Challenges in Cloud Computing Security

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Summary

- Cloud Computing Security Monitoring
- Federated Identity to Cloud Environment Using Shibboleth
- A Vision of Privacy on Identity Management Systems
- Risk-based Access Control Architecture for Cloud Computing
- RAClouds – Risk Analysis for Clouds

Cloud Computing Security Monitoring

Outline

1. INTRODUCTION
2. RELATED WORKS
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4. CLOUD MONITORING
5. SECURITY CONCERNS IN SLA
6. CLOUD SECURITY MONITORING
7. CASE STUDY

Outline

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9. CONCLUSIONS AND FUTURE WORKS

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1. INTRODUCTION

- Numerous threats and vulnerabilities that become more important as the use of the cloud increases, as well as, concerns with stored data and its availability, confidentiality and integrity.
- Need for monitoring tools and services, which provide a way for administrators to define and evaluate security metrics for their systems.

1. INTRODUCTION

- We propose a cloud computing security monitoring tool based on our previous works on both security and management for cloud computing.
- Features of cloud computing such as virtualization, multi-tenancy and ubiquitous access provide a viable solution to service provisioning problems.

1. INTRODUCTION

- What are the new risks associated with the cloud and what other risks become more critical?
- We provide some background in security concerns in cloud computing, briefly describe a previous implementation of a monitoring tool for the cloud, show how security information can be summarized and treated under a management perspective.

2. RELATED WORKS

- Uriarte and Westphall [4] proposed a monitoring architecture devised for private Cloud that considers the knowledge requirements of autonomic systems.
- Fernades et al. [5] surveys the works on cloud security issues, addressesing key topics: vulnerabilities, threats, and attacks, and proposes a taxonomy for their classification.

2. RELATED WORKS

- Cloud Security Alliance [6] has identified the top nine cloud computing threats. The report shows a consensus among industry experts.
- Mukhtarov et al. [7] proposed a cloud network security monitoring, which is based on flow measurements and implements an algorithm that detects and responds to network anomalies.

3. SECURITY CONCERNS IN CLOUDS

- Each cloud technology presents some kind of known vulnerability: Web Services, Service Oriented Architecture (SOA), Representational State Transfer (REST) and Application Programming Interfaces (API), virtualizarion, network infrastructure... [8].
- The usual three basic issues of security: availability, integrity and confidentiality are still fundamental in the cloud.

3. SECURITY CONCERNS IN CLOUDS

- Multi-tenant characteristic: one single vulnerable service in a virtual machine, exploitation of many services hosted in the same physical machine.
- Web applications and web services: susceptible to a lot of easily deployed attacks such as SQL injection, Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF) and session hijacking.

3. SECURITY CONCERNS IN CLOUDS

- Another important topic in cloud security is Identity and Access Management, because now data owners and data providers are not in the same trusted domain [9].
- The main security management issues of a Cloud Service Provider (CSP) are: availability management, access control management, vulnerability management, patch and configuration management, countermeasures, and cloud usage and access monitoring [10].

3. SECURITY CONCERNS IN CLOUDS

- The cloud is an easy target for an intruder trying to use its abundant resources maliciously, and the IDS also has to be distributed, to be able to monitor each node [11].
- Distributed Denial of Service (DDoS) attacks can have a much broader impact on the cloud, since now many services may be hosted in the same machine. DDoS is a problem that is still not very well handled.

3. SECURITY CONCERNS IN CLOUDS

- To maintain data security a provider must include, at least: an encryption schema, an access control system, and a backup plan [12].
- When moving to the cloud it is important that a prospective customer knows to what risks its data are being exposed. Some of the key points considered in this migration are presented in [13, 20, and 21].

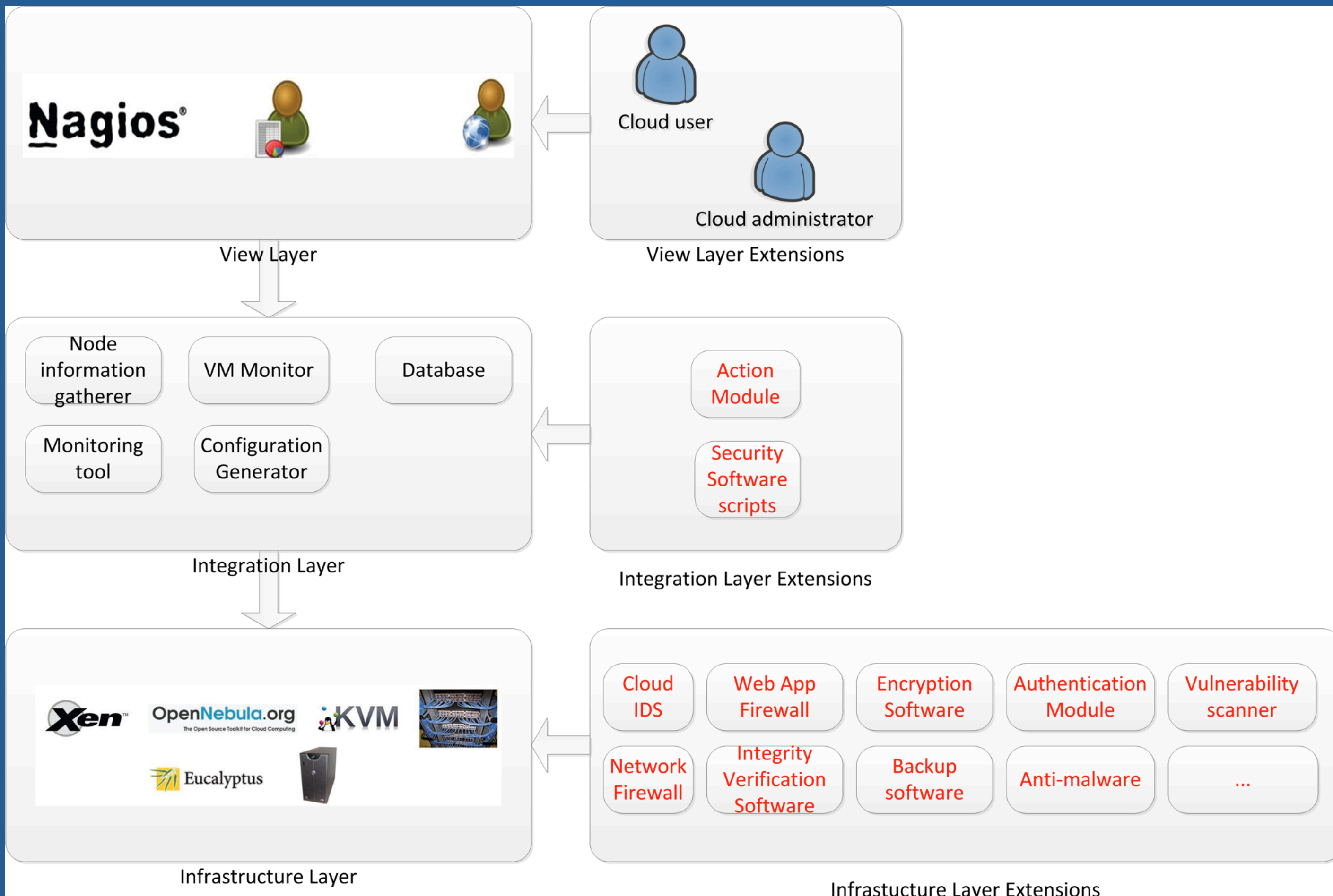
3. SECURITY CONCERNS IN CLOUDS

- Legal compliance is fundamental when dealing with cloud computing. In the cloud world, it is possible that data cross many jurisdiction borders.
- Availability and confidentiality are critical to the telecommunications business and if services are being deployed in a public cloud without a proper SLA [15].

4. CLOUD MONITORING

- Our team has previously proposed and implemented an open-source cloud monitoring architecture and tool called the Private Cloud Monitoring System (PCMONS) [14].
- The architecture of the system is divided in three layers: Infrastructure; Integration; and view.

4. CLOUD MONITORING



5. SECURITY CONCERNS IN SLA

- Providers must have ways to ensure their clients that their data is safe and must do so by monitoring and enhancing security metrics.
- SLAs may also be used in the definition, monitoring and evaluation of security metrics, in the form of Security SLAs, or Sec-SLAs [15].

6. CLOUD SECURITY MONITORING

- We now propose an extension to the PCMONS architecture and tool to enable security monitoring for cloud computing.
- We also present the security metrics which we consider adequate to be monitored in a cloud infrastructure and which provide a good picture of security as a whole in this environment.

6. CLOUD SECURITY MONITORING

- The tool uses data and logs gathered from security software available in the monitored systems, such as IDSs, anti-malware software, file system integrity verification software, backup software, and web application firewalls.
- The entities involved in the definition, configuration and administration of the security SLAs and metrics are:

6. CLOUD SECURITY MONITORING

- Cloud users; Cloud administrators; and Security applications.
- Data Security Metrics, Access Control Metrics and Server Security Metrics are shown in Table I, Table II, and Table III, respectively.
- If a virtual machine has had a huge number of failed access attempts in the last hours we may want to lock any further access.

6. CLOUD SECURITY MONITORING

TABLE I. DATA SECURITY METRICS

Metric	Description
Encrypted Data?	Indicates whether the data stored in the VM is encrypted
Encryption Algorithm	The algorithm used in the encryption/decryption process
Last backup	The date and time when the last backup was performed
Last integrity check	The date and time when the last file system integrity check was performed

6. CLOUD SECURITY MONITORING

TABLE II. ACCESS CONTROL METRICS

Metric	Description
Valid Accesses	The number of valid access attempts in the last 24 hours
Failed access attempts	The number of failed access attempts in the last 24 hours
Password change interval	The frequency with which users must change passwords in the VM's operating system

6. CLOUD SECURITY MONITORING

TABLE III. SERVER SECURITY METRICS

Metric	Description
Malware	Number of malware detected in the last anti-malware scan
Last malware scan	The date and time of the last malware scan in the VM
Vulnerabilities	Number of vulnerabilities found in the last scan
Last vulnerability scan	The date and time of the last vulnerability scan in the VM
Availability	Percentage of the time in which the VM is online

7. CASE STUDY

- We have implemented the metrics presented in Tables I-III and gathered the data generated in a case study.
- The following software were used to gather the security information: dm-crypt (encryption), rsync (backup), tripwire (filesystem integrity), ssh (remote access), clamAV (anti-malware), tiger (vulnerability assessment) and uptime (availability).

7. CASE STUDY

oneadmin i-322 stratus	AVAILABILITY	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	99.93%
	CIPHER	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	AES
	SSH_VALID	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	25
	IS_ENCRYPTED	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	yes
	LAST_BACKUP	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	2014-08-14 18:30:48
	LAST_INTEGRITY	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	2014-08-14 10:23:50
	LAST_MALWARE_SCAN	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	2014-08-14 10:02:42
	VULNERABILITIES	CRITICAL	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	111
	MALWARE_FOUND	CRITICAL	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	5
	PASSWORD_INTERVAL	OK	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	180 days
	SSH_FAIL	WARNING	2014-08-14 15:58:51	4d 1h 16m 40s	1/4	545

7. CASE STUDY

- It represents how the metrics are shown in Nagios and it is possible to see the vision that a network administrator has of a single machine.
- The metrics HTTP CONNECTIONS, LOAD, PING, RAM and SSH are from the previous version of PCMONS and are not strictly related to security, but they are show combined.

8. KEY LESSONS LEARNED

- The tool helps network and security administrator perceive violations to Sec-SLAs and actively respond to threats.
- The major piece of technology used to provide security in the cloud is cryptography.
- Data leakage and data loss are possibly the greatest concerns of cloud users.
- Backup and recovery are also fundamental tools to ensure the availability of customer data.

8. KEY LESSONS LEARNED

- SLAs are fundamental to provide customers with the needed guarantees.
- Definition of requirements and the monitoring of security metrics remain an important open research topic.
- The major decisions in this work were related to the security metrics and the software used to provide the necessary security data.

8. KEY LESSONS LEARNED

- The idea of analyzing logs to obtain security data is classical in information security and it seemed like a natural approach to our challenges.
- To read, parse and present the data we chose to use the Python programming language because it already formed the base of PCMONS (Private Cloud Monitoring System).

8. KEY LESSONS LEARNED

- Setting up a reliable testing environment was also extremely important to the success of the project.
- An important feature of this extension of PCMONS is that it can run over OpenNebula, OpenStack and CloudStack.
- The use of scripting languages in the development process, such as Python and Bash Script allowed us to define the metrics.

9. CONCLUSION AND FUTURE WORK

This work described:

- A few of our previous works in the field of Cloud Computing and how to bring them all together in order to develop a cloud security monitoring architecture; and

- The design and implementation of a cloud security monitoring tool, and how it can gather data from many security sources inside VMs and the network.

9. CONCLUSION AND FUTURE WORK

As future work:

- We can point to the definition and implementation of new metrics and a better integration with existing Security SLAs; and
- It would be important to study the integration of the security monitoring model with other active research fields in cloud security, such as Identity and Access Management and Intrusion Detection Systems.

10. REFERENCES

References indicated in this presentation:

- [4] R. B. Uriarte and C. B. Westphall, "Panoptes: A monitoring architecture and framework for supporting autonomic clouds," in IEEE Network Operations and Management Symposium, 2014.
- [5] D. Fernandes et al., "Security issues in cloud environments: a survey," International Journal of Information Security, 2014.

10. REFERENCES

References indicated in this presentation:

- [6] T. T. W. Group et al., "The notorious nine: cloud computing top threats in 2013," Cloud Security Alliance, 2013.
- [7] M. Mukhtarov et al., "Cloud network security monitoring and response system," CLOUD COMPUTING 2012 (The Third International Conference on Cloud Computing, GRIDs, and Virtualization).

10. REFERENCES

References indicated in this presentation:

- [8] B. Grobauer, et al., "Understanding cloud computing vulnerabilities," Security Privacy, IEEE, vol. 9, no. 2, March-April 2011.
- [9] X. Tan and B. Ai, "The issues of cloud computing security in high-speed railway," in Electronic and Mechanical Engineering and Information Technology (EMEIT), 2011 International Conference on, vol. 8, 2011.

10. REFERENCES

References indicated in this presentation:

- [10] F. Sabahi, “Cloud computing security threats and responses,” in Communication Software and Networks (ICCSN), IEEE 3rd International Conference on, 2011.
- [11] K. Vieira, et al., “Intrusion detection for grid and cloud computing,” IEEE IT Professional, vol. 12, no. 4, 2010.

10. REFERENCES

References indicated in this presentation:

- [12] L. Kaufman, “Data security in the world of cloud computing,” Security Privacy, IEEE, vol. 7, no. 4, 2009.
- [13] S. Chaves et al., “Customer security concerns in cloud computing,” in ICN, The Tenth Inter- national Conference on Networks, 2011.

10. REFERENCES

References indicated in this presentation:

- [14] S. A. Chaves, R. B. Uriarte, and C. B. Westphall, "Toward an architecture for monitoring private clouds,," Communications Magazine, IEEE, vol. 49, n. 12, 2011.
- [15] S. A. Chaves, C. B. Westphall, and F. Lamin, "Sla perspective in security management for cloud computing," in Networking and Services (ICNS), 2010 Sixth International Conference on, 2010.

10. REFERENCES

References indicated in this presentation:

- [20] D. R. dos Santos, C. M. Westphall, and C. B. Westphall, "A dynamic risk-based access control architecture for cloud computing," in IEEE Network Operations and Management Symposium (NOMS), 2014.
- [21] P. F. SIlva et al., "An architecture for risk analysis in cloud," in ICNS, The Tenth International Conference on Networking and Services, 2014.

Federated Identity to Cloud Environment Using Shibboleth

Content at a Glance

- Introduction and Related Works
- Cloud Computing
- Identity Management
- Shibboleth
- Federated Multi-Tenancy Authorization System on Cloud
  - Scenario
  - Implementation of the Proposed Scenario
  - Analysis and Test Results within Scenario
- Conclusions and Future Works

Introduction

- Cloud computing systems: reduced upfront investment, expected performance, high availability, infinite scalability, fault-tolerance.
- IAM (Identity and Access Management) plays an important role in controlling and billing user access to the shared resources in the cloud.

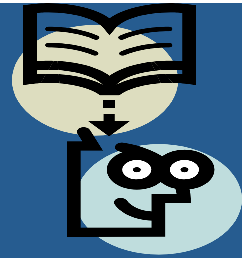
Introduction

- IAM systems need to be protected by federations.
- Some technologies implement federated identity, such as the SAML (Security Assertion Markup Language) and Shibboleth system.
- The aim of this paper is to propose a multi-tenancy authorization system using Shibboleth for cloud-based environments.

Related Work

- R. Ranchal et al. 2010 - an approach for IDM is proposed, which is independent of Trusted Third Party (TTP) and has the ability to use identity data on untrusted hosts.
- P. Angin et al. 2010 - an entity-centric approach for IDM in the cloud is proposed. They proposed the cryptographic mechanisms used in R. Ranchal et al. without any kind of implementation or validation.

This Work



- Provide identity management and access control and aims to: (1) be an independent third party; (2) authenticate cloud services using the user's privacy policies, providing minimal information to the Service Provider (SP); (3) ensure mutual protection of both clients and providers.
- This paper highlights the use of a specific tool, Shibboleth, which provides support to the tasks of authentication, authorization and identity federation.
- The main contribution of our work is the implementation in cloud and the scenario presented.

The NIST Cloud Definition Framework

Hybrid Clouds

Deployment Models

- Private Cloud
- Community Cloud
- Public Cloud

Service Models

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

Essential Characteristics

- On Demand Self-Service
- Broad Network Access
- Rapid Elasticity
- Resource Pooling
- Measured Service

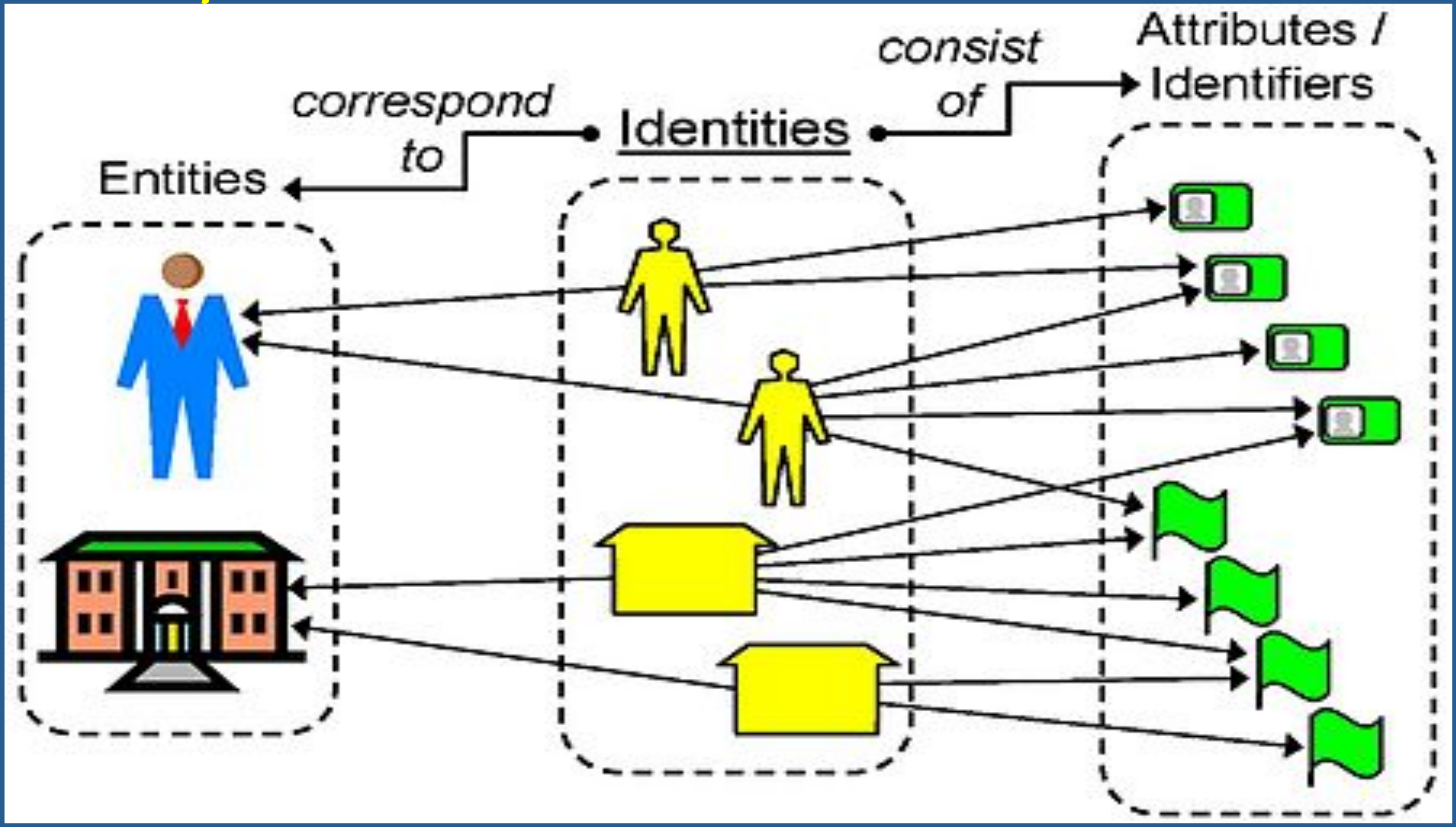
Common Characteristics

- Massive Scale
- Resilient Computing
- Homogeneity
- Geographic Distribution
- Virtualization
- Service Orientation
- Low Cost Software
- Advanced Security

Based upon original chart created by Alex Dowbor

Identity Management

- Digital identity is the representation of an entity in the form of attributes.



http://en.wikipedia.org/wiki/Identity_management

Identity Management

- Identity Management (IdM) is a set of functions and capabilities used to ensure identity information, thus assuring security.
- An Identity Management System (IMS) provides tools for managing individual identities.
- An IMS involves:
  - User
  - Identity Provider (IdP)
  - Service Provider (SP)

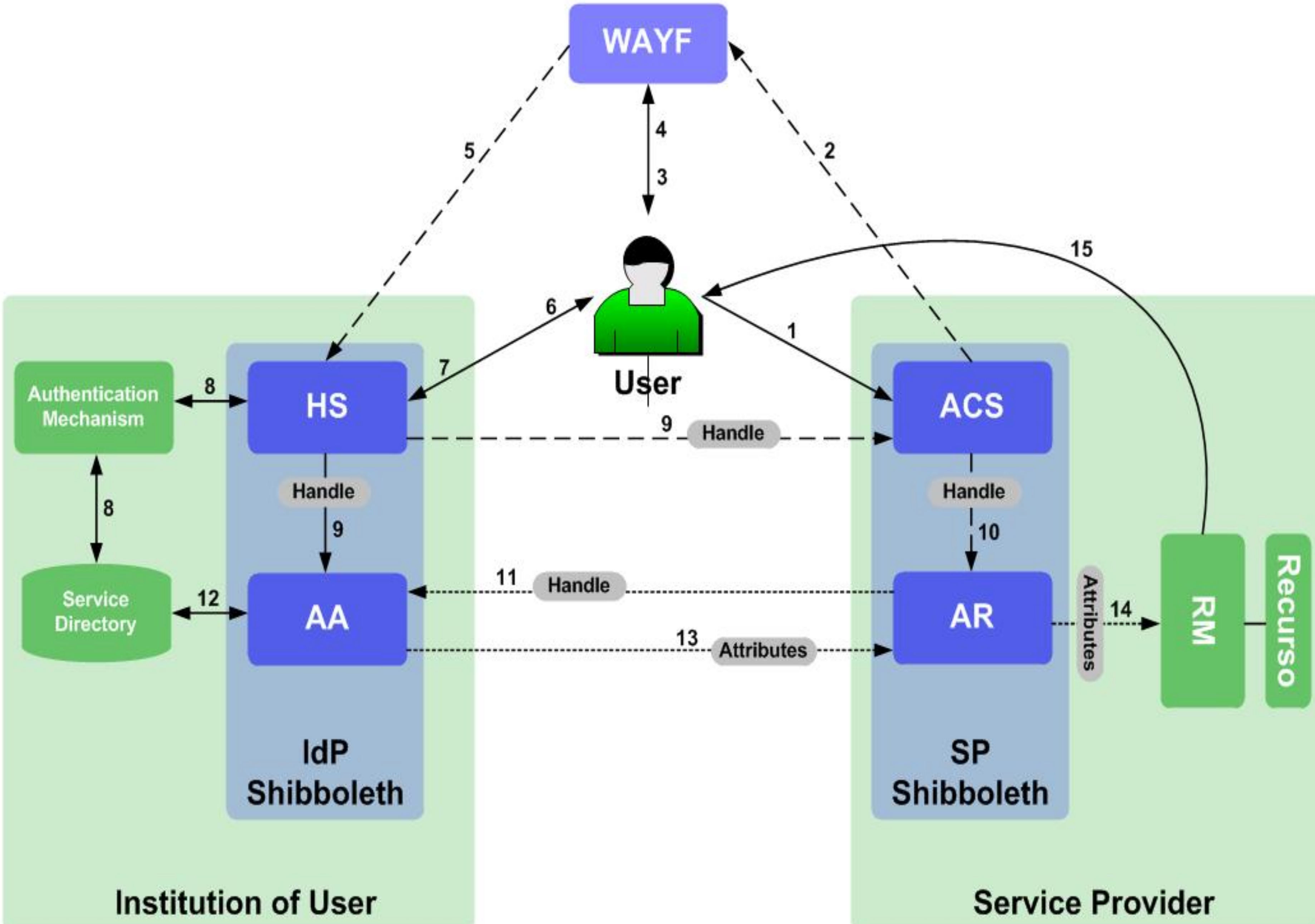
IMS

- *Provisioning:* addresses the provisioning and deprovisioning of several types of user accounts.
- *Authentication:* ensures that the individual is who he/she claims to be.
- *Authorization:* provide different access levels for different parts or operations within a computing system.
- *Federation:* it is a group of organizations or SPs that establish a circle of trust.

- The OASIS SAML (Security Assertion Markup Language) standard defines precise syntax and rules for requesting, creating, communicating, and using SAML assertions.
- The Shibboleth is an authentication and authorization infrastructure based on SAML that uses the concept of federated identity. The Shibboleth system is divided into two entities: the IdP and SP.

Shibboleth

- The IdP is the element responsible for authenticating users: Handle Service (HS), Attribute Authority (AA), Directory Service, Authentication Mechanism.
- The SP Shibboleth is where the resources are stored: Assertion Consumer Service (ACS), Attribute Requester (AR), Resource Manager (RM).
- The WAYF ("Where Are You From", also called the Discovery Service) is responsible for allowing an association between a user and organization.

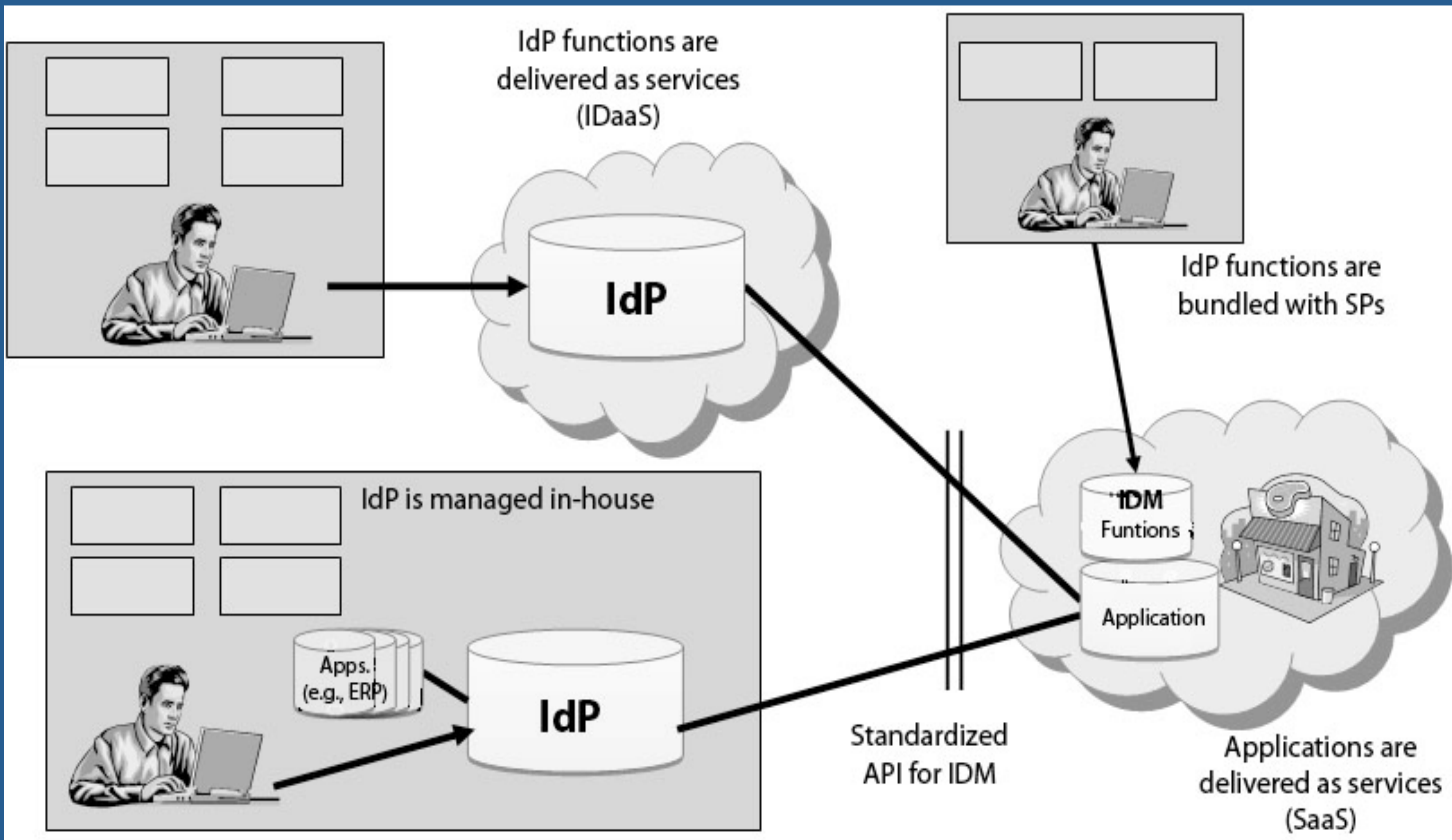

WAYF
5
4
3
2
User
15
6
1
7
Authentication Mechanism
8
HS
ACS
9
Handle
Handle
Handle
8
9
10
Service Directory
12
11
Handle
AA
AR
Attributes
14
RM
Recurso
13
Attributes
IdP Shibboleth
SP Shibboleth
Institution of User
Service Provider

In Step 1, the user navigates to the SP to access a protected resource. In Steps 2 and 3, Shibboleth redirects the user to the WAYF page, where he should inform his IdP. In Step 4, the user enters his IdP, and Step 5 redirects the user to the site, which is the component HS of the IdP. In Steps 6 and 7, the user enters his authentication data and in Step 8 the HS authenticate the user. The HS creates a handle to identify the user and sends it also to the AA. Step 9 sends that user authentication handle to AA and to ACS. The handle is checked by the ACS and transferred to the AR, and in Step 10 a session is established. In Step 11 the AR uses the handle to request user attributes to the IdP. Step 12 checks whether the IdP can release the attributes and in Step 13 the AA responds with the attribute values. In Step 14 the SP receives the attributes and passes them to the RM, which loads the resource in Step 15 to present to the user.

Federated Multi-Tenancy Authorization System on Cloud

- IdM can be implemented in several different types of configuration:
  - IdM can be implemented in-house;
  - IdM itself can be delivered as an outsourced service. This is called Identity as a Service (IDaaS);
  - Each cloud SP may independently implement a set of IdM functions.
- In this work, it was decided to use the first case configuration: in-house.

Configurations of IDM systems on cloud computing environments



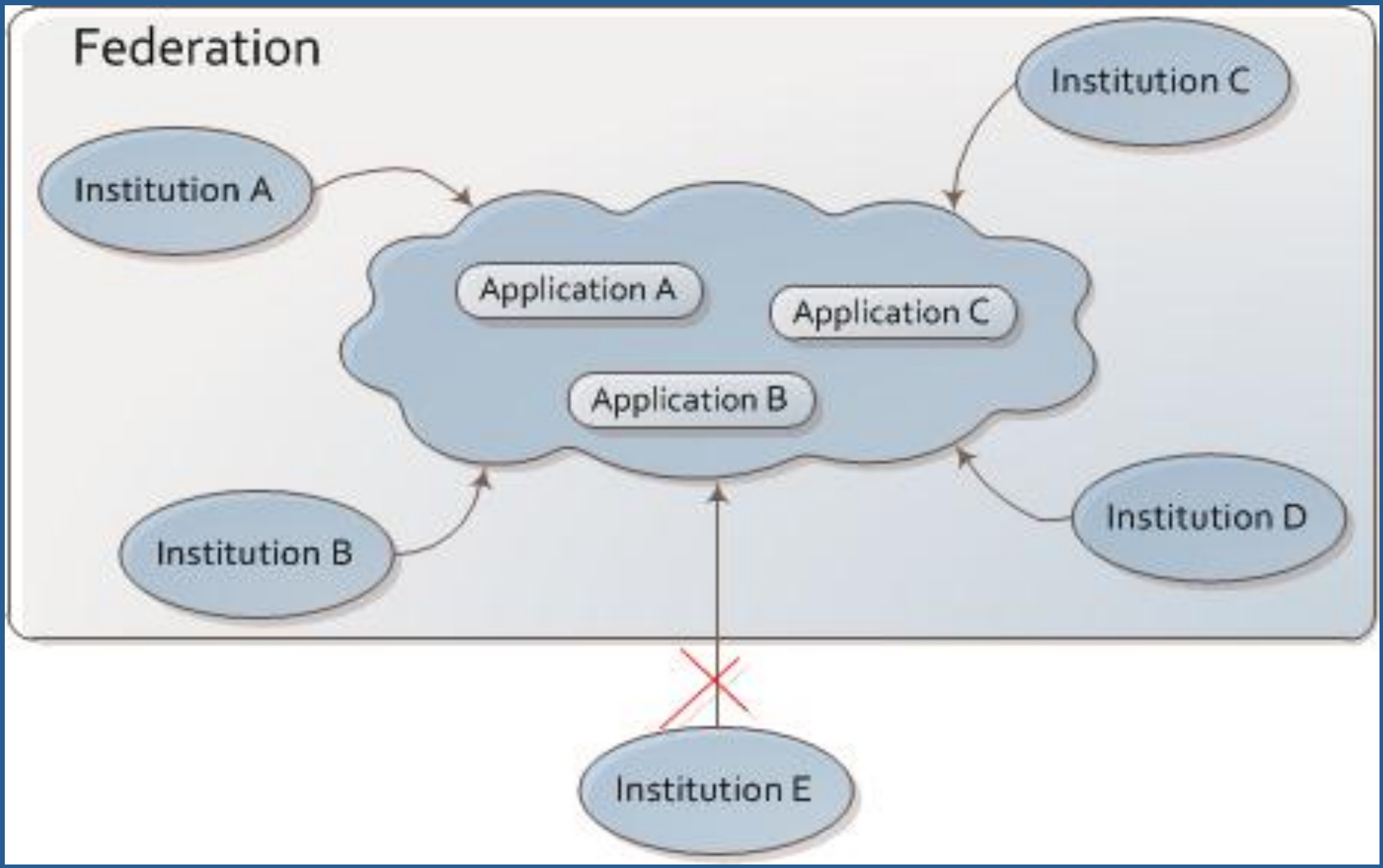
Federated Multi-Tenancy Authorization System on Cloud

- This work presents an authorization mechanism to be used by an academic institution to offer and use the services offered in the cloud.
- The part of the management system responsible for the authentication of identity will be located in the client organization.
- The communication with the SP in the cloud (Cloud Service Provider, CSP) will be made through identity federation.
- The access system performs authorization or access control in the environment.
- The institution has a responsibility to provide the user attributes for the deployed application SP in the cloud.
- The authorization system should be able to accept multiple clients, such as a multi-tenancy.

Scenario

- A service is provided by an academic institution in a CSP, and shared with other institutions. In order to share services is necessary that an institution is affiliated to the federation.
- For an institution to join the federation it must have configured an IdP that meets the requirements imposed by the federation.
- Once affiliated with the federation, the institution will be able to authenticate its own users, since authorization is the responsibility of the SP.

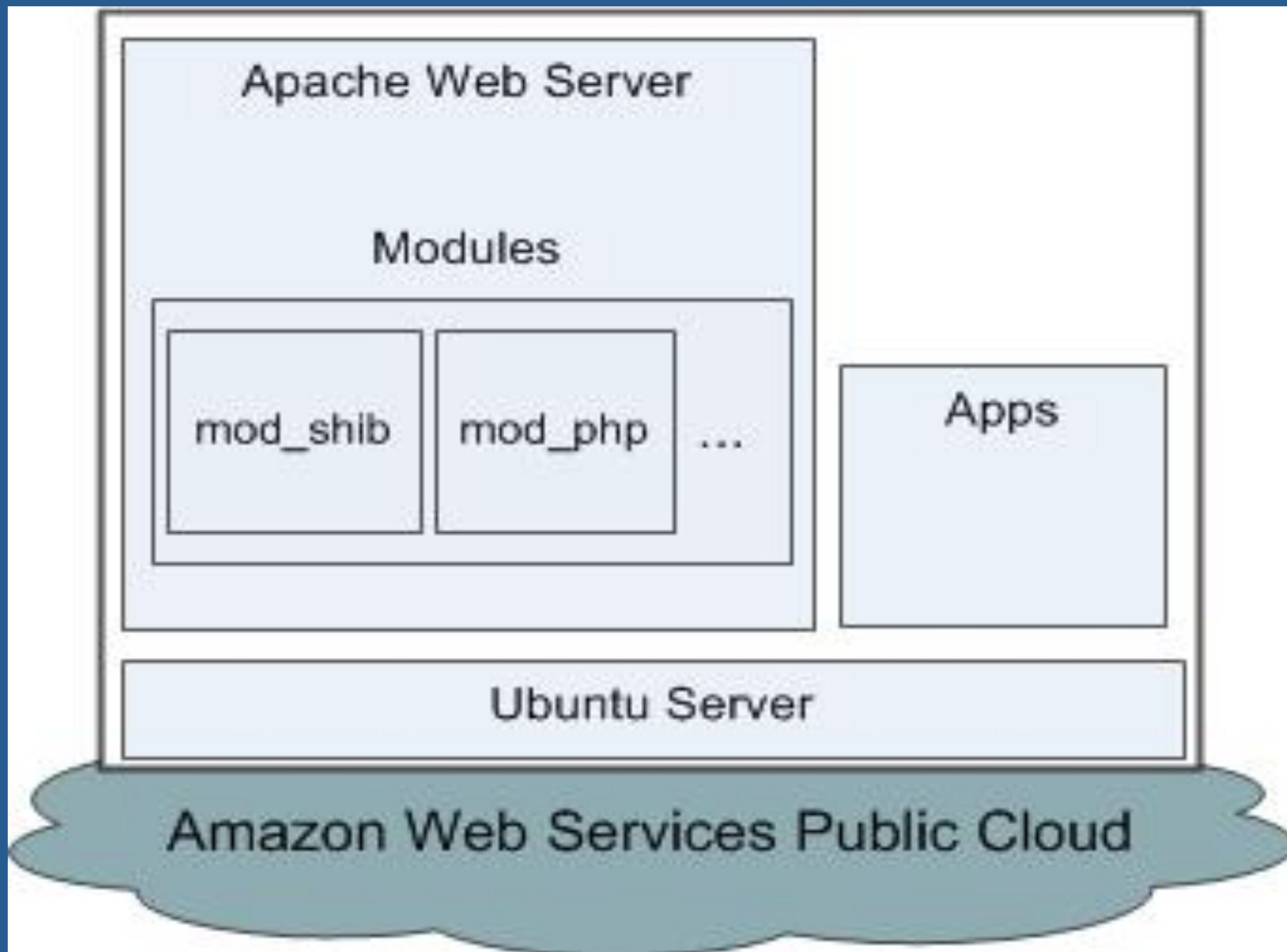
Scenario - Academic Federation sharing services in the cloud



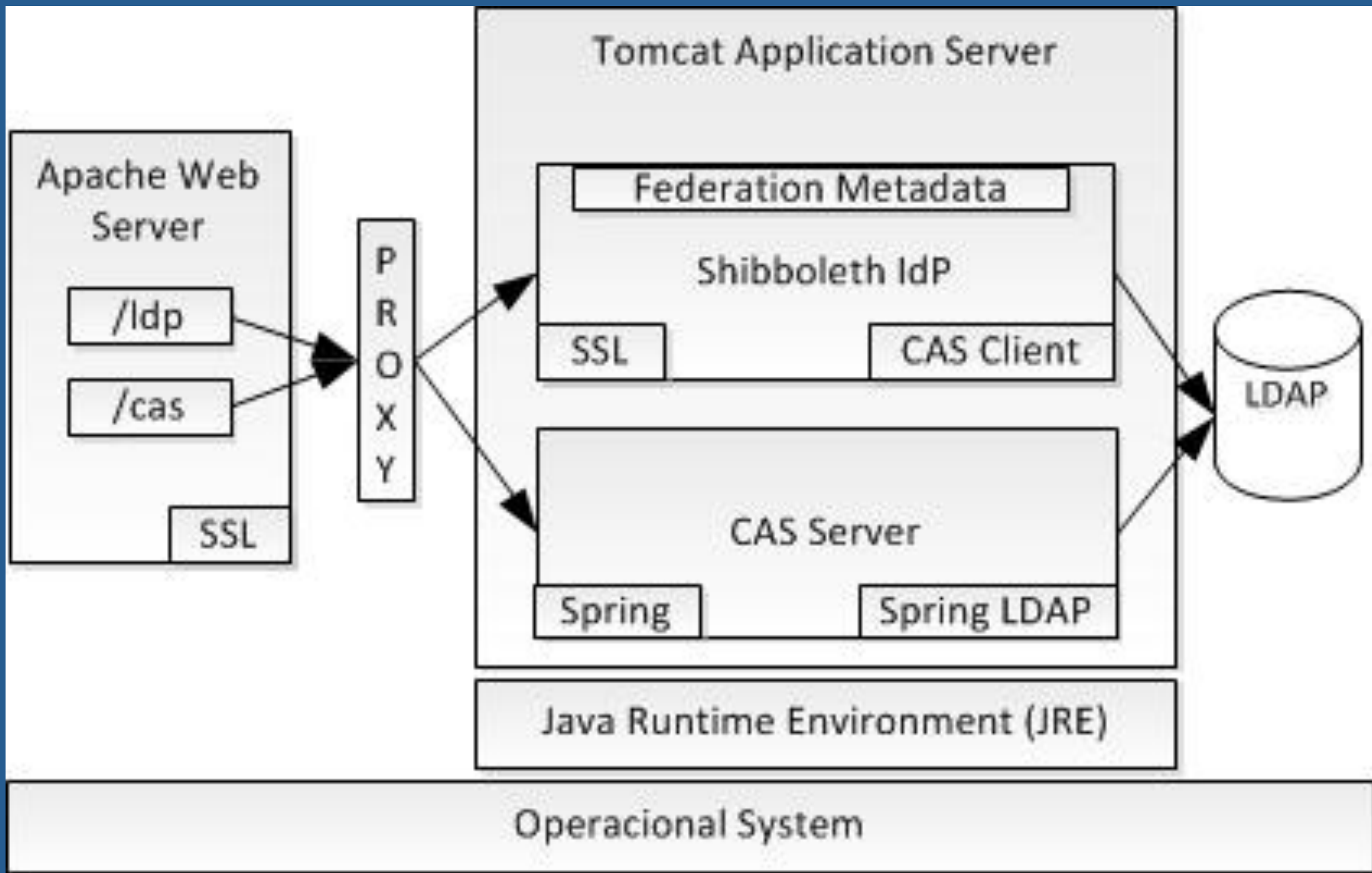
Implementation of the Proposed Scenario

- A SP was primarily implemented in the cloud:
  - an Apache server on a virtual machine hired by the Amazon Web Services cloud.
  - Installation of the Shibboleth SP.
  - Installation of DokuWiki, which is an application that allows the collaborative editing of documents.
  - The SP was configured with authorization via application, to differentiate between common users and administrators of Dokuwiki.

Implementation of the Proposed Scenario – Cloud Service Provider



Implementation of the Proposed Scenario – cloud IdP



Implementation of the Proposed Scenario

- The JASIG CAS Server was used to perform user authentication through login and password, and then passes the authenticated users to Shibboleth.
- The CAS has been configured to search for users in a Lightweight Directory Access Protocol (LDAP). To use this directory OpenLDAP was installed in another virtual machine, also running on Amazon's cloud.
- To demonstrate the use of SP for more than one client, another IdP was implemented, also in cloud, similar to the first. To support this task Shibboleth provides a WAYF component.

Analysis and Test Results within Scenario

- In this resulting structure, each IdP is represented in a private cloud, and the SP is in a public cloud.

The results highlighted two main use cases:

- *Read access to documents*
- *Access for editing documents*

Conclusions

- The use of federations in IdM plays a vital role.
- This work was aimed at an alternative solution to a IDaaS. IDaaS is controlled and maintained by a third party.
- The infrastructure obtained aims to: (1) be an independent third party, (2) authenticate cloud services using the user's privacy policies, providing minimal information to the SP, (3) ensure mutual protection of both clients and providers.

Conclusions

- This paper highlights the use of a specific tool, Shibboleth, which provides support to the tasks of authentication, authorization and identity federation.
- Shibboleth was very flexible and it is compatible with international standards.
- It was possible to offer a service allowing public access in the case of read-only access, while at the same time requiring credentials where the user must be logged in order to change documents.

Future Work

- We propose an alternative authorization method, where the user, once authenticated, carries the access policy, and the SP should be able to interpret these rules.
- The authorization process will no longer be performed at the application level.
- Expanding the scenario to represent new forms of communication.
- Create new use cases for testing.
- Use pseudonyms in the CSP domain.

Some References

- E. Bertino, and K. Takahashi, Identity Management - Concepts, Technologies, and Systems. ARTECH HOUSE, 2011.

- "Security Guidance for Critical Areas of Focus in Cloud Computing," CSA. Online at: http://www.cloudsecurityalliance.org.

- "Domain 12: Guidance for Identity and Access Management V2.1.," Cloud Security Alliance. - CSA. Online at: https://cloudsecurityalliance.org/guidance/csaguide-dom12-v2.10.pdf.

- D. W. Chadwick, Federated identity management. Foundations of Security Analysis and Design V, Springer-Verlag: Berlin, Heidelberg 2009 pp. 96–120.

Some References

- A. Albeshri, and W. Caelli, "Mutual Protection in a Cloud Computing environment," Proc. 12th IEEE Intl. Conf. on High Performance Computing and Communications (HPCC 10), pp. 641-646.

- R. Ranchal, B. Bhargava, A. Kim, M. Kang, L. B. Othmane, L. Lilien, and M. Linderman, "Protection of Identity Information in Cloud Computing without Trusted Third Party," Proc. 29th IEEE Intl. Symp. on Reliable Distributed Systems (SRDS 10), pp. 368–372.

- P. Angin, B. Bhargava, R. Ranchal, N. Singh, L. B. Othmane, L. Lilien, and M. Linderman, "An Entity-Centric Approach for Privacy and Identity Management in Cloud Computing," Proc. 29th IEEE Intl. Symp. on Reliable Distributed Systems (SRDS 10), pp. 177–183.

A Vision of Privacy on Identity Management Systems

Agenda

1. Background
   - Privacy
   - Identity management
   - Federation
2. Challenges
3. Conclusions
4. References

Privacy

Definition

- It is a fundamental human right [2]
- It is the control of release of personal data [1]
- It should be a vital characteristic of computing systems

Privacy/Characteristics

Characteristics of privacy [3]

- Undetectability
- Unlinkability
- Confidentiality

Privacy/Paradigms

Paradigms of privacy [4]

- Privacy as a control
- Privacy as confidentiality
- Privacy as practice

Privacy

Legislation to protect users' privacy

- Data Protection Directive – Europe [5]
- Health Insurance Portability and Accountability Act (HIPAA) – USA [6]
- Gramm-Leach-Bliley Act – USA [7]
- The Internet Bill of Rights – Brazil [8]

Legislations main goal

- Protect users against unwilling data disclosure and processing

Identity management/Access control model

Attribute Based Access Control (ABAC)

- Attributes are properties/characteristics of entities
- It uses attributes relevant for the request context
- It evaluates rules against attributes of entities

Fundamentos/Identities

Identity definition

- Set of attributes that represent a user or a system
- Also known as personally identifiable information (PII)

Example

Attribute	Value
ID	11111010101
Name	John
Last name	Smith
SSN	403289440
email	john.smith@home.com
roles	manager
...	...

Identity management

Definition

- The process of managing users' identity attributes [9]
- It deal with collection, authentication, and use of identities' attributes
- It provides means to create, manage and use identities
- Allows single sign on (SSO) and single log out (SLO)

Identity management

Roles in Identity management systems (IMS) [10]

- Users
- Identity
- Identity provider (IdP)
- Service provider (SP)

Identity management/Credentials

Credential definition

- Attributes used to authenticate a user a single user
- e.g. a par of login and password, biometrics or digital certificates

Identity management/Basic processes

Authentication

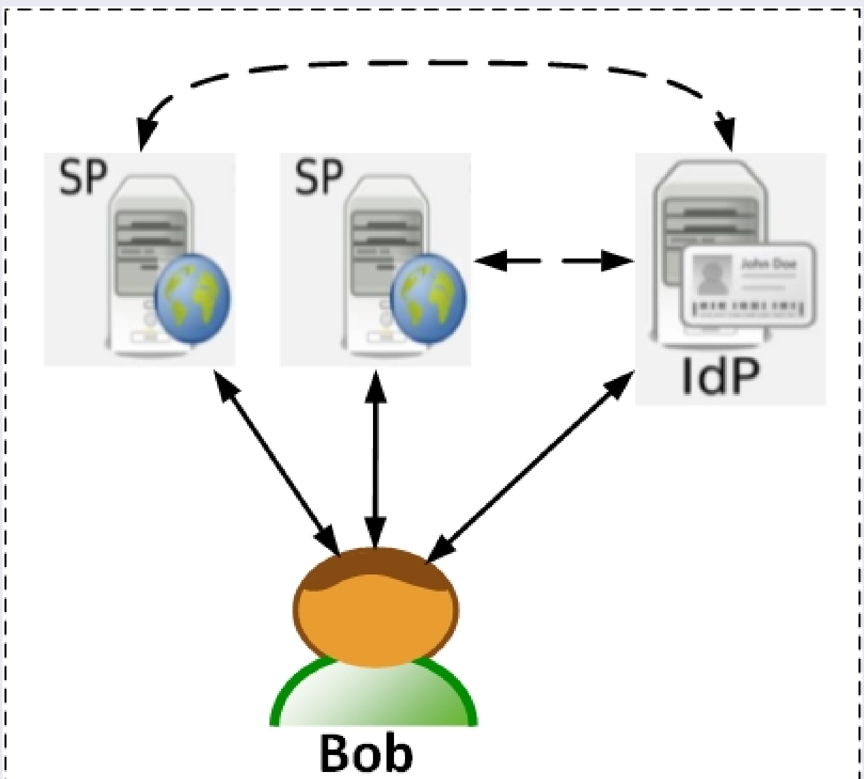
- Performed at the IdP
- It uses a credential to confirm identity

Authorization

- Mostly performed at the SP
- It uses users' attributes sent from the IdP to SP
- SP deliberates about the resource delivery

Identity management environment

Single administrative domain



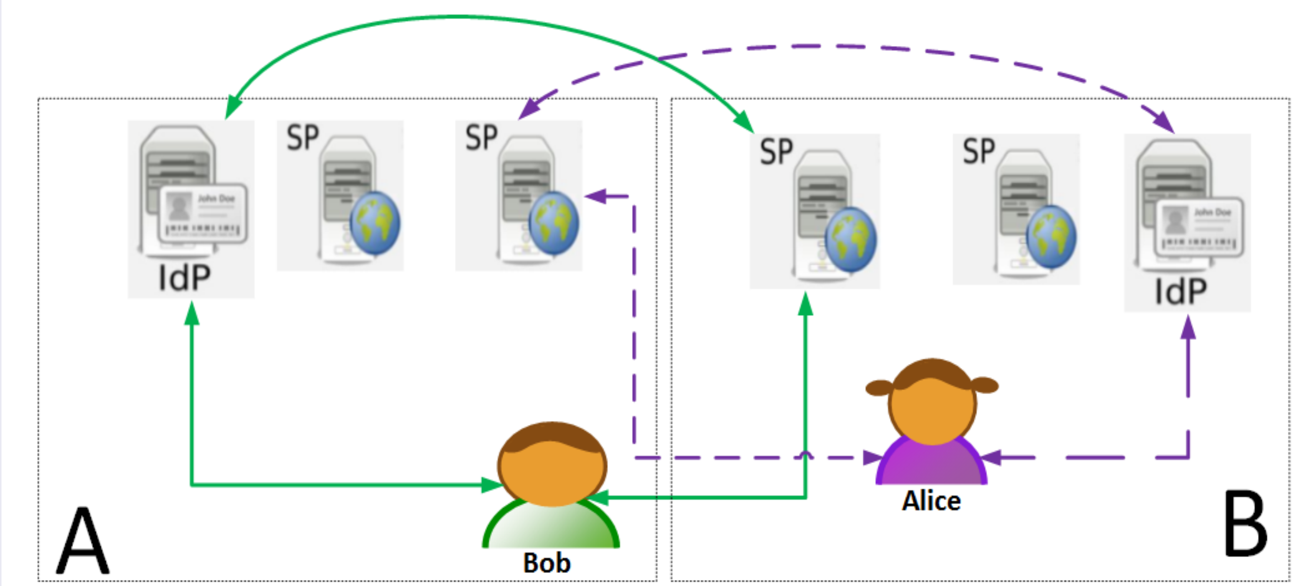
Federation

Definition

- An association of service providers and identity providers
- It allows users to access resources in multiple administrative domains (ADs)
- Users authenticate with their home AD

Federation/picture

Multiple ADs



Federation/technologies

Exchange data format

- Security Assertion Markup Language (SAML)
- OpenId Connect (JSON)

Federation/technologies

Frameworks/tools

- Authentic 2
- Higgins (Personal Data Service)
- OpenAM
- OpenId connect
- Ping federate
- Shibboleth

Federation/technologies

Frameworks characteristics

Project	Open Source?	Has a protocol	Owner	Data format	Who uses
Shibboleth	Yes	No	Internet2	SAML 1/2	Academia
OpenAM	Yes	No	ForgeRock	SAML 1/2, OpenId Connect	Industry
Authentic 2	Yes	No	Entr'ouvert	SAML 2, OpenID 1/2	Low adherence
OpenID Connect	Yes	Yes	OpenID	OpenId Connect (Json)	Industry/ academy
Higgins	Yes	No	Eclipse	SAML	Low adherence
Ping Federate	No	No	PingIdentity	SAML e OpenID	Industry

Cloud challenges

Cloud challenges

- Data management
- Data security
- Data privacy

Challenges on IMS

Lack of user control over PIIs stored on IdP

- Attributes stored out of user's boundaries
- Administrators with permissions and means to access user's attributes
- Attributes vulnerable to unwilling access and disclosure

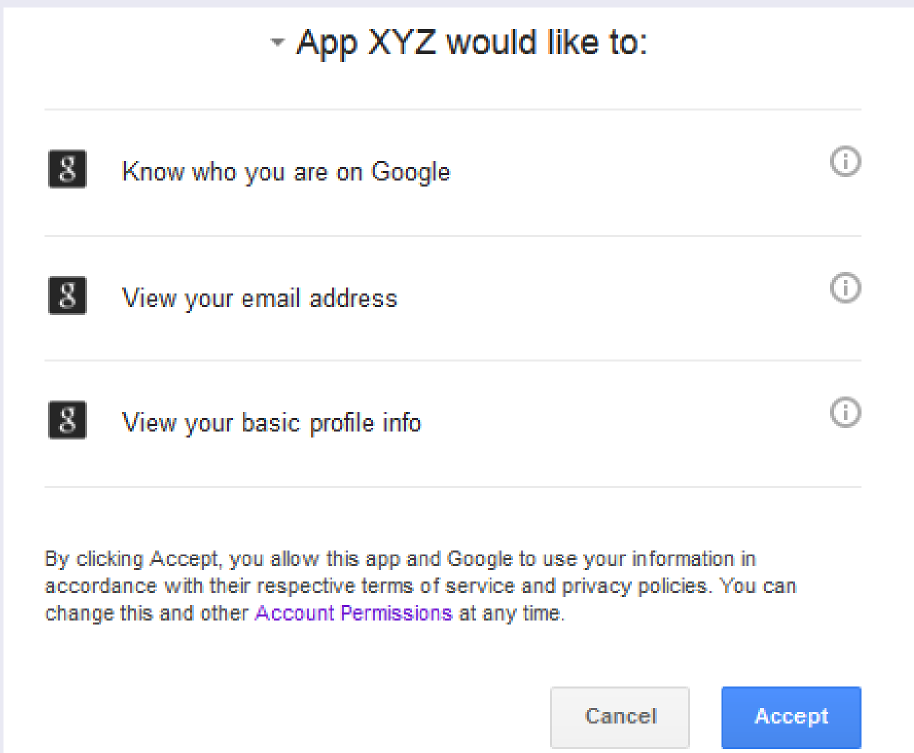
Challenges on IMS

Awareness of disclosure process

- Users are the owners of their attribute
- They must know which data is being disclosed
- The should be able to select/unselect any attribute

Challenges on IMS

Awareness of disclosure process



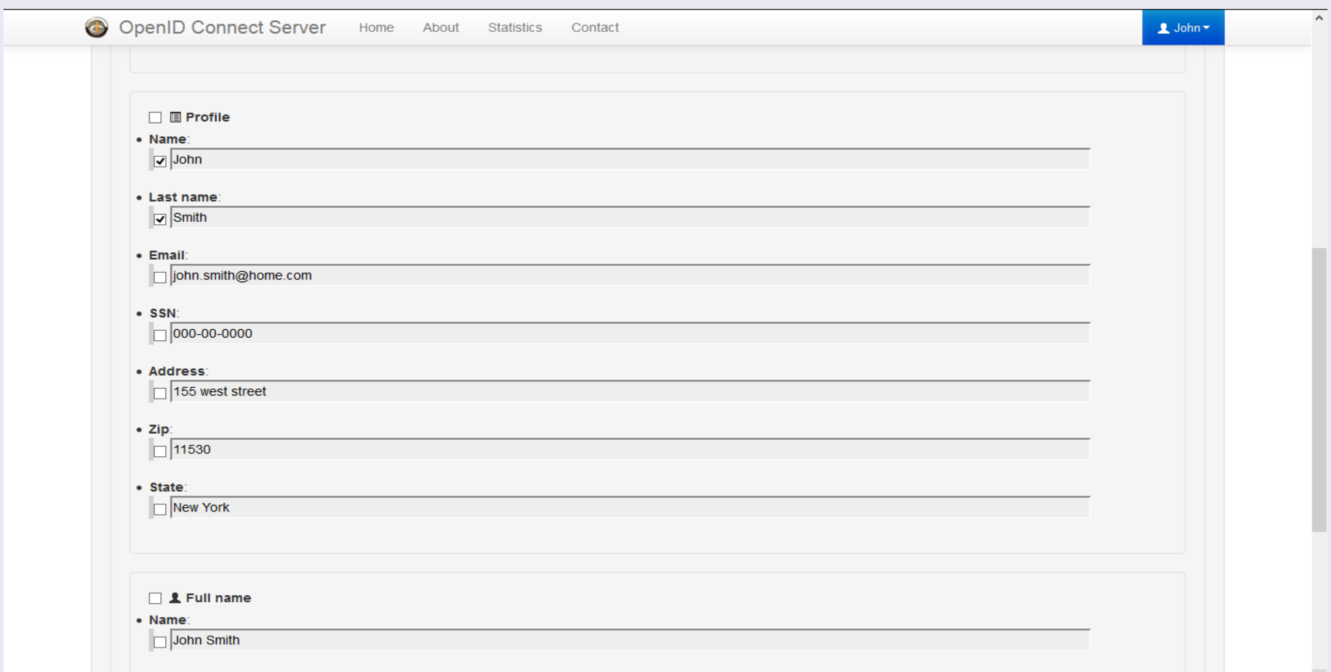
Challenges on IMS

Absence of disclosure support during dissemination process

- The dissemination process is a complex task
- The amount of attributes and its combination is huge
- Users do not have know-how to decide which set of attributes can bring more or less risk

Challenges on IMS

Absence of disclosure support during dissemination process



Challenges on IMS

Lack of means to control disclosed attributes

- Can the SP store the attributes? for how long?
- Can it be disseminated to third parties?
- Attributes control enforcement on SPs is a hard problem to solve
- The use of policies with the disclosed attributes can bring some light to this problem
- The use of policies brings up another problem. The policy enforcement on SPs

Conclusions

- There are no definitive answers for the present issues (for now)
- Privacy of attributes on IMS is a recent topic
- Mechanisms to provide effective control of attributes for users are still open for debates
- Disclosure support methods should be carefully studied and added to IMS
- Policy enforcement on SPs is an open problem to solve

Our work

We are researching methods:

- To provide users with control and privacy on attributes
- To assure privacy of attributes between providers interactions (SP-IdP, SP-SP)
- Support for users during the disclosure process

Our work

Funding

- Brazilian Funding Authority for Studies and Projects (FINEP)

Project

- Brazilian National Research Network in Security and Cryptography project (RENASIC)
- Conducted at Federal University of Santa Catarina (UFSC) in the Networks and Management laboratory (LRG).

The end

Discussion moment

- Questions
- Doubts
- Discussions

References I

[1] Landwehr, Carl and Boneh, Dan and Mitchell, John C and Bellovin, Steven M and Landau, Susan and Lesk, Michael E.
Privacy and cybersecurity: The next 100 years.
Proceedings of the IEEE, Special Centennial Issue, 2012.

[2] Lauterpacht, Hersch.
The Universal Declaration of Human Rights.
Journal Brit. YB Int'l L., 1948.

[3] Birrell, Eleanor and Schneider, Fred B
Federated identity management systems: A privacy-based characterization.
IEEE security & privacy. 2013.

[4] Diaz, Claudia and Gürses, Seda
Understanding the landscape of privacy technologies.
Extended abstract of invited talk in proceedings of the Information Security Summit. 2012.

[5] Directive, EU
95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data.
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:HTML

References II

[6] United States Congress
HEALTH INSURANCE PORTABILITY AND ACCOUNTABILITY ACT OF 1996.
http://www.gpo.gov/fdsys/pkg/PLAW-104publ191/html/PLAW-104publ191.htm

[7] United States Congress
GRAMM-LEACH-BLILEY ACT.
http://www.gpo.gov/fdsys/pkg/PLAW-106publ102/html/PLAW-106publ102.htm

[8] Civil, Casa
Lei N^{o} 12.965, DE 23 abril de 2014.
http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2014/lei/l12965.htm

[9] Chadwick, David W
Federated identity management.
Foundations of Security Analysis and Design V.

[10] Bertino, Elisa and Takahashi, Kenji
Identity Management: Concepts, Technologies, and Systems.
Artech House.

Risk-based Access Control Architecture for Cloud Computing

Agenda

- Introduction
- Related work
- Risk-based access control
- Proposed architecture
- Implementation and experiments
- Conclusion and future work

Introduction

- Cloud computing is a successful paradigm and cloud federations aim to make it even more efficient and scalable by sharing resources among providers

- In highly distributed, dynamic and heterogeneous environments, traditional access control models present problems, such as: scalability, flexibility and the use of static policies

- Dynamic access control models, like risk-based, provide greater flexibility and are able to handle exceptional requests (“break the glass”)

Introduction

- We present a model for dynamic risk-based access control for cloud computing
- The system uses quantification and aggregation of risk metrics that are defined in risk policies, which are created by the owners of the cloud resources
- It is built on top on an XACML architecture and allows the use of ABAC coupled with risk analysis

Related Work

- Fall et al. [1] - presents the first idea of risk-based AC for cloud. Propose using NSA RAdAC, but show no implementation

- Arias-Cabarcos et al. [2] - proposes the use of a fixed set of risk metrics for establishing identity federations in the cloud

- Sharma et al. [3] - uses risk-based AC on top of RBAC for cloud e-Health. Their model has 3 metrics (Confidentiality, Integrity and Availability)

Risk-based Access Control

- Traditional access control models employ static authorization, i.e., every decision is pre-established, based on the policies

- The idea behind dynamic access control is that the access requests must be analyzed taking into account contextual and environmental information such as security risk, operational need, benefit and others

- Real applications may require the violation of security policies, and the support for exceptional access requests is known as “break the glass”

Risk-based Access Control

- Uses a function that evaluates in “real time” each request
- Risk analysis can be qualitative, with levels of risk, or quantitative, where risk is usually defined as: Probability X Impact
- Many approaches to risk quantification: fuzzy logic, machine learning, probabilistic inference, …
  - usually based on the history of users and access

Proposed Architecture

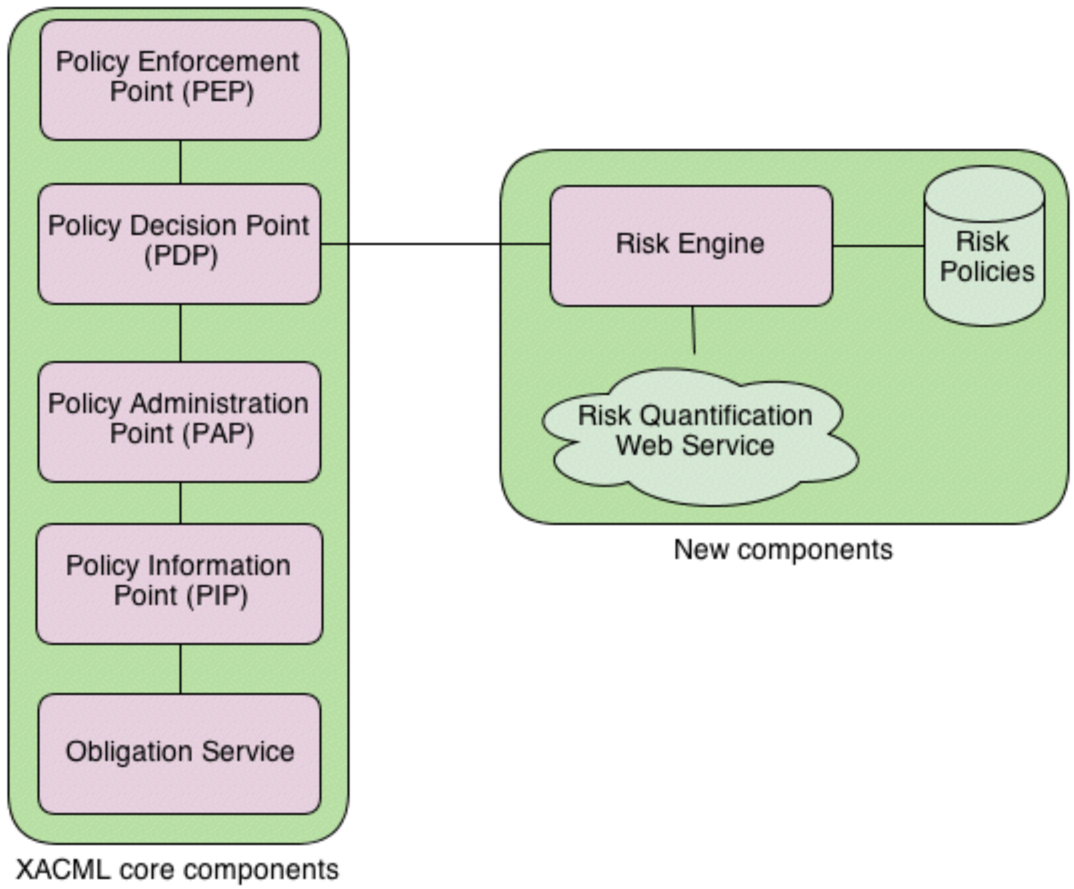
- XACML extension. ABAC and risk-based are taken in parallel and then combined to reach a final decision.
  - Combination rules: Deny overrides, Permit overrides, ABAC precedence, Risk precedence

- Risk decision is based on XML risk policies associated to a resource. A policy defines a set of risk metrics, how to quantify and aggregate them and an acceptable risk threshold

- Quantification and aggregation methods can be local (in the CSP) or external, defined by the resource owner as a web service

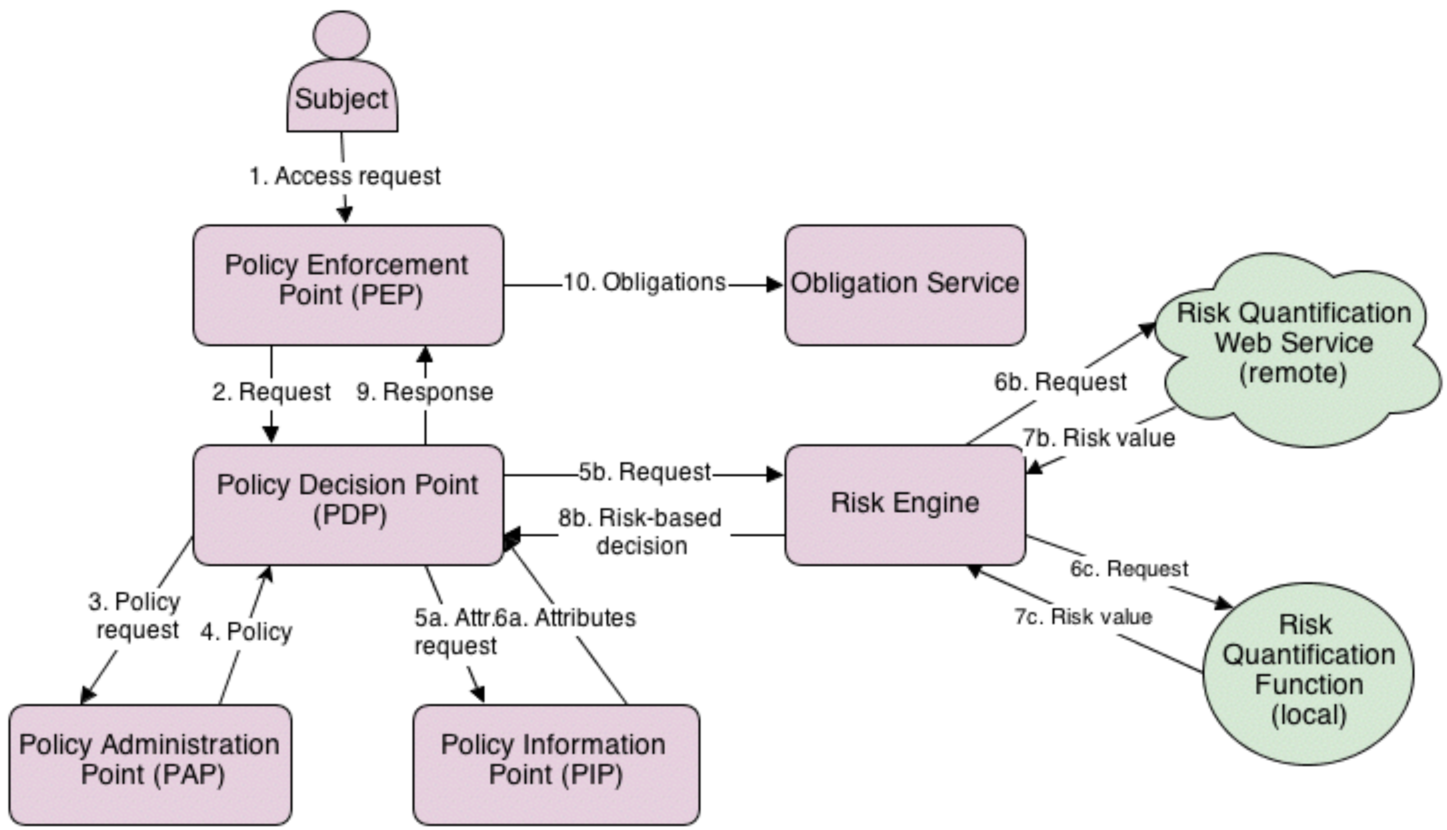
- The CSP has a basic risk policy, defining the maximum risk level accepted by it

Overview



Policy Enforcement Point (PEP)
Policy Decision Point (PDP)
Policy Administration Point (PAP)
Policy Information Point (PIP)
Obligation Service
XACML core components
Risk Engine
Risk Policies
Risk Quantification Web Service
New components

Decision process



Case study - cloud federation

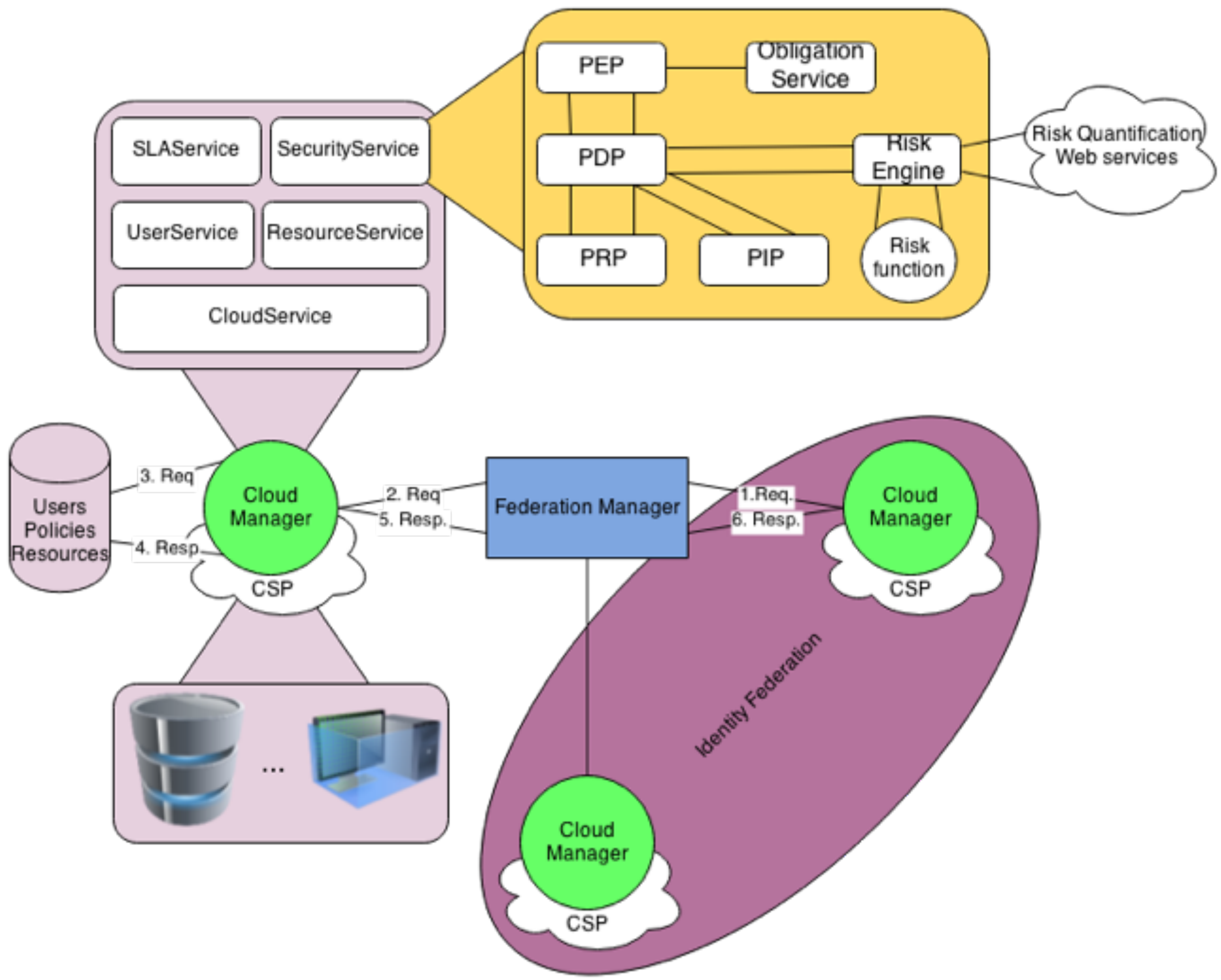
- Identity and Access Management is a big challenge when setting up a cloud federation

- It involves a notion of trust, which is usually mediated by an identity federation, this has two major issues:
  - trust agreements and interoperability

- To decrease the level of trust needed among participating clouds, we incorporate the notion of risk

- Also, interoperability may be increased, because a missing attribute in a message may also be considered as a risk factor, instead of stopping communication

Case study - cloud federation



Considerations

- The architecture allows a flexible AC system
- Risk analysis may be too subjective
    - The support of Obligations is essential
- Risk policies allow the use of many risk metrics, using diverse quantification and aggregation methods from different sources
- The main limitation is the performance overhead due to the processing of the risk policies and the quantification of the risk metrics

Implementation

- Three stages:
  - Access control architecture; Cloud federation; Risk quantification and aggregation methods

- Python, ndg-xacml, ZeroMQ, web.py, peewee, MySQL, OpenNebula

- Two risk policies implemented for tests:
  - Sharma et al. [3] : ((a * p1) + (i * p2) + (c * p3) + pastScore)

  - Britton and Brown [4] : 27 metrics

Experiments - risk policy


```
<rp:risk-policy version="1.0" xmlns:rp="http://inf. ufsc.br/~danielrs">
<rp:resource id="1"/><rp:user id="1"/> <rp:metric-set name="sharma2012">
        <rp:metric>
            <rp:name>Confidentiality</rp:name>
            <rp:quantification>https://localhost:8443/quantify-conf</rp:quantification>
        </rp:metric>
        <rp:metric>
            <rp:name>Availability</rp:name>
            <rp:quantification>https://localhost:8443/quantify-avail</rp:quantification>
</rp:metric>
        <rp:metric>
            <rp:name>Integrity</rp:name>
            <rp:quantification>https://localhost:8443/quantify-int</rp:quantification>
        </rp:metric>
    </rp:metric-set>
    <rp:aggregation-engine>https://localhost:8443/aggregate</rp:aggregation-engine>
    <rp:risk-threshold>1.5</rp:risk-threshold>
</rp:risk-policy>
```

Experiments

TABLE I. PERFORMANCE OF RISK POLICIES

Policy	min. (ms)	max. (ms)	avg (ms)
XACML	0.925	4.278	1.040
XACML+[34]	1.986	11.973	2.436
XACML+[33]	4.395	14.234	5.352

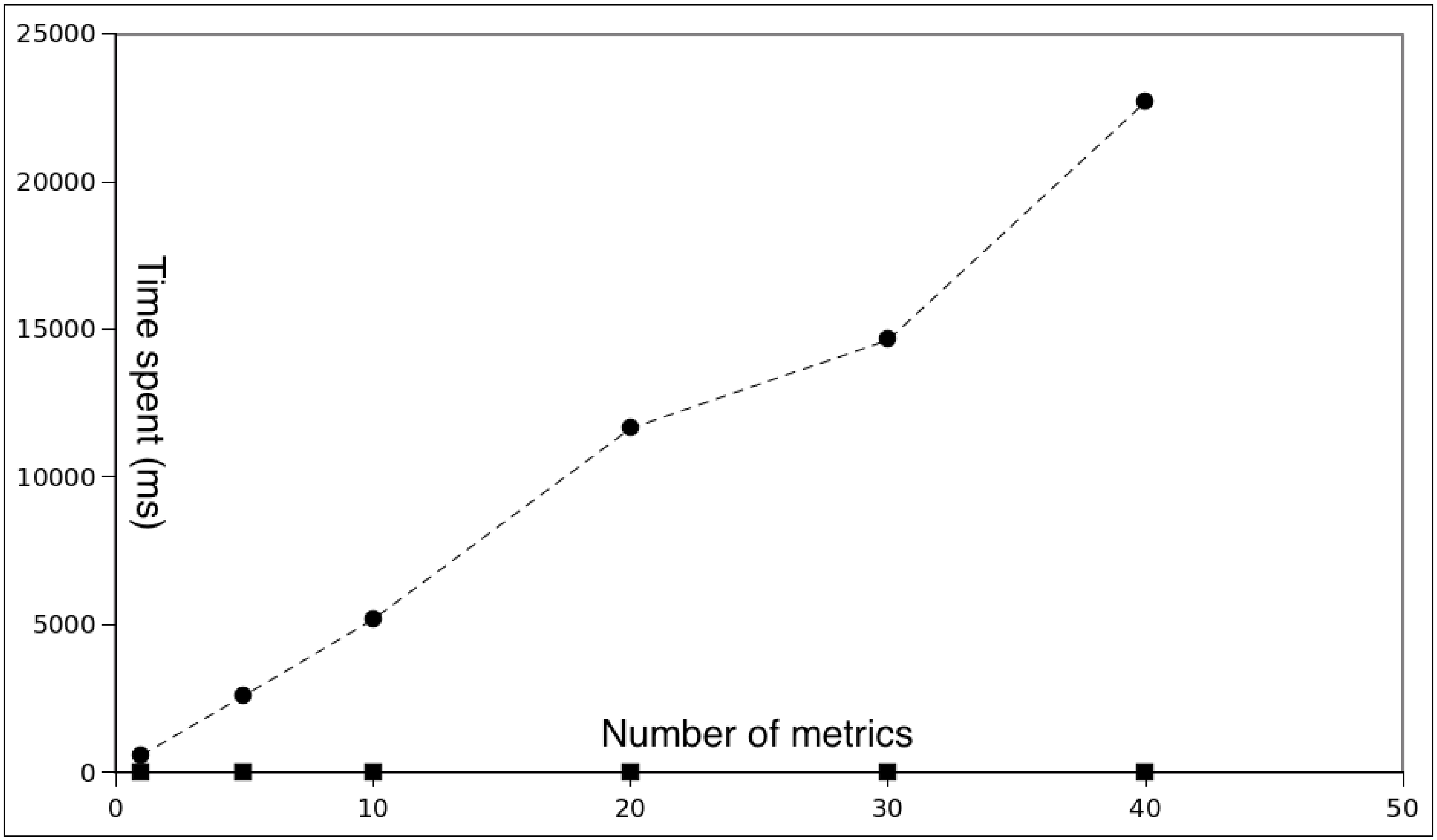
TABLE II. PERFORMANCE WITH A VARYING NUMBER OF METRICS

Number of metrics	min. (ms)	max. (ms)	avg (ms)
1	1.832	12.130	2.243
10	2.612	12.876	3.171
100	10.922	60.442	14.030
1000	96.041	175.245	121.383
10000	1168.511	1517.364	1361.025

TABLE III. PERFORMANCE WITH LOCAL AND EXTERNAL METRICS

Case	min. (ms)	max. (ms)	avg (ms)
A	1.057	9.372	1.46
B	1.824	15.564	4.574
C	1556.182	2813.56	1726.71
D	3247.563	10350.5	4220.6

Experiments



Conclusion

- AC systems for the cloud are of great importance and traditional AC models are not enough for the cloud

- Risk-based AC tend to be very specific to a given scenario, we tried to make it more general, to be applied in a CSP

- We presented, implemented and evaluated the performance of our architecture

- As future work, we would like to: integrate the architecture into a mature cloud federation project; implement other risk quantification methods; improve the performance of external metrics (caching, concurrent requests, …); and develop a reference set of risk metrics for the cloud

References

- [1] D. Fall, G. Blanc, T. Okuda, Y. Kadobayashi, and S. Yamaguchi, “Toward Quantified Risk-Adaptive Access Control for Multi-tenant Cloud Computing,” in *Proceedings of the 6th Joint Workshop on Information Security*, October 2011.

- [2] P. Arias-Cabarcos, F. Almenárez-Mendoza, A. Marín- López, D. Díaz-Sánchez, and R. Sánchez-Guerrero, “A metric-based approach to assess risk for “on cloud” federated identity management,” *Journal of Network and Systems Management*, vol. 20, pp. 513–533, 2012.

- [3] M. Sharma, Y. Bai, S. Chung, and L. Dai, “Using risk in access control for cloud-assisted ehealth,” in *IEEE 14th International Conference on High Performance Comput- ing and Communication, 2012*, 2012, pp. 1047–1052.

- [4] D. Britton and I. Brown, A security risk measurement for the RAdAC model, 2007.

RAClouds – Risk Analysis for Clouds

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- Introduction
- Related Work
- Approach of the Proposed Solution

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Introduction

- The safety evaluation of providers is a big challenge for CCs (CSA, 2011)

- Risk analysis includes (ISO 27005, 2011):
  - Identification of the need for controls
  - Evaluation of the efficiency of controls

Introduction

- Risk Analysis can assist the CC
  – for the selection and maintenance of your CSP

- But consider:
  – Business requirements
  – Broad scope of risk
  – Regardless of CSP

Introduction

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- The lack of these principles generates:
  - Disregard the requirements of the client's business
  - Limited selection of possible security requirements
  - Customer distrust regarding disclosure of risks encountered

Introduction

- Propose a computational model in which a CC *(consumer cloud)* can perform risk analysis in a CSP *(Cloud Service Proveder)* so:
  - – Adherent (needs CC);
  - – Comprehensive (proper scope);
  - – Independent (relative to CSP)

Related Work

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- **Dey (2013):** integration with mobile devices;
- **Zhou (2013):** performance testing;
- **Kolluru (2013):** Client connection to the cloud;
- **Lor (2012):** applications in federations of clouds;

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Related Work

- **Grobauer (2012):** Mapping specific vulnerabilities of cloud computing;
- **Rot (2013):** Study of threats in the cloud;
- **Luna (2012):** SLAs for cloud security;
- **Bleikertz (2013):** assessment by the CC;
- **Grezele (2013):** risks related to cloud database;

Related Work

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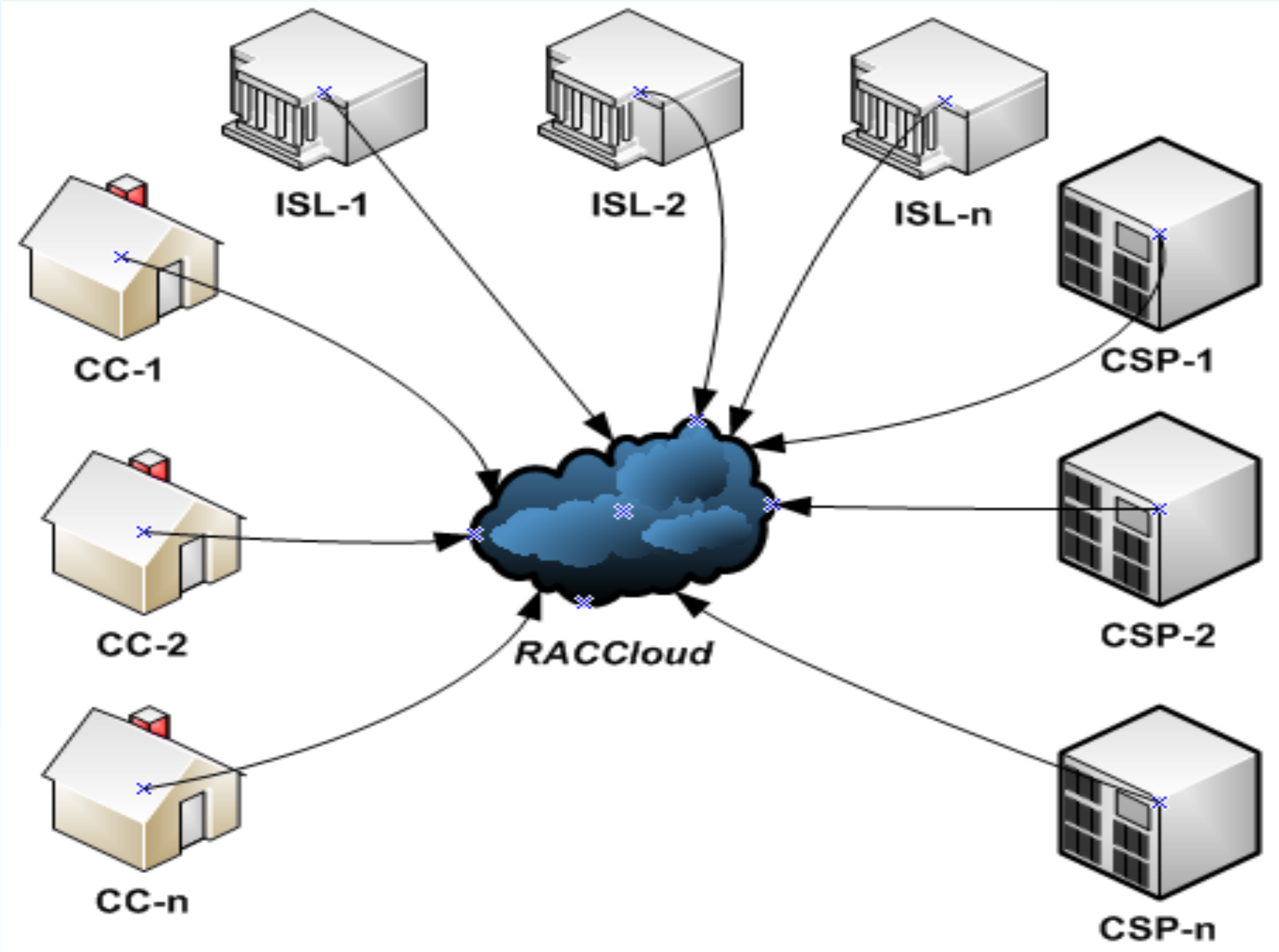
- Ristov (2012): Risk analysis based on ISO 27001;
- Ristov (2013): Risk Analysis for OpenStack, Eucalyptus, OpenNebula and CloudStack environment;
- Mirkovié (2013): ISO 27001 controls the cloud;
- Bhensook (2012) and Ullah (2013):
  - Effort CSA for safety assessment
  - CloudAudit model
  - Based on ISO 27001

Related Work

- **Hale (2012):** SecAgreement for monitoring security metrics;
- **Zech (2012):** Risk analysis of external interfaces;
- **Wang (2012):** analysis of risk based CVE;
- **Khosravani (2013):** a case study of the requirements of CC;
- **Lenkala (2013):** metrics for risk analysis in the cloud;
- **Liu (2013):** Risk assessment in virtual machines;

Proposed Solution



Proposed Solution

- **Agent ISL:**
  - Definition of threats and vulnerabilities
  - Risk describes a descriptor using RDL - *Risk Definition Languagem*
  - Specifies the form of risk assessment through a WSRA - *Risk Analyser WebService*
  - RDLs and provides WSRAs for RACloud

Proposed Solution

- **Agent CC:**
  - Definition of information assets
  - Complements the RDL with the impact of information
  - Provides extension to the RDL RACloud
  - Start the assessment and receive results

Proposed Solution

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- **CSP Agent:**
  - Imports RDLs RACloud
  - Implements calls to WSRAs
  - Make the Call of risk assessments of ISLs

Proposed Solution

Simbol	Description
T_x	Treat defined by ISL "x"
A_y	Information Asset defined by CC "y"
V_z	Vulnerability defined by ISL "z"

Simbol	Description
$eaf(T_x,w)$	Exposure analysis function of T_x on CSP "w"
$iaf(A_y)$	Impacto analysis function of A_y
$daf(V_z,w)$	Deficiency analysis function of V_z on CSP "w"

Proposed Solution

Simbol	Description
$DE_{T,x,w}$	Degree of Exposure related with T_x and w. $eaf(T_x,w)=DE_{T,x,w}$
$DI_{A,y}$	Degree of Impact related with A_y. $iaf(A_y)=DI_{A,y}$
$DD_{V,z,w}$	Degree of Deficiency related with V_z and w. $daf(V_z,w)=DD_{V,z,w}$

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Proposed Solution

Simbol	Description
$E_{T,V}$	Event relating T with V
$\alpha(T_x,V_z)$	Function correlating T and V $\alpha(T_x,V_z)=E_{T,V}$
$fp(E_{T,V})$	Function of probability of $E_{T,V}$ $fp(E)=(DE_{T,x,w}+DD_{V,z,w})/2$, or, $fp(E)=matrix(DE_{T,x,w},DD_{V,z,w})$
P_E	Probability of $E_{T,V}$ $fp(E_{T,V})=P_E$

Proposed Solution

Simbol	Description
$R_{E,A}$	Risk relating E and A
$\beta(E,A_y)$	Function correlating E and A_y $\beta(E,A_y)=R_{E,A}$
$raf(R_{E,A})$	Risk analysis function of $R_{E,A}$ $raf(R_{E,A})=(P_E+ DI_{A,y})/2$ ou $raf(R_{E,A})=matriz(P_E,DI_{A,y})$
$DR_{E,A}$	Degree of risk related with $R_{E,A}$ $raf(R_{E,A})=GR_{E,A}$

Proposed Solution

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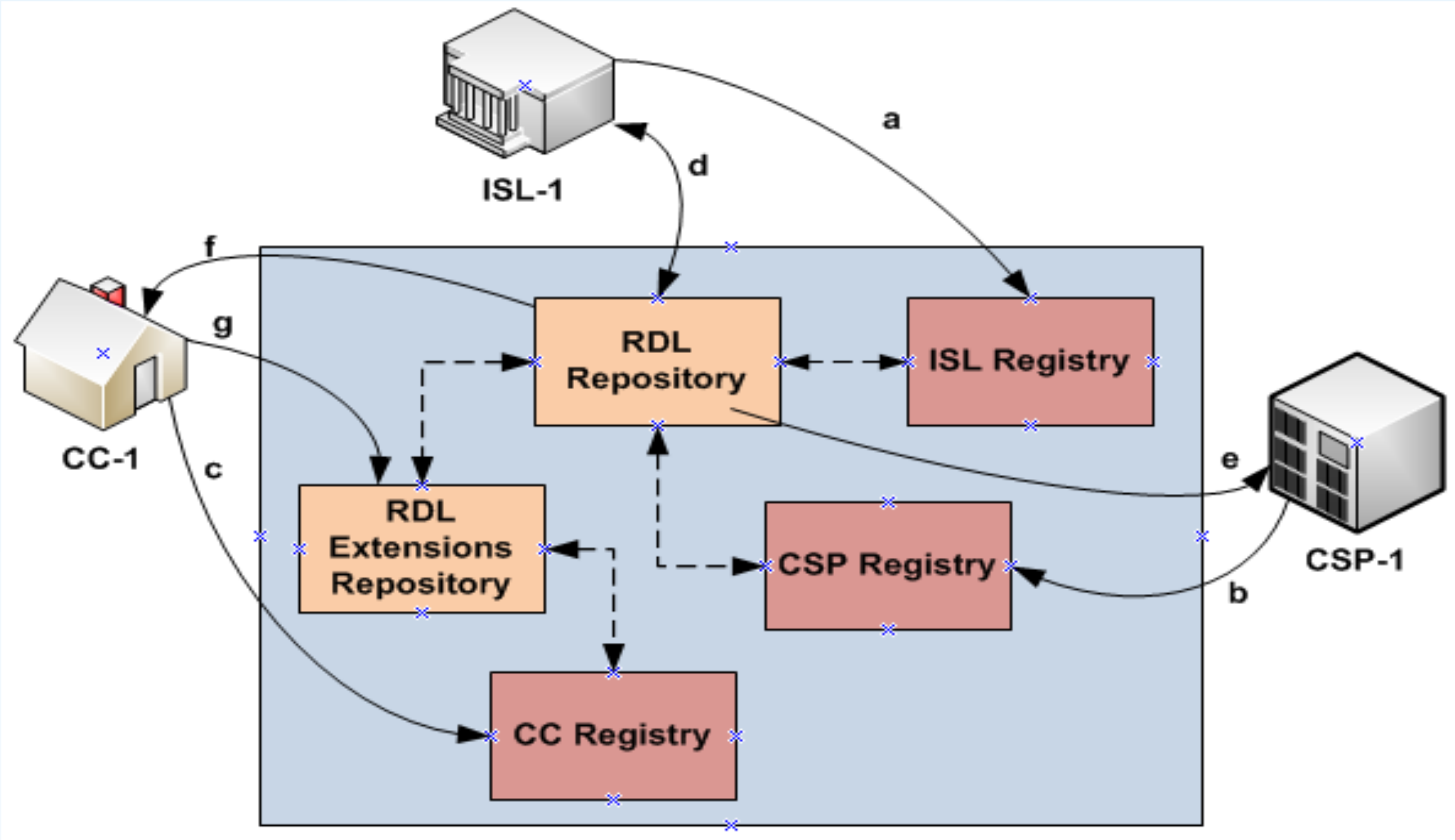
- Model is organized into:
  - **Specification phase:** environmental risk analysis is configured;
  - **Evaluation Phase:** risk analysis is performed;

Proposed Solution

- **Component Specification:**
  - ***Registry*** *Manager:* Records CC, CSP and ISL manager;
  - ***RDL Manager:*** descriptors of risk (threat + vulnerability) manager;
  - ***RDL Manager Extensions:*** Extensions RDL (information assets) manager;

Proposed Solution



Proposed Solution

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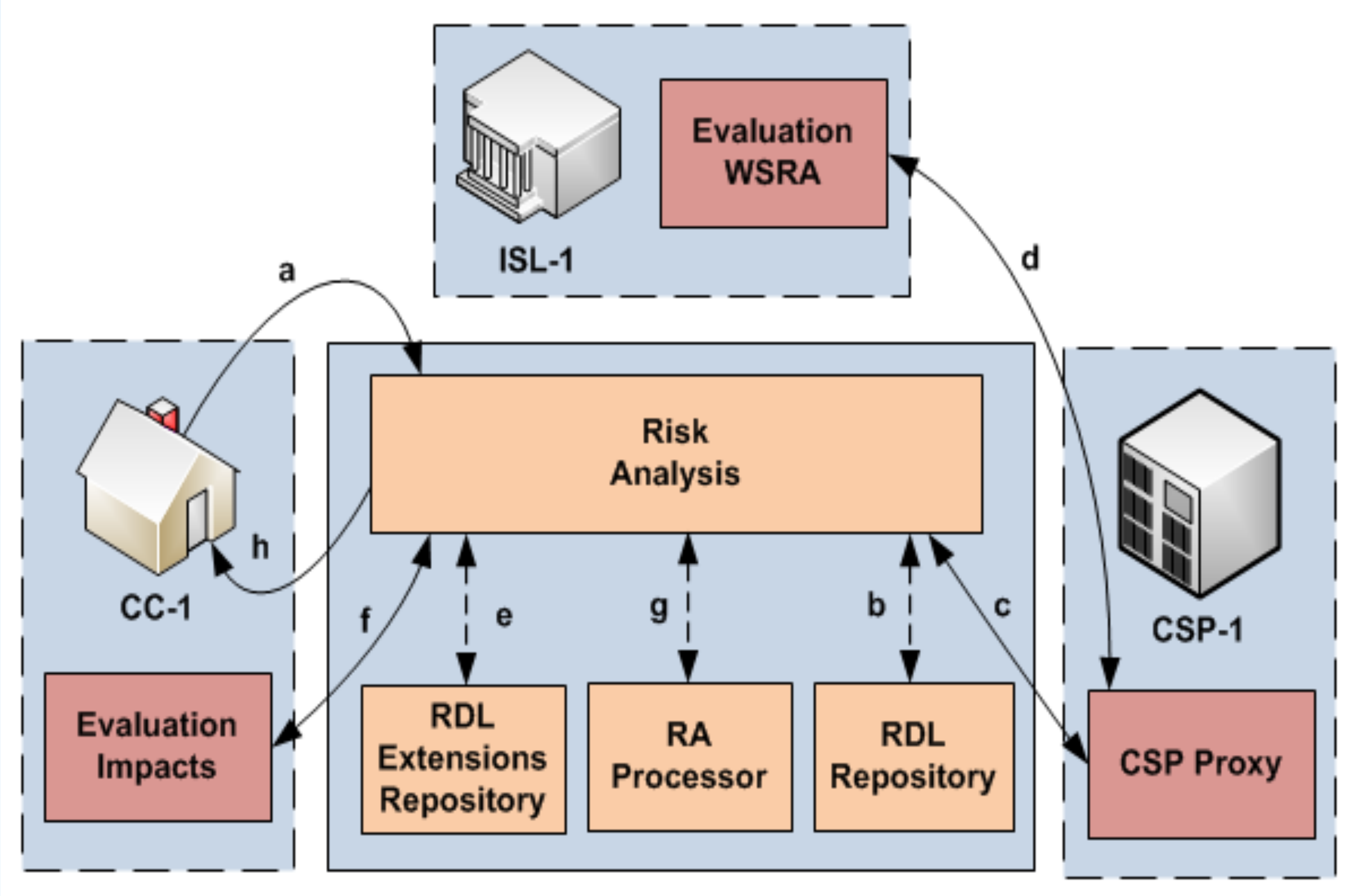
- **Components of Evaluation:**
  - ***Risk Analysis:*** Does the coordination between other internal components;
  - ***RA Processor:*** establishes relationships and makes the calculation of risk;
  - ***Impacts Evaluation:*** assessing the impact on CC;
  - **CSP Proxy:** call for testing the ISL;
  - ***WSRA Evaluation:*** evaluation of safety requirements;

Proposed Solution



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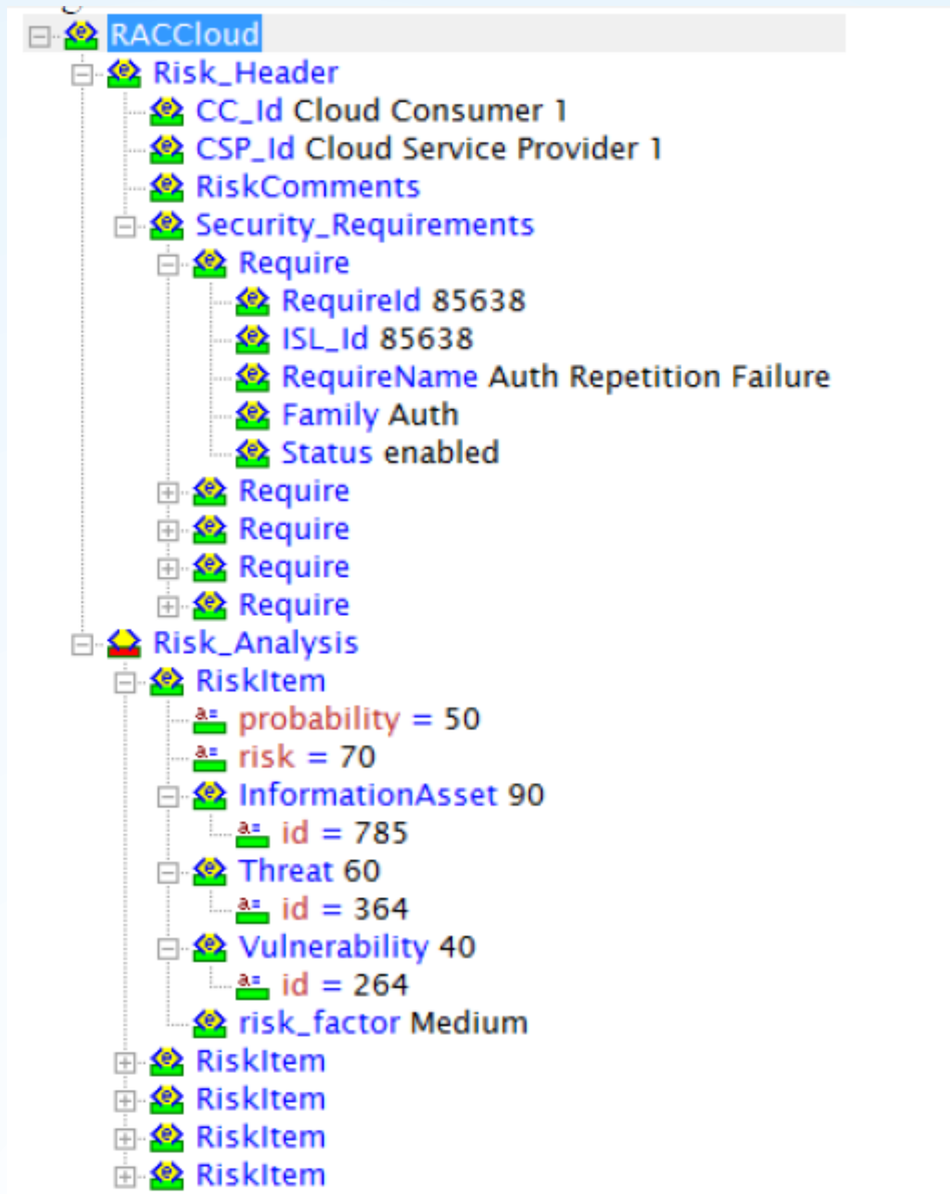
Proposed Solution



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Discussion

- Multiple ISLs can act in defining RDLs and WSRAs (coverage)
- The related works do not meet these characteristics
- Are usually focused on specific evaluations by PHC itself, without considering the CC

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Discussion

rdl_cc.xml

```xml
<?xml version="1.0" ?>
<RDL type="CC" id="9999">
    <source>Consumer-X</source>
    <branch>1</branch>
    <version>4.5.1a</version>
    <description>...</description>
    <informationAssets>
        <item id="123">
            <description>Email service</description>
            <type>service</type>
            <assessment>http://localhost:8080/evaluate?wsdl</assessment>
        </item>
        <item id="345">
            <description>Operation reports</description>
            <type>information</type>
            <assessment>http://localhost:8080/evaluate?wsdl</assessment>
        </item>
    </informationAssets>
</RDL>
```

Discussion

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rdl_isl.xml


```xml
<?xml version="1.0" ?>
<RDL type="ISL" id="8796">
    <source>LRG-UFSC</source>
    <branch>1</branch>
    <version>4.5.1a</version>
    <description>...</description>
    <vulnerabilities>
        <item id="12">
            <description>Cipher protocolo weak</description>
            <assessment>http://localhost:8081/assessItem12</assessment>
        </item>
        <item id="23">
            <description>Clear text password</description>
            <assessment>http://localhost:8081/assessMany</assessment>
        </item>
    </vulnerabilities>
    <threats>
        <item id="45">
            <description>Espionagem interna</description>
            <assessment>http://localhost:8081/assessMany</assessment>
        </item>
        <item id="67">
            <description>Abuso de direitos</description>
            <assessment>http://localhost:8081/assessMany</assessment>
        </item>
    </threats>
</RDL>
```

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References

- M. K. Srinivasan et al., “State-of-the-art cloud computing security taxonomies: a classification of security challenges in the present cloud computing environment”. ICACCI '12: Proceedings of the International Conference on Advances in Computing, Communications and Informatics. August 2012.
- J. Zhang, D. Sun and D. Zhai, "A research on the indicator system of Cloud Computing Security Risk Assessment," *Quality, Reliability, Risk, Maintenance, and Safety Engineering (ICQR2MSE), 2012 International Conference on* , vol., no., pp.121,123, 15-18 June 2012 doi: 10.1109/ ICQR2MSE. 2012.6246200.
- M. L. Hale and R. Gamble, "SecAgreement: Advancing Security Risk Calculations in Cloud Services," *Services (SERVICES), 2012 IEEE Eighth World Congress on* , vol., no., pp.133-140, 24-29 June 2012 doi: 10.1109/SERVICES.2012.31.
- P. Zech, M. Felderer and R. Breu, "Towards a Model Based Security Testing Approach of Cloud Computing Environments," *Software Security and Reliability Companion (SERE-C), 2012 IEEE Sixth International Conference on* , vol., no., pp.47,56, 20-22 June 2012 doi: 10.1109/SERE-C.2012.11.
- P. Wang et al., "Threat risk analysis for cloud security based on Attack-Defense Trees," *Computing Technology and Information Management (ICCM), 2012 8th International Conference on*, vol.1, no., pp. 106-111, 24-26 April 2012.
- S. Ristov, M. Gusev and M. Kostoska, "A new methodology for security evaluation in cloud computing," *MIPRO, 2012 Proceedings of the 35th International Convention* , vol., no., pp.1484-1489, 21-25 May 2012.
- J. Morin, J. Aubert and B. Gateau, "Towards Cloud Computing SLA Risk Management: Issues and Challenges," *System Science (HICSS), 2012 45th Hawaii International Conference on* , vol., no., pp. 5509-5514, 4-7 Jan. 2012 doi: 10.1109/HICSS.2012.602.