MEIM MASTER IN ENTREPRENEURSHIP INNOVATION MANAGEMENT IN COLLABORATION WITH MIT SLOAN

IN COLLABORATION WITH MIT MANAGEMENT SLOAN SCHOOL

UNIVERSITÀ DEGLI STUDI DI NAPOLI PARTHENOPE

MASTER MEIM 2022-2023

Security Issues in Cloud Computing

PART TWO – SELECTED TOPICS IN CLOUD SECURITY

Luigi CATUOGNO, PhD

Associate Professor in Computer Science at Università degli Studi di Napoli Parthenope (ITALY)

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Selected Topics in Cloud Security

User Authentication

Access Control and Security Policy Enforcemement (Authorization)

Secure Data Outsourcing

Multi-tenancy and Workload Isolation

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User authentication

Mechanisms for user recognition through

- PIN/password
- Biometric measures
- Cryptographic tokens
- Multi-factor authentication schemes

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User authentication

In the cloud, due to the potentially huge number of user and the high services interoperability, an authentication system plays a fundamental role.

In particular, it is required to be:

- Fast and scalable
- Able to handle the whole user account lifecycle automatically
- Able to identify and solve a wide range of possible faults or abuse without human intervention
- interoperable

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User authentication

SINGLE RESOURCE/SINGLE DOMAIN

In origin, the authentication system were designed to protect:

Single resources

- e.g. one computer/server, a DBMS system

Within a single domain

- i.e. the entity which groups together a pool of resources and the users that are allowed to use them.

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User authentication

SINGLE RESOURCE/SINGLE DOMAIN

For example, in a UNIX host, the domain includes the host computer and its users (that are listed in the password file)

- Only users included in such database: are allowed to log-in the computer
- Users listed in the password file are able to log-in only this computer

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User authentication

MULTIPLE RESOURCES/SINGLE DOMAIN

Within distributed systems, domains encompass multiple resources, so that a centralized user authentication system is used by every resource in the domain

- (Kerberos, Raidus, Active Directory, LDAP...)

For example:

- In a corporate network, users are registered with the central authority
- user are able to sign-on every computer of the network

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User authentication

MULTIPLE RESOURCES/MULTIPLE DOMAINS

What if users need to access to resources from multiple domains?

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User authentication

MULTIPLE RESOURCES/MULTIPLE DOMAINS

Traditional (centralized) systems are not designed to *interoperate* so, either:

- *Users are asked to handle multiple credentials in order to access resources from different domains*

or:

- *Domain authorities agree tp disclose each others information about their users, and their internal resources*

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Federated Authentication *(single sign-on)*

MULTIPLE RESOURCES/MULTIPLE DOMAINS

Joining the *federation,* multiple domain tenants agree on a common set of policies and protocols in order to manage identification and trust among their respective users and resurces

- users transparently access services operating in any federated domain, authenticating themselves with their home domain authority
- only information related to users' privilege determination are transferred among domains

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Shibboleth

FEDERATED AUTHENTICATION SYSTEM

Developed by the Internet2 consortium since 2000

- Version 1.0 was released in 2003
- Version 2.0, released in 2008

Current version :2.4 is maintained by the Shibbolet Consortium

https://shibboleth.net

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Shibboleth

FEDERATED AUTHENTICATION SYSTEM

Components:

- Web browser
  - Is the agent through which the user starts the sign-on process
- Resource
  - The service the user wishes to access to
- Identity Provider
  - The component which authenticates the user
- Service Provider
  - Performs the sign-on process for the resource

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Shibboleth

FEDERATED AUTHENTICATION SYSTEM

- Access Control is performed by matching attributes provided by Identity Providers against rules stated by Service Providers
- Attributes and protocol messages (assertions) are described using the Secure Assertion Markup Language (SAML) standards

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Shibboleth

FEDERATED AUTHENTICATION SYSTEM

- Trust is established within a Public Key Infrastructure (usually by means of X509 certificates)
- Terms and conditions of use of information exchanged between peers are set out in the agreement
  - Confidentiality, retention…

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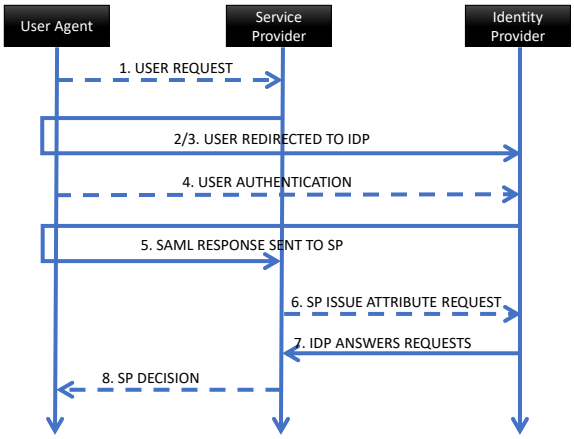
Shibboleth

FEDERATED AUTHENTICATION SYSTEM



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Delegated Authorization

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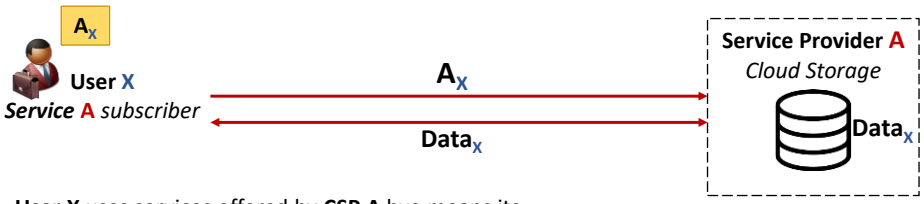
Delegated Authorization



User X uses services offered by **CSP A** bye means its front-end application (or through its web interface)

User X has previously subscribed with **CSP A** and has got his private access credentials A_x

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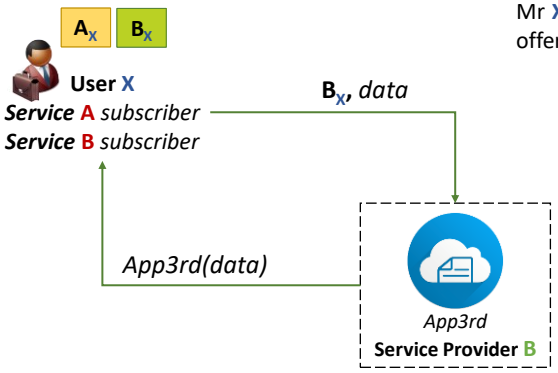
Delegated Authorization



Mr X also subscribes the service by CSP B which offers an application for data processing…

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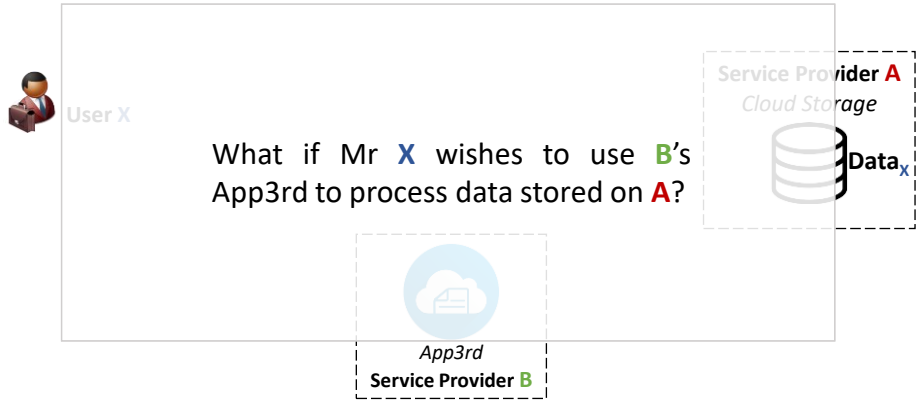
Delegated Authorization



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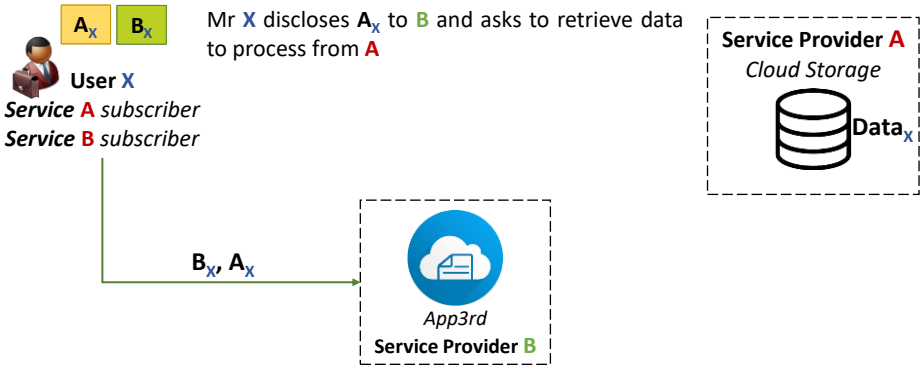
Delegated Authorization

CREDENTIAL DISCLOSURE



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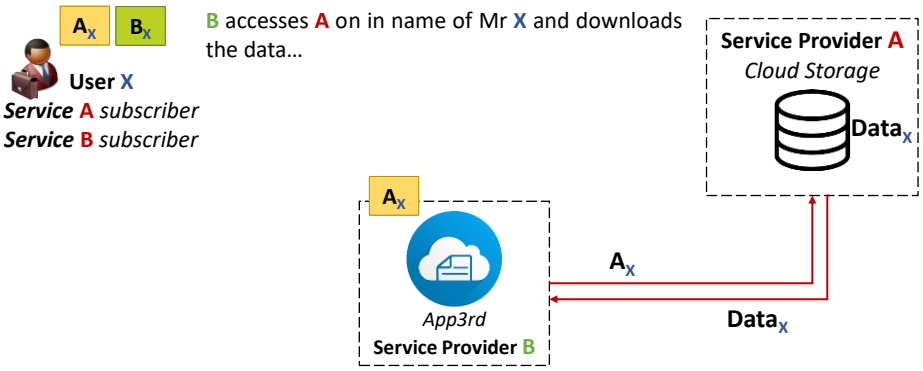
Delegated Authorization

CREDENTIAL DISCLOSURE



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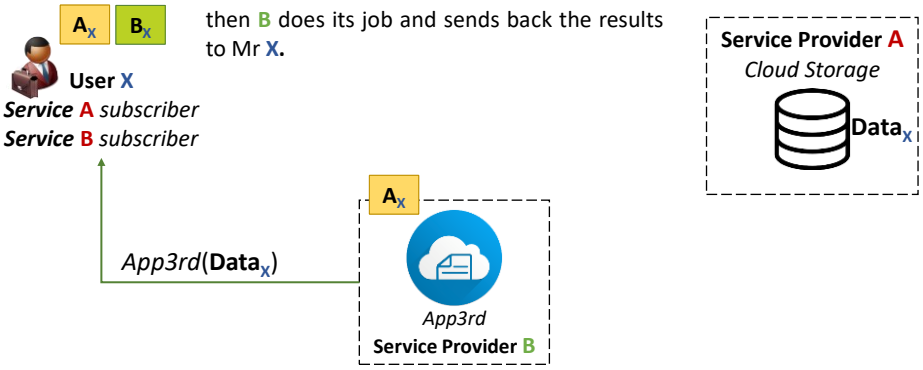
Delegated Authorization

CREDENTIAL DISCLOSURE



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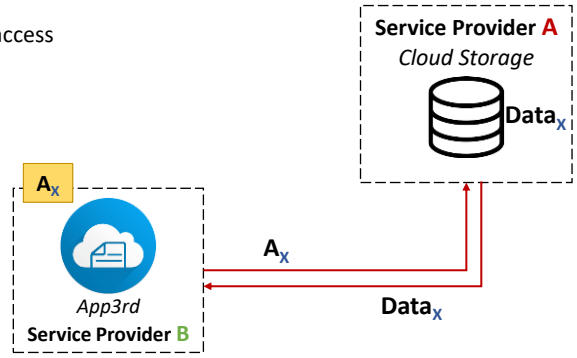
Delegated Authorization

CREDENTIAL DISCLOSURE

The point is that now CSP **B** has got free access to the data Mr **X** has stored on **A**...



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OAuth (OpenAUTHorization)

DELEGATED AUTHORIZATION

Open standard protocol for delegated authentication. It enables *front-end applications* to use a remote resource (e.g. a cloud based service) on behalf of a subscriber, without releasing its credentials.

- Developed since 2006 by Blain Cook
- Version 1.0 was released in 2007 (RFC-5849)
- Version 2.0 (OAuth2) was released in 2012 (RFC-6750)

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OAuth2

DELEGATED AUTHORIZATION

Resource Owner: *(Mr X, in our example)* is the owner of remote resources. She subscribed an agreement with the *Resource Server* to manage (e.g. store) her resources remotely.

Resource/API Server: *(CSP A)* is the Service Provider by whom the Resource Owner stored her data. The Resource Server allows to access to such data to whoever provides an *Access Token* on behalf of the Resource Owner.

The Client *(CSP B)* is the application which requests the access to the data. It must previously request the proper Access Token.

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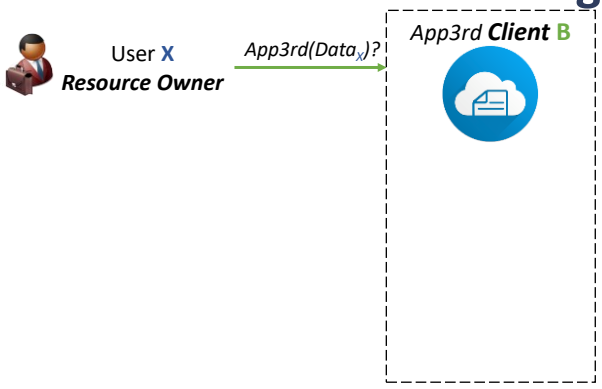
OAuth2: authorization code grant



1 User **X** ask **B** to process $Data_X$ stored in **A**

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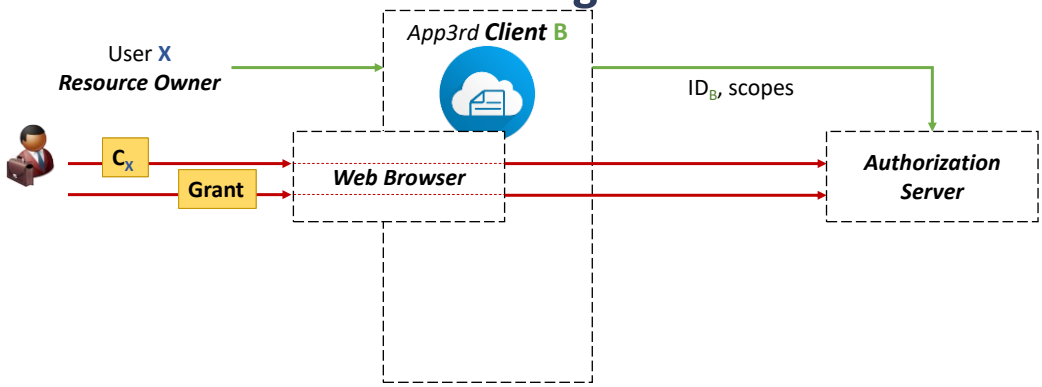
OAuth2: authorization code grant



2 ***Client*** **B** contacts the Authorization Server, sends its ID and asks for the required privileges(scopes) to accomplish.

3 ***Client*** **B** redirects **X** to the authorization in order to grant such privileges

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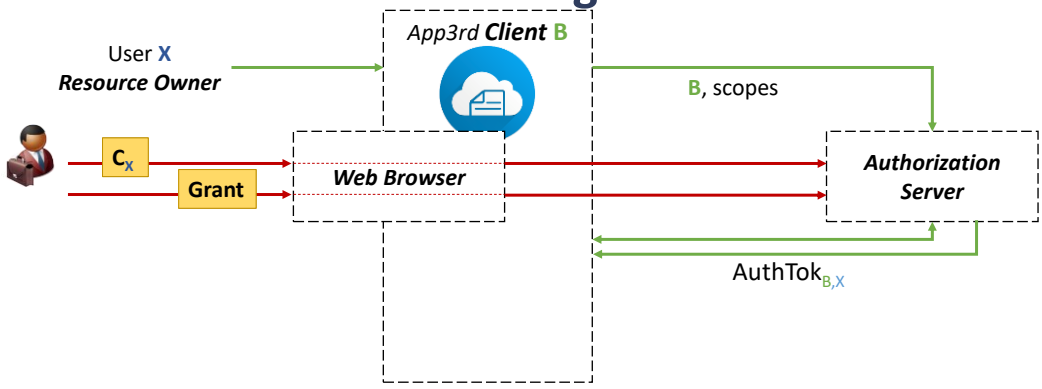
OAuth2: authorization code grant



4 L'***Authorization Server*** first authenticates the ***Client*** then sends it an ***Authorization Token***

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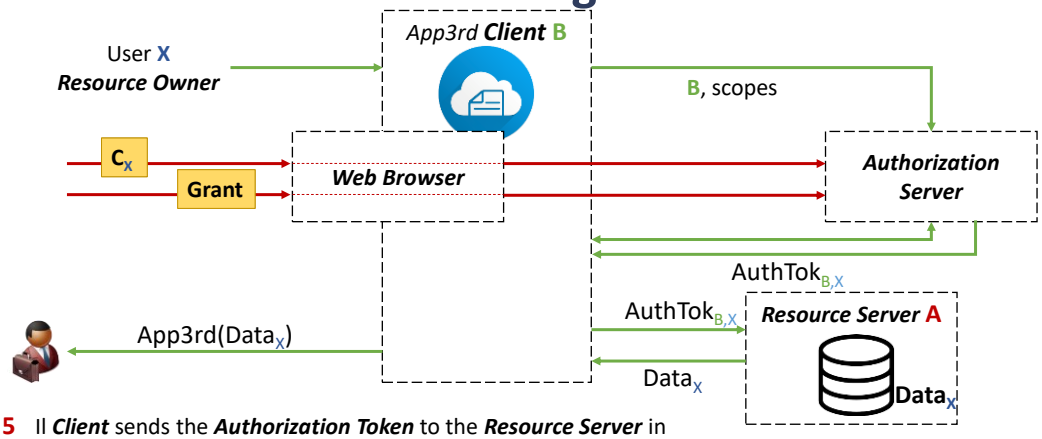
OAuth2: authorization code grant



5 Il ***Client*** sends the ***Authorization Token*** to the ***Resource Server*** in order to download the data

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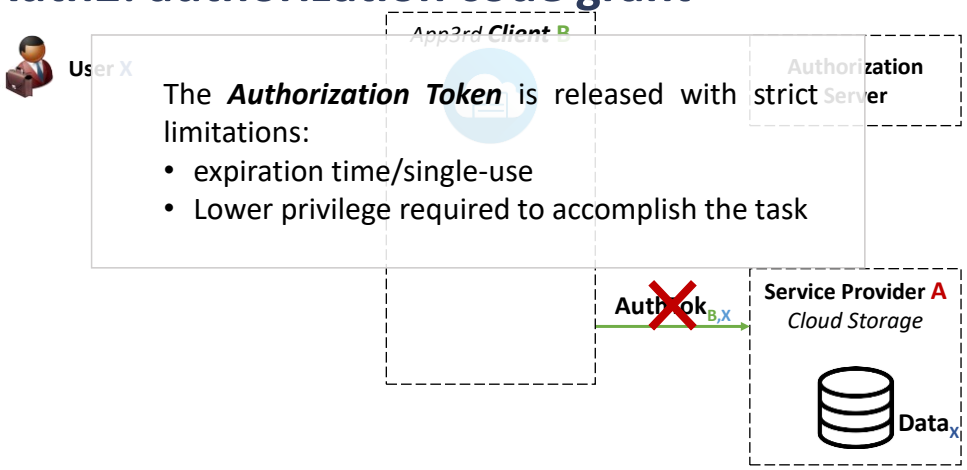
OAuth2: authorization code grant



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Secure Data Outsourcing

HOMOMORPHIC ENCRYPTION

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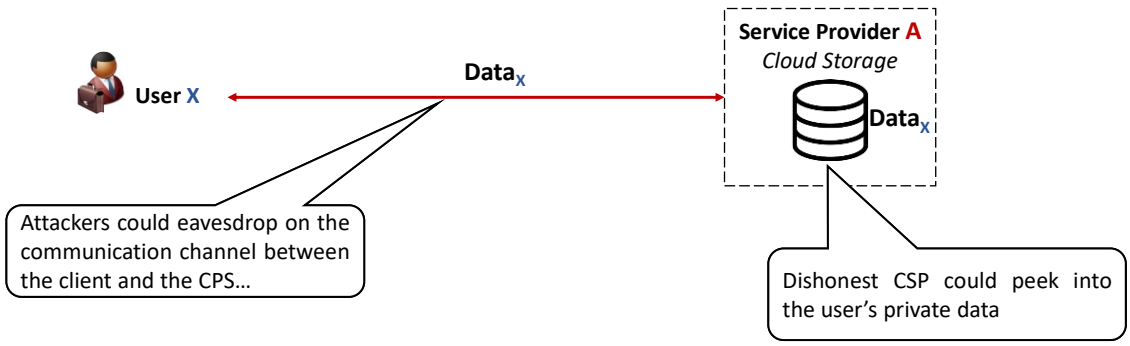
Secure data outsourcing

THREAT MODEL



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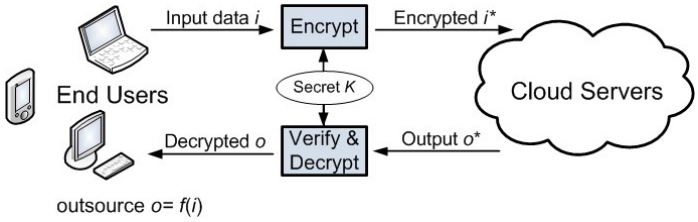
Secure Data Outsourcing

NAIVE SOLUTION



1 The data owner locally encrypt the data with a simmetric key ***K*** before uploading it to the cloud storage

Whoever has the key ***K*** is *authorized* to read/modify such data

2 The data owner uploads encrupted data. Neither possible eavesdropers nor anybody at the CSP have access to data contents

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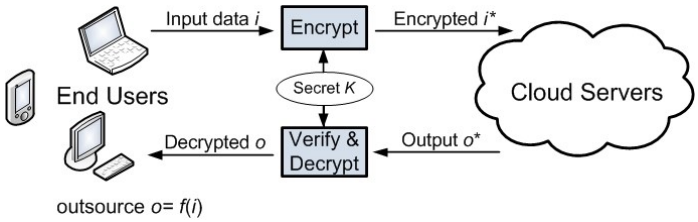
Secure Data Outsourcing

NAIVE SOLUTION



3 to accesse the data, whoever is in charge can…

- first download and then decrypted it locally (using ***K***)
- Decrypting (and re-encrypting once the task is completed) directly on the cloud…

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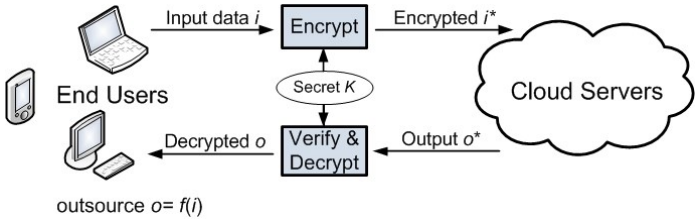
Secure Data Outsourcing

NAIVE SOLUTION



outsource $o = f(i)$

3 to accesse the data, whoever is in charge can…

- first download and then decrypted it locally (using ***K***) **NOT EFFICIENT**
- Decrypting (and re-encrypting once the task is completed) directly on the cloud… **INEFFICIENT**

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Homomorphic encryption

Leads to the capability to perform certain computation on encryped date without decrypting it first

Entails *cryptographic primitives* in which (every) operation to do on a *plaintext* has a *peer* (possibly different) that can be done on the corresponding *cyphertext* to compute the same result.

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Homomorphic Encryption

Data: strings «Hello, » and «World!»
Operation: concatenation(s_1,s_2)→s_3

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Homomorphic Encryption

Data: strings «Hello, » and «World!»
Operation: concatenation(s_1,s_2)→s_3

Informally, an HE primitive H is such that: given an encryption key K, let:

- $X_1=H_{Enc}(K,s_1)$, $X_2=H_{Enc}(K,s_2)$ and foo() *is somehow* $H_{Enc}(K,$*concatenation()*$)$

Then:

- $X_3=foo(X_1,X_2)$ and $H_{Dec}(X_3)=S_3$

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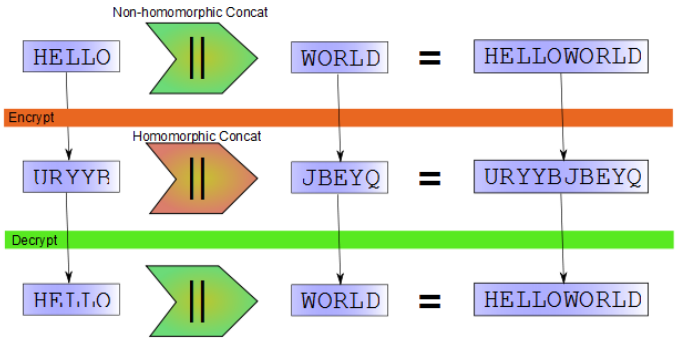
Homomorphic Encryption



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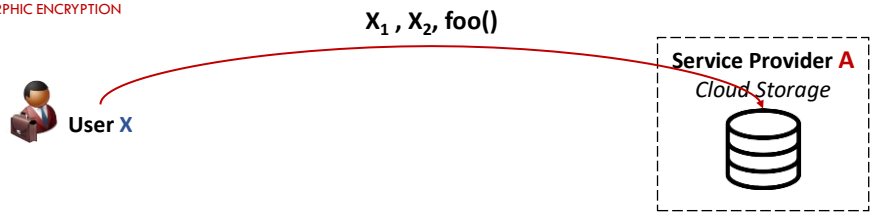
Secure data outsourcing

HOMOMORPHIC ENCRYPTION



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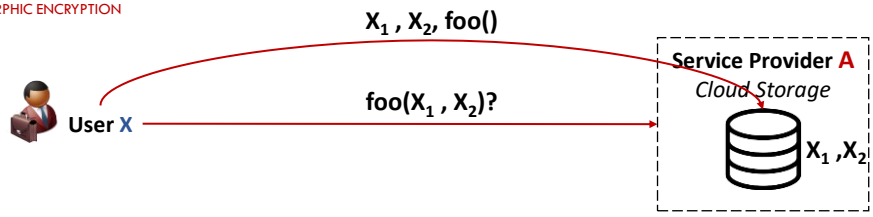
Secure data outsourcing

HOMOMORPHIC ENCRYPTION



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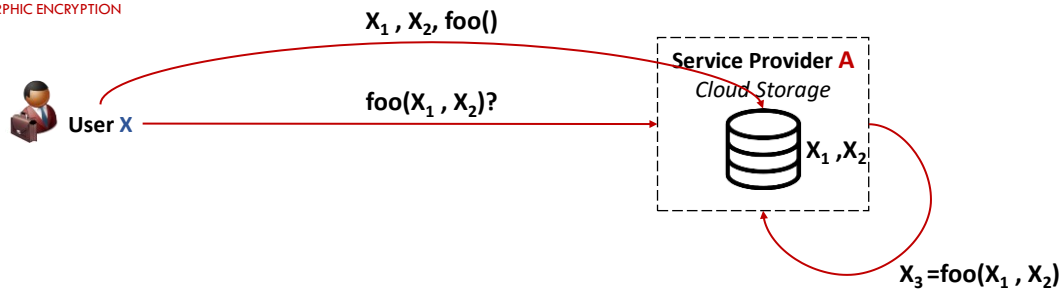
Secure data outsourcing

HOMOMORPHIC ENCRYPTION



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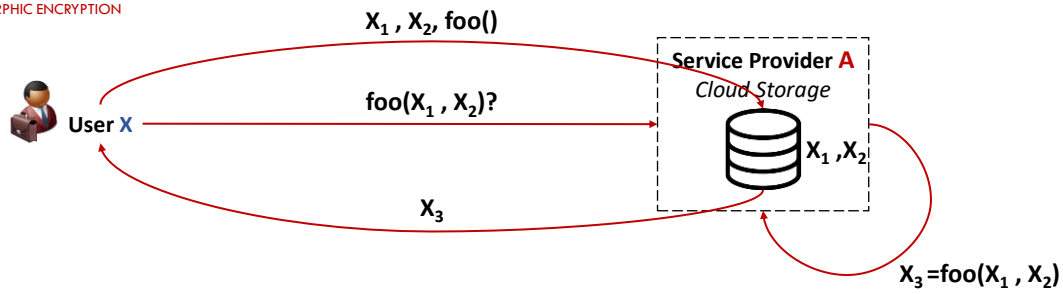
Secure data outsourcing

HOMOMORPHIC ENCRYPTION



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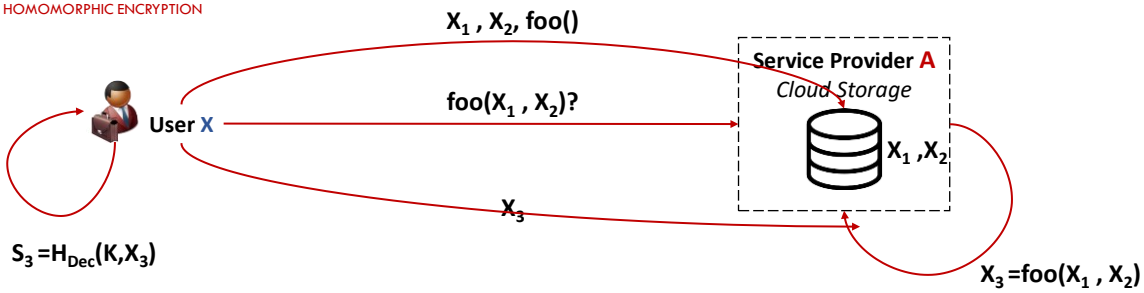
Secure data outsourcing

HOMOMORPHIC ENCRYPTION



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Encrypted queries to Encrypted Databases

A CASE STUDY

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Actors…

ENCRYPTED QUERIES TO ENCRYPTED DATABASES

One *Data Owner* - **DO**

- Manages access rights to the data originating from *data sources*
  - Allows data sources to directly upload data to the storage server without any intervention
  - Has complete control on the type of queries each query source is allowed to issue

Several *Data Sources* – **DS**

- Store data to the *storage server* in encrypted form, on behalf of *data owner*

Several *Query Sources* – **QS**

- Issue `SELECT-FROM-WHERE` queries to the *query processor* under the control of the *data owner*

One *Query Processor* – **QP**

- Enjoys physical access to the encrypted data and performs the queries issued by the *query sources*

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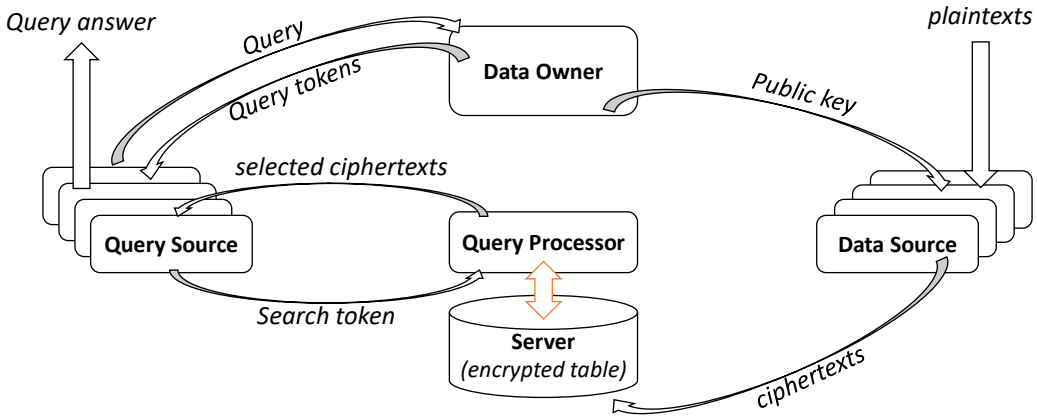
Encrypted Queries to Encrypted Databases



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Multi-tenancy and Workload Separation

TRUSTED VIRTUAL DOMAINS (TVD)

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Trusted Virtual Domains (TVD)

Trusted Virtual Domains (TVDs) are a facility ensuring different workloads (belonging to different tenants) can share a common ITC infrastructure (data center, network) beeing kept strictly isolated each other.

Workload: Applications / Virtual Machines

ICT Infrastructure: Physical Machine + hypervisor + Trusted Computing + Network infrastructure

TVDs fit the *multi-tenant data center* scenario, in which a data-center provider offers its server farm to host and execute multiple (possibly) interconnected workloads. Every workload owner *has the impression* to be the only who uses the infrastructure.

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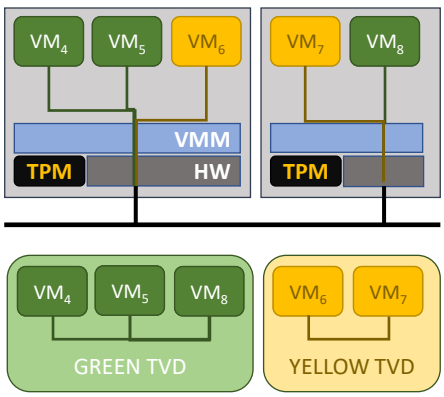
Trusted Virtual Domains (TVD)

- Coalition of Virtual Machines (VM) that
  - Trust each other
  - Enforce a common security policy (TVD Policy)
  - Span over a physical infrastructure, shared with other TVDs
- The underlying virtualization layer
  - Isolates virtual machines of different TVDs in separated compartments
  - Connects virtual machines of the same TVD through a dedicated and isolated VLAN



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TVD Policy

TRUSTED VIRTUAL DOMAINS

Enforcement of a twofold access control policy:

- Physical platform eligibility criteria to host any TVD workloads
- Virtual Machines eligibility to join any TVD

TVD Deploy protocol

- A «TVD Master» measures (attestation) the physical platform and check it fits the requirements to run VMs in its domain
- Eventually a «TVD Proxy» is instantiated on the platform

TVD Join protocol

- The TVD Proxy measures any VM running on the pysical platform that requests to access the TVD. Access is granted if VM integirty and requested properties are successfully verified

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Enterprise Rights Management

A CASE STUDY

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Application scenario: Remote Maintenance

A CASE STUDY

Complex equipment come with a technical on-site support facility

On-site operators are provided of mobile devices which let them…

- Searching and browsing any knowledge source provided by the manufacturer
- Interacting with a remote «expert room» through the network
- Performing in situ probing, measurement and diagnostic tasks

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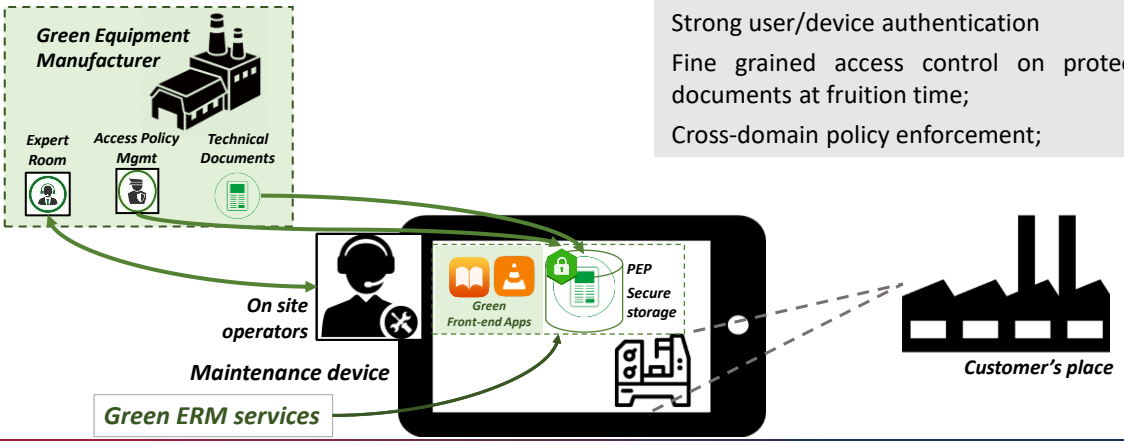
Enterprise Rights Management

A CASE STUDY: REMOTE MANAGEMENT

- Document encyption;
- Strong user/device authentication
- Fine grained access control on protected documents at fruition time;
- Cross-domain policy enforcement;



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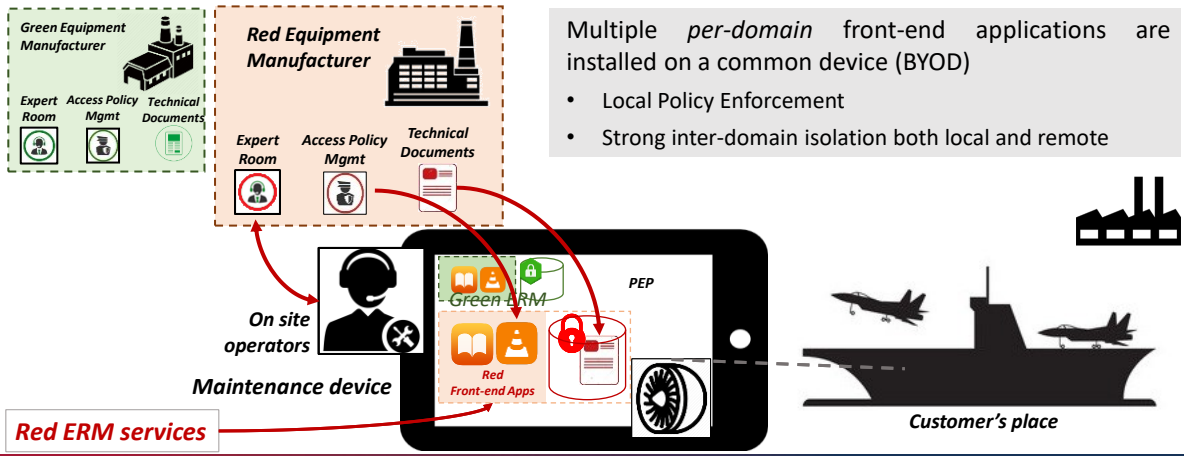
Enterprise Rights Management

A CASE STUDY: REMOTE MANAGEMENT



Multiple *per-domain* front-end applications are installed on a common device (BYOD)

- Local Policy Enforcement
- Strong inter-domain isolation both local and remote

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