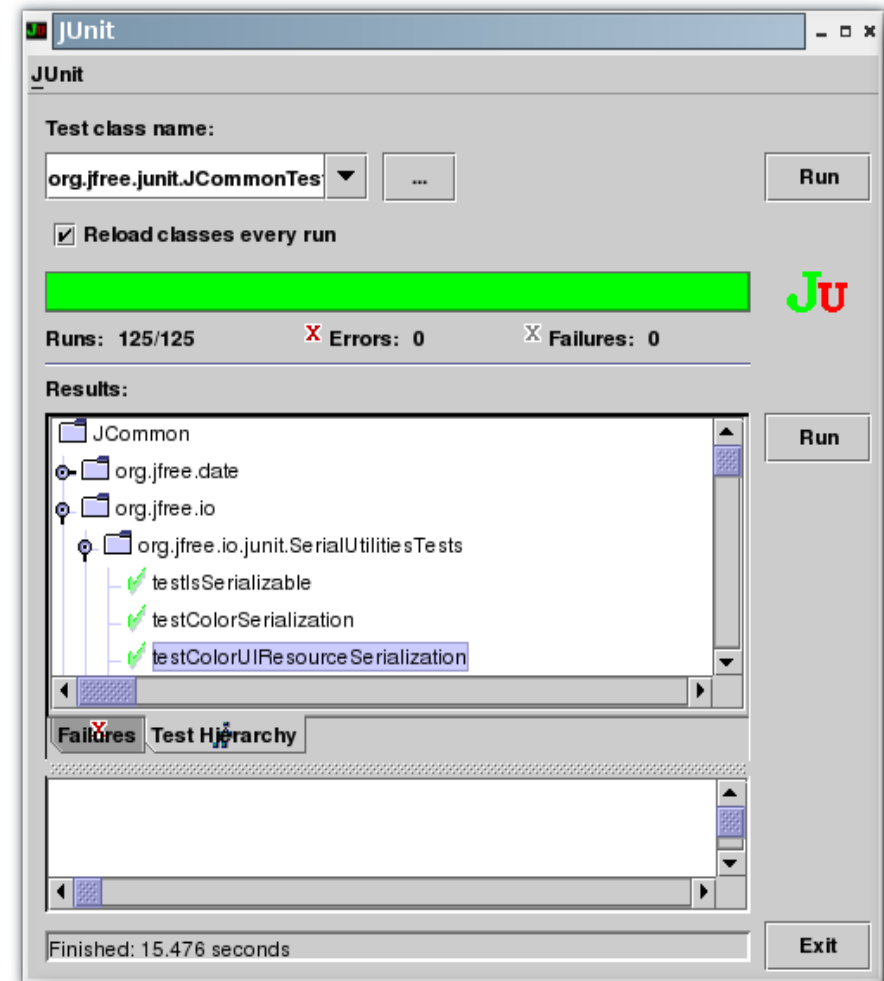
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Goals for a Better Testing Approach

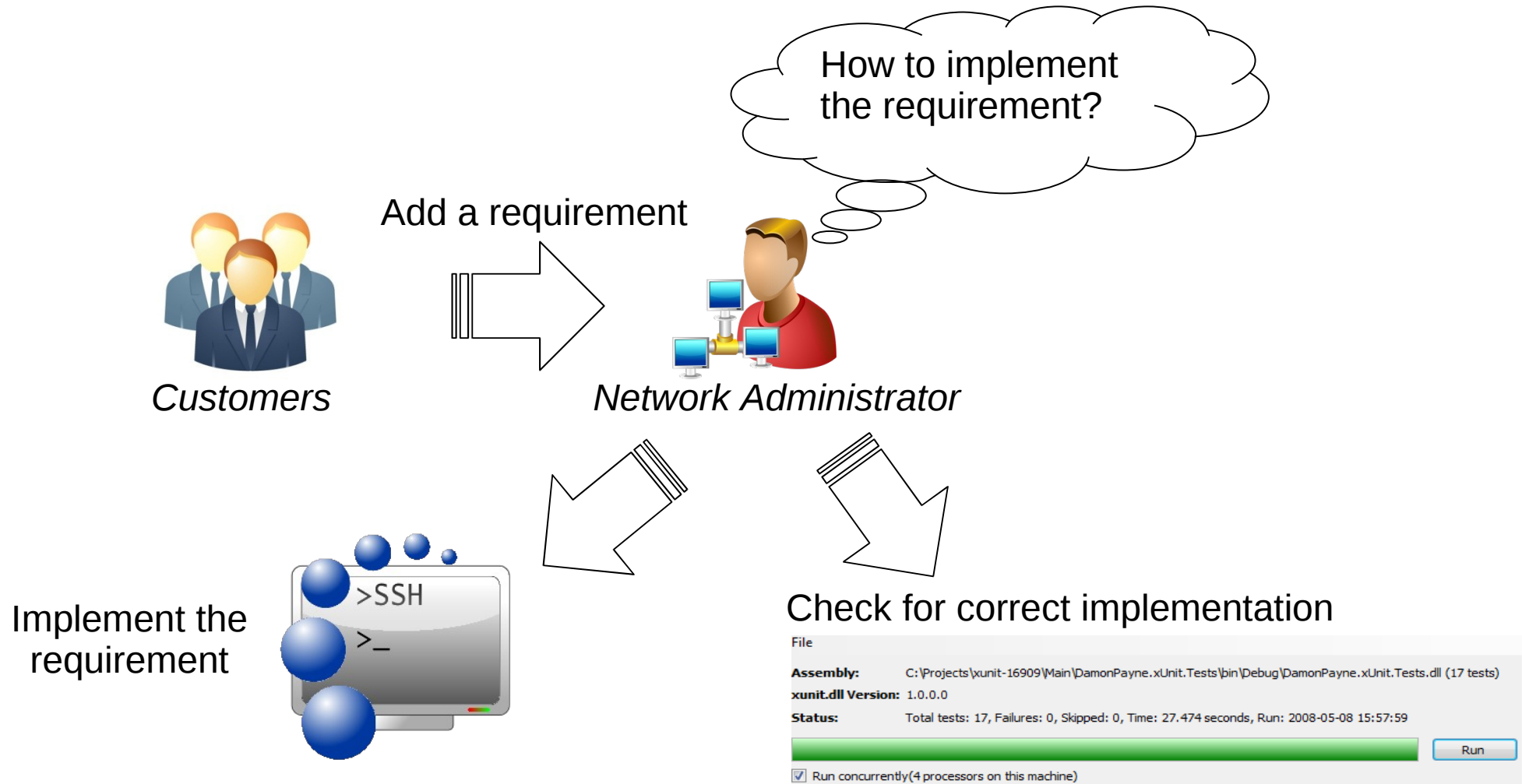
- Address **uncovered issues** in current practice
 - Test all the requirements
 - Test right after deployment
- Promote **deep automation** of network testing
 - Testing should be effective, easy, repeatable and affordable
 - As such, automated testing means less effort, less errors, less costs: automation has the potential to save both time and money!!
- **Unifying** different (testing) algorithms and tools
 - A generic framework for integrating different algorithms (possibly different approaches)
 - Reuse knowledge in network testing and verification

Basic Idea

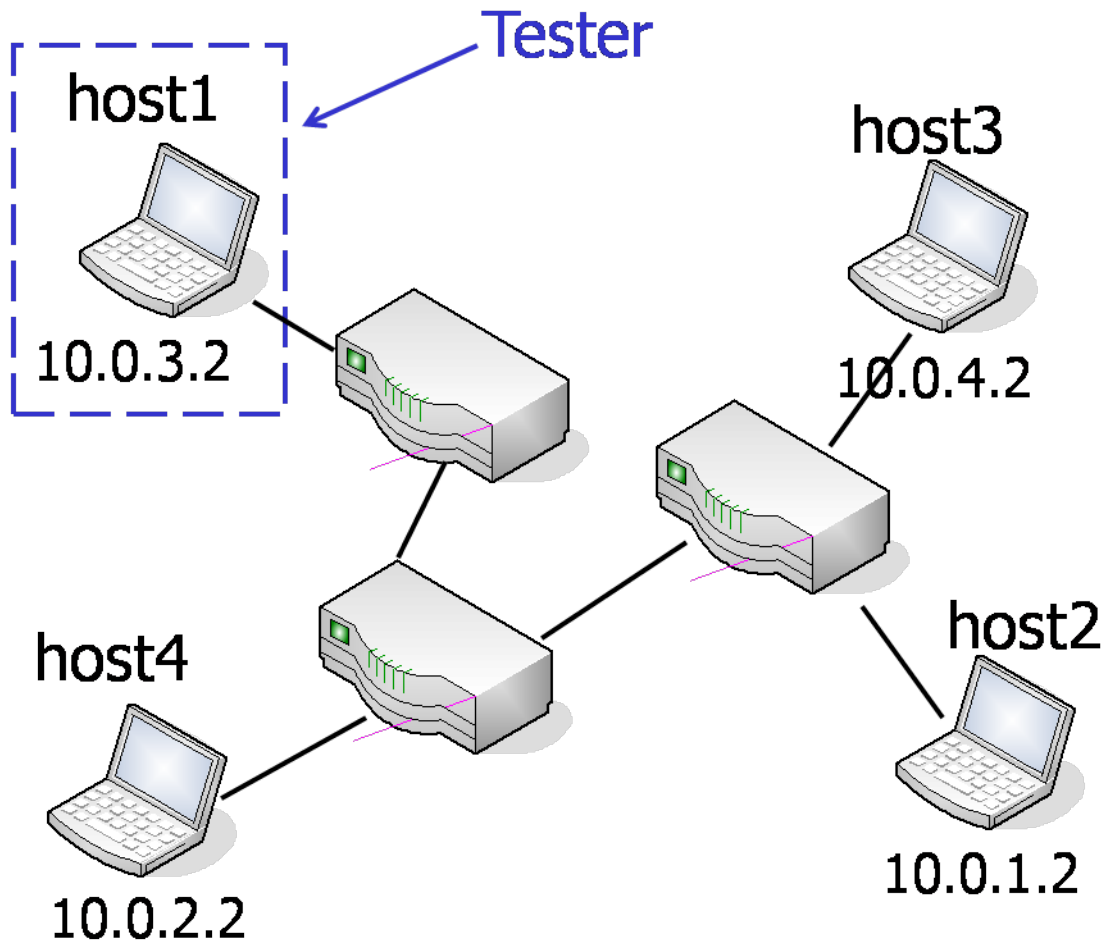
- Take inspiration from **software engineering** (TDD and xUnit)
 - Network tests should be easy to execute and results should be straightforward to understand
 - Standard tools should be used to edit, design and run tests
- A network administrator should be able to **push a button** and verify that **all the requirements are satisfied**
 - Test correct implementation of new requirements
 - Check that old requirements are not disrupted (regression testing)



A Typical Use Case



Basic Idea in Practice



Inter LAN-Cluster
Test Case

```
host1:# run test
connettività da 10.0.3.0 a
  10.0.1.0... ok
connettività da 10.0.3.0 a
  10.0.4.0... ok
connettività da 10.0.1.0 a
  10.0.2.0... ok
collegamento con ssh
  a 10.0.1.2... ok
connettività da 10.0.1.0 a
  10.0.2.0... ok
```

Network Test Cases

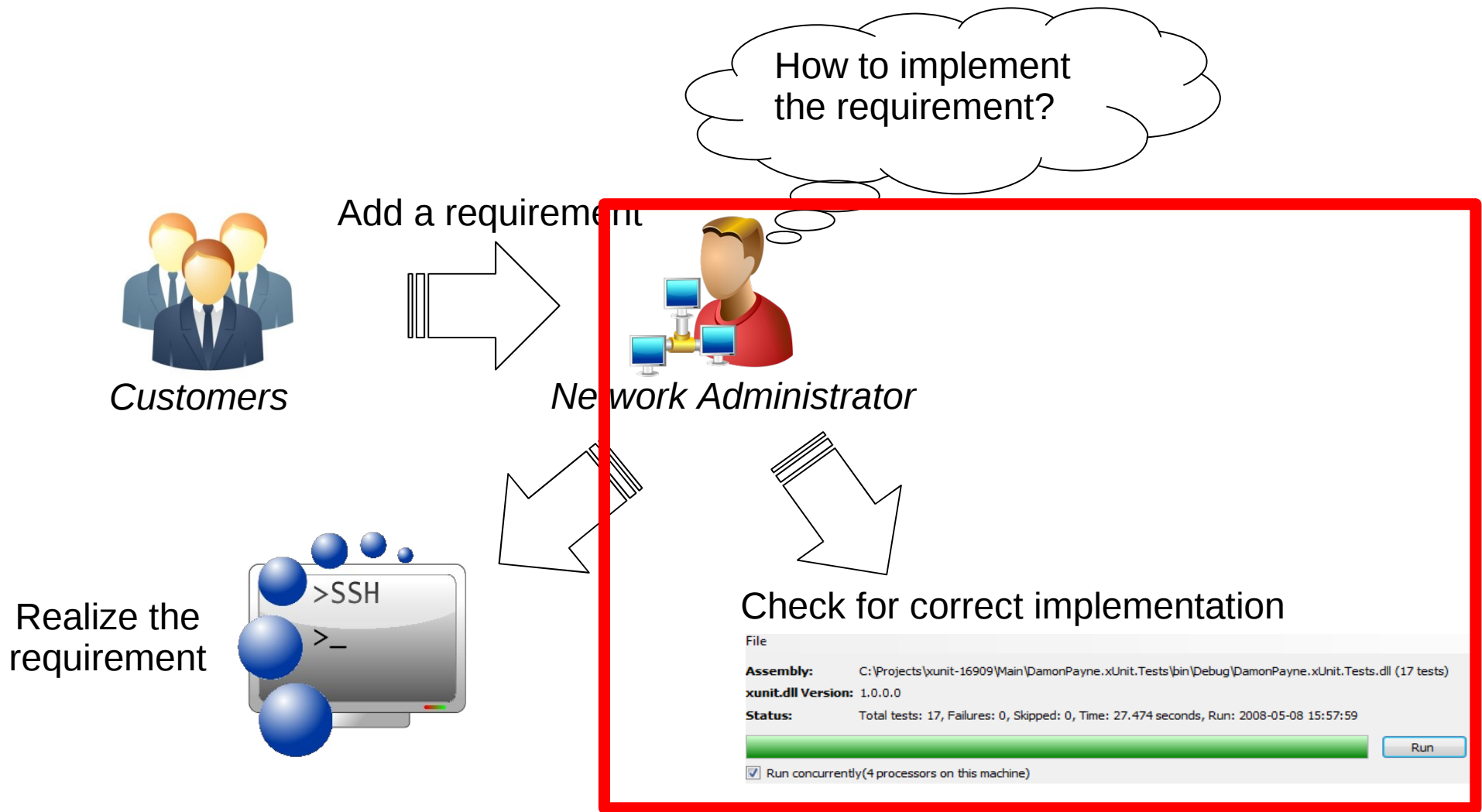
- We define a **network test case** as a series of operations which are performed to verify a **single requirement**, and, by extension, the **software** that, **automatically and autonomously**, performs those operations.
- We impose some features on the network test cases in order to realize our objectives
 - remember that we wish to make network testing effective, easy, repeatable and affordable

Network Test Cases: Features

	Effective	Ease	Repeatable
Requirement Oriented	X		
Boolean		X	
Autonomous		X	X
Stateless	X		X
Composable		X	X
Mutually Dependent	X	X	X
Annotated and selectable	X	X	X
Coarse-grained and community-shared	X	X	X
Safe or recoverable		X	X

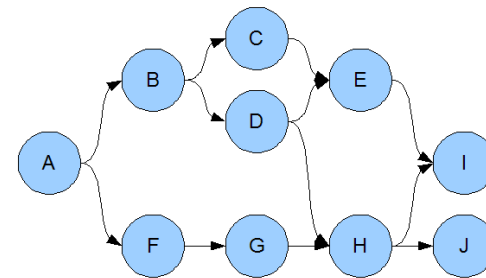
inherited by software
specific to network

An Insight in the Use Case



An Insight in the Use Case

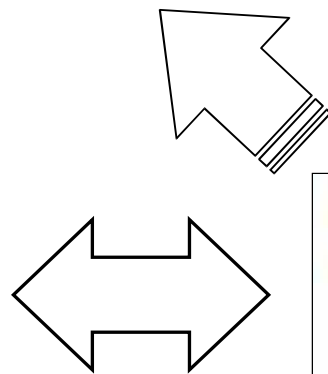
test selection
based on
annotations



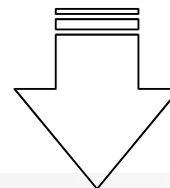
topological
sort for
ordering of
tests



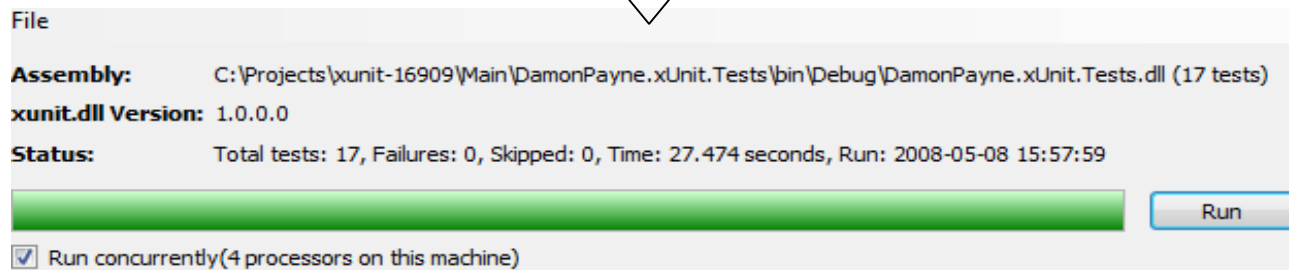
Network Administrator



*Platform for
automated
testing*

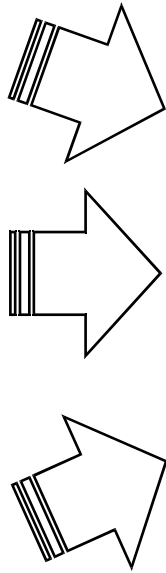
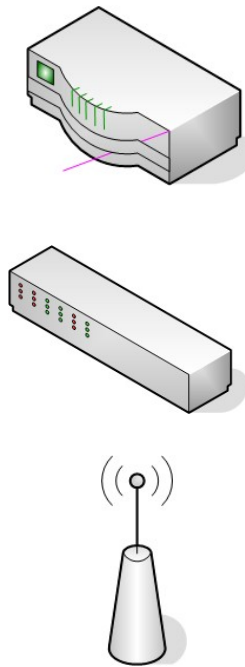


test execution
and
result report

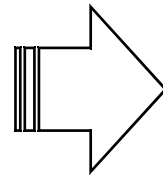


The Vision

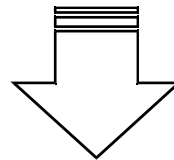
Extraction & Parsing



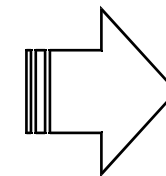
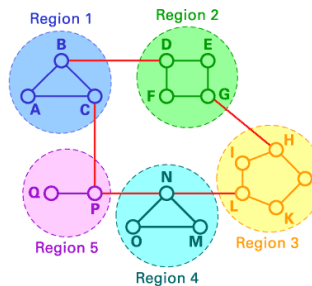
Test Configuration



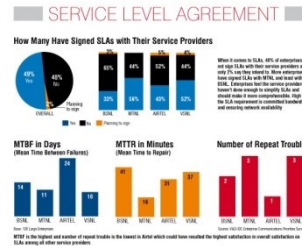
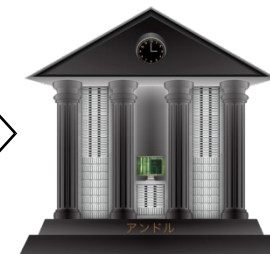
Testing Tool



Network Test Cases



Software Library



Network Requirements

TEST1... OK
 TEST2... OK
 TEST3... OK
 TEST4... FAIL

Outline

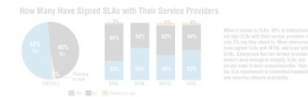
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- **Projects**

Projects

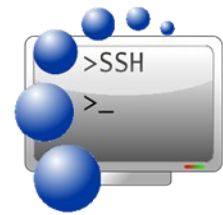
PROJECT:
conception, design and implementation of network test cases

- intradomain IP connectivity
- **routing correctness**
- service reachability
- performance

SERVICE LEVEL AGREEMENT

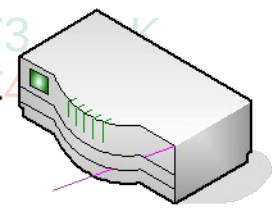
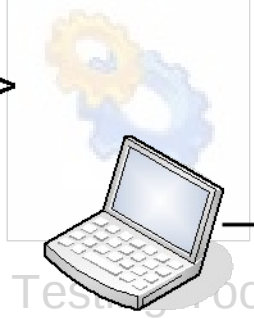


Network Requirements

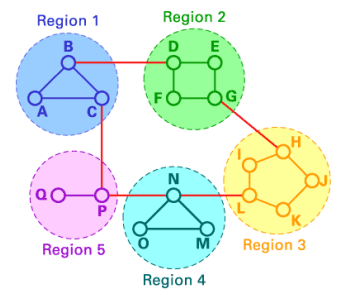


```
router-juniper> show ip bgp  
BGP table version is 0, ...
```

Network	Next Hop	...	Path
* 2.0.0.0/16	202.249.2.169		165 138 i
* >	202.112.60.243		289 965 559 i
* >	202.249.2.169		6453 12654 i

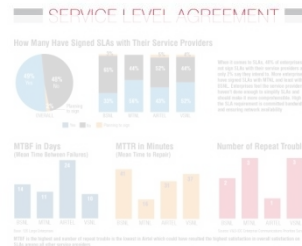
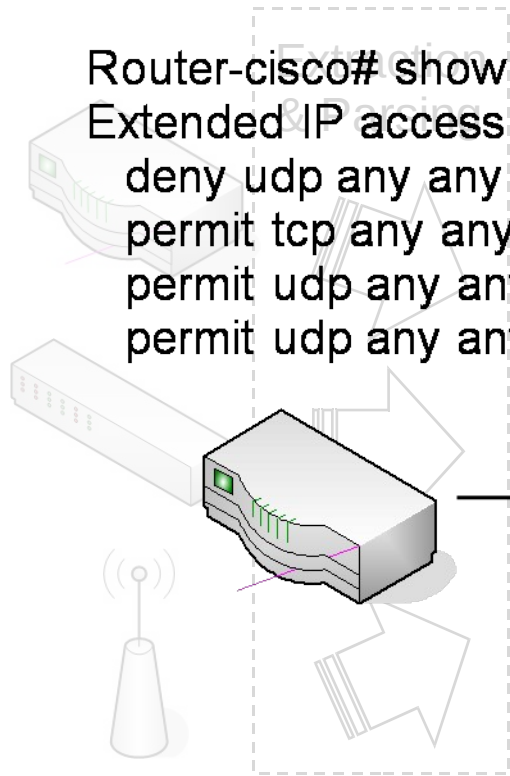


Network Test Cases



Projects

```
Router-cisco# show ip access-list
Extended IP access list 101
deny udp any any eq ntp
permit tcp any any
permit udp any any eq tftp
permit udp any any eq domain
```

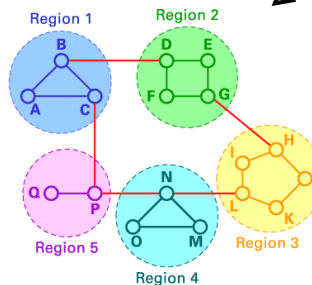


Network Requirements

PROJECT:
understanding, realization
and evaluation of already
known algorithms
- routing correctness
- **firewall testing**



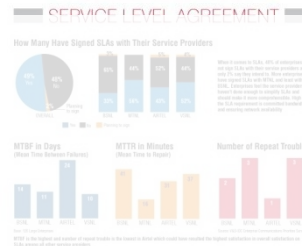
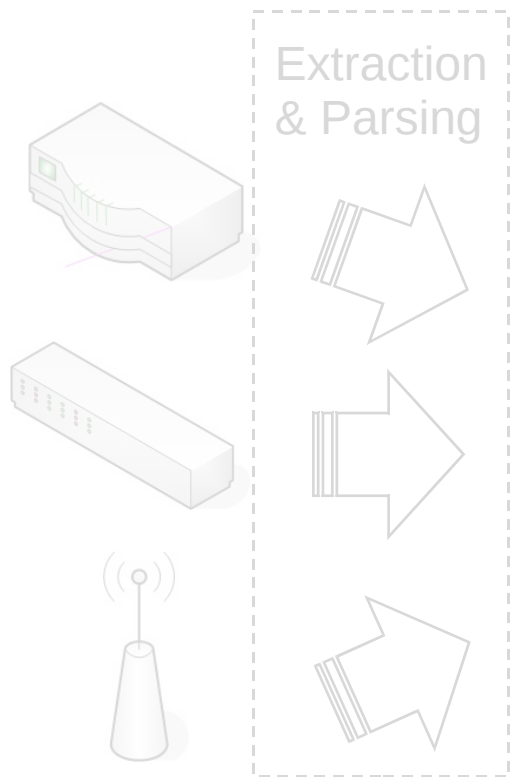
Network Test Cases



Software Library



Projects



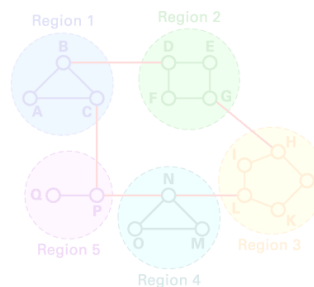
Network Requirements

PROJECT:

realization of software which can be used as support for network test cases
- re-player di dump MRT (MRT → BGP session)

Testing Tool

Network Test Cases



Software Library

TEST1... OK
TEST2... OK
TEST3... OK
TEST4... FAIL