Testing in Clouds

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Who am I?

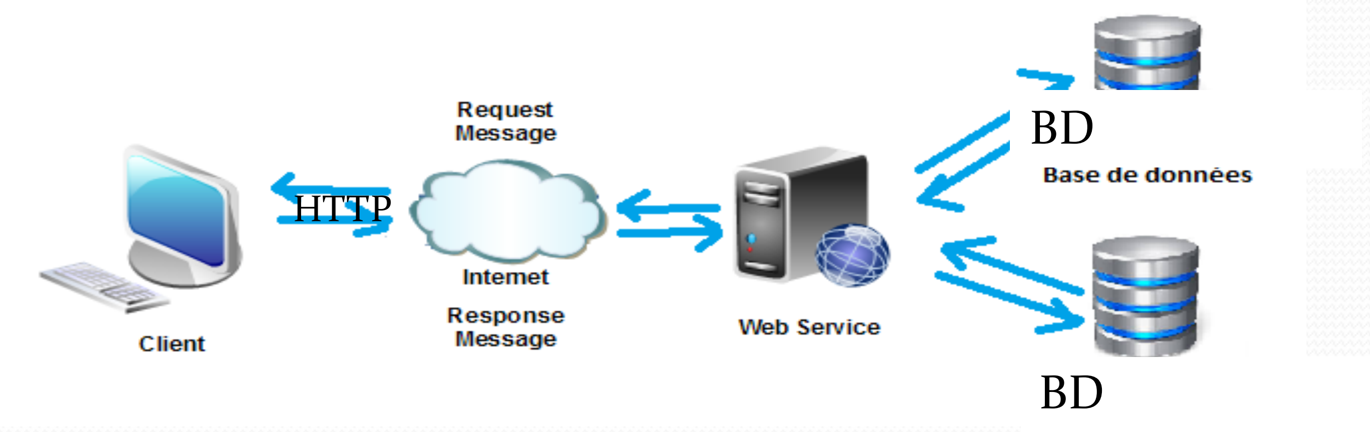
```
Public void setUp(){
Identity id=new Identity(“salva”);}

Public void testid (){
assertEquals(id.surname, ”sébastien”);
assertEquals(id.name, ”salva”);
assertEquals(id.labo, ”LIMOS”);
assertEquals(id.city ”Clermont-Ferrand”);

assertArrayEquals(id.recherche, new String[] {“Model-based Testing”, “model inference“, “passive testing“, “security“});
}
```

Outline

- Cloud computing ?
- Testing in clouds
- Model-based testing example

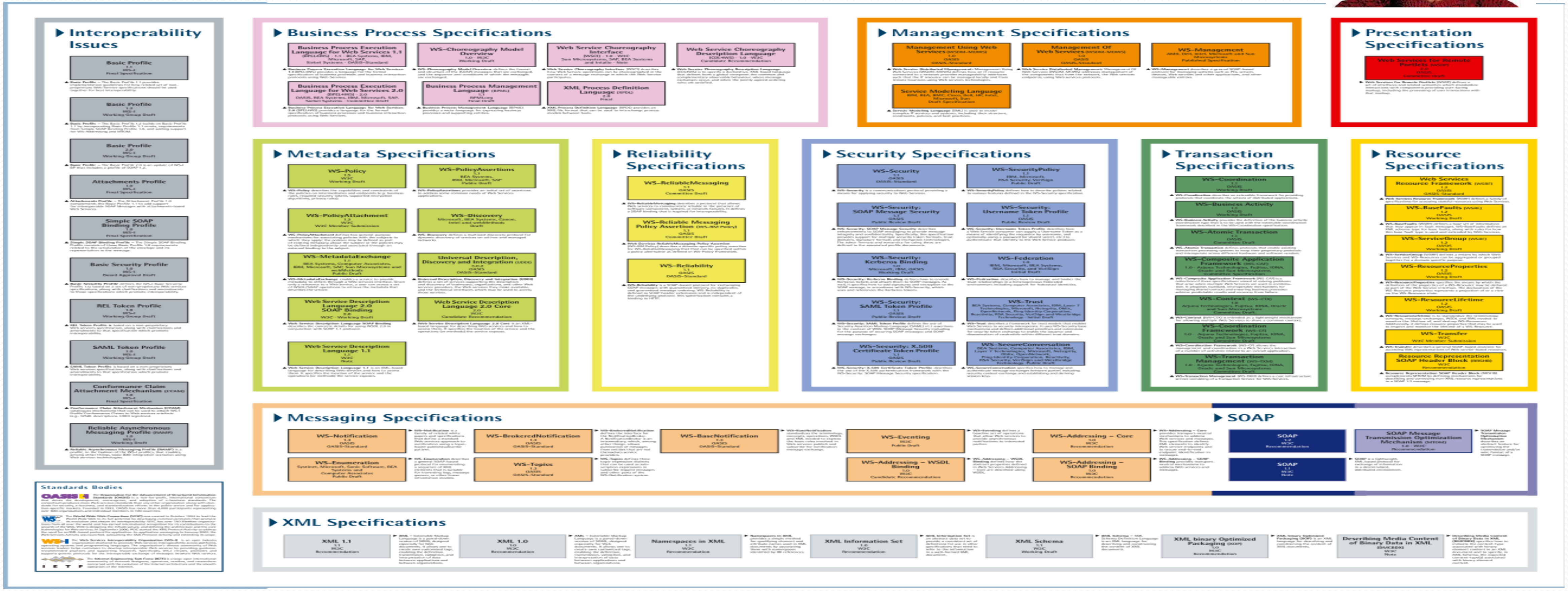
A Short comment on Apps

- In this talk, apps deployed in clouds are Web services
  - Why? most of the Apps deployed in Clouds (PaaS) are Web services
    - A lot of works about Web service testing, Web service composition, etc.
  - SOAP, REST ?
  - Composite Web service ? Orchestration, choregraphy ?



A Short comment on Apps

- Some WS standards



Interoperability Issues

- Basic Profile 1.1 WS-I Final Specification
- Basic Profile 1.2 WS-I Working Group Draft
- Basic Profile 2.0 WS-I Working Group Draft
- Attachments Profile 1.0 WS-I Final Specification
- Simple SOAP Binding Profile 1.0 WS-I Final Specification
- Basic Security Profile 1.0 WS-I Board Approval Draft
- REL Token Profile 1.0 WS-I Working Group Draft
- SAML Token Profile 1.0 WS-I Working Group Draft
- Conformance Claim Attachment Mechanism (CCAM) 1.0 WS-I Final Specification
- Reliable Asynchronous Messaging Profile (RAMP) 1.0 WS-I Working Draft

Business Process Specifications

- Business Process Execution Language for Web Services 1.1 (BPEL4WS) - 1.1 - BEA Systems, IBM, Microsoft, SAP, Siebel Systems - OASIS-Standard
- WS-Choreography Model Overview 1.0 - W3C Working Draft
- Web Service Choreography Interface (WSCI) - 1.0 - W3C Sun Microsystems, SAP, BEA Systems and Intalio - Note
- Web Service Choreography Description Language (CDL4WS) - 1.0 - W3C Candidate Recommendation
- Business Process Execution Language for Web Services 2.0 (BPEL4WS) - 2.0 OASIS, BEA Systems, IBM, Microsoft, SAP, Siebel Systems - Committee Draft
- Business Process Management Language (BPML) 1.1 BPMI.org Final Draft
- XML Process Definition Language (XPDL) 2.0 Final

Management Specifications

- Management Using Web Services (WSDM-MUWS) 1.0 OASIS OASIS-Standard
- Management Of Web Services (WSDM-MOWS) 1.0 OASIS OASIS-Standard
- WS-Management AMD, Dell, Intel, Microsoft and Sun Microsystems Published Specification
- Service Modeling Language IBM, BEA, BMC, Cisco, Dell, HP, Intel, Microsoft, Sun Draft Specification

Presentation Specifications

- Web Services for Remote Portlets (WSRP) 2.0 OASIS Committee Draft

Metadata Specifications

- WS-Policy 1.5 W3C Working Draft
- WS-PolicyAssertions 1.1 BEA Systems, IBM, Microsoft, SAP Public Draft
- WS-PolicyAttachment 1.2 W3C W3C Member Submission
- WS-Discovery Microsoft, BEA Systems, Canon, Intel and webMethods Draft
- WS-MetadataExchange 1.1 BEA Systems, Computer Associates, IBM, Microsoft, SAP, Sun Microsystems and webMethods Public Draft
- Universal Description, Discovery and Integration (UDDI) 3.0.2 OASIS OASIS-Standard
- Web Service Description Language 2.0 SOAP Binding 2.0 W3C - Working Draft
- Web Service Description Language 2.0 Core 2.0 W3C Candidate Recommendation
- Web Service Description Language 1.1 1.1 W3C Note

Reliability Specifications

- WS-ReliableMessaging 1.1 OASIS Committee Draft
- WS-Reliable Messaging Policy Assertion (WS-RM Policy) 1.1 OASIS Committee Draft
- WS-Reliability 1.1 OASIS OASIS-Standard

Security Specifications

- WS-Security 1.1 OASIS OASIS-Standard
- WS-SecurityPolicy 1.1 IBM, Microsoft, RSA Security, VeriSign Public Draft
- WS-Security: SOAP Message Security 1.1 OASIS Public Review Draft
- WS-Security: Username Token Profile 1.1 OASIS Public Review Draft
- WS-Security: Kerberos Binding 1.0 Microsoft, IBM, OASIS Working Draft
- WS-Federation 1.0 IBM, Microsoft, BEA Systems, RSA Security, and VeriSign Initial Draft
- WS-Security: SAML Token Profile 1.1 OASIS Public Review Draft
- WS-Trust BEA Systems, Computer Associates, IBM, Layer 7 Technologies, Microsoft, Netegrity, Oblix, OpenNetwork, Ping Identity Corporation, Reactivity, RSA Security, VeriSign and Westbridge Technology - Initial Draft
- WS-Security: X.509 Certificate Token Profile 1.1 OASIS Public Review Draft
- WS-SecureConversation BEA Systems, Computer Associates, IBM, Layer 7 Technologies, Microsoft, Netegrity, Oblix, OpenNetwork, Ping Identity Corporation, Reactivity, RSA Security, VeriSign and Westbridge Technology Public Draft

Transaction Specifications

- WS-Coordination 1.1 OASIS Working Draft
- WS-Business Activity 1.1 OASIS Working Draft
- WS-Atomic Transaction 1.1 OASIS Committee Draft
- WS-Composite Application Framework (WS-CAF) 1.0 - Arjuna Technologies, Fujitsu, IONA, Oracle and Sun Microsystems Committee Specification
- WS-Context (WS-CTX) 1.0 Arjuna Technologies, Fujitsu, IONA, Oracle and Sun Microsystems Committee Draft
- WS-Coordination Framework (WS-CF) 1.0 - Arjuna Technologies, Fujitsu, IONA, Oracle and Sun Microsystems Committee Draft
- WS-Transaction Management (WS-TXM) 1.0 - Arjuna Technologies, Fujitsu, IONA, Oracle and Sun Microsystems Committee Draft

Resource Specifications

- Web Services Resource Framework (WSRF) 1.2 OASIS OASIS-Standard
- WS-BaseFaults (WSRF) 1.2 OASIS Working Draft
- WS-ServiceGroup (WSRF) 1.2 OASIS Working Draft
- WS-ResourceProperties 1.2 OASIS Working Draft
- WS-ResourceLifetime 1.2 OASIS Working Draft
- WS-Transfer W3C W3C Member Submission
- Resource Representation SOAP Header Block (RRSHB) W3C Recommendation

Messaging Specifications

- WS-Notification 1.3 OASIS OASIS-Standard
- WS-BrokeredNotification 1.3 OASIS OASIS-Standard
- WS-BaseNotification 1.3 OASIS OASIS-Standard
- WS-Eventing W3C Public Draft
- WS-Addressing – Core 1.0 W3C Recommendation
- WS-Enumeration Systinet, Microsoft, Sonic Software, BEA Systems and Computer Associates Public Draft
- WS-Topics 1.3 OASIS OASIS-Standard
- WS-Addressing – WSDL Binding 1.0 W3C Candidate Recommendation
- WS-Addressing – SOAP Binding 1.0 W3C Recommendation

SOAP

- SOAP 1.2 W3C Recommendation
- SOAP 1.1 W3C Note
- SOAP Message Transmission Optimization Mechanism (MTOM) 1.0 - W3C Recommendation

XML Specifications

- XML 1.1 1.1 W3C Recommendation
- XML 1.0 1.0 W3C Recommendation
- Namespaces in XML 1.0 W3C Recommendation
- XML Information Set 1.0 W3C Recommendation
- XML Schema 1.1 W3C Working Draft
- XML binary Optimized Packaging (XOP) 1.0 W3C Recommendation
- Describing Media Content of Binary Data in XML (DMCBDX) W3C Note

Standards Bodies

OASIS · W3C · WS-I · IETF

I Cloud computing

Cloud computing definition ?

“… the market seems to have come to the conclusion that cloud computing has a lot in common with obscenity--you may not be able to define it, but you’ll know it when you see it”

James Urquhart – The Wisdom of Clouds

Cloud origin

- Cloud computing, introduced by

- Amazon (2002), suite of cloud-based services including storage, computation and even human intelligence through the Amazon Mechanical Turk.
- 2006, Amazon launched its Elastic Compute cloud (EC2)
- was announced as "Azure" in October 2008 and was released on 1 February 2010 as Windows Azure, before being renamed to Microsoft Azure on 25 March 2014. **Google App Engine** (often referred to as **GAE** or simply **App Engine**)

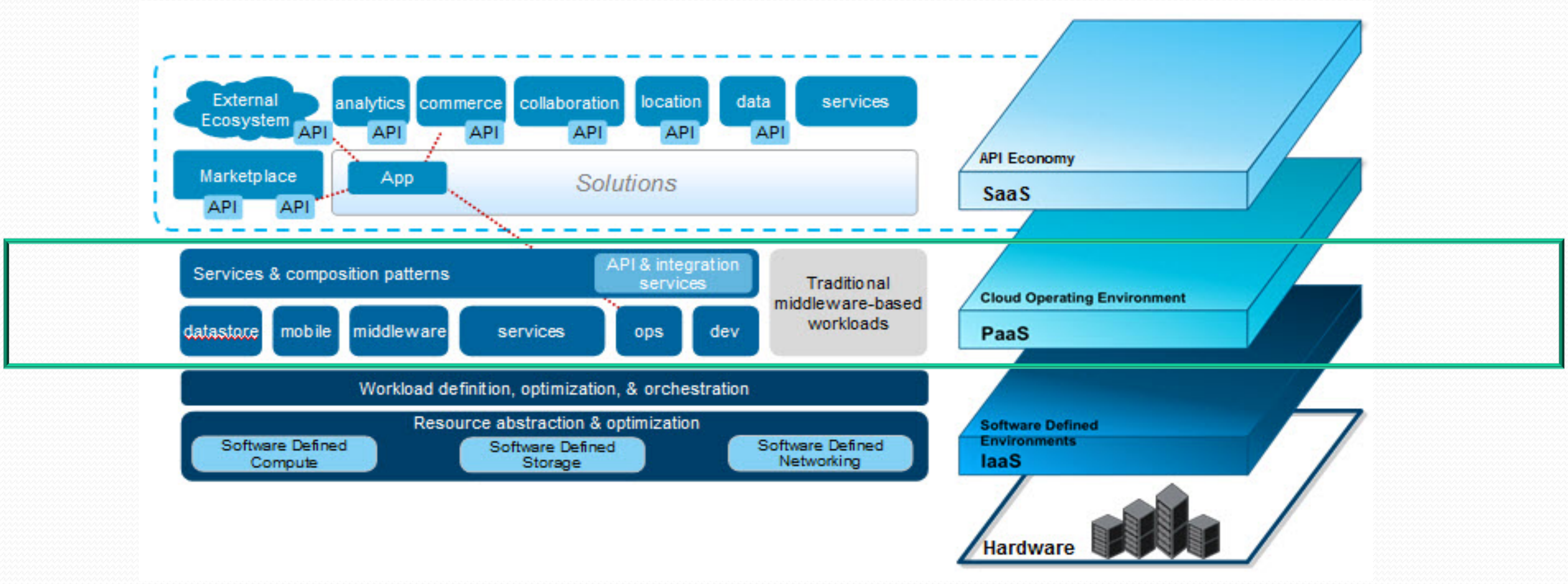
Cloud origin

- Now: GAE, Azure EC2, IBM SmartCloud, Oracle Cloud, Heroku, etc.
  - Dockers, micro-services

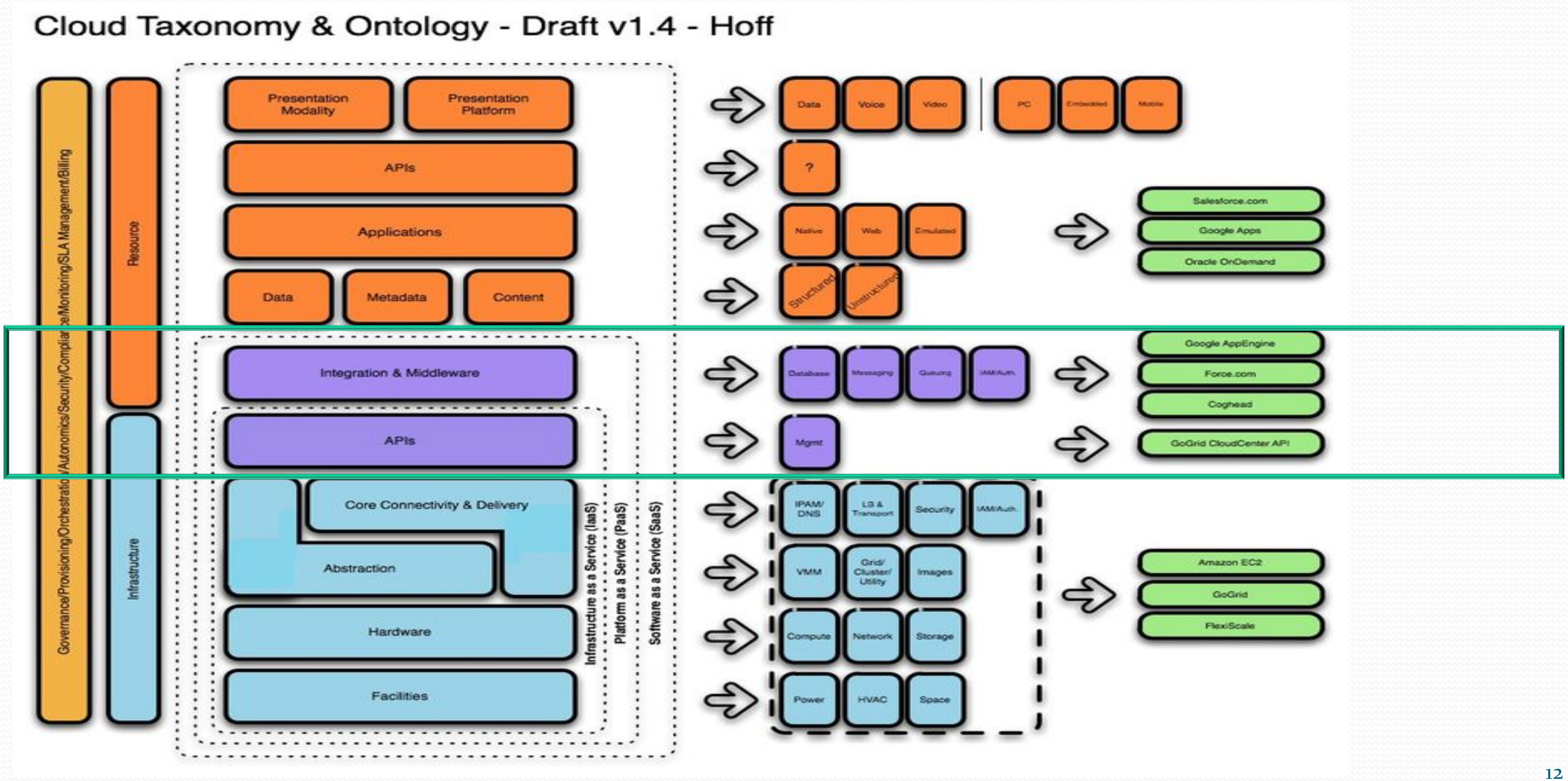
Cloud features :

  - new API,
  - storage,
  - compute,
  - Scalability (long term),
  - Elasticity (short term),
  - etc.

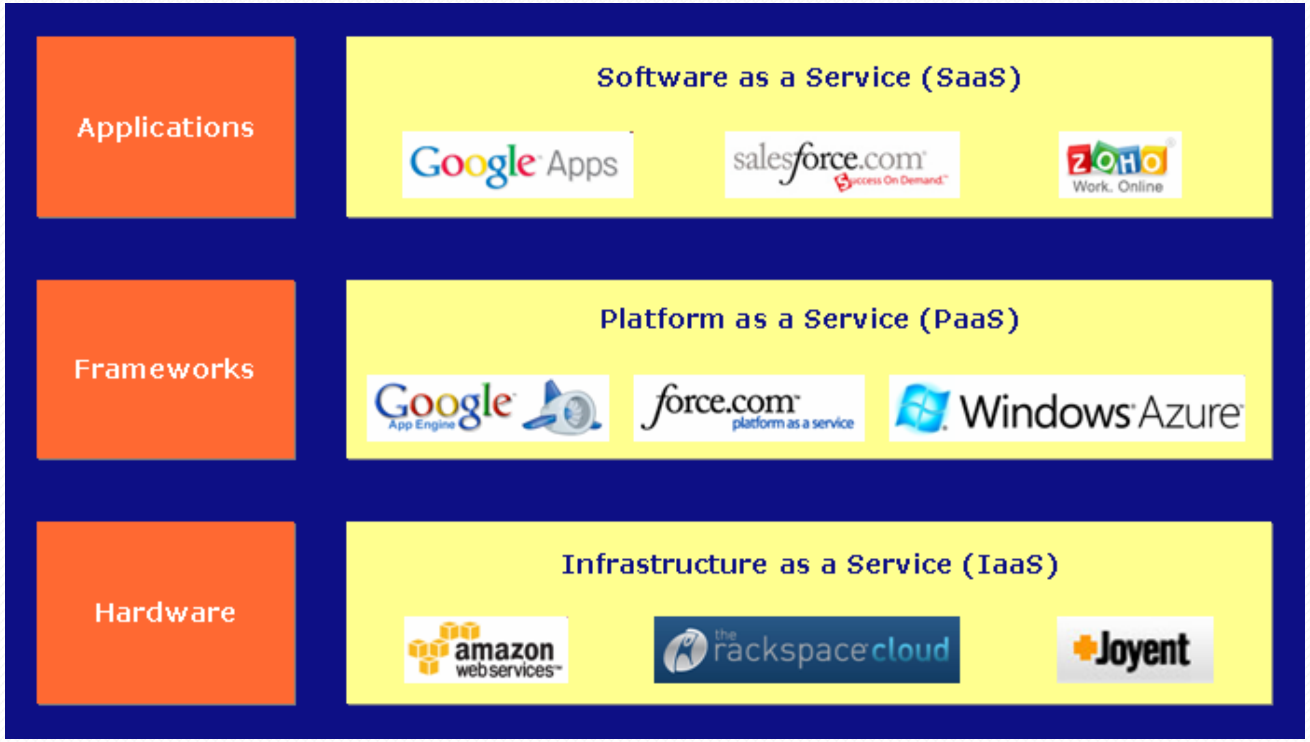
Architecture


External Ecosystem
API
analytics
API
commerce
API
collaboration
API
location
API
data
API
services
Marketplace
API
API
App
Solutions
Services & composition patterns
API & integration services
Traditional middleware-based workloads
datastore
mobile
middleware
services
ops
dev
Workload definition, optimization, & orchestration
Resource abstraction & optimization
Software Defined Compute
Software Defined Storage
Software Defined Networking
API Economy
SaaS
Cloud Operating Environment
PaaS
Software Defined Environments
IaaS
Hardware

Architecture


Cloud Taxonomy & Ontology - Draft v1.4 - Hoff

Architecture



- PaaS : platform as a service
  - Deployment of apps (web services, etc.) in extensible env.
  - OS+ App server (glassfish, jboss, etc.) + persistance layer + API
  - Ex: GAE, Windows Azure, openshift, etc.

- SaaS : software as a service
  - Service proposed to Customers (Dropbox, ?)

Deployment models

- Public Cloud: solutions open for public use with access over a network (Internet)
  - ex: Amazon, Microsoft, Google

- Private Cloud: private infrastructure available to a unique organisation.

  - Hardware, software have to be managed by the organisation.

  - Need of re-evaluating the required resources periodically and the Security issues after every modification

  - Loss of several advantages of Clouds: flexibility, scalability

Deployment models

- Hybrid Cloud :

  - Composed of 2 or more private, public clouds bound together(several providers)

  - Support several deployment models

  - Share the same advantages as public and private clouds (flexibility, scalability)

  - Sensitive data can be stored into the private part

Some Open source PaaS

	Year	sponsors	Languages
CLOUD FOUNDRY™	2011	VMware	Spring,Rails, sinatra, node.js
OPENSHIFT™ PaaS by Red Hat® Cloud	2011	Red hat	Express-ruby, PHP, python, flex, jboss, java EE6
WSO2 Stratos	2009	WSo2	Tomcat, jboss, java EE6
stackato™	2012	HP	Java, Ruby, Perl, Java, etc

platform: Openstack

Cloud example:

Windows Azure insight

PaaS Windows Azure

- IaaS and SaaS layers not seen here

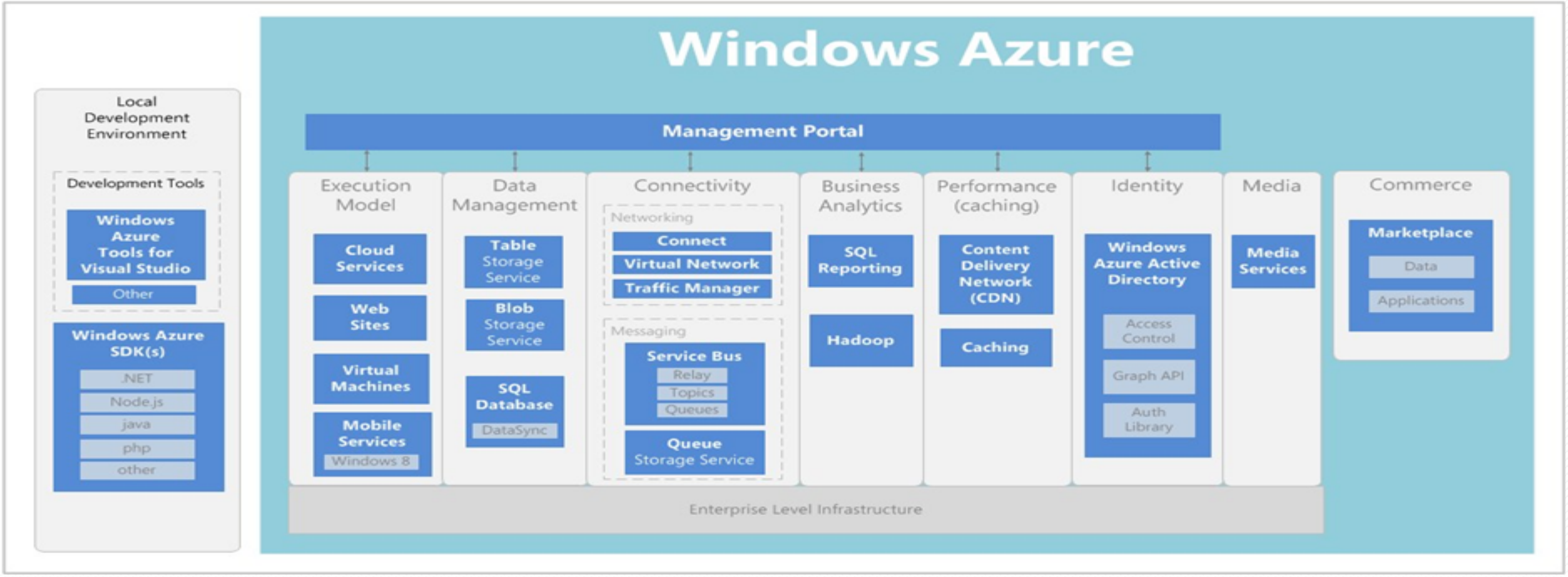
- Services of the PaaS layer :

  - Langages:
    - C# VB, Python, Java, PHP, Ruby, etc.

  - Type of Apps :
    - Web Services SOAP, REST, plain/text,
    - Web sites

  - Admin, performance analysis, interfaces, etc.

PaaS Windows Azure

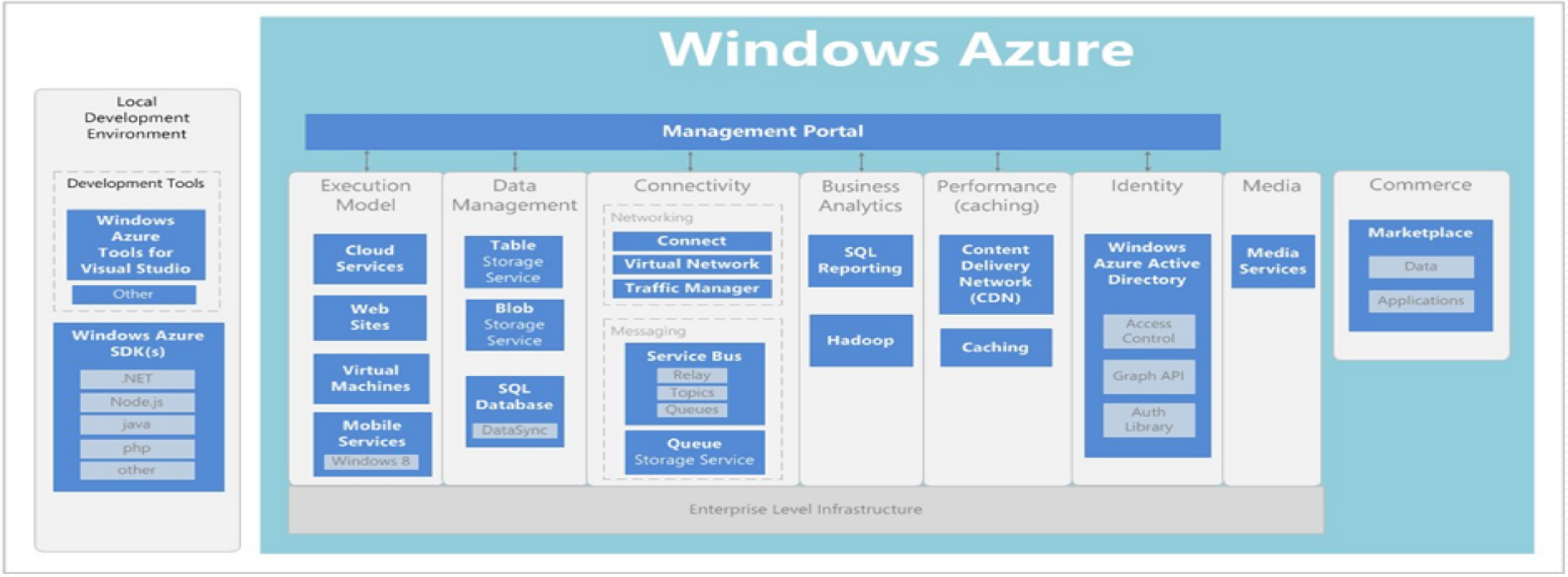


Service Bus: message queuing platform build by Azure that provides Relay and Brokered messaging capabilities

Identity/Acces control: manages access to service bus, supports protocols like OAuth v1 v2, Simple Web Tokens (SWT) for REST services, or SAML, WS-Federation et WS-Trust for SOAP services

Cloud services : SOAP Rest web services, web role, worker roles

PaaS Windows Azure



Blobs: blob files allowing to store files or meta-data
Table: non relational tables, fulfilled with entities,
Queue asynchronous FIFO between apps
Drive manage and configure vituel disks

PaaS Windows Azure

- Web and worker roles:

- Web Role:
  - Apps called with HTTP Requests / responses (Web pages, WCF Web services, etc.)

- Worker role:
  - Service running in the background. Cannot be called via HTTP

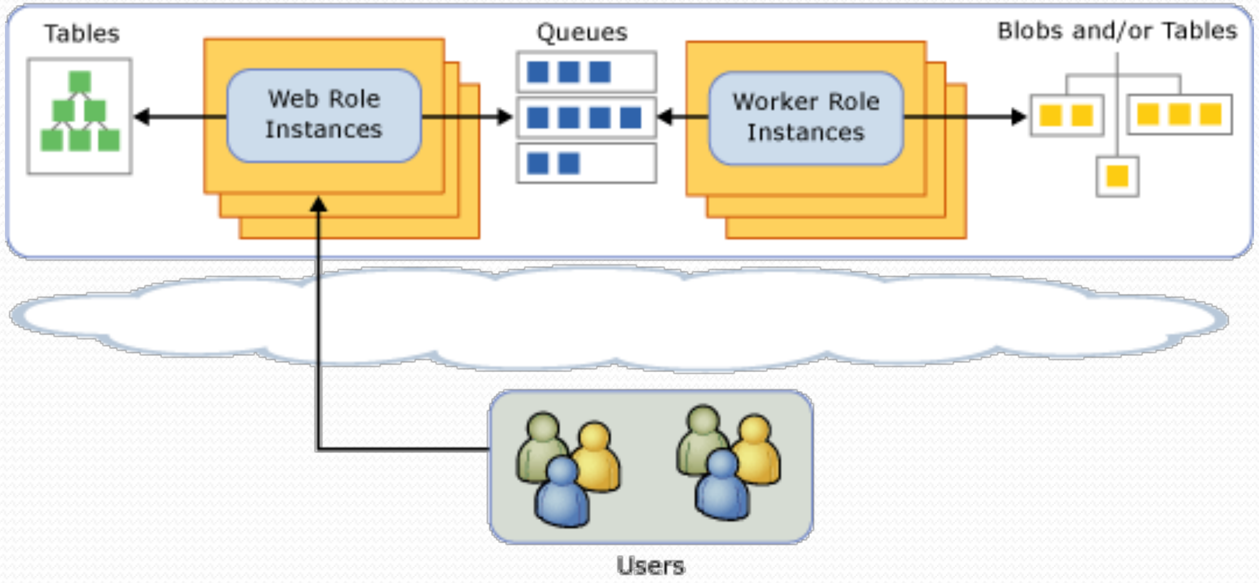
- Web services and workers can interact through Queues:
  - workers yield Data, Web services read it and answer

PaaS Windows Azure

Web and worker roles

- Web service can change of state
- Web and worker roles can be put in different VMs (manual distribution)

A massively scalable web app with background processing

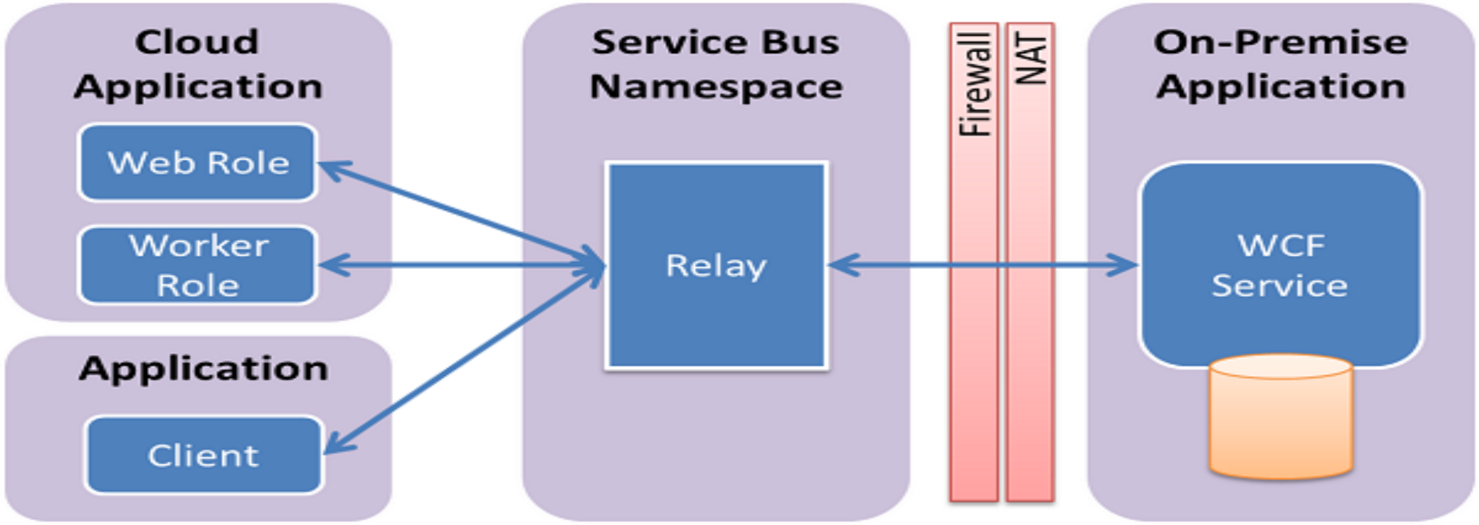


PaaS Windows Azure

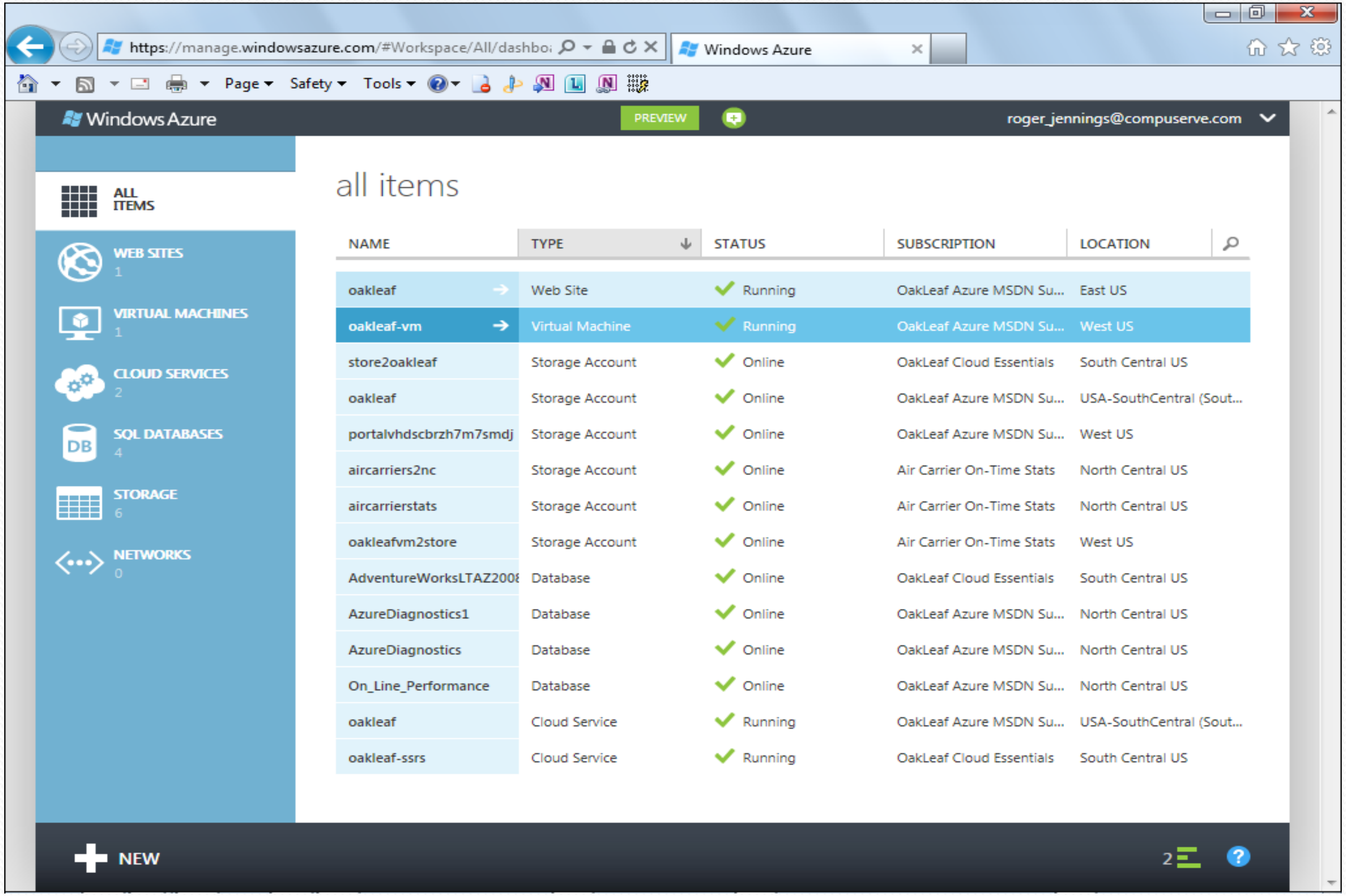
- Example with ServiceBus:

- Relay messaging: Relay between entitites:
- Build hybid apps partly deployed in Azure,
- The whole app is secured by the Relay

- https://www.windowsazure.com/en-us/develop/net/how-to-guides/service-bus-relay/



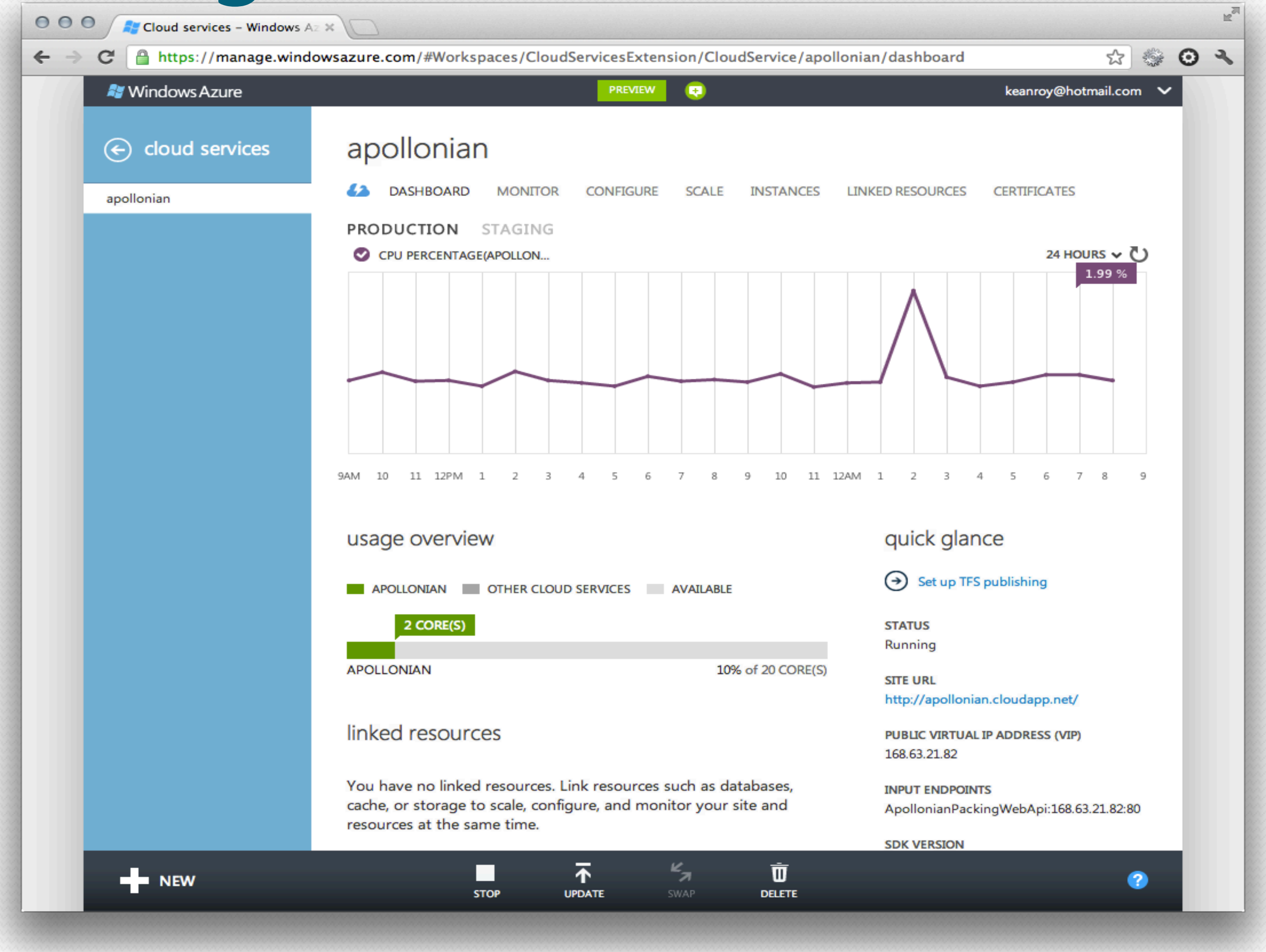
Azure Management Console



all items

NAME	TYPE	STATUS	SUBSCRIPTION	LOCATION
oakleaf	Web Site	✓ Running	OakLeaf Azure MSDN Su...	East US
oakleaf-vm	Virtual Machine	✓ Running	OakLeaf Azure MSDN Su...	West US
store2oakleaf	Storage Account	✓ Online	OakLeaf Cloud Essentials	South Central US
oakleaf	Storage Account	✓ Online	OakLeaf Azure MSDN Su...	USA-SouthCentral (Sout...
portalvhdscbrzh7m7smdj	Storage Account	✓ Online	OakLeaf Azure MSDN Su...	West US
aircarriers2nc	Storage Account	✓ Online	Air Carrier On-Time Stats	North Central US
aircarrierstats	Storage Account	✓ Online	Air Carrier On-Time Stats	North Central US
oakleafvm2store	Storage Account	✓ Online	Air Carrier On-Time Stats	West US
AdventureWorksLTAZ2008	Database	✓ Online	OakLeaf Cloud Essentials	South Central US
AzureDiagnostics1	Database	✓ Online	OakLeaf Azure MSDN Su...	North Central US
AzureDiagnostics	Database	✓ Online	OakLeaf Azure MSDN Su...	North Central US
On_Line_Performance	Database	✓ Online	OakLeaf Azure MSDN Su...	North Central US
oakleaf	Cloud Service	✓ Running	OakLeaf Azure MSDN Su...	USA-SouthCentral (Sout...
oakleaf-ssrs	Cloud Service	✓ Running	OakLeaf Cloud Essentials	South Central US

Azure Management Console


Cloud services – Windows A
https://manage.windowsazure.com/#Workspaces/CloudServicesExtension/CloudService/apollonian/dashboard
Windows Azure
PREVIEW
keanroy@hotmail.com
cloud services
apollonian
DASHBOARD
MONITOR
CONFIGURE
SCALE
INSTANCES
LINKED RESOURCES
CERTIFICATES
PRODUCTION
STAGING
CPU PERCENTAGE(APOLLON...
24 HOURS
1.99 %
9AM 10 11 12PM 1 2 3 4 5 6 7 8 9 10 11 12AM 1 2 3 4 5 6 7 8 9
NEW
STOP
UPDATE
SWAP
DELETE

apollonian

usage overview

APOLLONIAN · OTHER CLOUD SERVICES · AVAILABLE

2 CORE(S)

APOLLONIAN — 10% of 20 CORE(S)

linked resources

You have no linked resources. Link resources such as databases, cache, or storage to scale, configure, and monitor your site and resources at the same time.

quick glance

Set up TFS publishing

STATUS
Running

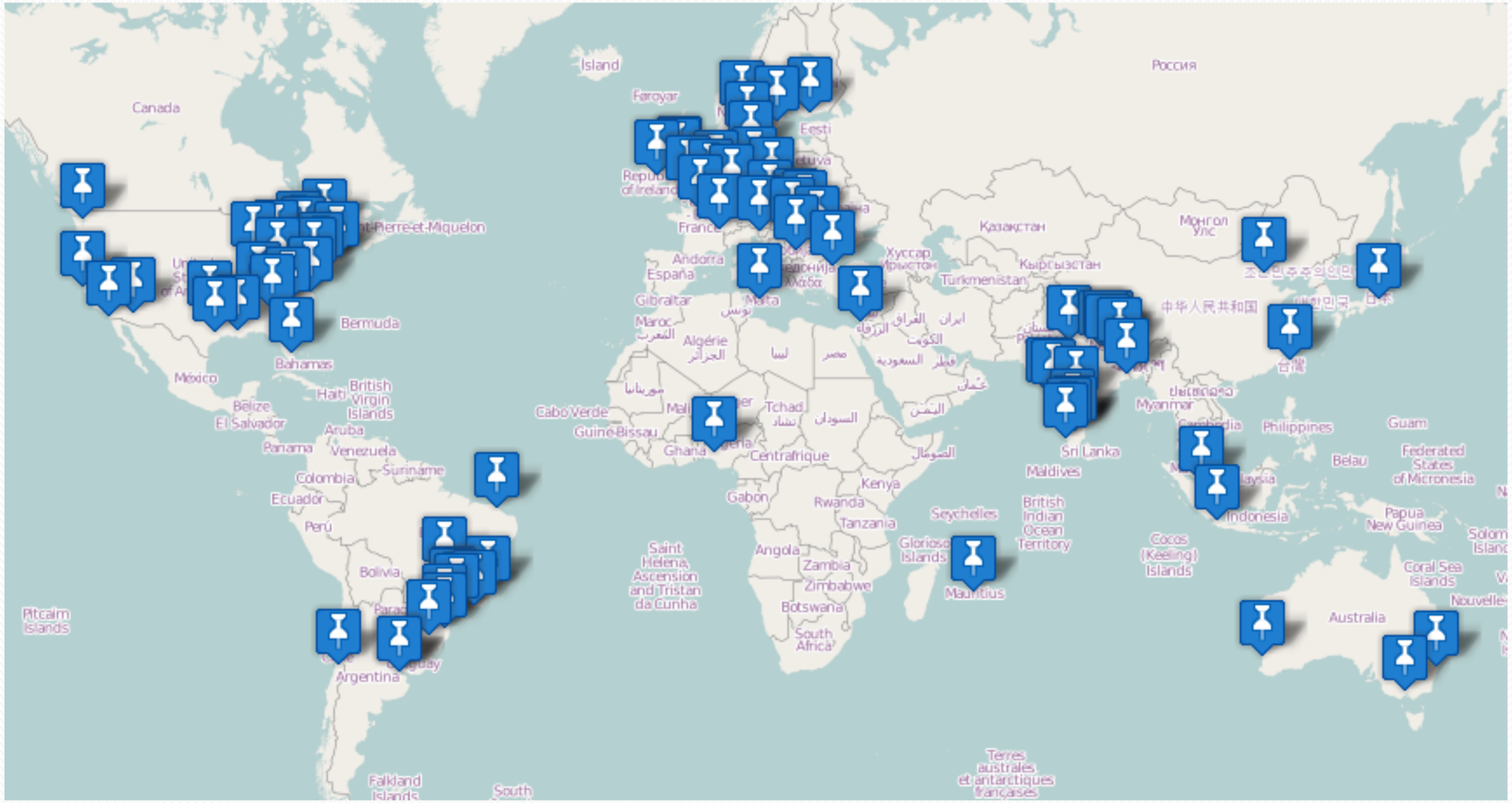
SITE URL
http://apollonian.cloudapp.net/

PUBLIC VIRTUAL IP ADDRESS (VIP)
168.63.21.82

INPUT ENDPOINTS
ApollonianPackingWebApi:168.63.21.82:80

SDK VERSION

Apps localisation



Where is my Mi App ?

II Model based testing / clouds

3 2 1 Fight

[CHN15]

- **Testing Clouds vs.**
  - Testing cloud architectures (VM, network, load, etc.) => perf, cloud properties [D-Cloud]
  - Cloud simulators (Cloudsim, Greencloud, etc.)

- **Testing with Clouds vs.**
  - Use of clouds for testing
  - Testing as a service (a lot of commercial solutions available: Xamarin Test Cloud, pCloudy)

- **Testing in Clouds**
  - Testing Apps, web services, deployed in clouds

Testing in Clouds

- Conformance testing of Apps
  - Regression testing

- Security testing
  - Availability
  - Checking privacy, secret, authorization, integrity

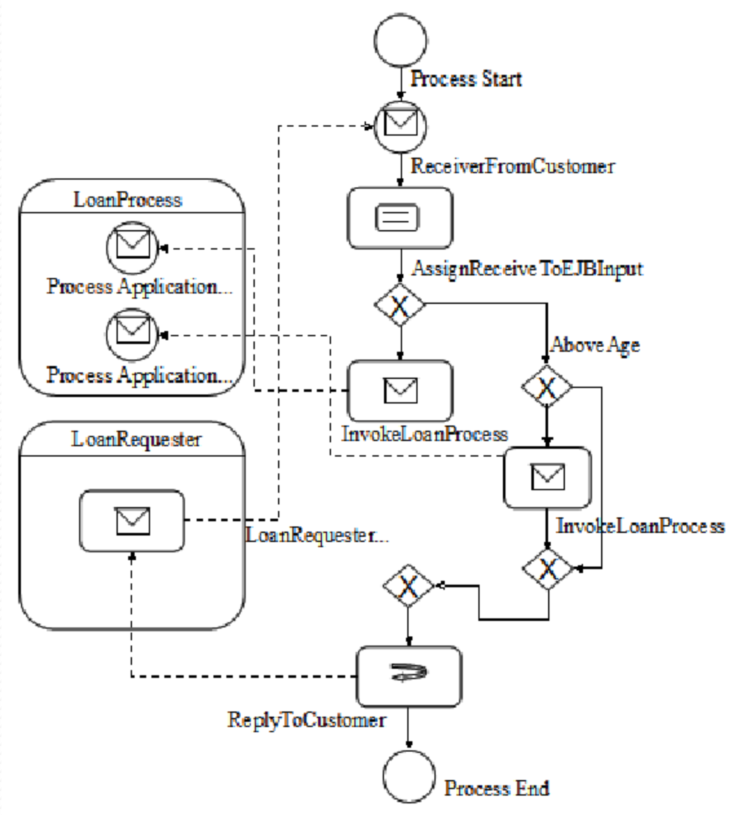
- Interoperability testing (betwen 2 services in different clouds, etc.)

- Third-party dependencies

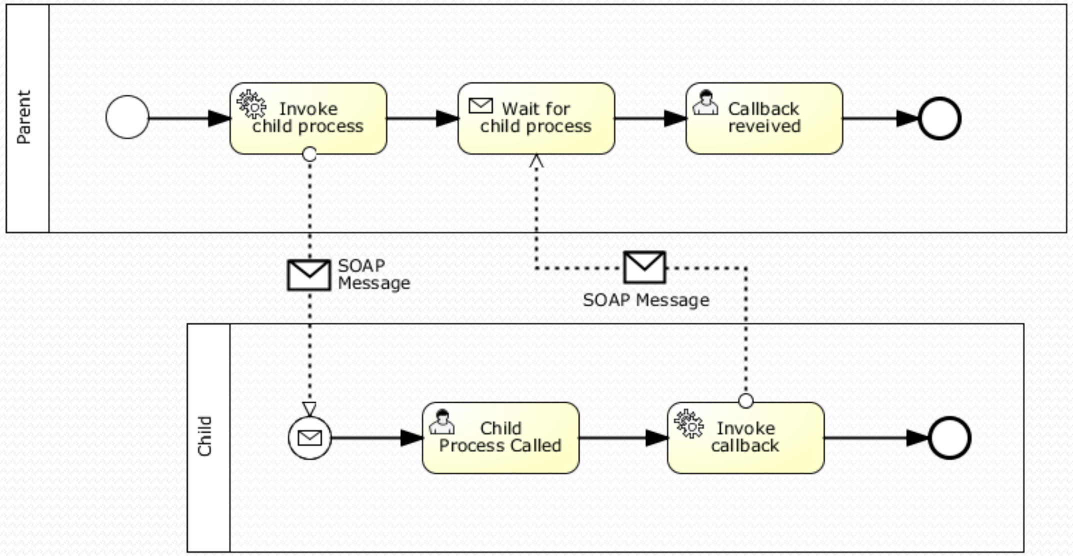
Models

High level languages (ws-BPEL, BPMN, etc.)

WS-BPEL



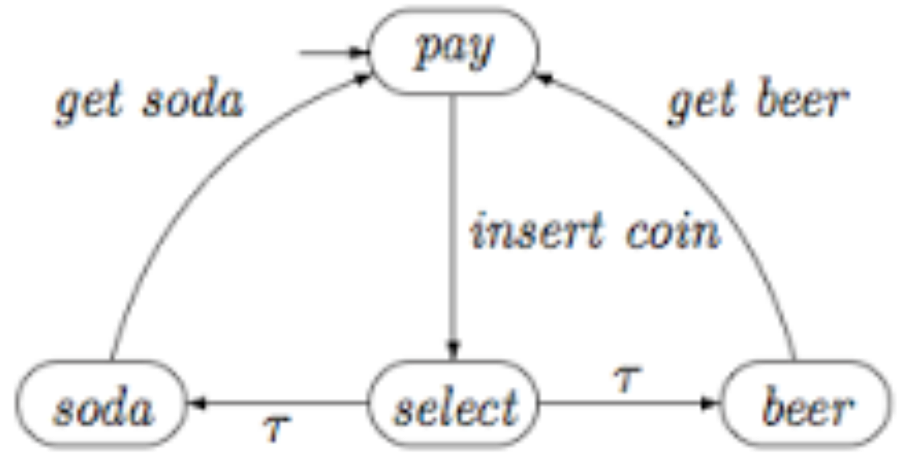
BPMN



Formal Model based on transition systems

=>Formal models encoding the functionnal behaviours of WS, of composite WS

- Transition systems
- Transition labels: ! stands for emission and ? stands for reception
  - Supported by many tools



Model name ?

LTS

Formal Model based on transition systems

- Symbolic models:
  - Modelisation of parameters, data constraints

STG, IOSTS, EFSM

- Timed models:

Add the modelisation of time constraints (delays between two calls, etc.)

TA, TEFSM

IOSTS

- IOSTS (IOLTS) considered here

Why ?

- IOSTS (and IOLTS) can be represented with graphs and with process-algebraic behaviour expression [Tre96]
- ?req1;!resp1 | ?req2; !resp2

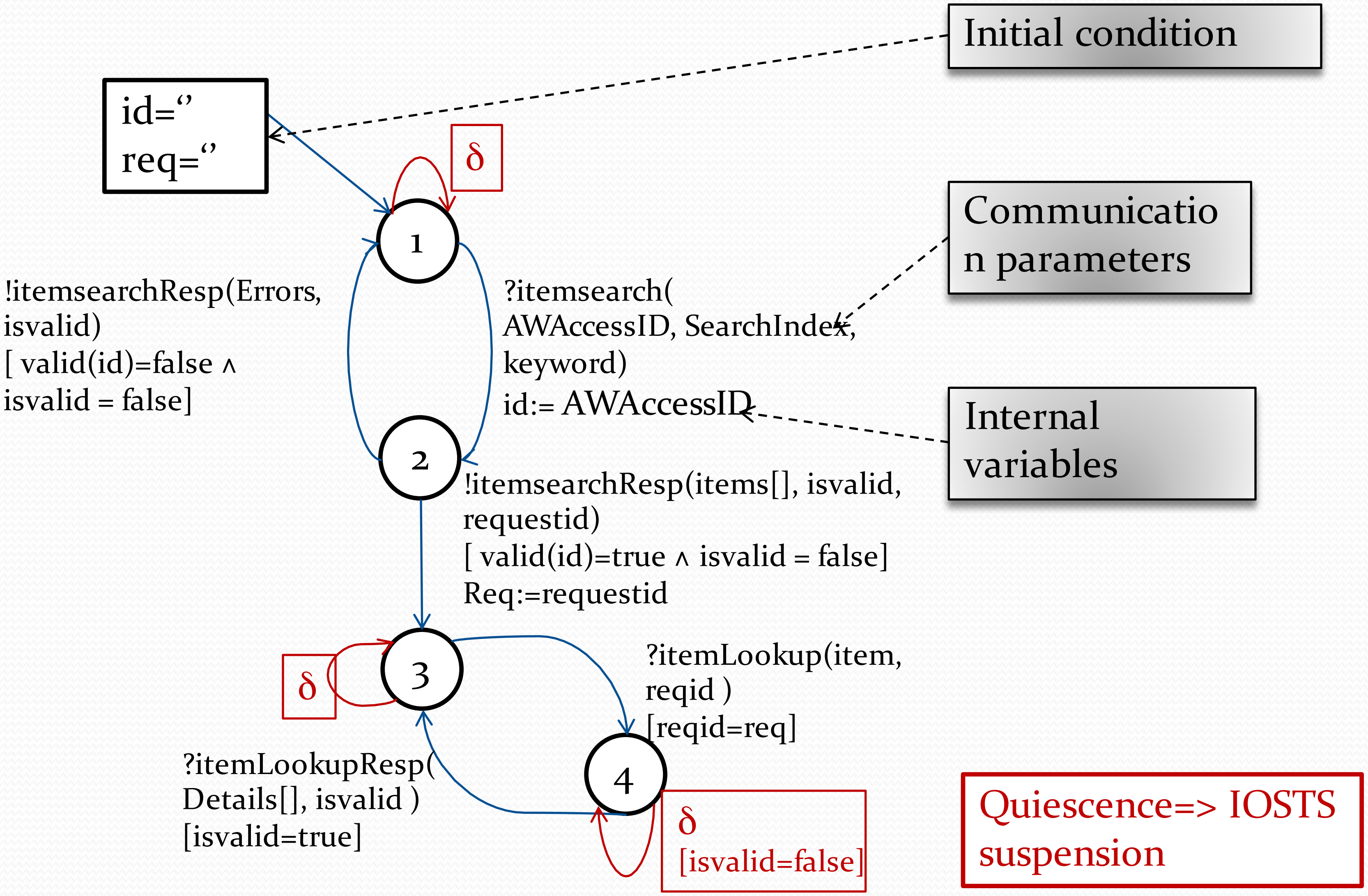
- Advantage: model transformations, modifications can be given with inference rules

If condition

Then action

IOSTS

Example:
Amazon Web service



id=“
req=“

Initial condition

Communication parameters

Internal variables

δ

1

!itemsearchResp(Errors, isvalid)
[valid(id)=false ∧ isvalid = false]

?itemsearch(AWAccessID, SearchIndex, keyword)
id:= AWAccessID

2

!itemsearchResp(items[], isvalid, requestid)
[valid(id)=true ∧ isvalid = false]
Req:=requestid

δ

3

?itemLookup(item, reqid)
[reqid=req]

?itemLookupResp(Details[], isvalid)
[isvalid=true]

4

δ
[isvalid=false]

Quiescence=> IOSTS suspension

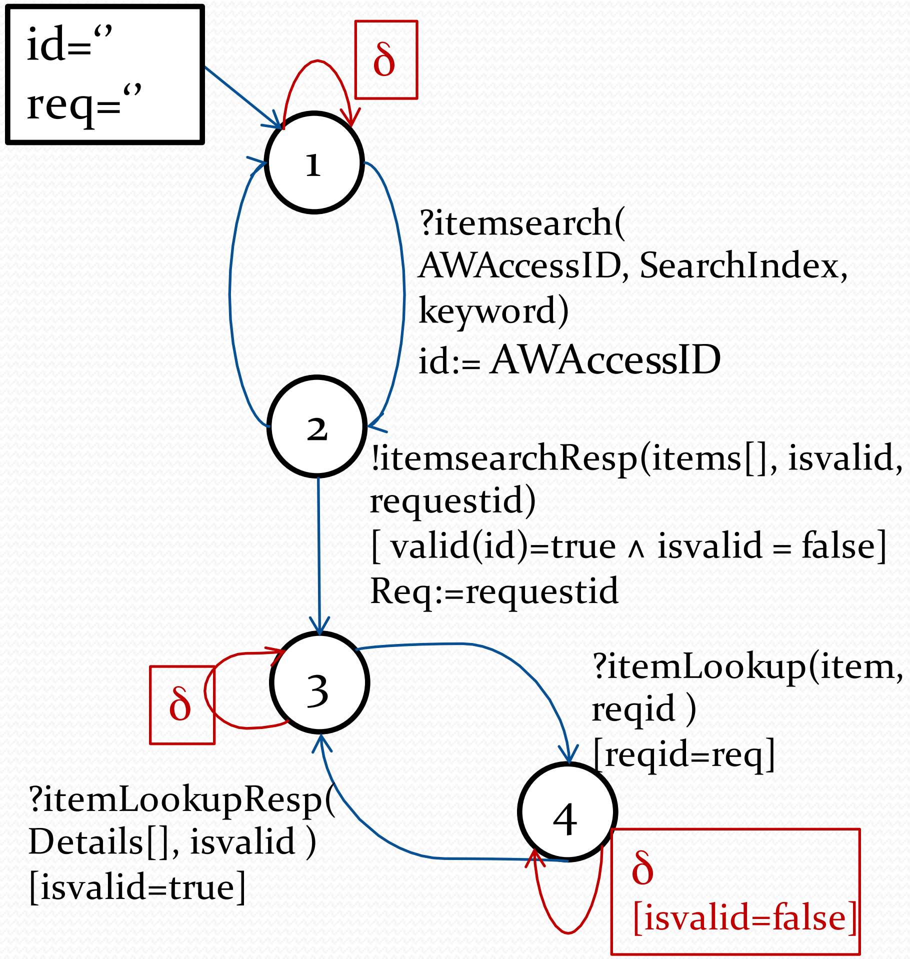
IOSTS->IOLTS

- Express behaviours that may be infinite

→ underlying (valued) model : IOLTS semantic

$$S = \left\langle L, l_0, V, V_0, I, \Lambda, \rightarrow \right\rangle$$

IOSTS->IOLTS



id=‘’
req=‘’

1

δ

?itemsearch(
AWAccessID, SearchIndex,
keyword)
id:= AWAccessID

2

!itemsearchResp(items[], isvalid,
requestid)
[valid(id)=true ∧ isvalid = false]
Req:=requestid

3

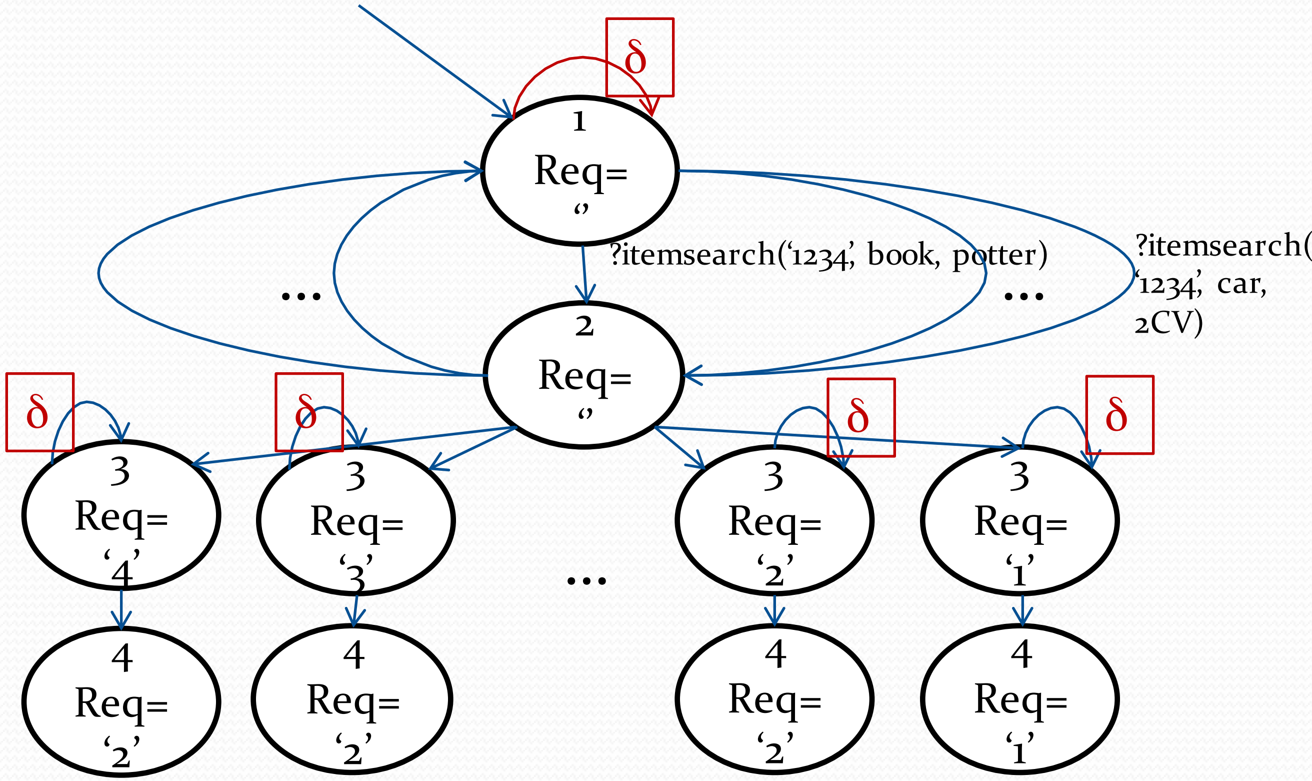
δ

?itemLookup(item,
reqid)
[reqid=req]

4

δ
[isvalid=false]

?itemLookupResp(
Details[], isvalid)
[isvalid=true]



δ

1
Req=
‘’

?itemsearch(‘1234’, book, potter)

?itemsearch(
‘1234’, car,
2CV)

…

…

2
Req=
‘’

δ

3
Req=
‘4’

4
Req=
‘2’

δ

3
Req=
‘3’

4
Req=
‘2’

…

δ

3
Req=
‘2’

4
Req=
‘2’

δ

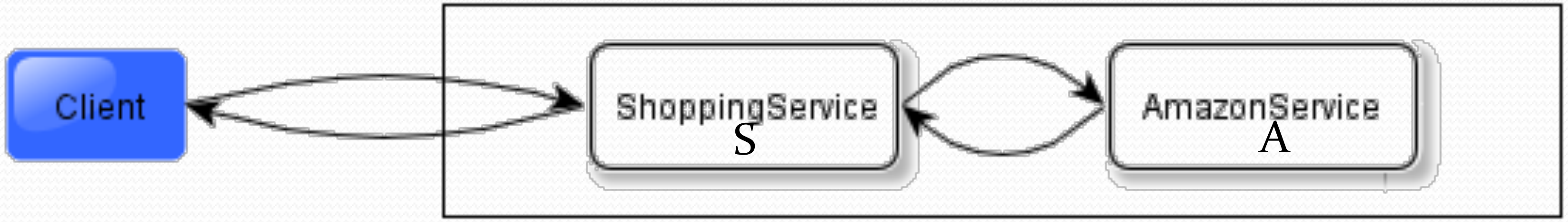
3
Req=
‘1’

4
Req=
‘1’

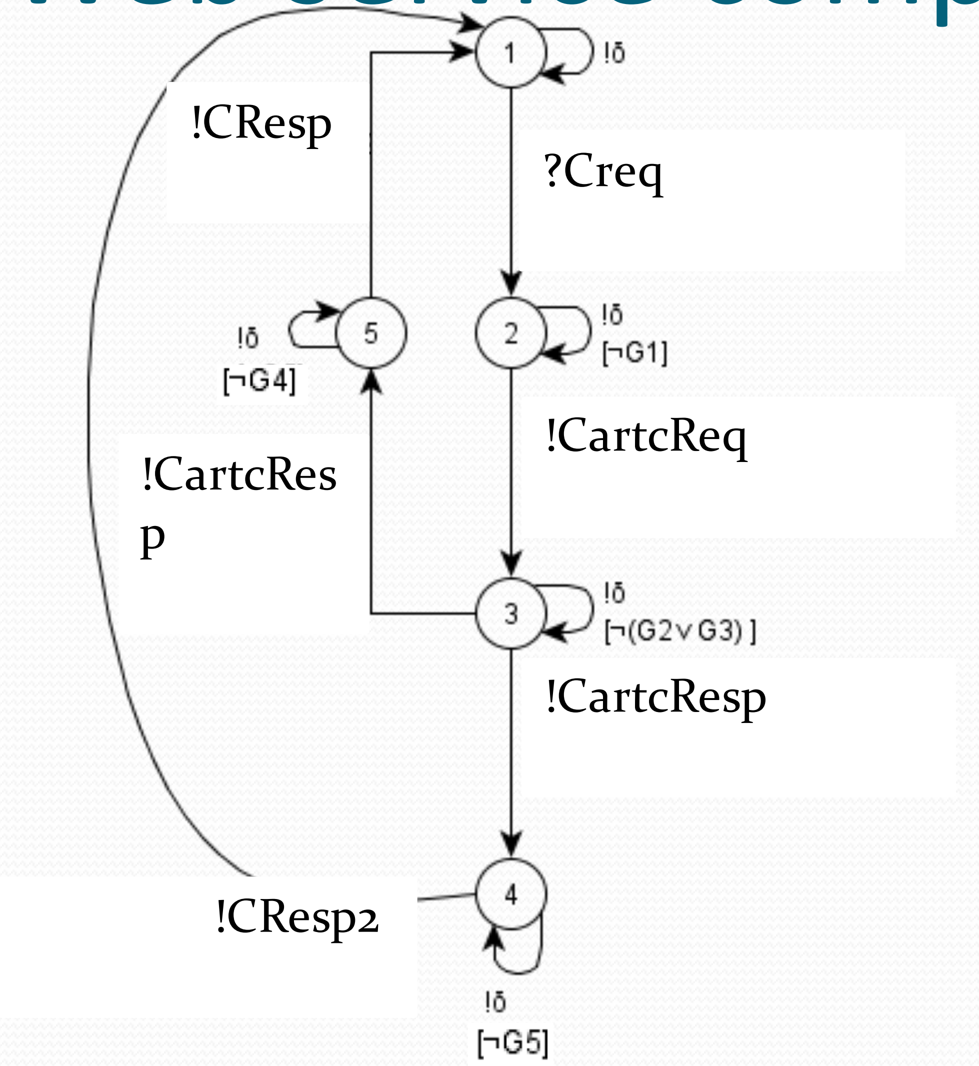
Web service composition modelisation

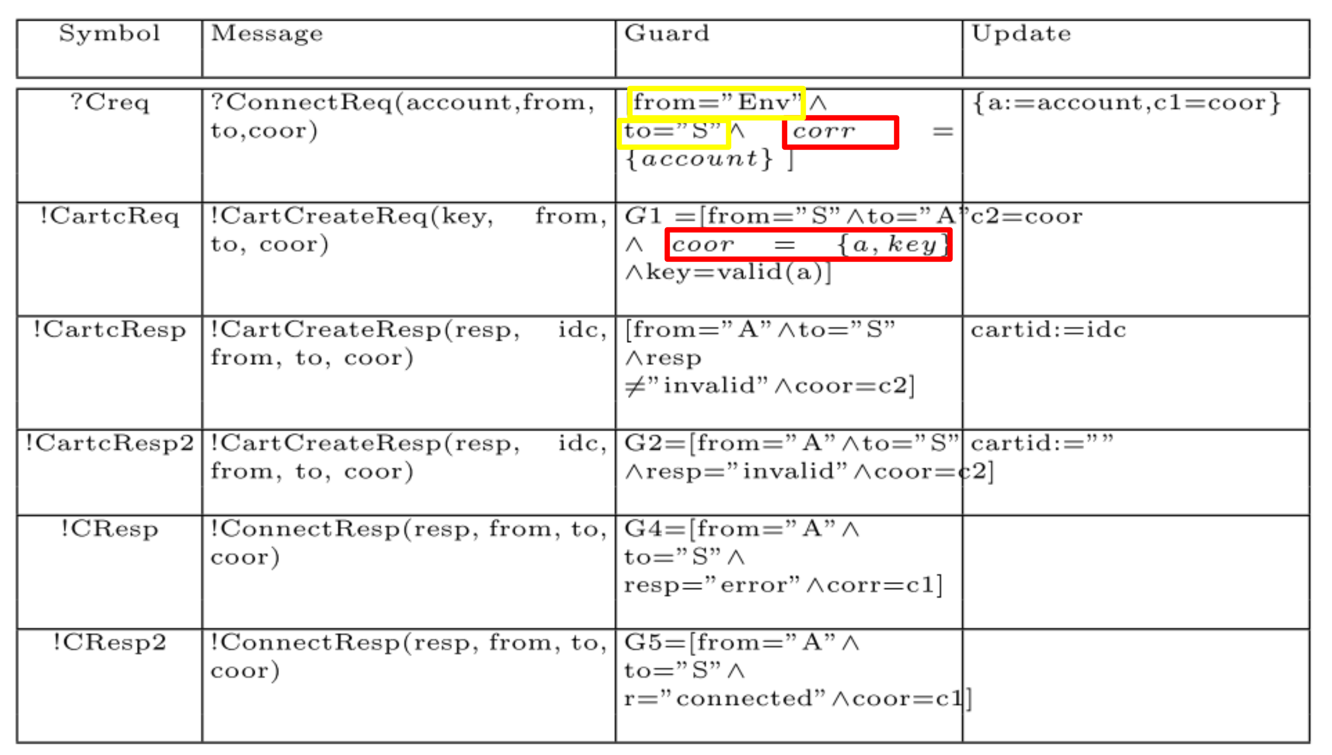
- Desc. of the services, parameters, correlations, etc.

- Example:



Web service composition modelisation



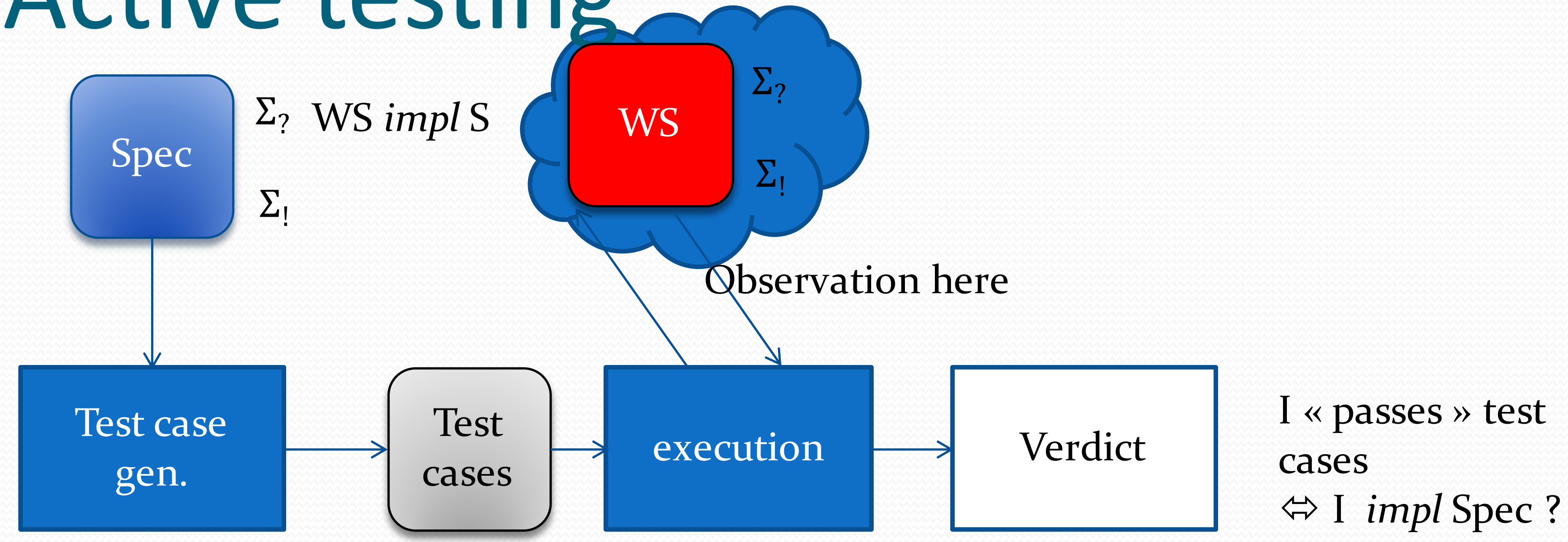


Symbol	Message	Guard	Update
?Creq	?ConnectReq(account,from, to,coor)	from="Env"∧ to="S"∧ *corr* = {*account*}]	{a:=account,c1=coor}
!CartcReq	!CartCreateReq(key, from, to, coor)	*G*1 =[from="S"∧to="A"∧ *coor* = {*a*, *key*} ∧key=valid(a)]	c2=coor
!CartcResp	!CartCreateResp(resp, idc, from, to, coor)	[from="A"∧to="S" ∧resp ≠"invalid"∧coor=c2]	cartid:=idc
!CartcResp2	!CartCreateResp(resp, idc, from, to, coor)	G2=[from="A"∧to="S" ∧resp="invalid"∧coor=c2]	cartid:=""
!CResp	!ConnectResp(resp, from, to, coor)	G4=[from="A"∧ to="S"∧ resp="error"∧corr=c1]	
!CResp2	!ConnectResp(resp, from, to, coor)	G5=[from="A"∧ to="S"∧ r="connected"∧coor=c1]	

Model-based testing in clouds

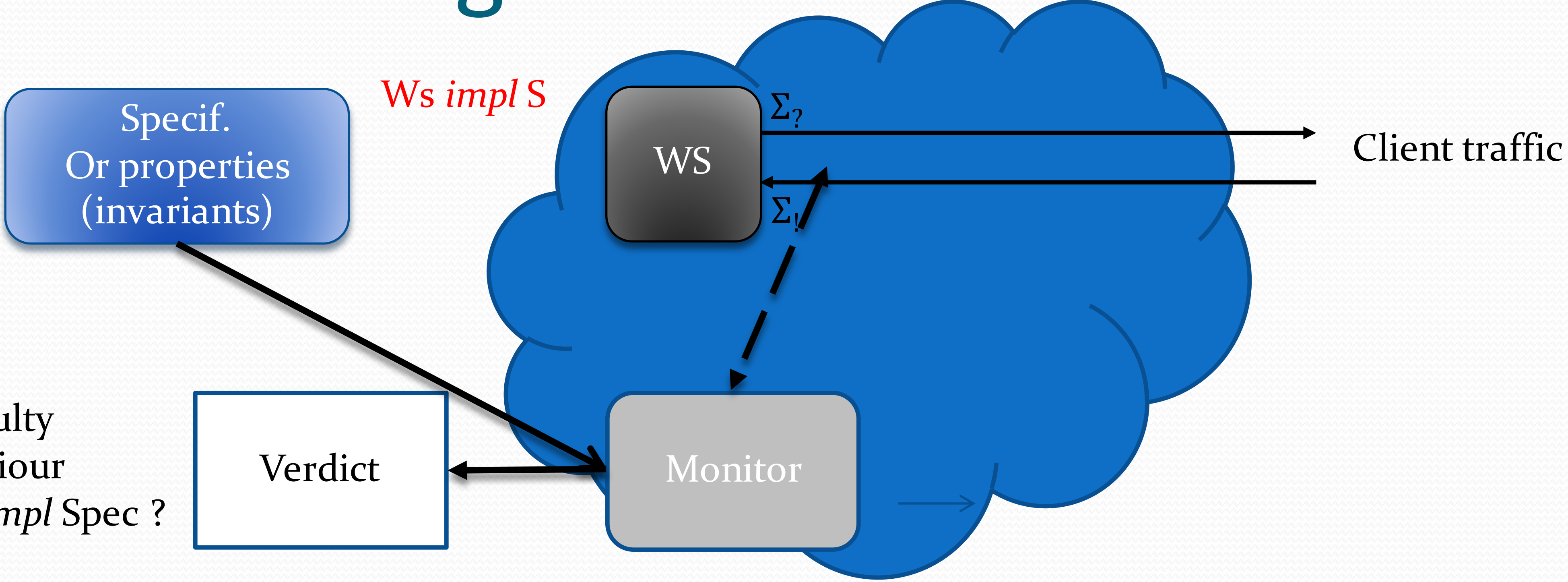
- Type of testing
  - active
  - passive, Runtime Verification
- Security, robustness, conformance etc.

Active testing



From web service composition model -> test case gen. -> test case exec. -> verdict

Passive testing of Web services



Monitoring of web service compositions
No direct interaction with WS

[ACN10][BDANG7][BP09], etc.

Passive testers

- Offline modes
- Trace collection
- Trace of WS belongs to traces of S?
- Or property traces ?

- Online mode

Online Tester based on a « checker state algorithm »

- Simplified algo:
  - Stores the specification states reached in L
- Message observed m =>
  - Covers specification (or derived model) from states of L with m -> set of states S'
  - Check whether the states of S' are « bad » states => fail
  - Check whether the states of S' are « good » states => invariant holds
    - L = L'
    - And so forth

Runtime verification of Web services

- Comes from verification
- Verification of prop. at runtime (during execution)

- Prop. in logics (LTL, CTL, nomad, etc.), automata, etc.

- Check whether prop. hold at runtime (passively)

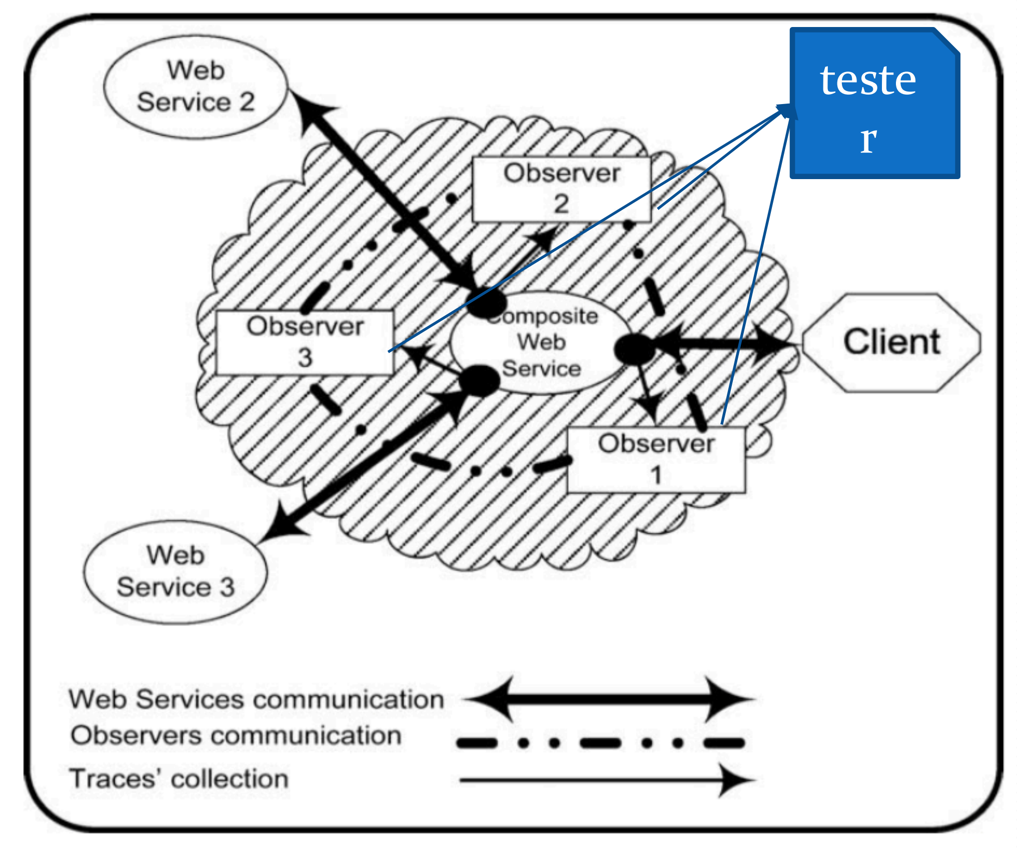
  - Generation of a Monitor model from properties
  - Monitor + passive tester -> verdicts: violation of prop, etc.

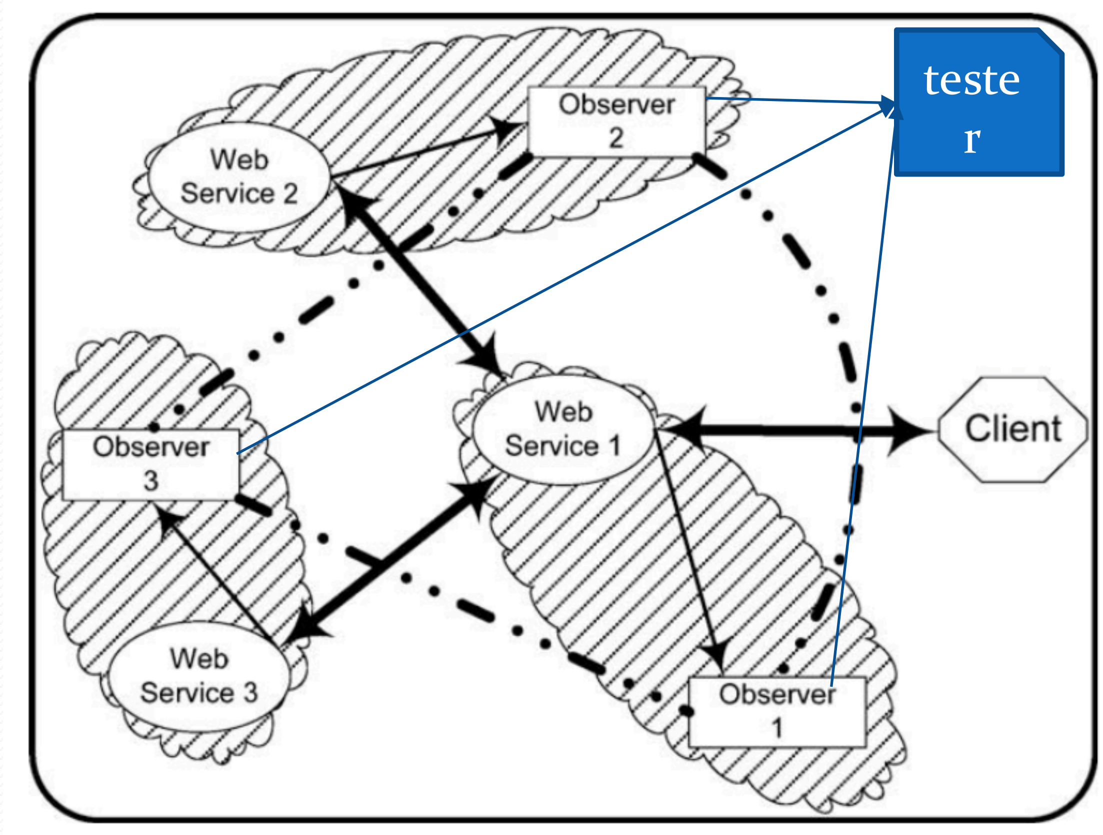
- [CPFC10][RPG06] [SC14], etc.

Observations, testing architectures

- Collect of the WS requests, responses in Clouds
  - With network sniffers? (when VM are available)
  - By modifying cloud engines ?
    - ⇒ Difficult
  - By instrumentation of the WS codes
  - With Agents: SNMP agent, mobile agents

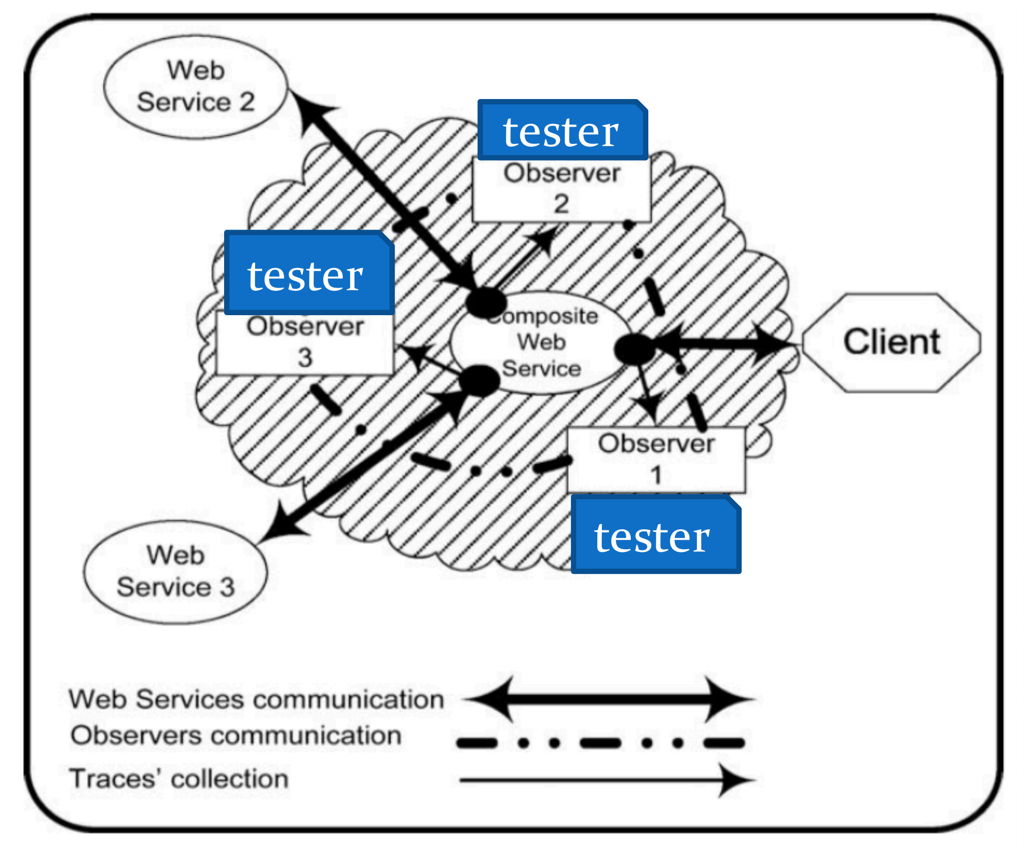
Observations, testing architectures

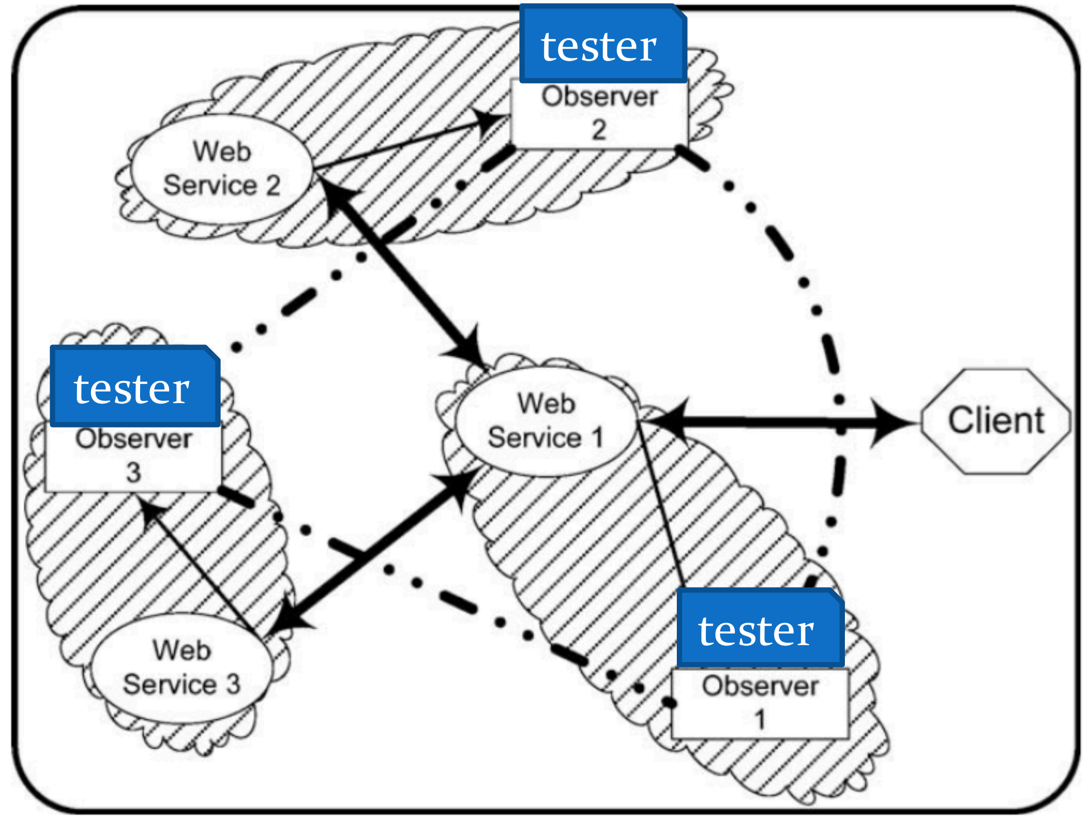




- [BDSG09] [SP15]

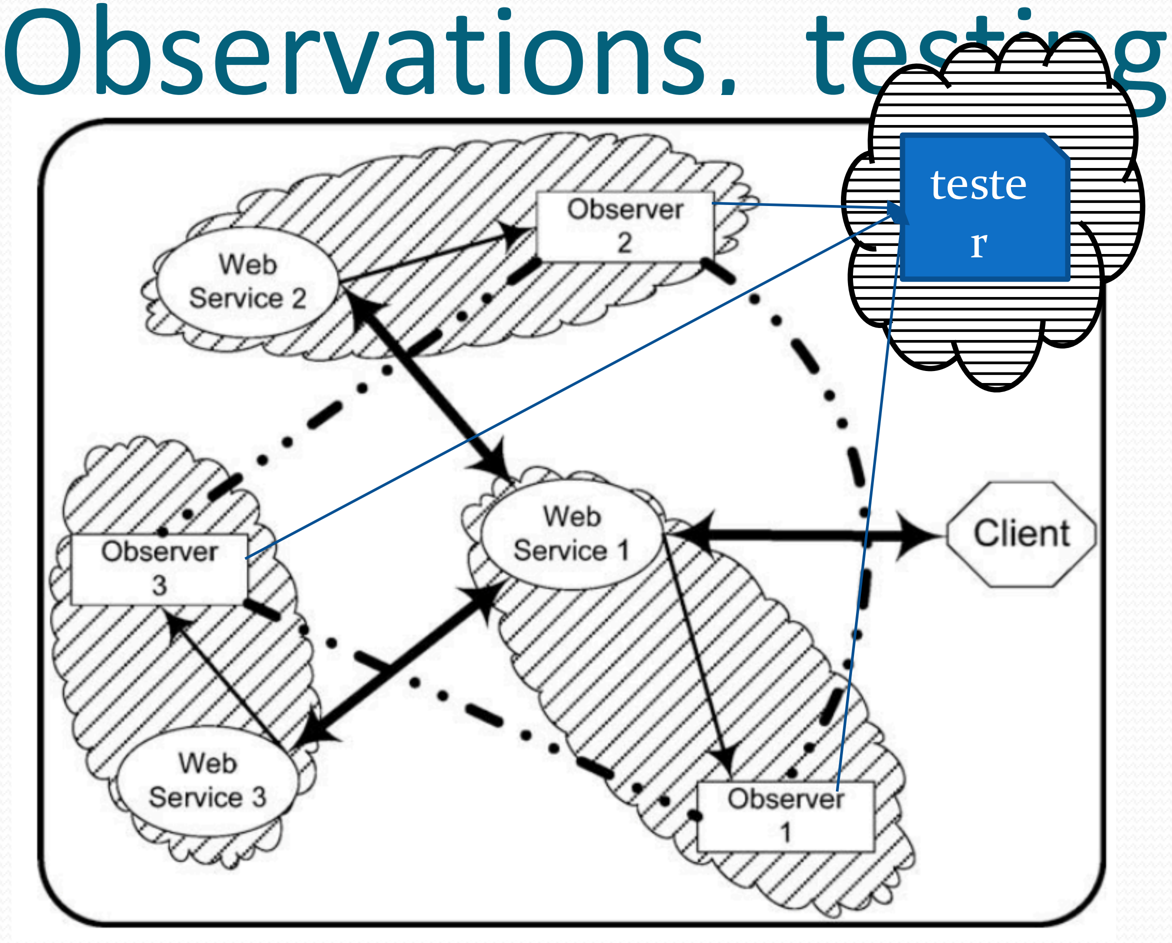
Observations, testing architectures

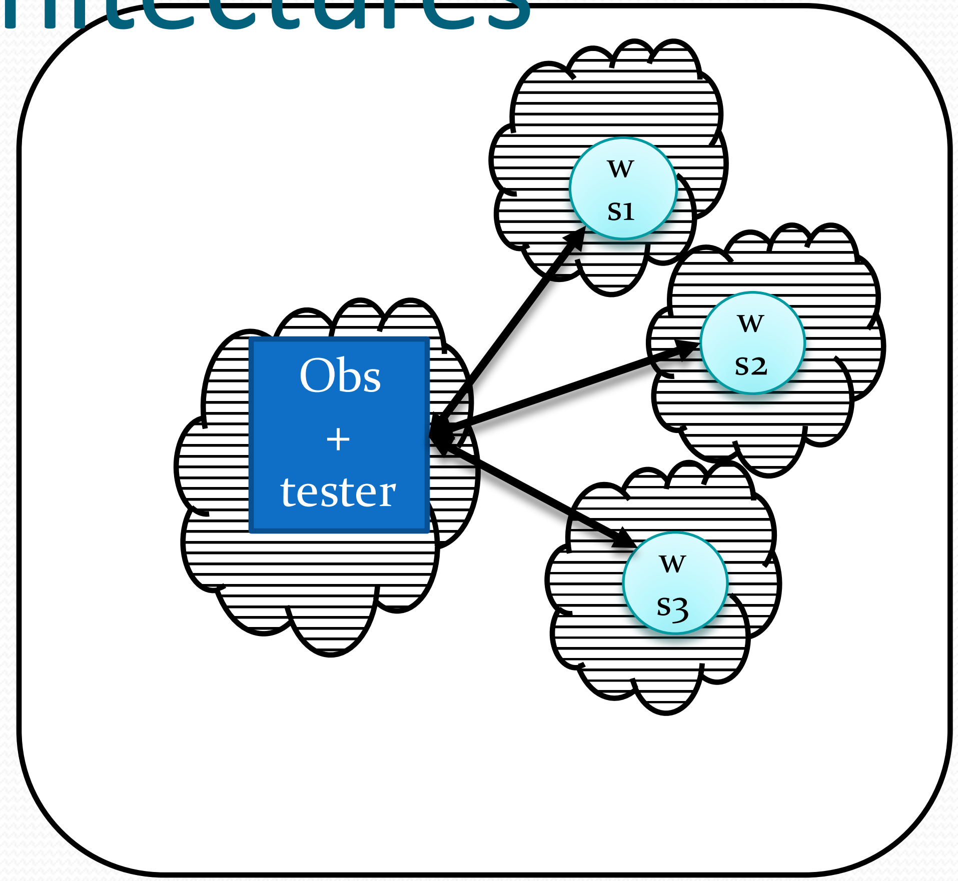




- [BDSG09] [SP15]

Observations, testing architectures





- [BDSG09] [SP15]

Testing in Clouds issues

1. Web service composition level of abstraction ?
   - Test the composite Service
   - Test of all the components?

2. Controllability
   - Can all the service be requested ? (workers: no)

3. Observability of the messages in Clouds ?
   - -> need of specific observers
   - Sniffers cannot be added to PaaS
   - -> code instrumentation, Cloud instrumentation, agents, etc.

Testing in Clouds issues

4. Message receipt modes
   - Synchronous mode ? No
   - Clouds => delays => asynchronous mode is closer to reality [NKRW11]
   - "Asynchronous communication delays obscure the observation of the tester"
   - Loss of messages, interleaving, delays (HTTP timeouts, etc.)-> see [PYL03] [NKRW11] , etc.

=> Different implementation relations

- Preorder
- ioco -> ioco$_U$ (under-specified models) [VRT03], etc.

=> Show that you have Finite test case number / sound test algorithms

- WS methods composed of parameters -> difficult to build exhaustive test suite
- -> need of test assumptions

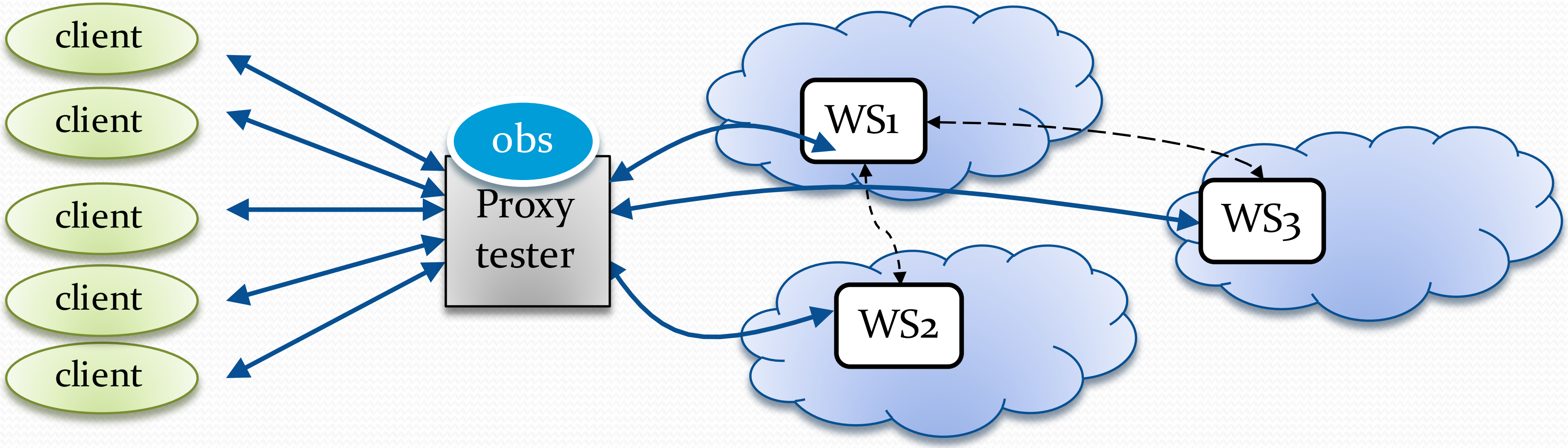
III Testing in clouds example

Passive testing with proxy-tester

Passive testing with proxy-testers

[S11d] [SP15]

- Proxy-testing principle

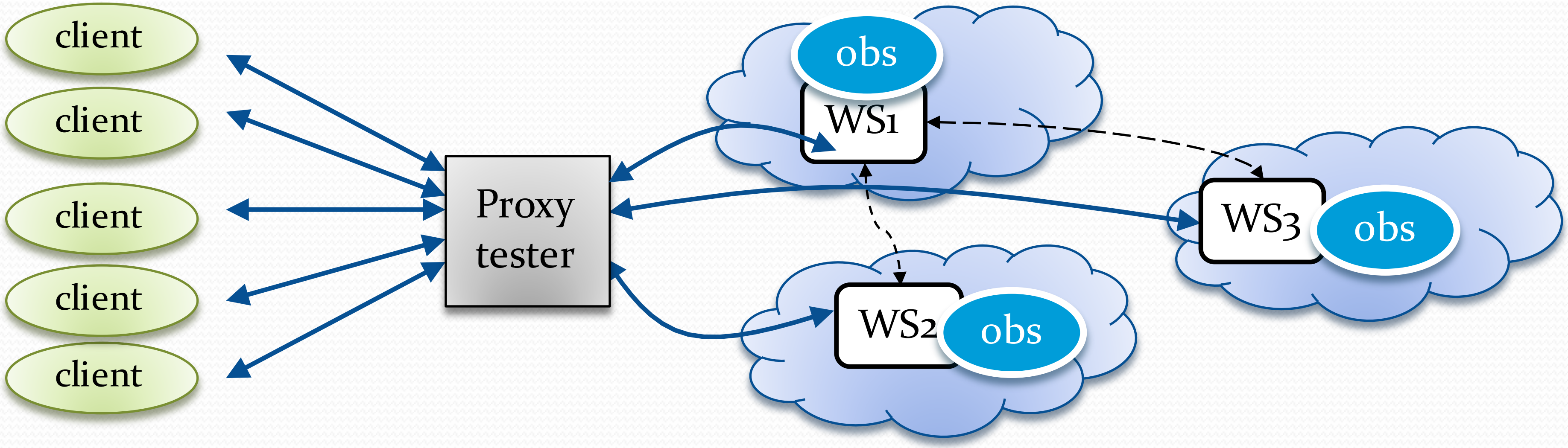


- Assumptions: message redirection to proxy (possible in practice), message synchronisation (light protocol to order messages, network latency << quiescence obs.)

Passive testing with proxy-testers

[S11d] [SP15]

- Proxy-testing principle



- Assumptions: message redirection to proxy (possible in practice), message synchronisation (light protocol to order messages, network latency << quiescence obs.)

Passive testing with proxy-testers

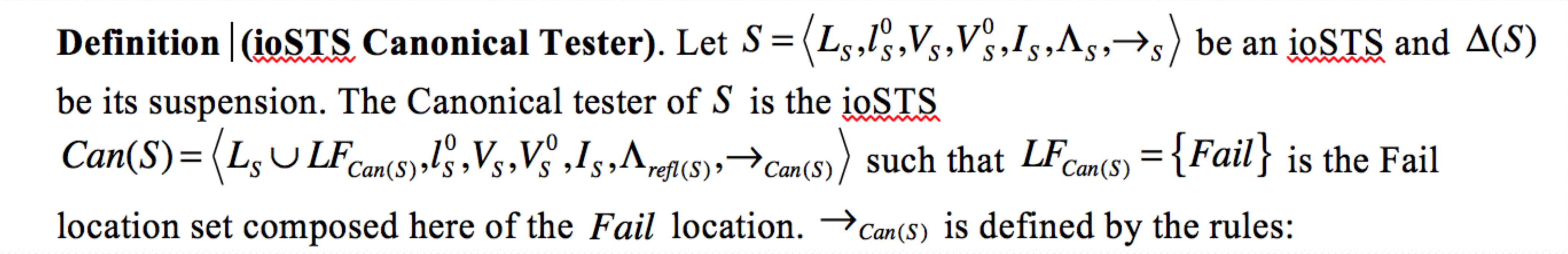
[S11d] [SP15]

- Passive testing with proxy concept ? =>
  1. passive tester algorithm
  2. + automatic gen. of proxy-tester models for checking whether ioco holds

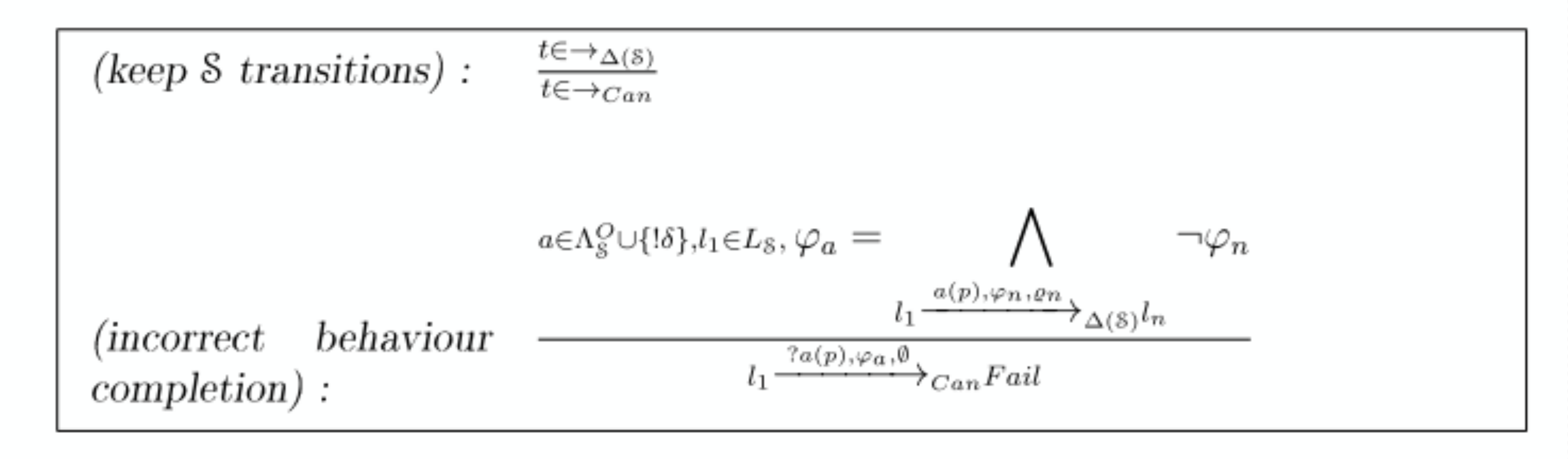
- Proxy-tester model to express message exchanged
- between client <-> Web services
- among Web service

- Proxy-tester model generated from specification

IOSTS canonical tester



Definition | (ioSTS Canonical Tester). Let $S=\langle L_S, l_S^0, V_S, V_S^0, I_S, \Lambda_S, \rightarrow_S\rangle$ be an ioSTS and $\Delta(S)$ be its suspension. The Canonical tester of S is the ioSTS $Can(S)=\langle L_S \cup LF_{Can(S)}, l_S^0, V_S, V_S^0, I_S, \Lambda_{refl(S)}, \rightarrow_{Can(S)}\rangle$ such that $LF_{Can(S)}=\{Fail\}$ is the Fail location set composed here of the *Fail* location. $\rightarrow_{Can(S)}$ is defined by the rules:

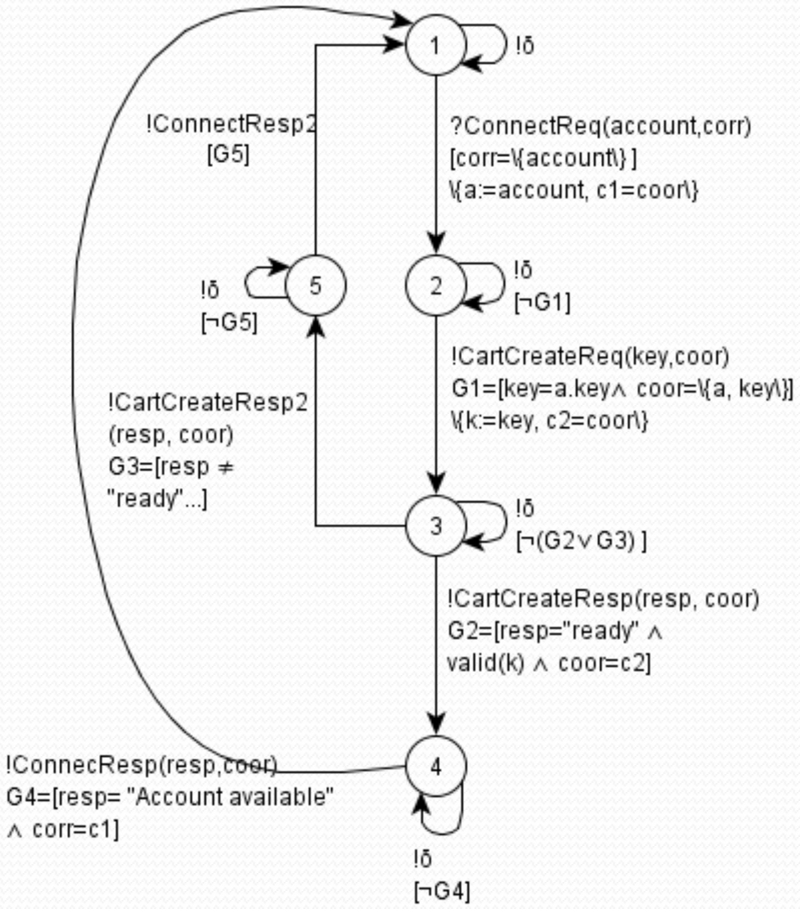


(keep $\mathcal{S}$ transitions) : $\dfrac{t\in\rightarrow_{\Delta(\mathcal{S})}}{t\in\rightarrow_{Can}}$

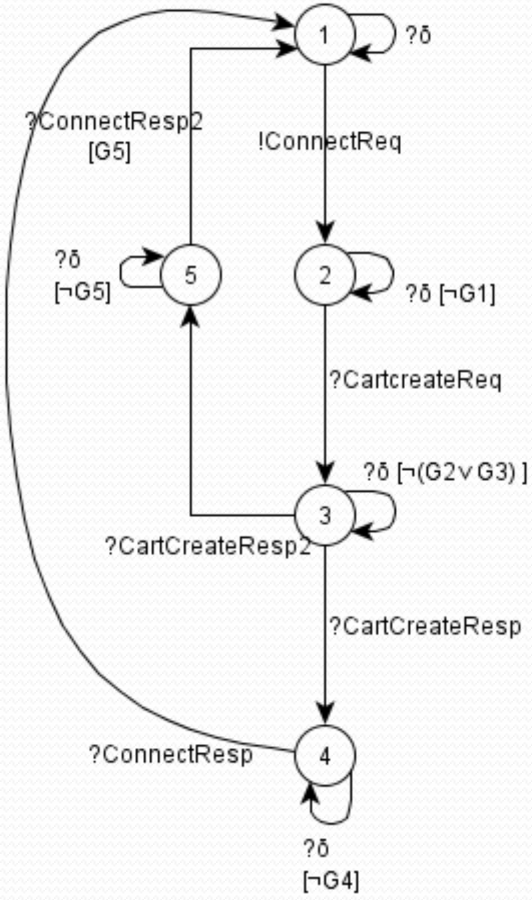
(incorrect behaviour completion) :

$$\frac{a\in\Lambda^O_{\mathcal{S}}\cup\{!\delta\}, l_1\in L_{\mathcal{S}}, \varphi_a = \bigwedge_{l_1 \xrightarrow{a(p),\varphi_n,\varrho_n}_{\Delta(\mathcal{S})} l_n} \neg\varphi_n}{l_1 \xrightarrow{?a(p),\varphi_a,\emptyset}_{Can} Fail}$$

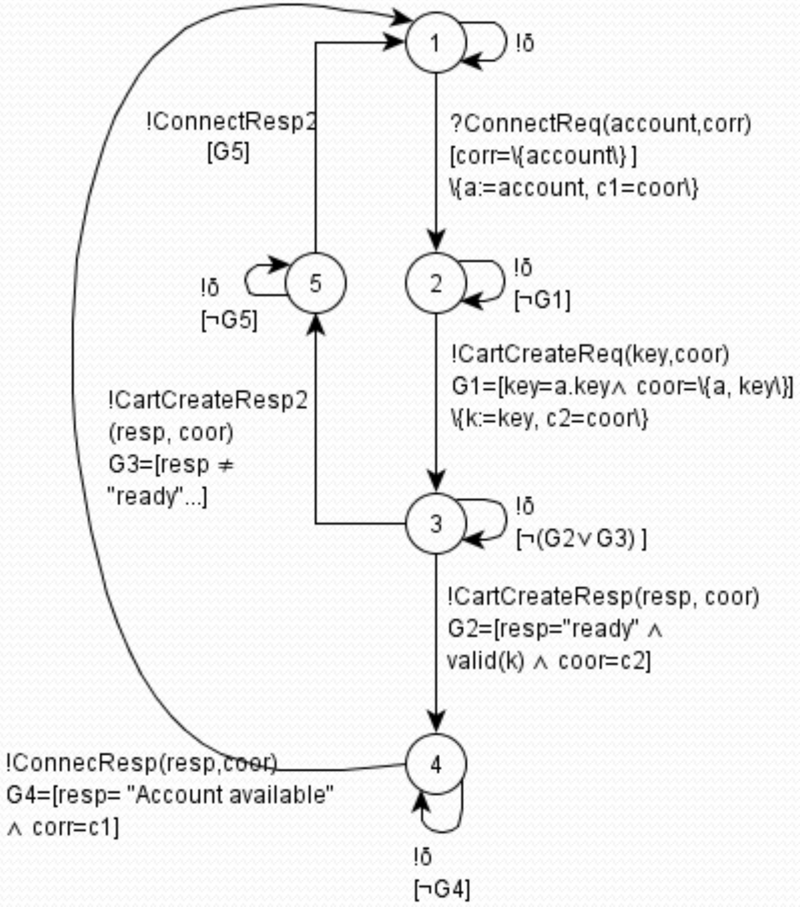
IOSTS canonical tester



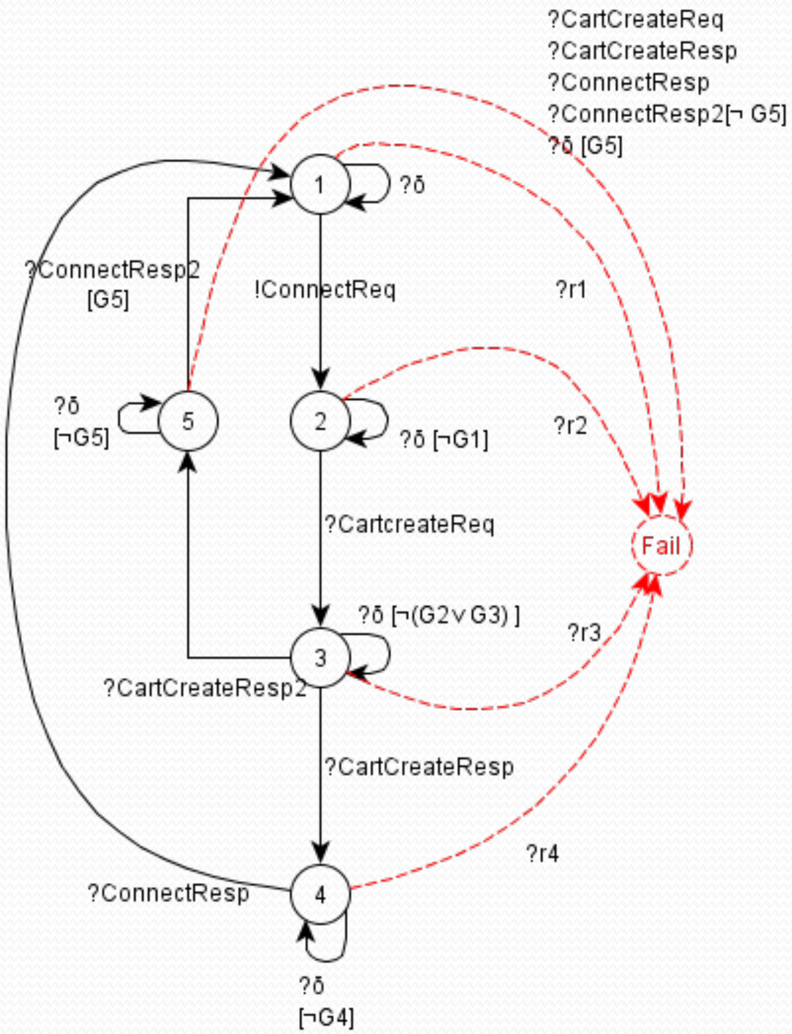
Caonical
tester



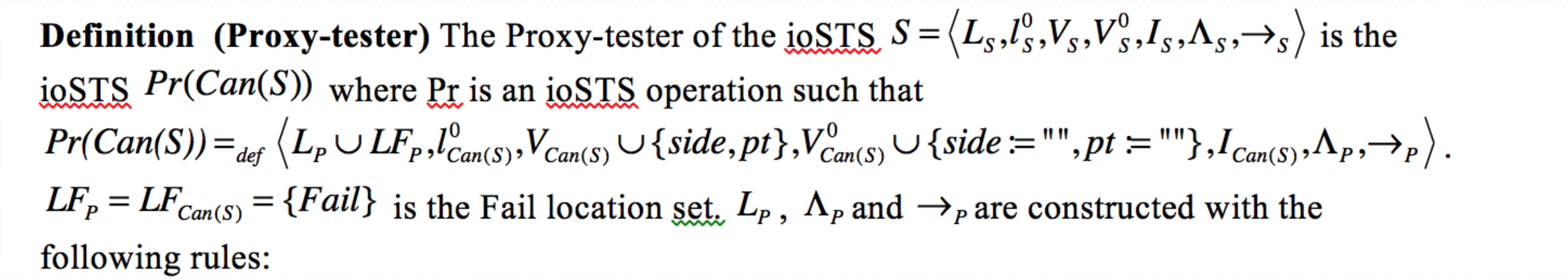
IOSTS canonical tester



Caonical tester



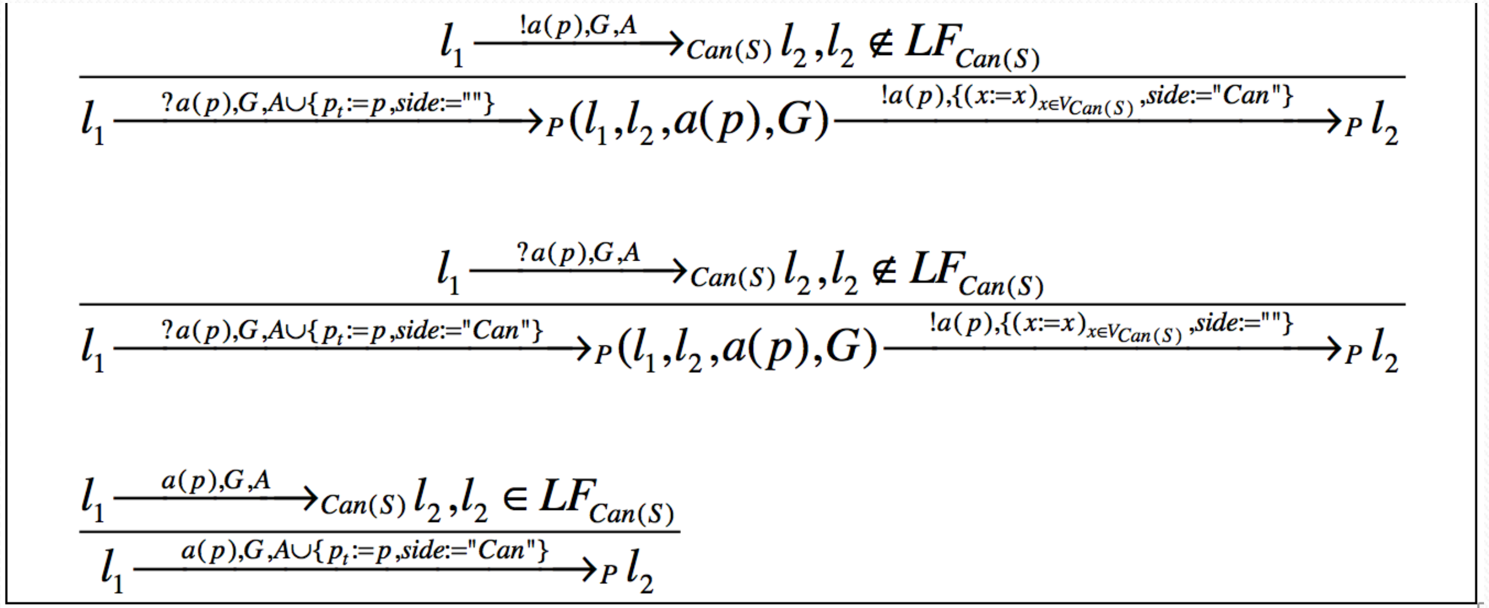
Proxy-tester model gen.



Definition (Proxy-tester) The Proxy-tester of the ioSTS $S = \langle L_S, l_S^0, V_S, V_S^0, I_S, \Lambda_S, \rightarrow_S \rangle$ is the ioSTS $Pr(Can(S))$ where Pr is an ioSTS operation such that

$$Pr(Can(S)) =_{def} \langle L_P \cup LF_P, l_{Can(S)}^0, V_{Can(S)} \cup \{side, pt\}, V_{Can(S)}^0 \cup \{side := "", pt := ""\}, I_{Can(S)}, \Lambda_P, \rightarrow_P \rangle .$$

$LF_P = LF_{Can(S)} = \{Fail\}$ is the Fail location set. L_P , Λ_P and $\rightarrow_P$ are constructed with the following rules:



CLient to WS

$$\frac{l_1 \xrightarrow{!a(p),G,A}_{Can(S)} l_2, l_2 \notin LF_{Can(S)}}{l_1 \xrightarrow{?a(p),G,A\cup\{p_t:=p,side:=""\}}_P (l_1, l_2, a(p), G) \xrightarrow{!a(p),\{(x:=x)_{x\in V_{Can(S)}},side:="Can"\}}_P l_2}$$

WS to Any

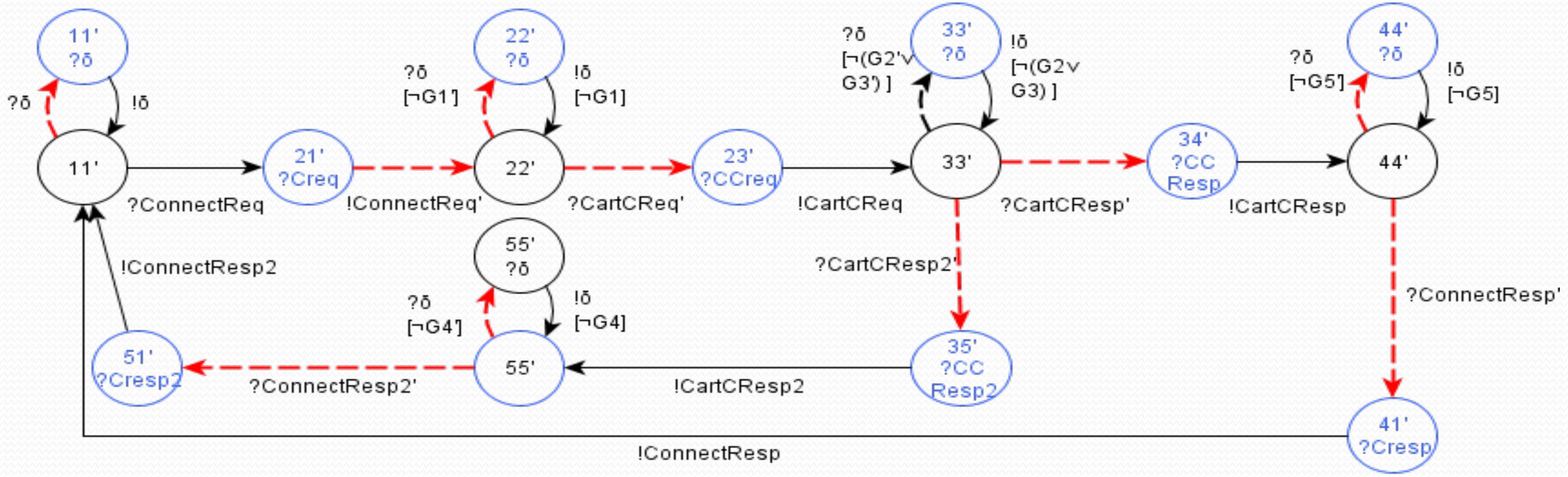
$$\frac{l_1 \xrightarrow{?a(p),G,A}_{Can(S)} l_2, l_2 \notin LF_{Can(S)}}{l_1 \xrightarrow{?a(p),G,A\cup\{p_t:=p,side:="Can"\}}_P (l_1, l_2, a(p), G) \xrightarrow{!a(p),\{(x:=x)_{x\in V_{Can(S)}},side:=""\}}_P l_2}$$

Wrong behaviour

$$\frac{l_1 \xrightarrow{a(p),G,A}_{Can(S)} l_2, l_2 \in LF_{Can(S)}}{l_1 \xrightarrow{a(p),G,A\cup\{p_t:=p,side:="Can"\}}_P l_2}$$

Proxy-tester model gen.

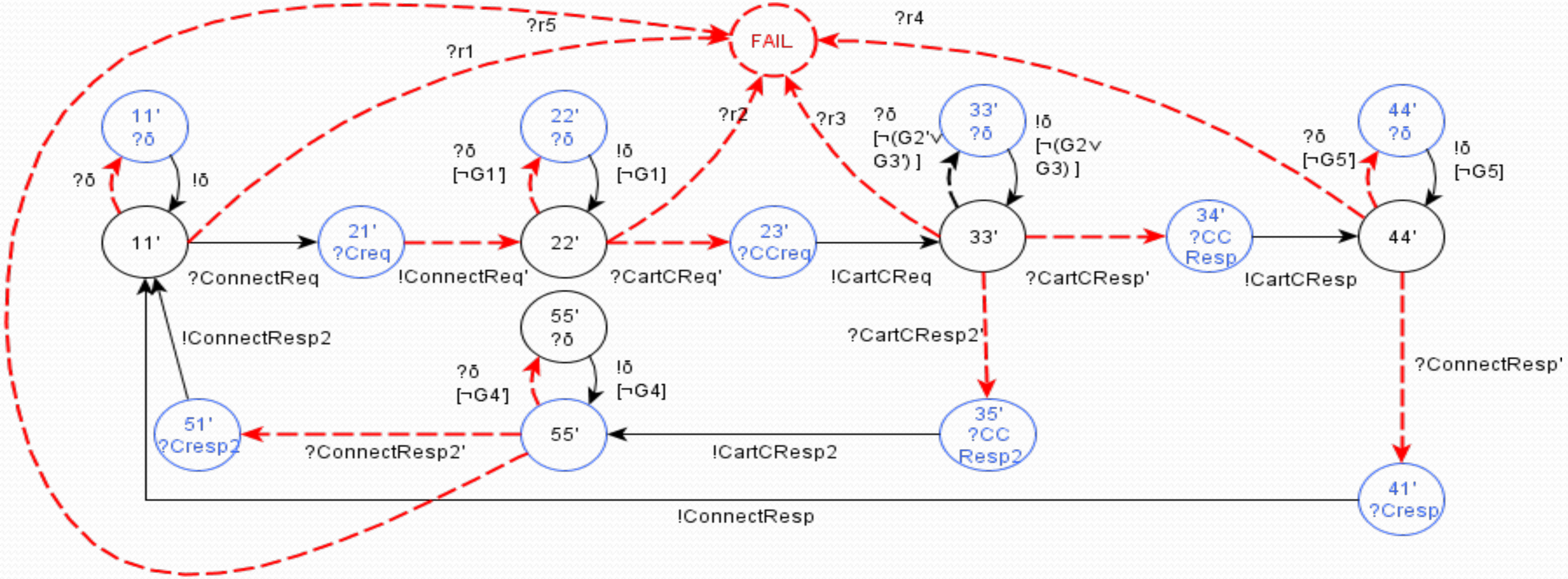
- Illustration:



Property on traces: $Traces^{CAN}_{Fail}(P\ (S)) = Traces_{Fail}(CAN(S))$

Proxy-tester model gen.

- Illustration:



Property on traces: $Traces_{Fail}^{CAN}(P\ (S)) = Traces_{Fail}(CAN(S))$

What to do with proxy-tester model ?

- Ioco implementation relation

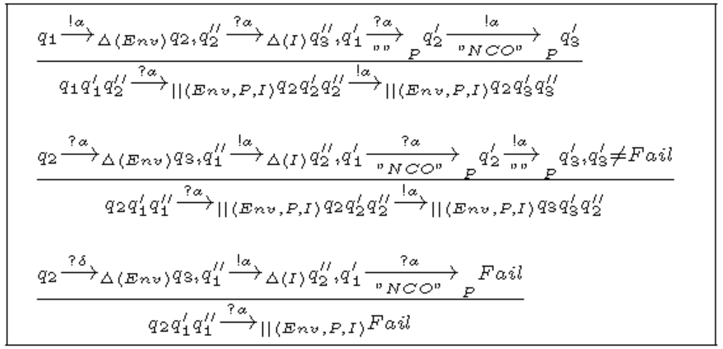
$I\ ioco\ S \Leftrightarrow \forall \sigma \in Traces(\Delta(S)).(O\cup\{\delta\}) \cap Traces(\Delta(I)) \subseteq Traces(\Delta(S))$ (RUSU05a)

$I\ ioco\ S \Leftrightarrow Traces(\Delta(I)) \cap NCTraces(\Delta(S))) = \emptyset$

Prop. on traces
$NCTraces(\Delta(S))$
$= Traces_{Fail}^{can}(CAN(S))$

$I\ ioco\ S \Leftrightarrow Traces(\Delta(I)) \cap Traces_{Fail}^{CAN}(P(S)) = \emptyset$

Def. Parallel execution
$||(\mathrm{Env}, \mathrm{P}, \mathrm{I}\ ) = \mathrm{IOLTS}$



$$\frac{q_1 \xrightarrow{!a}_{\Delta(Env)} q_2, q_2'' \xrightarrow{?a}_{\Delta(I)} q_3'', q_1' \xrightarrow[\text{""}]{?a}_{P} q_2' \xrightarrow[\text{"NCO"}]{!a}_{P} q_3'}{q_1 q_1' q_2'' \xrightarrow{?a}_{||(Env,P,I)} q_2 q_2' q_2'' \xrightarrow{!a}_{||(Env,P,I)} q_2 q_3' q_3''}$$

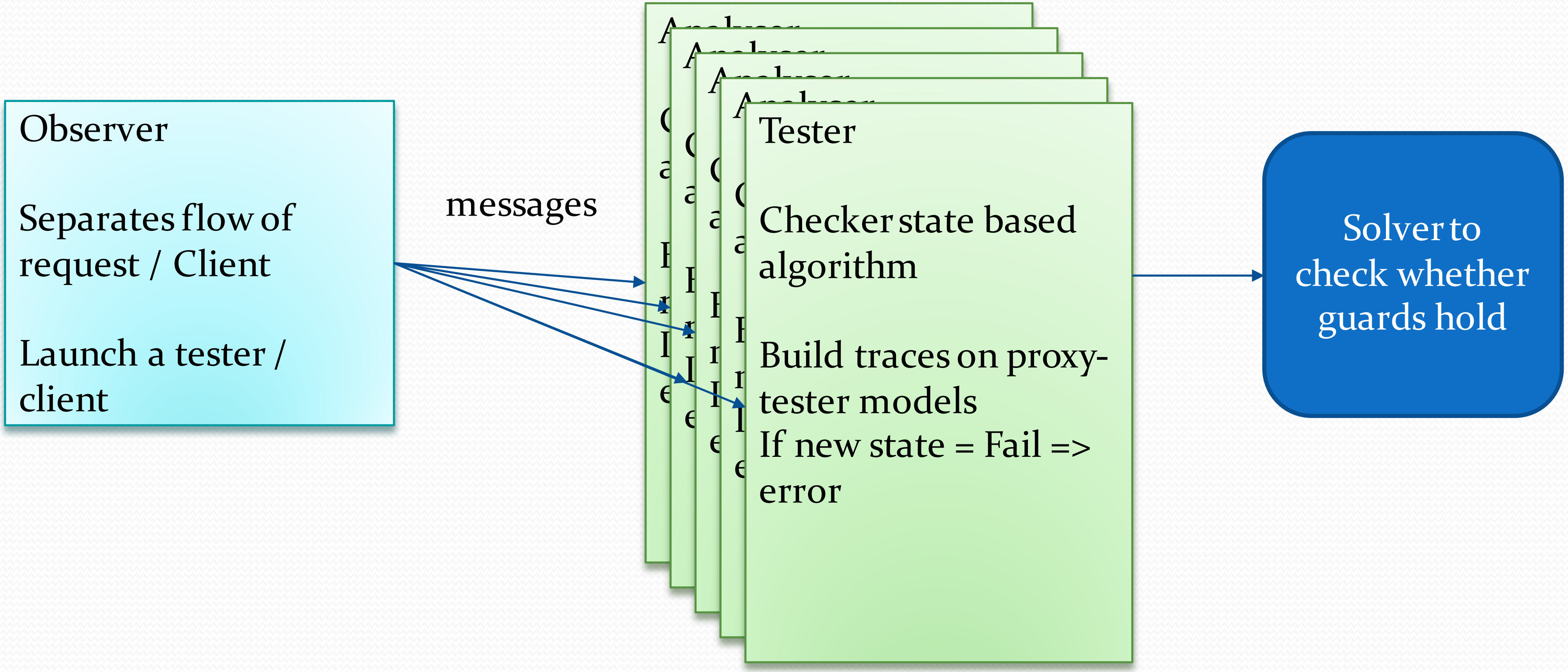
$$\frac{q_2 \xrightarrow{?a}_{\Delta(Env)} q_3, q_1'' \xrightarrow{!a}_{\Delta(I)} q_2'', q_1' \xrightarrow[\text{"NCO"}]{?a}_{P} q_2' \xrightarrow[\text{""}]{!a}_{P} q_3', q_3' \neq Fail}{q_2 q_1' q_1'' \xrightarrow{?a}_{||(Env,P,I)} q_2 q_2' q_2'' \xrightarrow{!a}_{||(Env,P,I)} q_3 q_3' q_2''}$$

$$\frac{q_2 \xrightarrow{?\delta}_{\Delta(Env)} q_3, q_1'' \xrightarrow{!a}_{\Delta(I)} q_2'', q_1' \xrightarrow[\text{"NCO"}]{?a}_{P} Fail}{q_2 q_1' q_1'' \xrightarrow{?a}_{||(Env,P,I)} Fail}$$

$I\ ioco\ S \Leftrightarrow Traces_{Fail}(||(\mathrm{Env}, \mathrm{P}, \mathrm{I}\ )) = \emptyset$

⇒ Proxy tester + passive tester Algo:
Builds traces
If a trace -> Fail => error

Passive tester algorithm



Observer

Separates flow of request / Client

Launch a tester / client

Tester

Checker state based algorithm

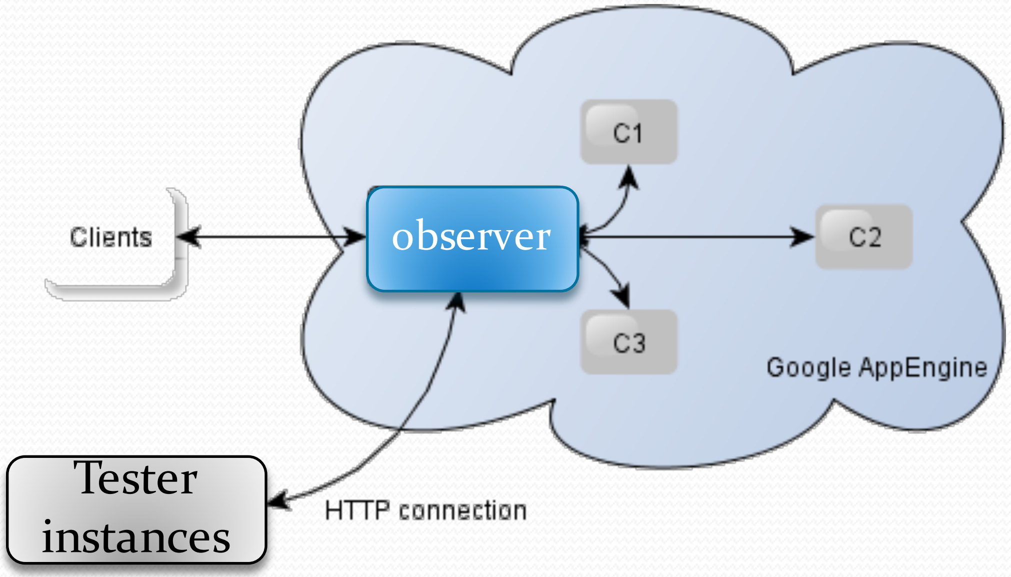
Build traces on proxy-tester models

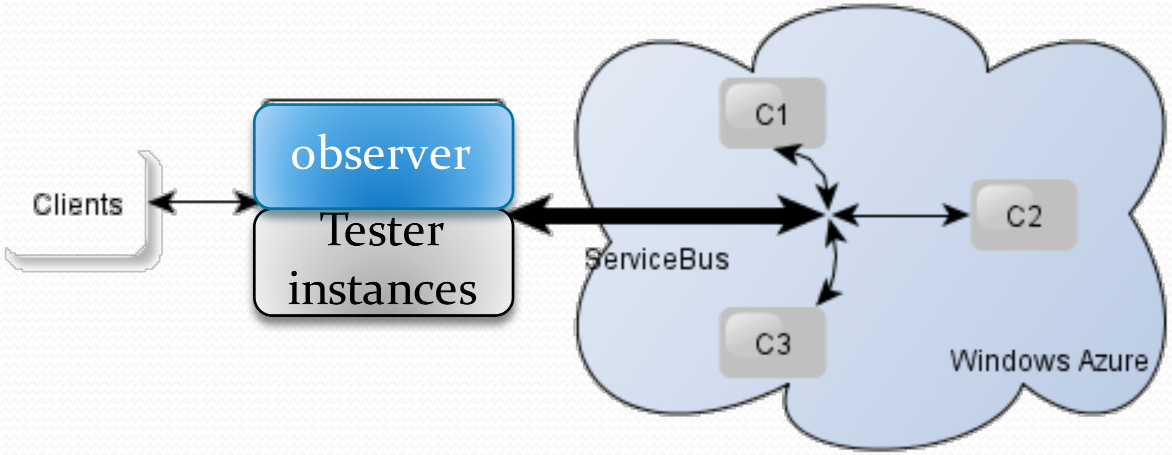
If new state = Fail => error

Solver to check whether guards hold

Passive testing with proxy-tester

- Implementation on 2 Clouds
  - Windows Azure and Google AppEngine





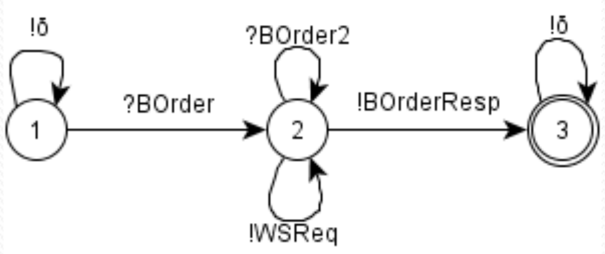
Runtime verification with proxy-testers

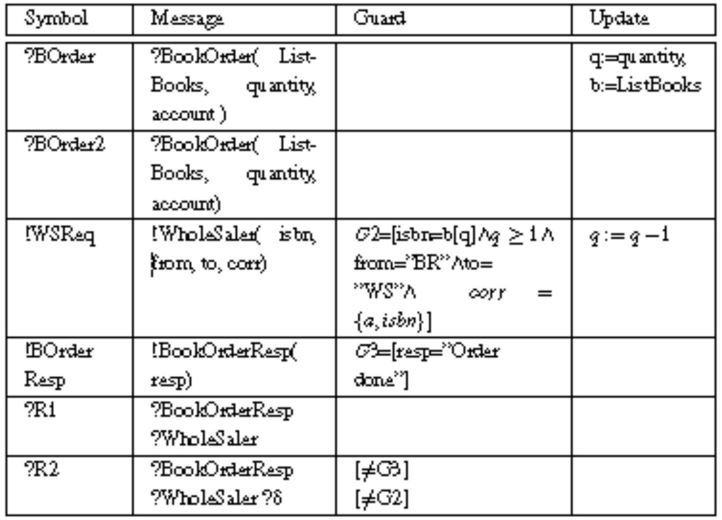
- Completion of Proxy-tester models with
  - Safety properties ‘’nothing bad ever happens”
  - “A language L is a *safety language* if every word not in L has a finite bad prefix”
- Safety property modeled with ioSTSs ☺

  IOSTS expresses behaviours that violates property with a Violate state

Runtime verification with proxy-testers

safety property example



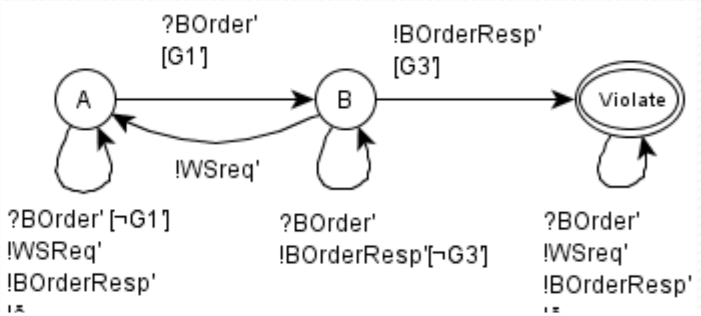


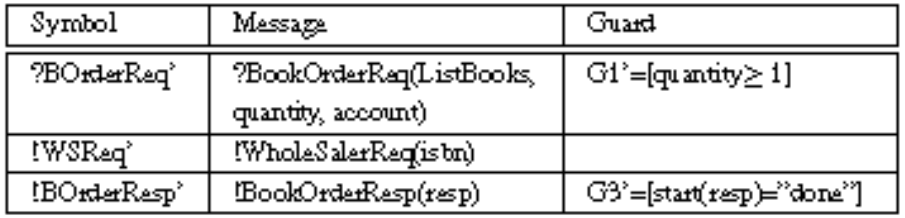
Symbol	Message	Guard	Update

?BOrder	?BookOrder(List-Books, quantity, account)		q:=quantity,
			b:=ListBooks

?BOrder2	?BookOrder(List-Books, quantity, account)		
!WSReq	!WholeSaler(isbn, from, to, corr)	$G2$=[isbn=b[q]∧$q \geq 1 \wedge$ from=”BR”∧to= ”WS”∧ $corr = \{a, isbn\}$]	$q := q - 1$
!BOrder Resp	!BookOrderResp(resp)	$G3$=[resp=”Order done”]	
?R1	?BookOrderResp ?WholeSaler		
?R2	?BookOrderResp ?WholeSaler ?δ	[≠G3] [≠G2]	

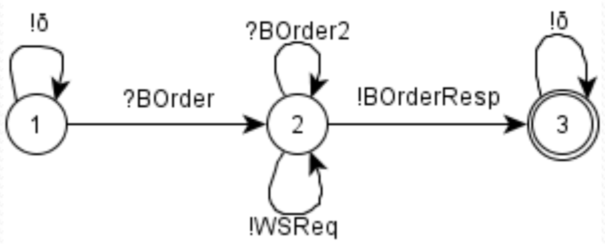
”the receipt of an order confirmation (labelled by done) without requesting the wholesaler is BAD”



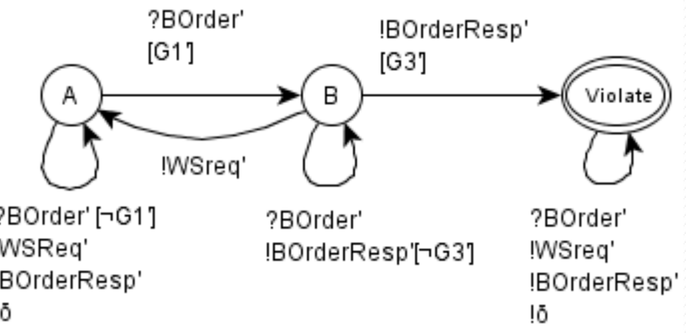


Symbol	Message	Guard
?BOrderReq’	?BookOrderReq(ListBooks, quantity, account)	G1’=[quantity≥ 1]
!WSReq’	!WholeSalerReq(isbn)	
!BOrderResp’	!BookOrderResp(resp)	G3’=[start(resp)=”done”]

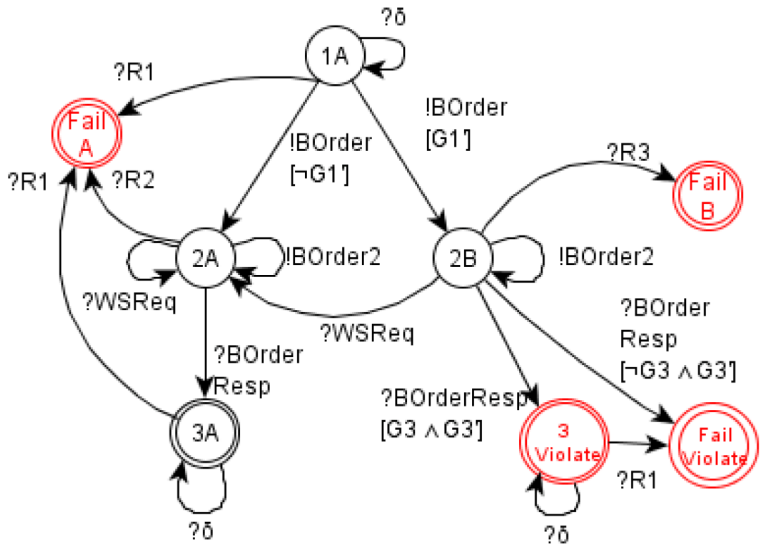
Runtime verification with proxy-testers



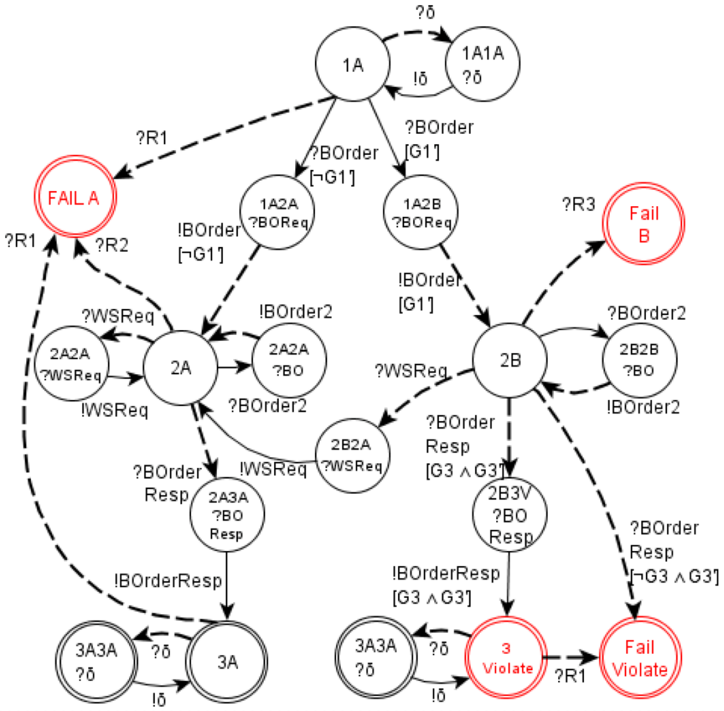
specification



safety property



Monitor (canonical tester // prop)



Proxy monitor

Runtime verification with proxy-testers

- Algorithm soundness

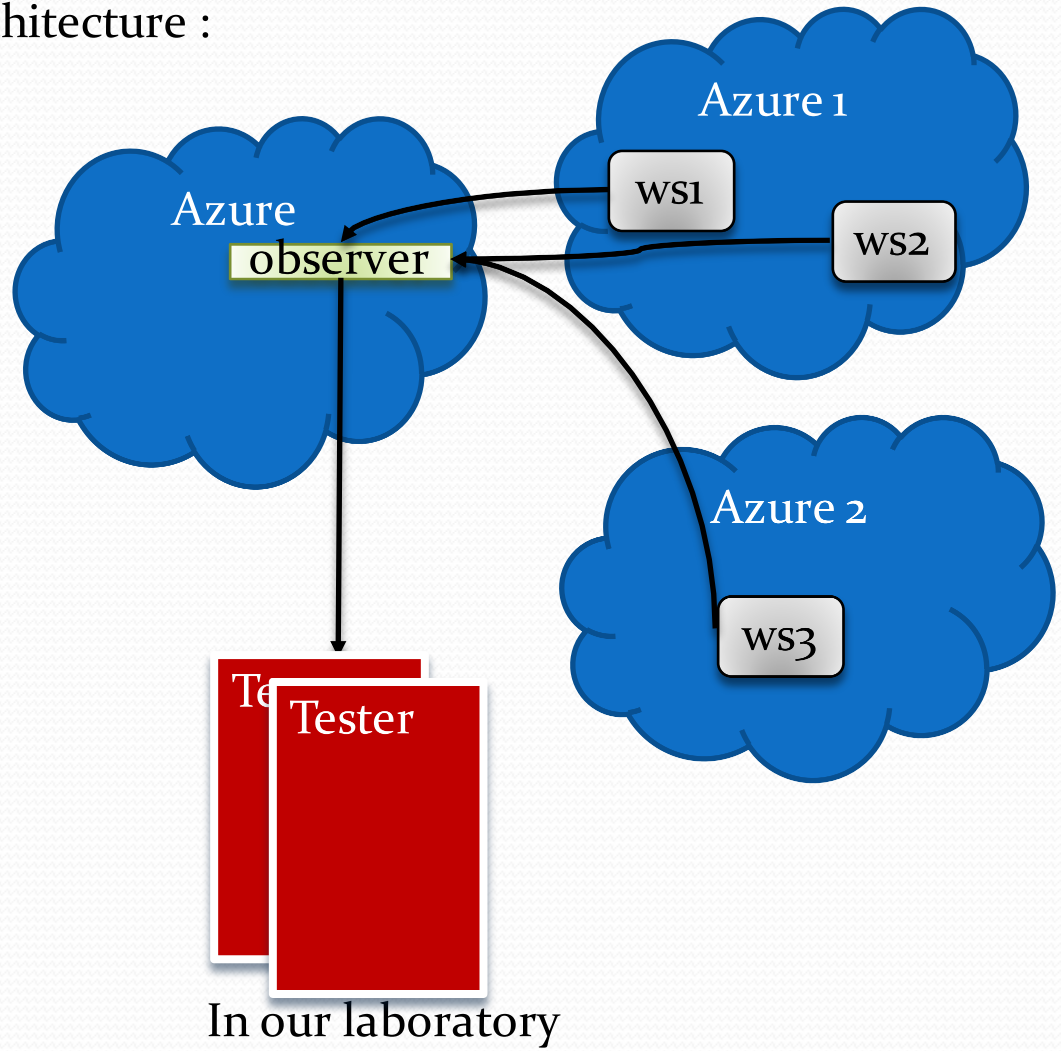
- Trace -> Fail => ioco not safisfied

- Trace -> Violate => safety prop. Violated

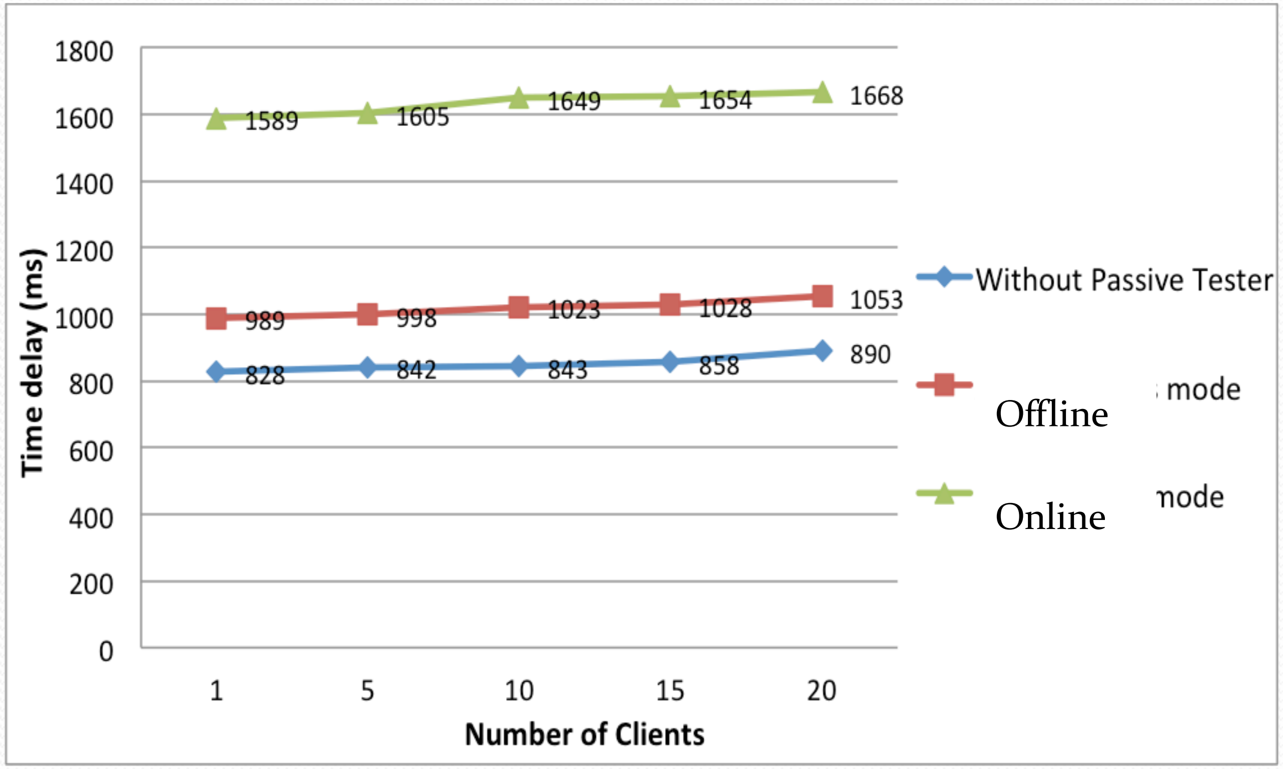
- Trace -> Fail/Violate => both

Evaluation

Architecture :



Cloud = Azure
3 Web services
1-20 mocked clients in the same time doing 20 requests



Limitations ?

- Bottlenecks on observer, Solver -> latencies issues

- The more clients, the more testers => requires more resources

>50 clients => online mode ko

But?

- We could benefit from the cloud features !
- Unlimited number of VMs and cpu => parallel observer, unlimited tester instances

Conclusion

Conclusion

- What makes testing apps in clouds more difficult ?
  - Dynamic nature of clouds
  - difficulty to observe outputs (asynchronous communication mode, hidden messages in compositions)
  - Protocols, APIs,
- Need of additional test hypotheses or to revisit Implementation relations
- But, testing in clouds can benefits from clouds
  - Rely on the flexibility of clouds to implement testers

Some Perspectives

- Other kinds of observers for clouds ?
  - Add Monitor services to Web service compositions
  - Complete Web service codes with observers ?
  - Build Docker containers for testing
-
- Model-based testing requires models
  - Writing model is dificult and error-prone
  - -> model inference of composite service ? (active, passive inference, etc.)

- Apps developped for clouds often associated with Big data
  - Testing the «big data » side of these apps (robusteness)?

Thank you

- Questions ?

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- [CPFC10] Automated Runtime Verification for Web Services, Tien-Dung Cao 1 Trung-Tien Phan-Quang 1 Patrick Félix 1 Richard Castanet, IEEE international Conference on Web Services, Jul 2010, Miami, United States. pp.76-8

Choregraphie, orchestration ?

Gestion des services web

Orchestration des services

- Lorsqu'un service web coordonne d'autres services

- Par des processus BPEL (processus écrit en XML qui décrit comment interagissent les WS suivant des stimuli extérieurs)

- Besoin d'un serveur qui exécute les processus BPEL
la gestion des erreurs doit être gérée par le processus (mécanisme de replis, re-exécution du processus)

- Langage de programmation de processus mais aussi interface graphique (boites)

Gestion des services web

Chorégraphie de services

- Chaque service web mêlée dans la chorégraphie connaît exactement quand ses opérations doivent être exécutées et avec qui l’interaction doit avoir lieu.

- Description des interactions de service uniquement de pair à pair

- Pas de processus, chaque service connait les actions à effectuer par rapport aux messages reçus

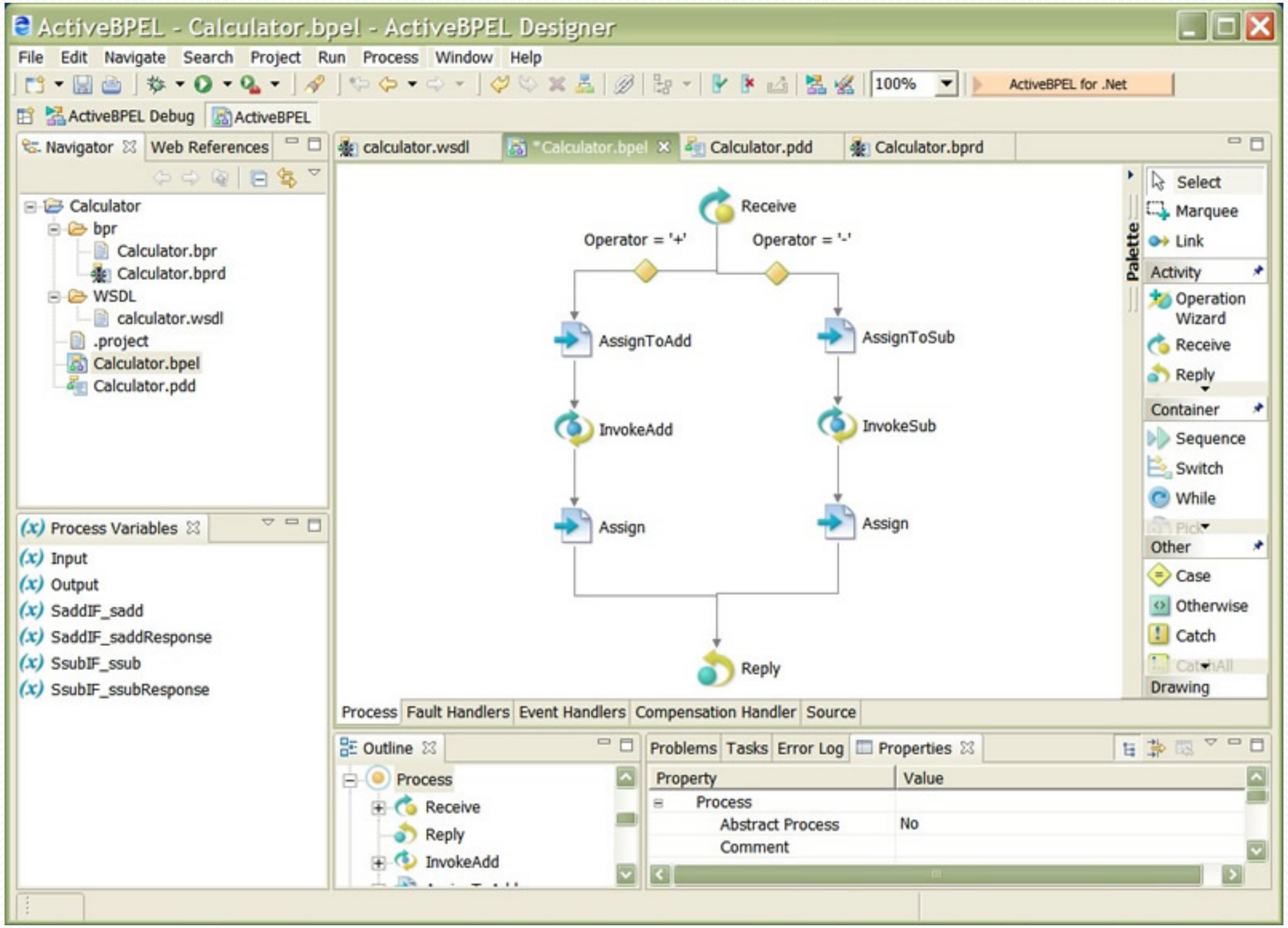
- Langage en XML WS-CL ou WSCI

Apercu de WSBPEL

- Definition des partenaires
- Utilisation de variables, assignation de valeurs (assign)
- Activités basiques (invoque, receive, reply, wait, throw)
- Activités structurés (while, switch, sequence,pick(temporisation)
- Correlation = session
- Scope découpage d’un processus en plusieurs parties
  - Pl. handler possibles par scope (conpensation, fault, event)

Apercu de WSBPEL

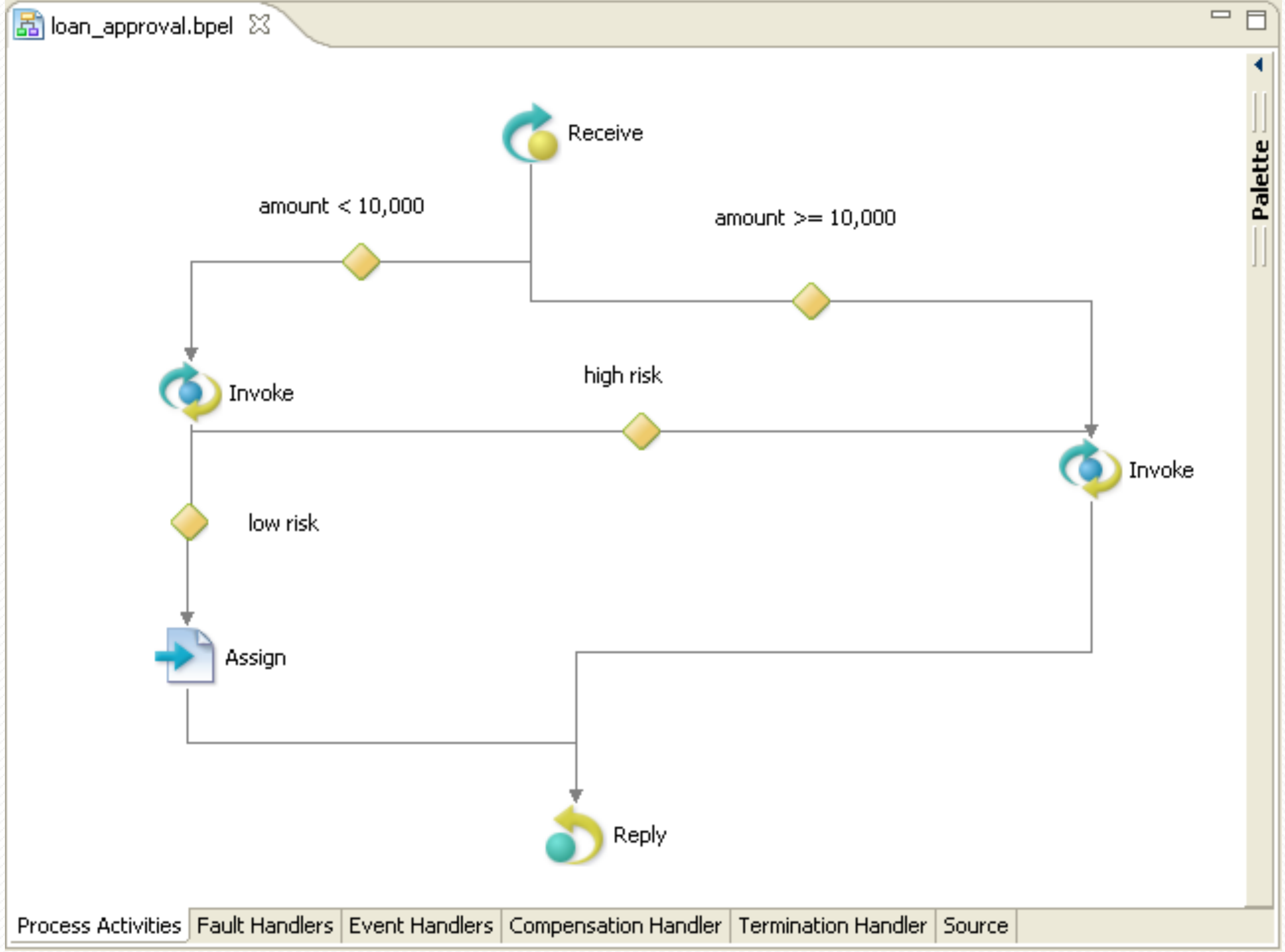
Avec ActiveBPEL



Property	Value
Process	
Abstract Process	No
Comment	

Aperçu de WSBPEL

Avec ActiveBPEL


loan_approval.bpel
Receive
amount < 10,000
amount >= 10,000
Invoke
high risk
Invoke
low risk
Assign
Reply
Palette
Process Activities
Fault Handlers
Event Handlers
Compensation Handler
Termination Handler
Source