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DIPARTIMENTO
DI MATEMATICA E INFORMATICA

# DIGITAL IDENTITIES AND IAM

## Cybersecurity with Laboratory

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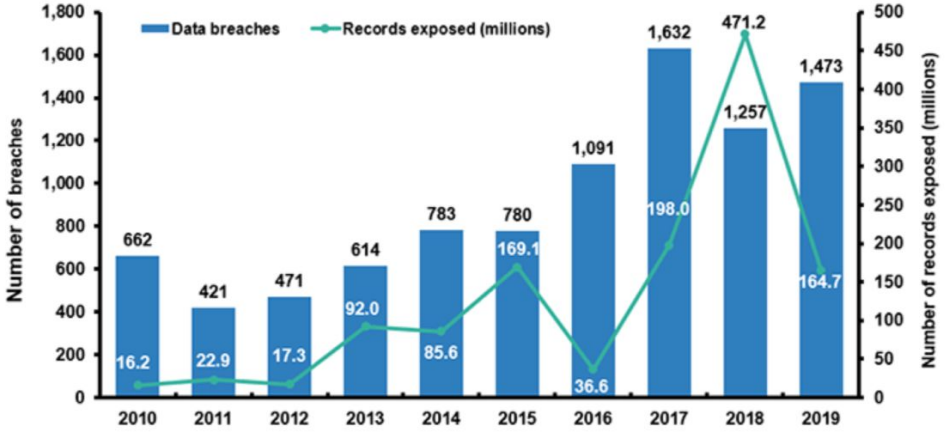
# Digital Identities

# Identity Theft

***Identity theft*** *occurs when someone uses another person's personal* ***identifying information****, like their name, identifying number, or credit card number,* ***without their permission****, to commit fraud or other crimes.*

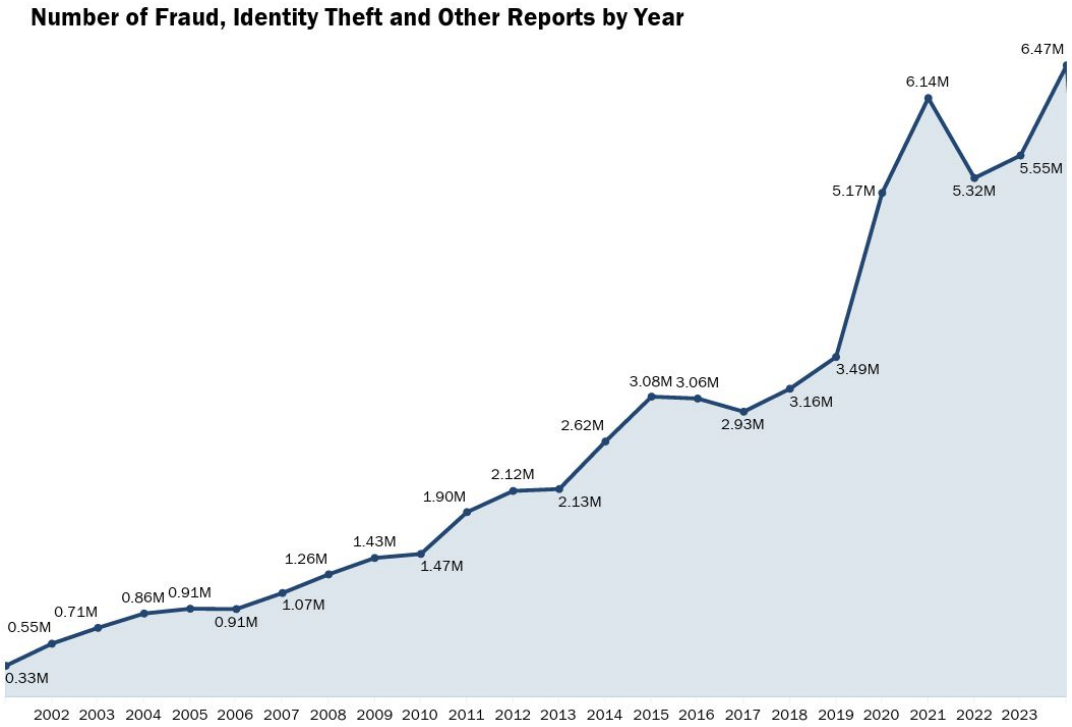
# Identity Theft and Fraud

In 2019, **14.4 million** consumers became victims of identity fraud. Overall, 33 percent of U.S. adults have experienced **identity theft**, which is more than twice the global average. More than one in four older adults, aged 55 and over, have experienced identity theft.




Source: [Identity Theft Resource Center]

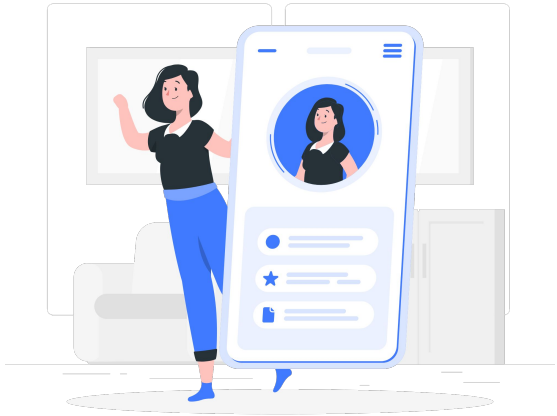
# Identity Theft and Fraud



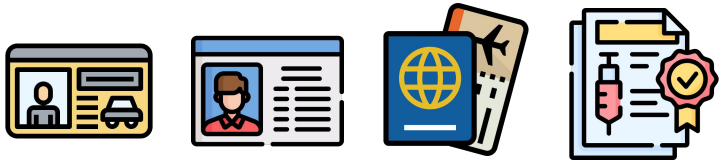

Source: [Consumer Sentinel Network Data Book]

# Digital Identity

*A digital identity is **information** on an **entity** used by computer systems to **represent** an **external agent**. That agent may be a person, organization, application, or device. ISO/IEC 24760-1 defines identity as **"set of attributes related to an entity"**.*



- They contain the **minimum of attributes** needed in that context
- Useful for **assessment** and **authentication**



# Identity, identifier and account

The term “identifier” refers to a **single attribute** whose purpose is to **uniquely identify** a person or entity, within a **specific context**.

- email addresses,
- passport numbers,
- driver’s license numbers,
- employee numbers.


*Nonhuman entities, such as agents, bots, or devices, may be identified by an **alphanumeric string of characters** assigned at their time of creation or registration within a context where they will act.*

# Attributes

- Human identities may include attributes such as **name**, **age**, **address**, **phone number**, **eye color**, and **job title**.
- Nonhuman identities may include attributes such as an owner, **IP address.**
- The attributes which make up an identity may be used for authentication and authorization

*An online identity consists of **at least one identifier** and a **set** of **attributes** for a user or entity in a particular context, such as an application or suite of applications.*

# Account

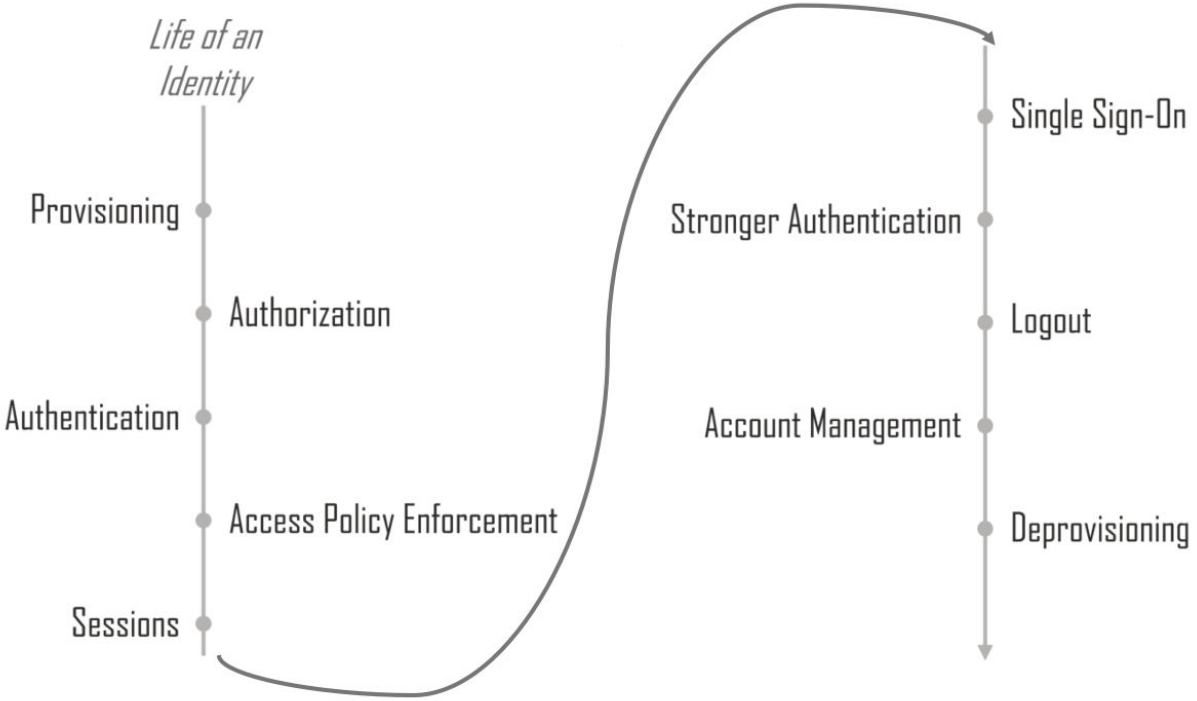
- An identity is associated with an **account** in each such context.
- Identity attributes may be **contained** within an application's account object, or they may be **stored separately** and referenced from the account object.

*An account is defined as a **local construct** within a **given application** or **application suite** that is used to perform **actions** within that context.*

# Separation between ID/Account

- An account may have its own identifier in addition to that of the identity associated with it.
- Having an account identifier separate from the identity associated with the account provides a **degree of separation**.
- The account identifier can be used in other application records to **make it easier for users to change the username** or other identifier associated with their account.
- It should be noted that **an account can have more than one identity associated with it through account linking**.
- **Nonhuman actors can certainly have identities as well.**

# Events in an identity life



# Provisioning

- The act of **creating an account** and associated identity information is often referred to as **provisioning**.
- The objective of the provisioning phase is to establish an account with associated identity data.
- It involves **obtaining or assigning a unique identifier for the identity**, optionally a **unique identifier for the account** distinct from that of the identity, **creating an account** and **associating identity profile attributes with the account**.

# Authorization

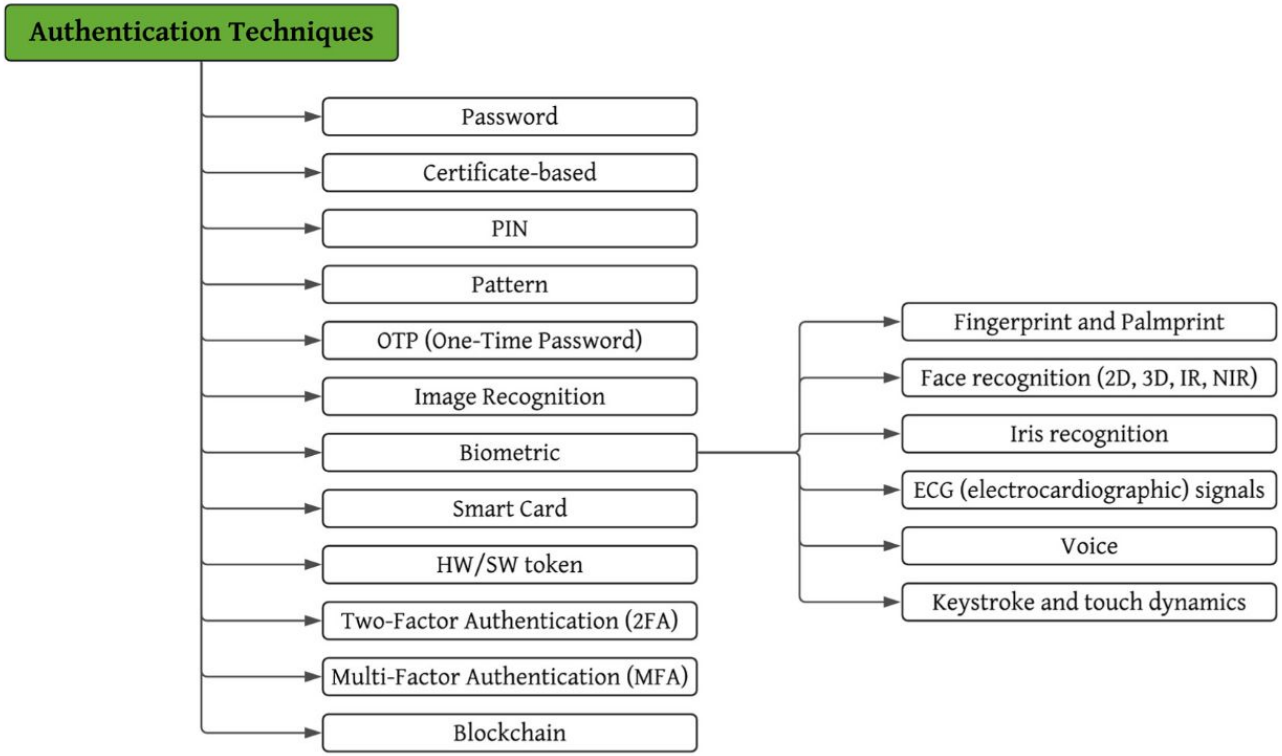
- When an account is created, it is often necessary to specify **what the account can do**, in the form of privileges.
- We use the term **authorization** for the **granting of privileges** that govern what an account is **allowed to do**.
- Authorization for an account is typically done at the time an account is **created** and may be **updated** over time.

# Authentication

- A user provides an identifier to indicate the account they wish to use and enters login credentials for the account.
- These are validated against credentials previously registered during the account provisioning phase.

*Authentication is a key aspect of trust-based identity attribution, providing a* ***codified assurance*** *of the identity of one entity to another. Someone (or something) authenticates to* ***prove that they're the user they claim to be.***

# Authentication Techniques



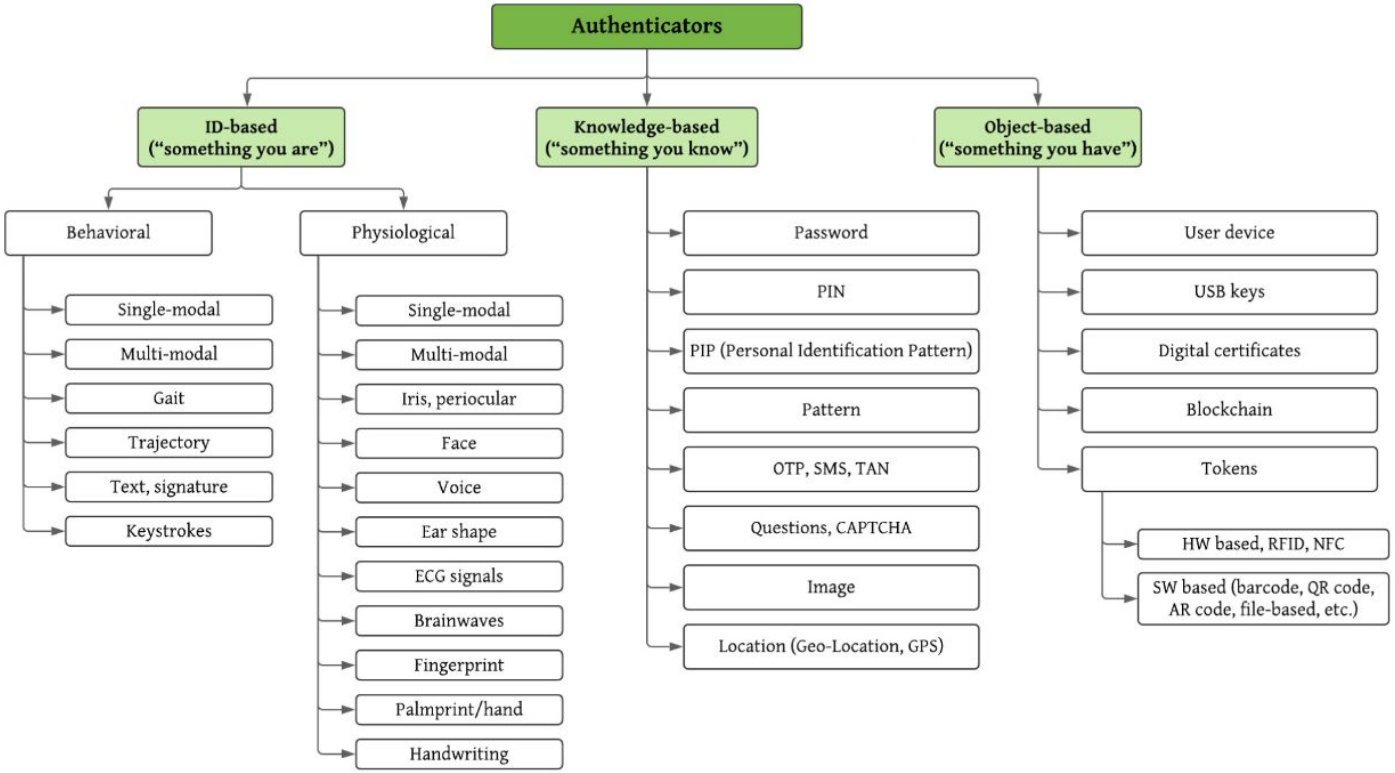

The general authentication techniques [13].

# Authentication Factors


Authentication factors are **methods** for proving a user's identity. They commonly fall into these basic types:

- **Knowledge**: "*something you know*" (ex. pin or password).
- **Possession**: "*something you have*" (ex. mobile phone, encryption key device).
- **Inherence**: "*something you are*" (ex. fingerprint, facial recognition, iris scan).

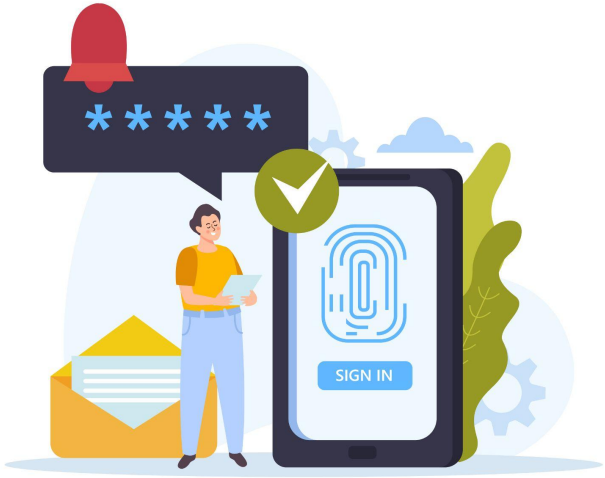
# Authenticators




Classification of the authenticator types [13].

# Multi-factor authentication

***Multi-factor authentication (MFA)*** *is a user verification method that requires more than one type of authentication factors.*




MFA factors:

- Push notifications
- SMS notifications
- One-time passwords

**Multi-channel protocol**: A protocol where messages are sent on two or more at least **independent** channels.

# Authentication vs. authorization

| Authentication | Authorization |
| --- | --- |
| Determines whether users are **who they claim** to be | Determines what **users can and cannot access** |
| Challenges the user to **validate credentials** (for example, through passwords, answers to security questions, or facial recognition) | Verifies whether **access is allowed** through policies and rules |
| Usually done before authorization | Usually done after successful authentication |
| Generally, transmits info through an **ID Token** | Generally, transmits info through an **Access Token** |
| Generally governed by the **OpenID Connect (OIDC) protocol** | Generally governed by the **OAuth 2.0 framework** |

# Access Policy Enforcement

*An access control system **validates an identity access** to a computing **resource**, which can be a service, storage space or online resource.*

- Authorization specifies what a user or entity is allowed to do, and access policy enforcement checks that a **user's requested actions** are **allowed** by the **privileges they've been authorized to use**.
- An **Access Policy** defines the **permissions** and **duration** of **access** to an Asset.

# Access Control models

- **Discretionary Access Control (DAC)**: method of limiting access to resources (such as data sets) based on the **identity of users** or **groups** to which the users belong. **End users** have **total control** over their resources.
- **Mandatory Access Control (MAC)**: a method of limiting access to resources based on the **sensitivity of the information** that the resource contains and the **authorization** of the **user** to access information with that level of sensitivity. You define the sensitivity of the resource by means of a **security label** (ex. Top Secret, Secret, Restricted, Confidential, or Internal).
- **Attribute-Based Access Control (ABAC)**: policies consider **user attributes.**
- **Role-based Access control (RBAC)**: an access mechanism defined based on the concepts of **role and permission**.
- **Originator Control (ORCON)**: hybrid between MAC and DAC. Control privileges on an object can only be changed by the "**originator**" of the object.

# Access Control models

| AC Type | Description | Control Criterion | Who decides access | Notes |
|---|---|---|---|---|
| **Discretionary Access Control (DAC)** | Limits access to resources based on user or group identity. | User or group **identity**. | The resource owner (end user). | The user has full control over their own data. |
| **Mandatory Access Control (MAC)** | Restricts access based on the **sensitivity of information and user authorization**. | **Sensitivity level** (e.g., Top Secret, Confidential). | The system or security administrator. | Uses **security labels** to classify data (e.g. *Bell–LaPadula* model). |
| **Attribute-Based Access Control (ABAC)** | Determines access based on **attributes** of users, resources, and context. | **Attributes** (e.g., role, location, time, device). | System-defined policies. | Flexible and dynamic (defined in NIST SP 800-162). |
| **Role-Based Access Control (RBAC)** | Grants permissions based on organizational **roles**. | User's assigned **role**. | **Administrator** who defines roles and permissions. | Efficient for organizations, standardized in NIST RBAC (2004). |
| **Originator Control (ORCON)** | Hybrid between MAC and DAC; only the **originator** of a resource can change access privileges. | **Origin and authorization level** of the object. | The **originator (creator)** of the resource. | Ensures ongoing control by the creator, often used in defense contexts. |

# Sessions

- Some applications, typically traditional web applications and sensitive applications, only allow a user to **remain active for a limited period** of time before requiring the user to authenticate again.
    - A session tracks information
- The **session timeout** settings will typically vary by the sensitivity of the data in the application.

# Single Sign-On

***Single sign-on (SSO)*** *is a mechanism that uses a* ***single action of authentication*** *to permit an authorized user to access all related, but independent software systems or applications* ***without being prompted to log in again*** *at each of them during a particular session.*

- After a user accesses one application, they may wish to do something else involving another application.
- SSO is the ability to **log in once** and then access additional protected resources or applications with the **same authentication requirements**, without having to **re-enter credentials**.
- Single sign-on is possible when a set of applications has **delegated authentication to the same entity**.

# Stronger authentication

- **Step-up authentication** is the act of **elevating** an existing authentication session to a higher level of assurance by **authenticating with a stronger form of authentication**.
- For example, a user might initially log in with a username and password to establish an authentication session.
- Later, upon accessing a more sensitive feature or application with **higher authentication requirements**, the user would be prompted for additional credentials, such as a **one-time password** generated on their mobile phone.

# Logout

- At a minimum, the act of logging out should terminate the **user's application session**.
- If they return to the application, they would have to authenticate again before being granted access.
- In situations where **single sign-on** is used, there may be **multiple sessions to terminate**.
    - It is a design decision as to which sessions should be terminated when the user logs out of one application.

# Account Management and Recovery

- During the course of an identity's lifetime, it may be necessary to **change various attributes** of the user profile for the identity.
    - For example, a user may need to update their email address or phone number, password, name.
- In a company, a user's profile might be updated to reflect a new position, address, or privileges such as roles
- Account **recovery** is a mechanism to validate a user is the legitimate owner of an account through some **secondary means** and then allow the user to establish **new credentials.**
    - **Lost password reset by email**

# Deprovisioning

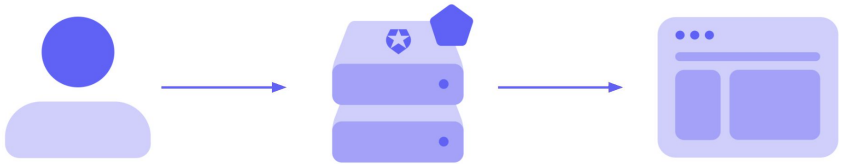
- There may come a time when it is necessary to **close an account**.
- In this case, the user's account and associated identity information must be deprovisioned so that it can no longer be used.
- Deprovisioning may take the form of completely **deleting the account** and associated identity information or simply **disabling** the account, to preserve information for audit purposes

# Identity and Access Management

# Identity and Access Management (IAM)

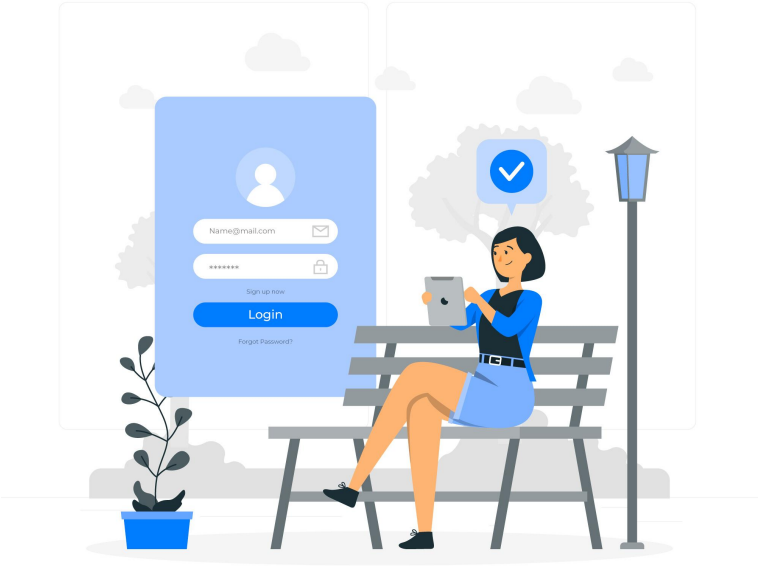
*An **Identity and Access Management (IAM)** is a set of services that support the **creation**, **modification**, and **removal** of identities and associated accounts, as well as the **authentication** and **authorization** required to access resources.*

A **digital resource** is any **combination of applications** and **data** in a computer system. Ex. web applications, APIs, platforms, devices, or databases.



Identity and access management verifies the user and controls their access to the resource.

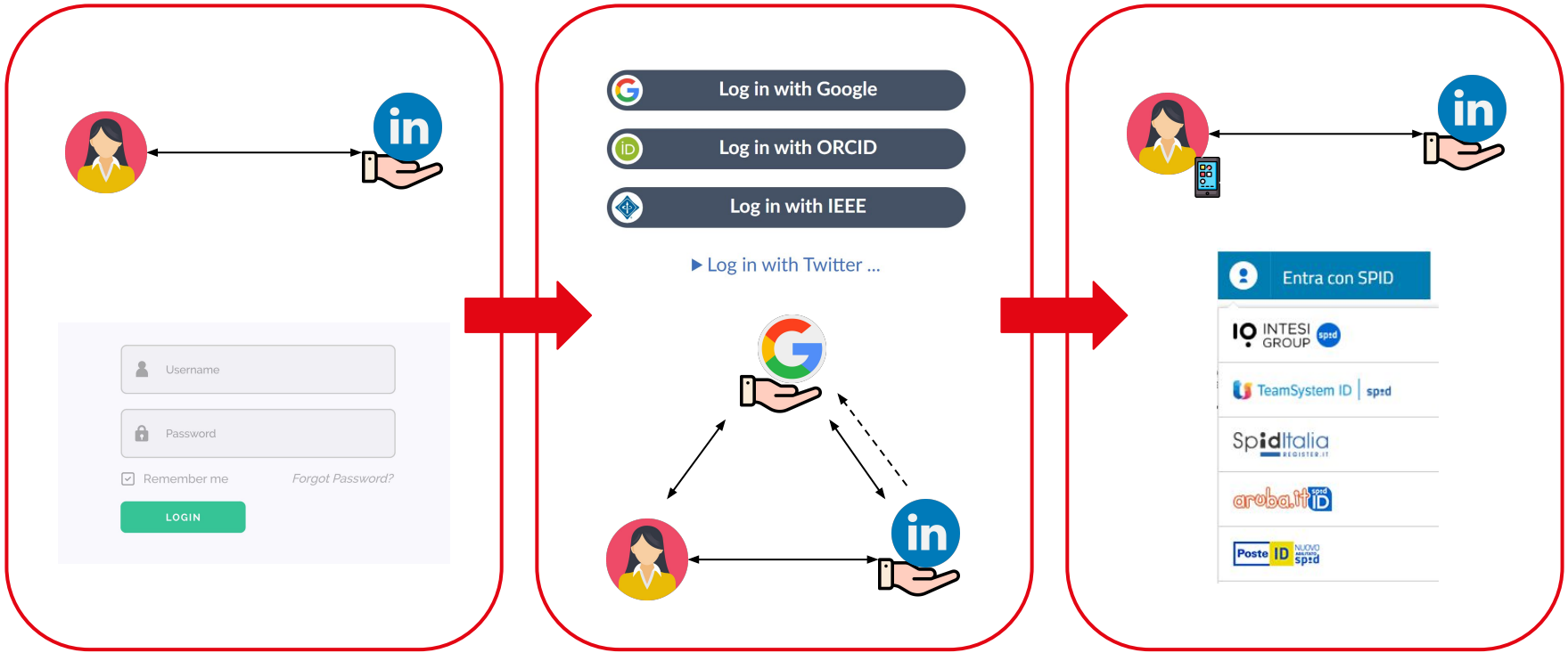
# Identity and Access Management (IAM)




## Verification of ownership:

- Identification
- Authentication
- Authorization

# IAM evolution



# Self-Sovereign Identity

***Self Sovereign Identity (SSI)*** *is a sovereign, durable and portable identity for any person, organization or entity that allows its owner to access all digital services using* ***verifiable credentials*** *in a* ***privacy-preserving*** *manner.*

# Why SSI?

A July 2019 study by MobileIron reported in Security InfoCenter said that when users encounter password troubles:

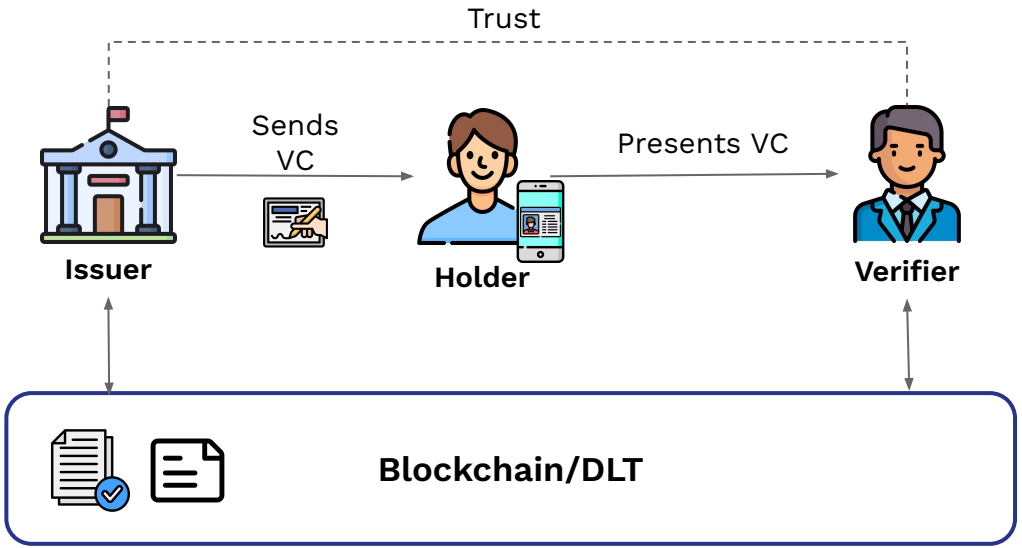
- 68% feel disrupted.
- 63% feel irritated and frustrated.
- 62% feel they have wasted time.

Moreover

- IT security leaders felt they could reduce their risk of breach by almost half (43%) by eliminating passwords.
- 86% of those security leaders would do away with passwords if they could.

Source: 8 in 10 IT Leaders Want to Eliminate Passwords

# Self-Sovereign Identity




## Verifiable Credentials

*A **verifiable credential** is a set of **metadata** and **claims** that cryptographically prove who issued it.*

## Decentralized Identifiers


**URN-encoded** decentralized identifier.

# Decentralized Identifiers

*A **Decentralized Identifier (DID)** is a new type of globally unique identifier encoded using a **Uniform Resource Name (URN)**. It provides a verifiable and decentralized means for interacting with a DID Subject controlling the DID.*

An example DID is:

**did:sov:WRfXPg8dantKVubE3HX8pw**

- **did** indicates that it is a DID;
- **sov** is the DID Method Name for Sovrin DIDs. All DIDs support the same basic functionality, but they differ in how that functionality is **implemented**, e.g. how exactly a DID is created or where and how a DID's associated DID document is stored and retrieved;
- **WRfXPg8dantKVubE3HX8pw** identifies the DID subject.

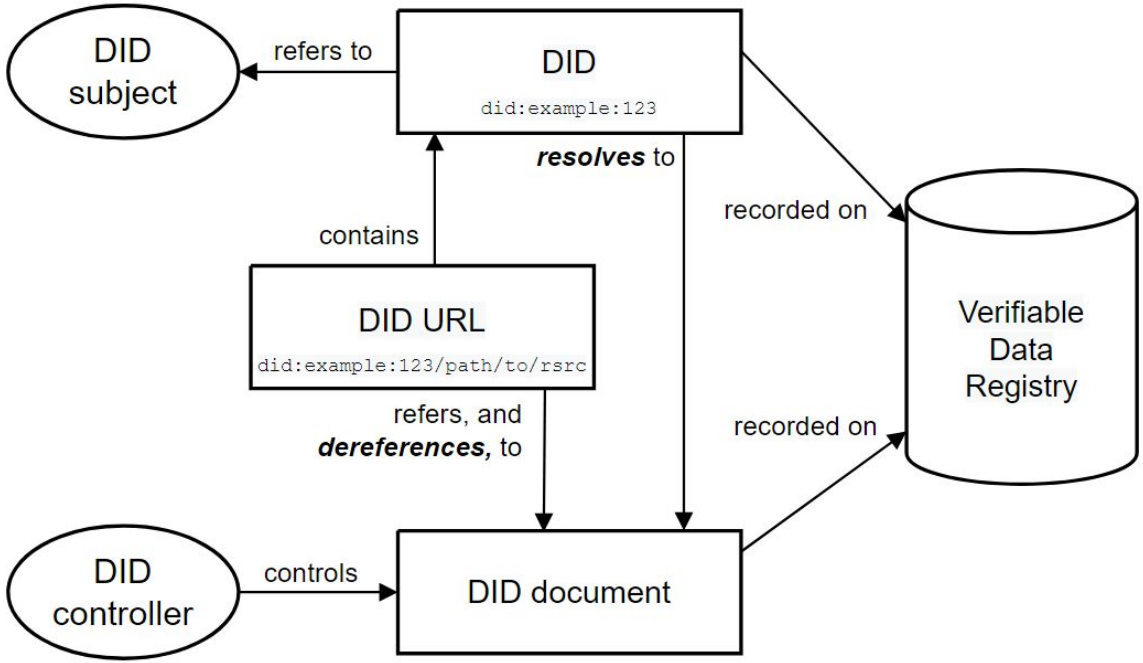
# DID Methods

- Different DID “methods”:
  - did:**sov**:WRfXPg8dantKVubE3HX8pw
  - did:**btcr**:xz35-jzv2-qqs2-9wjt
  - did:**v1**:test:nym:3AEJTDMSxDDQpyUftjuoeZ2Bazp4Bswj1ce7FJGybCUu
  - did:**uport**:2omWsSGspY7zhxaG6uHyoGtcYxoGeeohQXz
  - did:**erc725**:ropsten:2F2B37C890824242Cb9B0FE5614fA2221B79901E

- DID methods need a method specification.
- Define method-specific syntax.
- Define method-specific **CRUD** operations: **Create, Read (Resolve), Update, Delete (Revoke)**

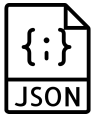
| Method | DID Prefix |
|---|---|
| **Sovrin** | did:sov: |
| **Veres One** | did:v1: |
| **uPort** | did:uport: |
| **Bitcoin** | did:btcr: |
| **Blockstack** | did:stack: |
| **ERC725** | did:erc725: |
| **IPFS** | did:ipid: |

# DID architecture



# DID Resolution

- DID Resolution: DID → DID Document




  - Set of public keys
  - Set of service endpoints
  - Authentication methods
  - Timestamps, proofs
  - Other identifier metadata

- May be dynamically constructed rather than actually stored in this form.
- Can support resolution parameters.
- Can return resolution metadata.

# DID document

```
{
    "@context": [
        "https://www.w3.org/ns/did/v1",
        "https://w3id.org/security/suites/ed25519-2020/v1"
    ]
    "id": "did:example:123456789abcdefghi",
    "controller": "did:example:123456789abcdefghi",

    "authentication": [{

        "id": "did:example:123456789abcdefghi#keys-1",
        "type": "Ed25519VerificationKey2020",
        "controller": "did:example:123456789abcdefghi",
        "publicKeyMultibase": "zH3C2AVvLMv6gmMNam3uVAjZpfkcJCwDwnZn6z3wXmqPV"
    }]

```

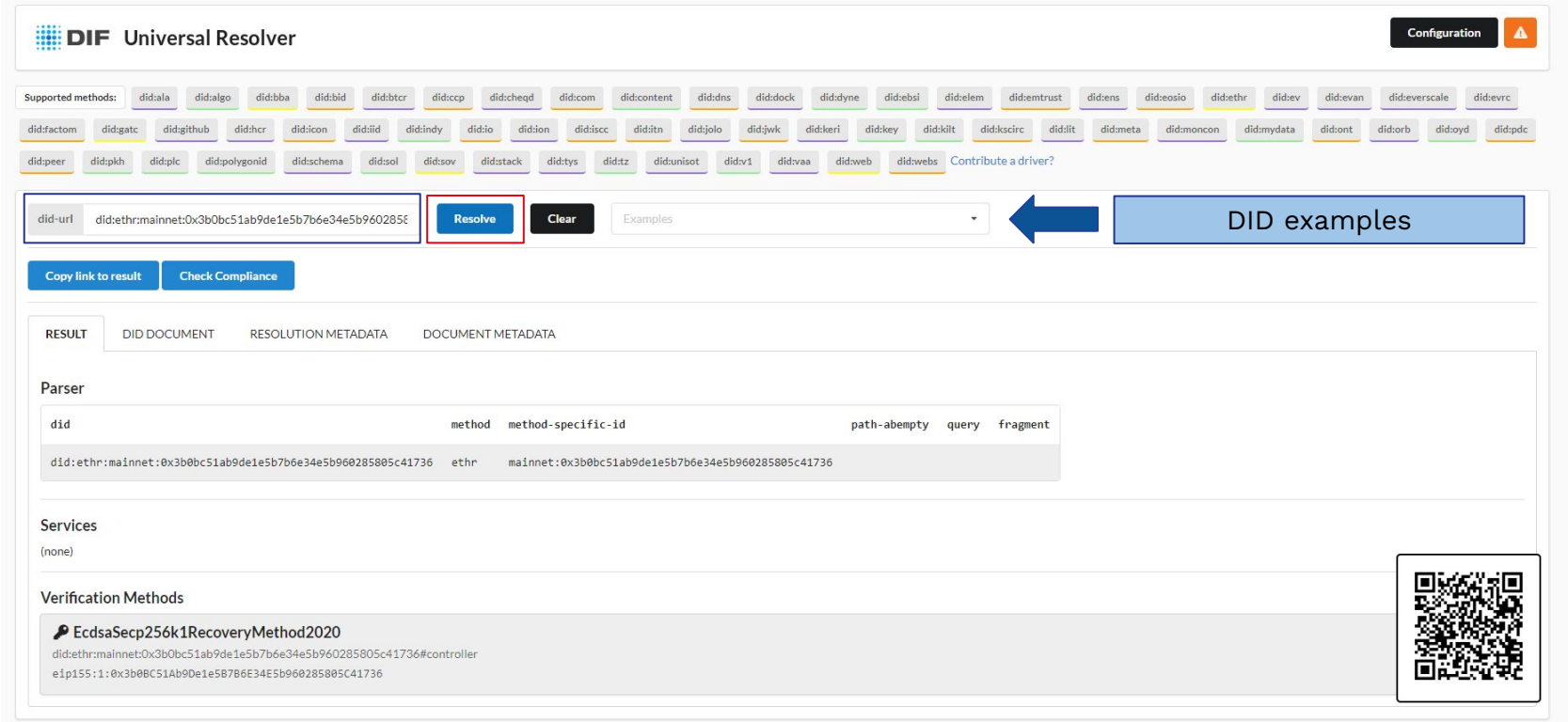
# DID Universal Resolver

The **Universal Resolver** resolves **Decentralized Identifiers (DIDs)** across many different **DID methods**, based on the W3C DID Core 1.0 and DID Resolution specifications. It is a work item of the DIF Identifiers&Discovery Working Group.

- Looks up (“resolves”) DID to its DID Document.
- Provides a universal API that works with all DID methods.
- Uses a set of configurable “drivers” that know how to connect to the
- target system.

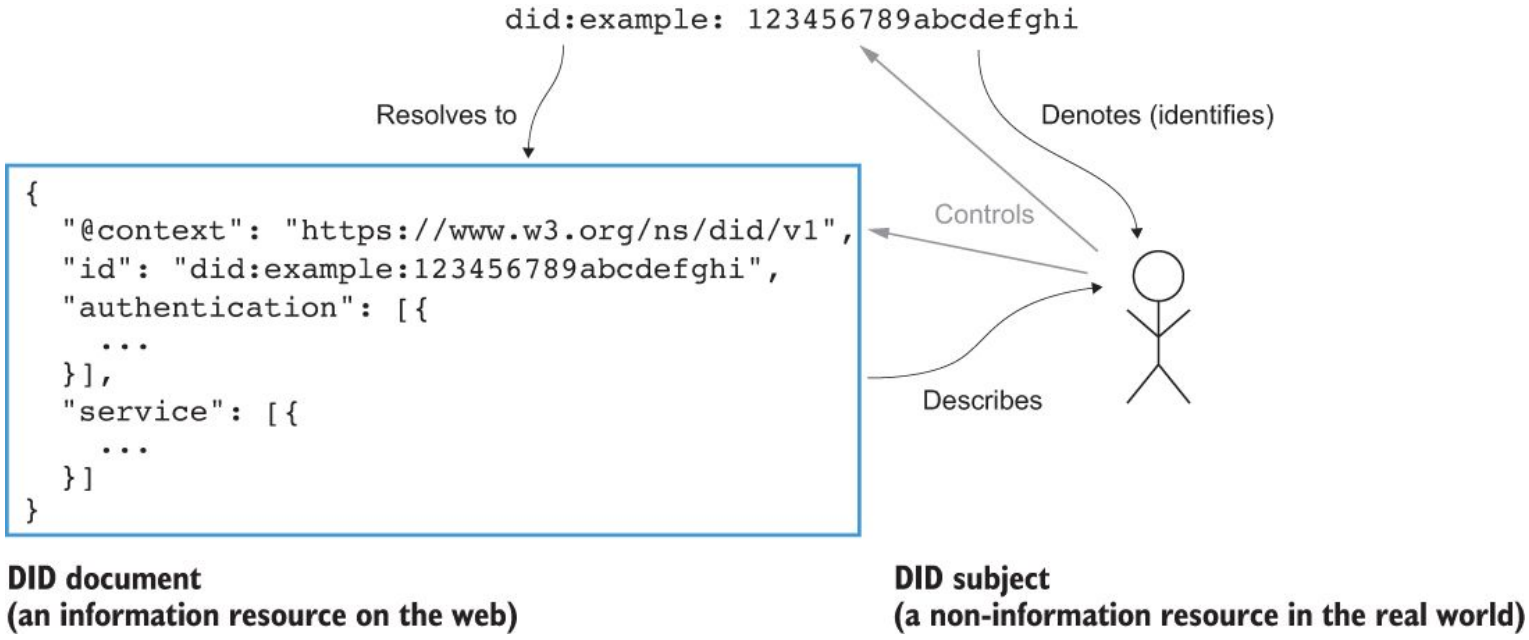
Link: https://dev.uniresolver.io/
Github link: https://github.com/decentralized-identity/universal-resolver

# DID Universal Resolver




Example: https://dev.uniresolver.io/#did:ethr:mainnet:0x3b0bc51ab9de1e5b7b6e34e5b960285805c41736

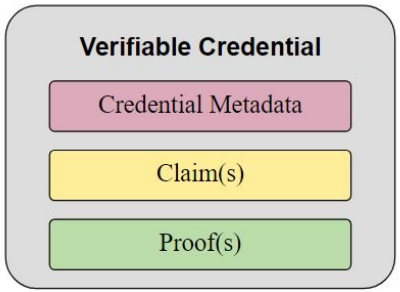
# DID example


did:example: 123456789abcdefghi
Resolves to
Denotes (identifies)
{
"@context": "https://www.w3.org/ns/did/v1",
"id": "did:example:123456789abcdefghi",
"authentication": [{
...
}],
"service": [{
...
}]
}
Controls
Describes
DID document
(an information resource on the web)
DID subject
(a non-information resource in the real world)

# Verifiable Credentials

*A **credential** is a set of one or more claims made by an issuer.*

*A **verifiable credential** is a set of tamper-evident claims and metadata that cryptographically prove who issued it.*




Credentials might also include an identifier and metadata to describe properties of the credential, such as:

- the issuer;
- the expiry date and time;
- a representative image;
- a public key to use for verification purposes;
- the revocation mechanism and so on.

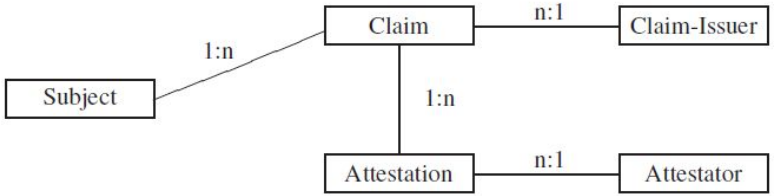
# VC example

```
{
  "@context": [
    "https://www.w3.org/2018/credentials/v1",
    "https://www.w3.org/2018/credentials/examples/v1"
  ],
  "id": "http://example.edu/credentials/3732",
  "type": ["VerifiableCredential", "UniversityDegreeCredential"],
  "issuer": "https://example.edu/issuers/565049",
  "issuanceDate": "2010-01-01T00:00:00Z",
  "credentialSubject": {
    "id": "did:example:ebfeb1f712ebc6f1c276e12ec21",
    "degree": {
      "type": "BachelorDegree",
      "name": "Bachelor of Science and Arts"
    }
  }
}
```

The example uses two types of identifiers. The first identifier is for the verifiable credential and uses an **HTTP-based URL**. The second identifier is for the subject of the verifiable credential (the thing the claims are about) and uses a **decentralized identifier**, also known as a DID.

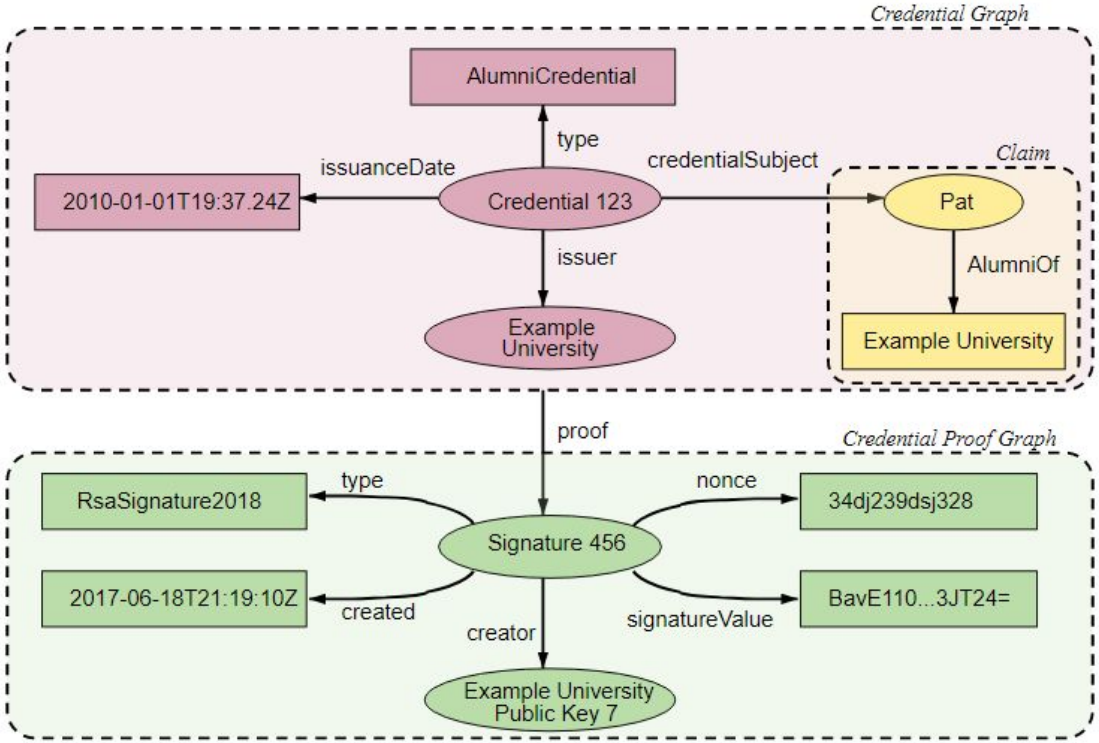
# Attestation

**Verifiable credentials** are verifiable through a **signature** of an **attestation issuer** that has either issued the claim himself or can attest the correctness of it .




*An **attestation** can be seen as a **proof** in form of a **signature** attesting to a certain claim and metadata needed for verification .*

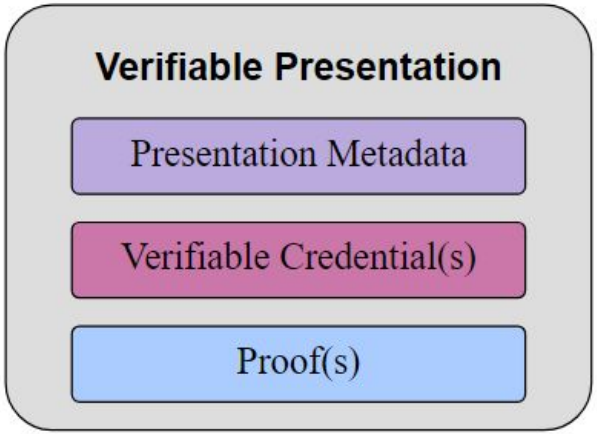
# Verifiable Credential



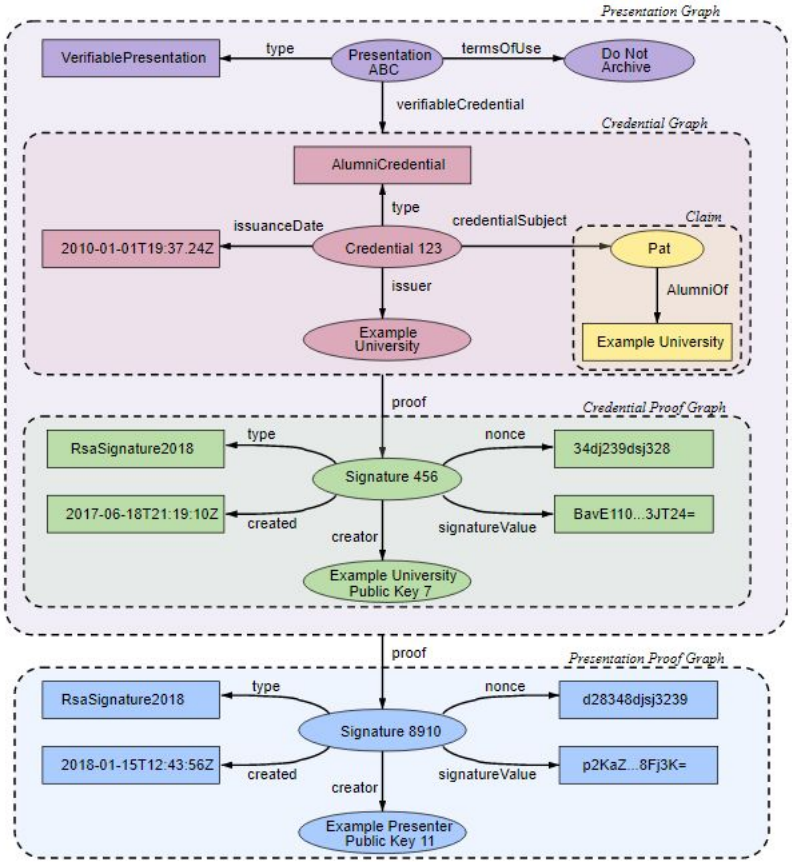
# Verifiable Presentation

*A **verifiable presentation (VP)** expresses data from **one or more verifiable credentials** and is packaged in such a way that the authorship of the data is verifiable.*

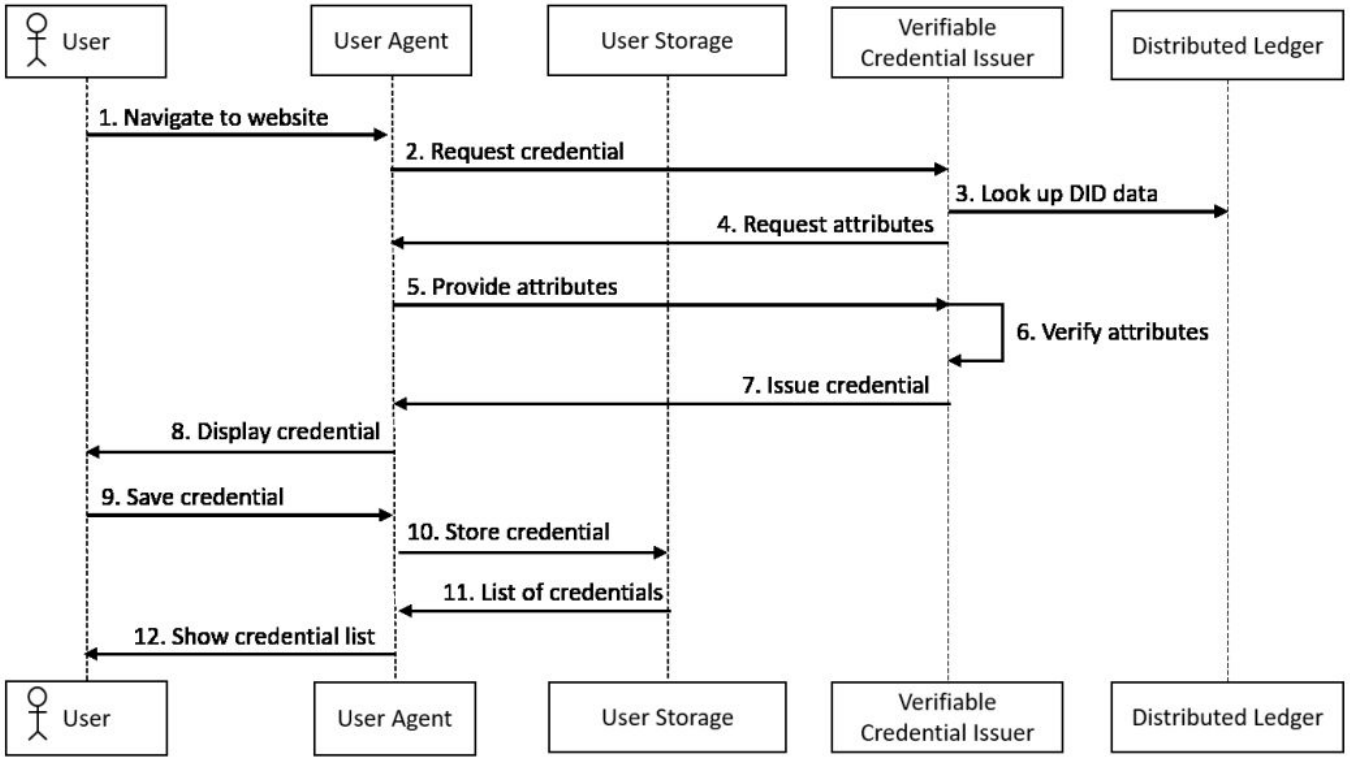
Presentations may be used to combine and present credentials. The data in a presentation is often about the same subject, but might have been issued by multiple issuers.



# VP example


Presentation Graph
VerifiablePresentation
type
Presentation ABC
termsOfUse
Do Not Archive
verifiableCredential
Credential Graph
AlumniCredential
type
issuanceDate
credentialSubject
Claim
2010-01-01T19:37:24Z
Credential 123
Pat
issuer
AlumniOf
Example University
Example University
proof
Credential Proof Graph
RsaSignature2018
type
nonce
34dj239dsj328
Signature 456
2017-06-18T21:19:10Z
created
signatureValue
BavE110...3JT24=
creator
Example University Public Key 7
proof
Presentation Proof Graph
RsaSignature2018
type
nonce
d28348djsj3239
Signature 8910
2018-01-15T12:43:56Z
created
signatureValue
p2KaZ...8Fj3K=
creator
Example Presenter Public Key 11

# VC workflow

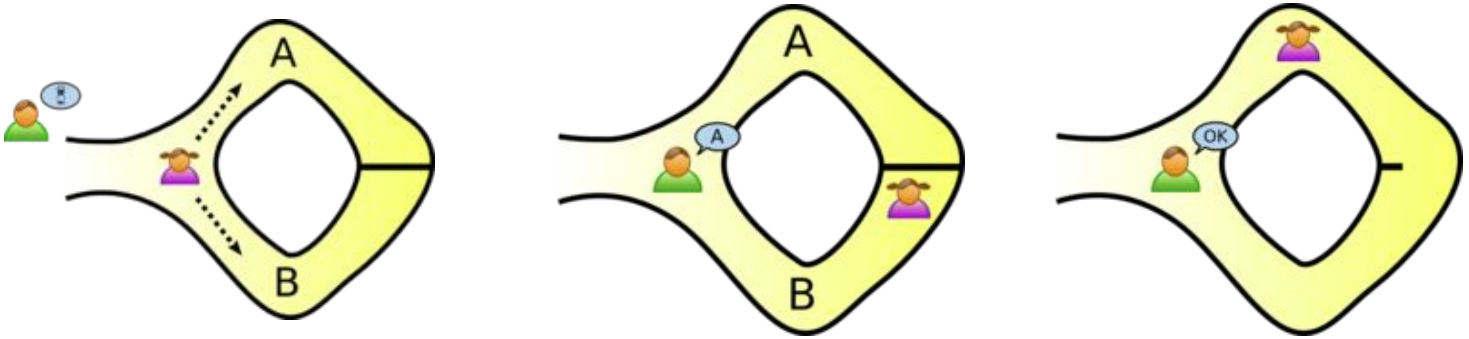



Credential workflow [15].

# Zero-Knowledge Proof

***Zero Knowledge Proof (ZKP)*** *is a digital method whereby one party proves to another party the* ***possession of information without revealing it****.*

Since Victor would choose A or B at random, she would have a **50% chance** of guessing correctly. If they were to **repeat** this trick many times, say **20 times** in a row, her chance of successfully anticipating all of Victor's requests would be reduced to **1 in** $2^{20}$, or $\mathbf{9.54 \times 10^{-7}}$.




The Ali Baba cave example [14].

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