Decentralized Identifiers (DIDs)

Presentation held for W3C Evangelists, 2020-04-27

Ivan Herman, ivan@w3.org

These slides: https://iherman.github.io/did-talks/talks/2020-evangelists/

Introduction

Importance of identifiers in a digital world

- It is increasingly important to identify persons, concepts, things…
  - any reasoning, control, associations, etc., of resources rely on this ability
- The digital economy relies on proper identification to combine information from different sources
  - it is vital that identifiers are unique

Globally unique identifiers are all around us!

- They are becoming ubiquitous:
  - persons
  - companies, institutions,…
  - books, magazines,…
  - retail items
  - genes, proteins, viruses,…
  - stars, galaxies,…
  - vehicles, airplanes,…
  - intelligent home devices, Internet/Web of Things,…

What are the problems?

A typical experience

Consider these two scholarly references:

- *Tomislav Strinić, Damir Buković, Ljubomir Pavelić, Josip Fajdić, Ivan Herman, Ivica Stipić, Ivan Palada & Ivana Hirš, "Anthropological and clinical characteristics in adolescent women with dysmenorrhea". Collegium antropologicum, 27(2), (2003).*
- *Ivan Herman, Markus Gylling, "Bridging the Web and Digital Publishing", The Journal of Electronic Publishing, (2015).*

- Only one of the two publications is mine…
- The name is not enough; you need a *unique personal identification* to avoid problems with, in this case, homonyms
- This has become even more important in a networked, digital world

Of course, I do have identifiers

- ivan@w3.org
- ivan@ivan-herman.net
- https://www.w3.org/People/Ivan/
- https://www.ivan-herman.net/
- 0000-0003-0782-2704 (ORCID)
- 89df9321-bf5c-4237-aabc-1f8f202ab5c6 (UUID)

There is a need for many identifiers!

- One person may have to have many different identifiers, depending on the person's various facets in life
  - there should be a *very easy* way to create as many unique identifiers as needed!
- Are the aforementioned identifiers really the right ones?
  - note that most of them are created for another purpose (email, personal information site) and are "just" used as identifiers…

Problems with current identifiers

- *Ease of creation*
  - https://www.ivan-herman.net depends on buying a host name
  - ivan@w3.org is not meant to be an identifier, and an email address is not "cheap"
- *Decentralized*
  - https://www.ivan-herman.net depends on a single point of failure; what happens if the hosting site disappears?
  - 0000-0003-0782-2704 depends on the ORCID database. What happens if it is discontinued, hacked, etc?

Problems with current identifiers

- *Persistent*
  - When I leave the W3C then ivan@w3.org disappears…
  - If I do not pay for the `ivan-herman.net` domain any more, the URL disappears…
- *Resolvable*
  - How can I get more information on what 0000-0003-0782-2704 identifies?
- *(Cryptographically) Verifiable*
  - What about https://www.ivan-herman.com? How can one prove that this domain is ***not*** referring to me?
  - What happens if I stop paying for the domain and somebody else buys it?

Identifiers may fulfill several requirements

- HTTPS URIS are:
  - resolvable
  - verifiable by a human and through HTTPS and certificates
  - *but:* centralized, not persistent, complex to create
- ORCID numbers are:
  - persistent (while ORCID is around, that is), easy to create
  - verifiable by a human but not cryptographically
  - *but:* centralized, only resolvable by turning them into a special URL
- UUID-s are
  - persistent, decentralized, easy to create
  - *but:* not resolvable, not verifiable

No identifiers display all those characteristics!

Goals of DIDs

- *Ease of creation*
  - it should be quick and "cheap" to create possibly thousands of DIDs
- *Decentralized*
  - do not depend on centralized registries, identity providers, authorities, etc.
  - the DID has a sovereign controller:
    - the entity identified by the DID (the subject), or
    - whoever else who has the privilege to control the DID (e.g., the owner of a dog "controls" the DID identifying the dog)

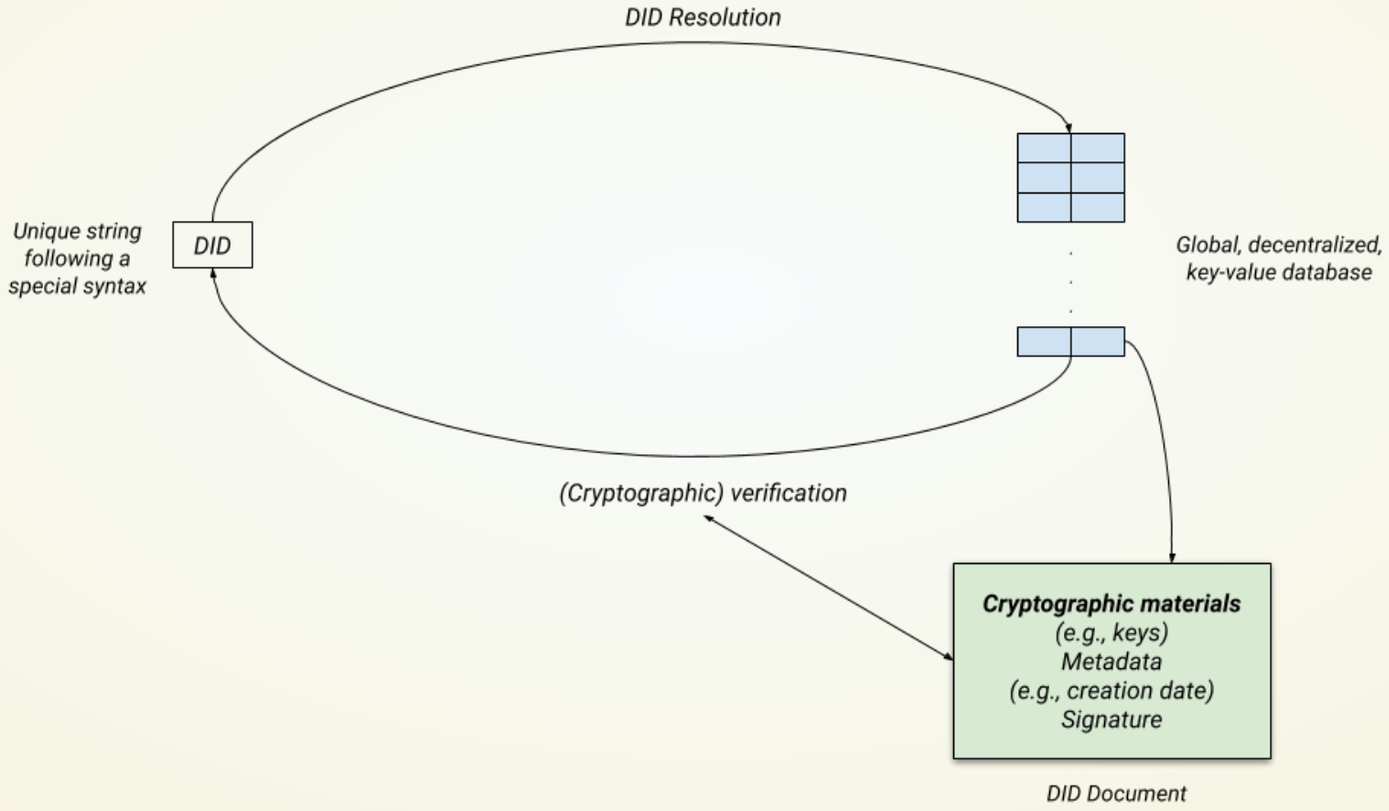
Goals of DIDs

- *Persistent*
  - once created, it is permanently assigned to the subject
- *Resolvable*
  - it is possible to find out basic set of information on the subject
- *Cryptographically verifiable*
  - there is a mechanism to cryptographically prove that it indeed identifies a specific subject (possibly controlled by a separate controller) and nothing else

A DID is a self-sovereign identity, i.e., lifetime, portable, and verifiable digital identity that does not depend on any centralized authority

High level view on DIDs

High level view: DIDs and DID Documents



“Global, distributed, key-value database”

- There may be several of those!
  - in the DID world, the term *method* is used for the different approaches
- Different methods can have very different characteristics
  - May be based on distributed ledgers (generic or specialized)
  - DID documents stored may be on specialized sites (e.g., github)
  - May be ephemeral DIDs with lighter requirements (e.g., on an intelligent device)
- The choice depends on the relative importance of the various requirements for a specific usage

DID Documents

- Contain cryptographic information related to the subject (and controller) of the DID
  - verify the control of the DID document, i.e., its authenticity
  - trusted communication
  - the DID documents may be signed
  - information about, e.g., key revocations
- May also include other types of data related to the subject
  - reference to a Web site
  - various services
  - etc.
- May or may not physically "exist" somewhere in the database
  - some methods generate them on-the-fly

DIDs and DID Documents are closely coupled

- DIDs have the right characteristics through the DID Document
  - DID documents are the “representation data and metadata” of a DID in the Web architecture
- A DID Document is tightly bound to the DID it “describes”
- DID+DID Document may be also used as a decentralized cryptographic keychain for various cryptography applications

Serialization of DID Documents

- DID Documents are defined as an abstract data model
- Can be serialized as:
  - JSON
  - JSON-LD
  - CBOR
  - other serializations may come to the fore

Some use cases

There are simple ones

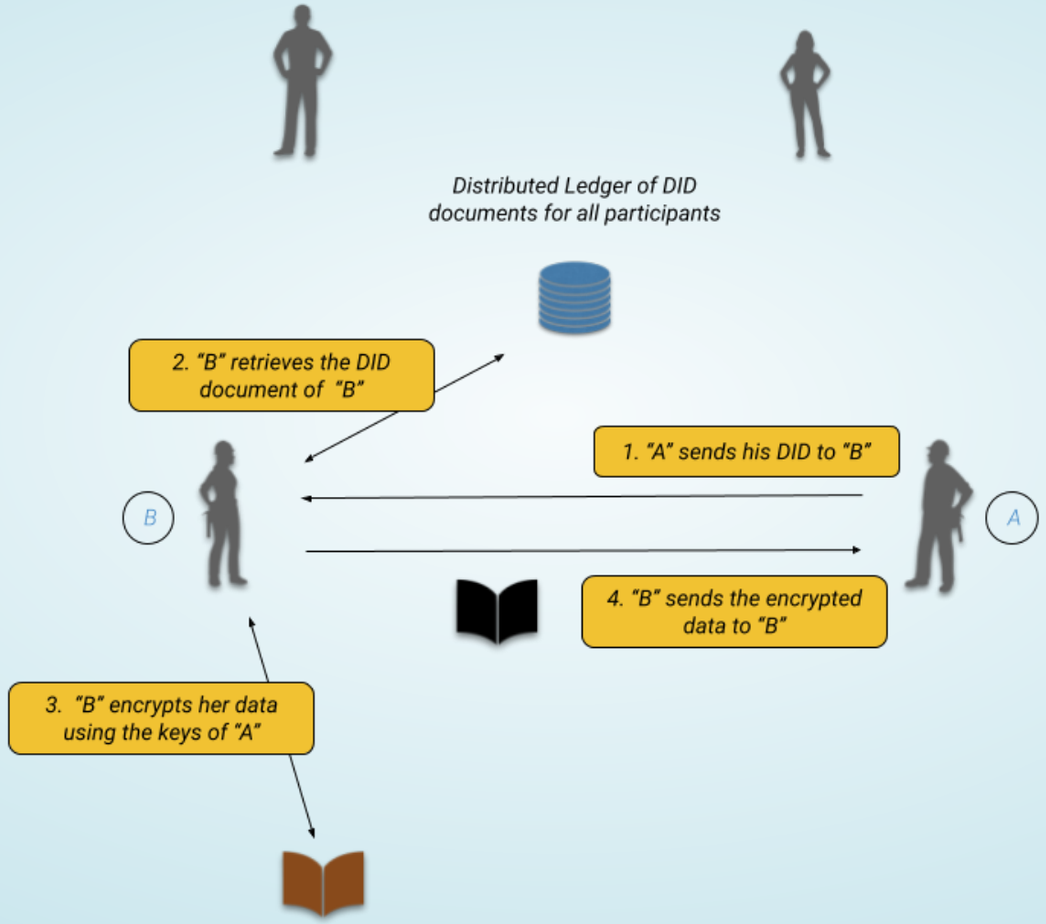
- Securing unique, secure, etc., identities for persons, animals, objects,…
  - unique and unambiguous literature references
  - consistent semantic statements on “resources”
  - identify objects in an internet of “things”
  - etc.
- DID usage is often bound to Verifiable Credentials
  - e.g., life-long credential proving a University Degree, identified with a DID
  - there are discussions on using DID+VC experimentally as a tool for a COVID-19 proximity checking apps

Find information on purchased goods

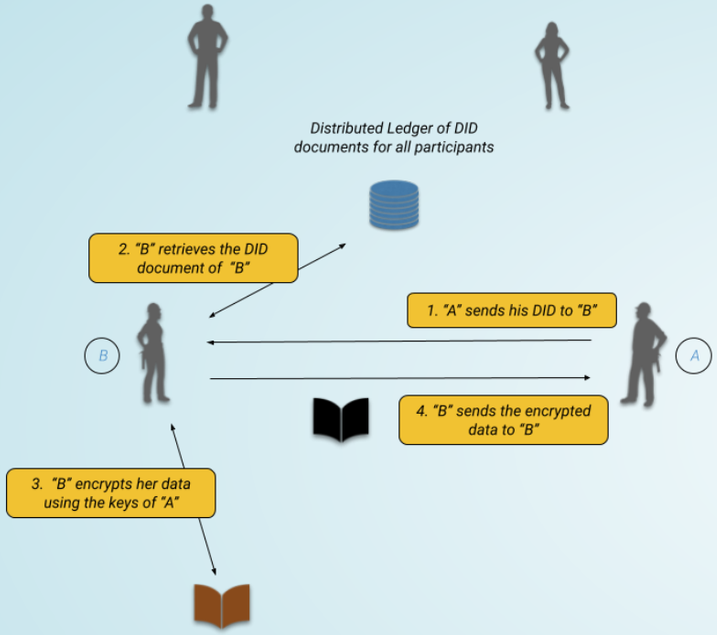
Find information on purchased goods

- It is very important that:
  - the identification is unique and persistent
  - the information has not been tampered with
- The same mechanism can be used for constituent parts of goods but the information can remain fully decentralized

Pool of relationships



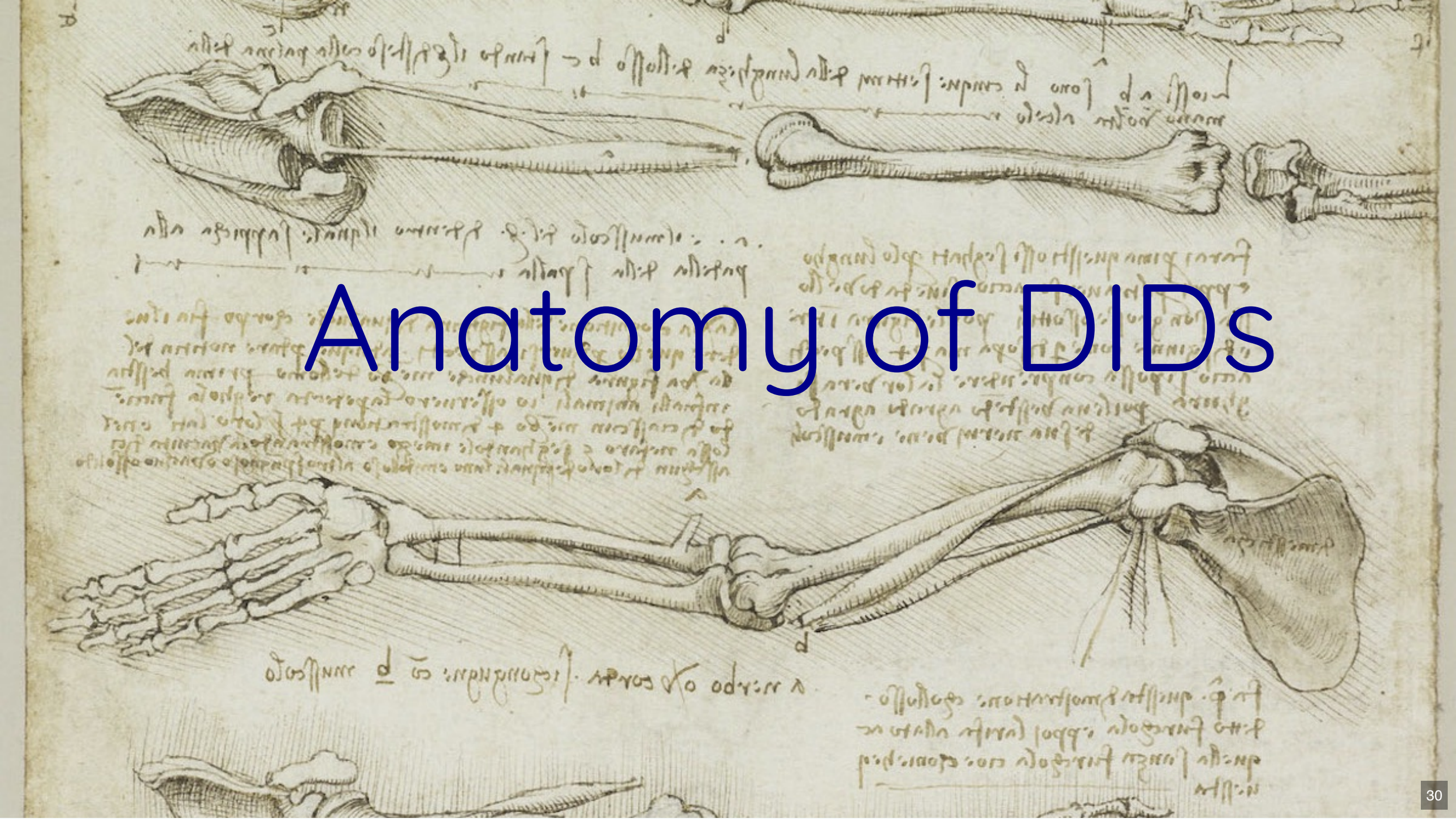
Pool of relationships



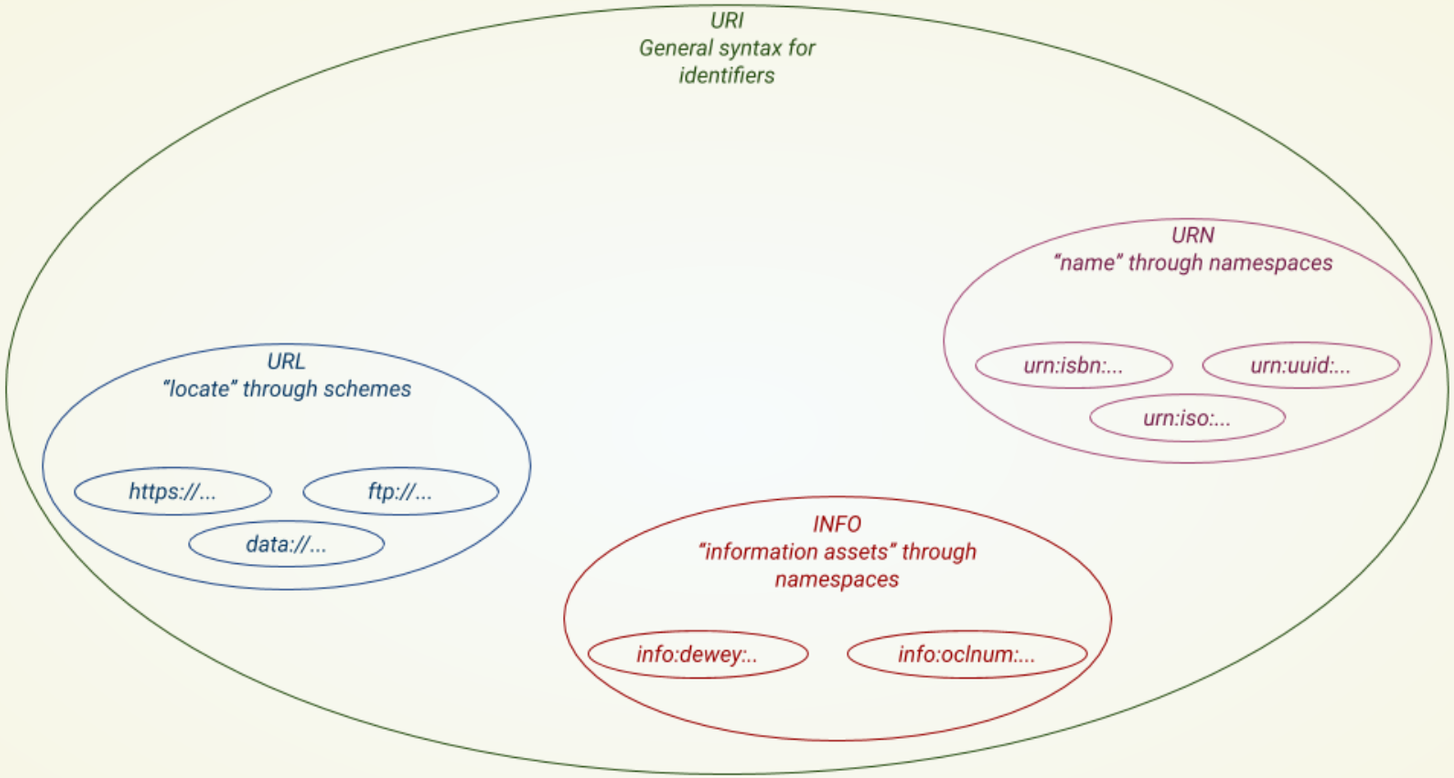
- No need for a complex and centralized key management system
- Both “A” and “B” may remain anonymous

Technical dive in to DIDs

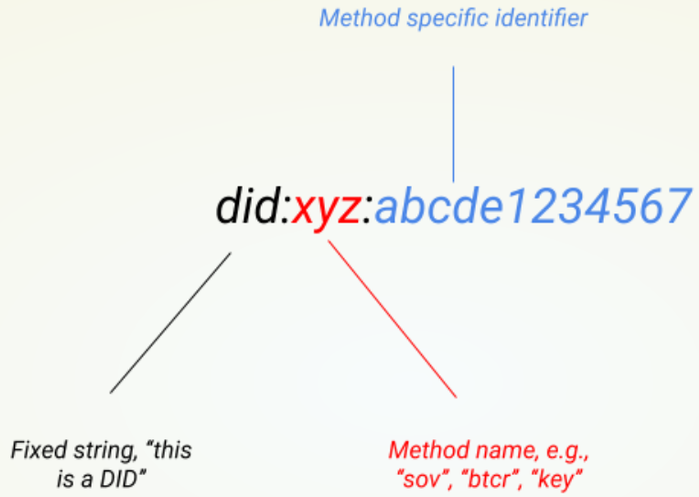
Anatomy of DIDs



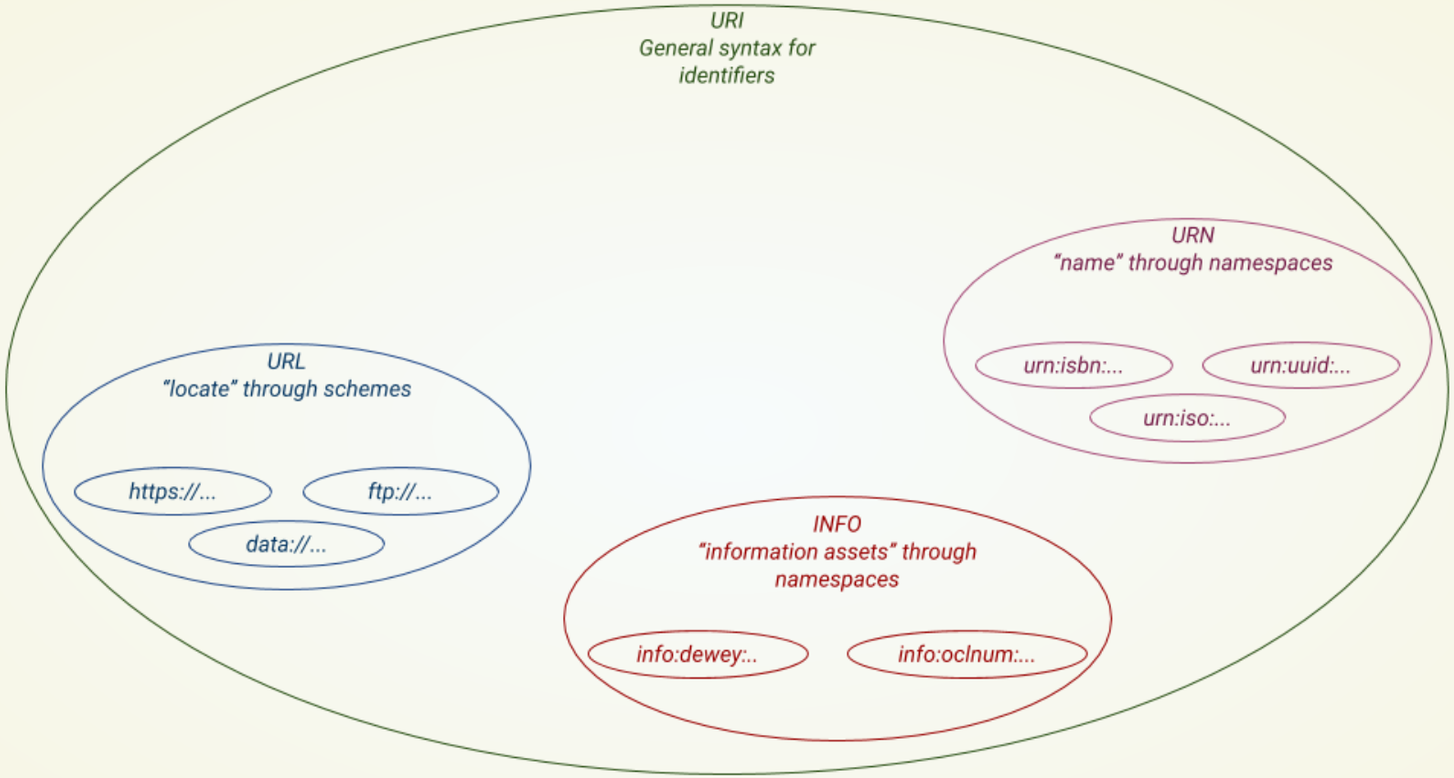
Reminder: URIs, URNs, URLs, …



DID is a new type of URI



DID is a new type of URI



Why is it important that it is a URI

- DID are within the IETF/W3C world
  - tools, libraries may be used to manage them
  - existing specifications automatically apply to DIDs:
    - "`<a href='did:btcr:xyv2-xzpq-q9wa-p7t'>abcd</a>`" is valid HTML
    - "`<did:btcr:xyv2-xzpq-q9wa-p7t> a rdf:Class.`" is a valid RDF Turtle statement
- *DIDs are part of the Web*

Examples for ledger based DIDs

- `did:btcr:xyv2-xzpq-q9wa-p7t`
  - built “on top” of the Bitcoin blockchain
  - the method specific identifier is generated from the bitcoin transaction position reference
- `did:sov:mnjkl98uipsndg2hdjdjuf7`
  - based on a dedicated distributed ledger (Sovrin)
  - the method specific identifier generated from either a simple UUID or the subject’s public keys

Ledger based DIDs

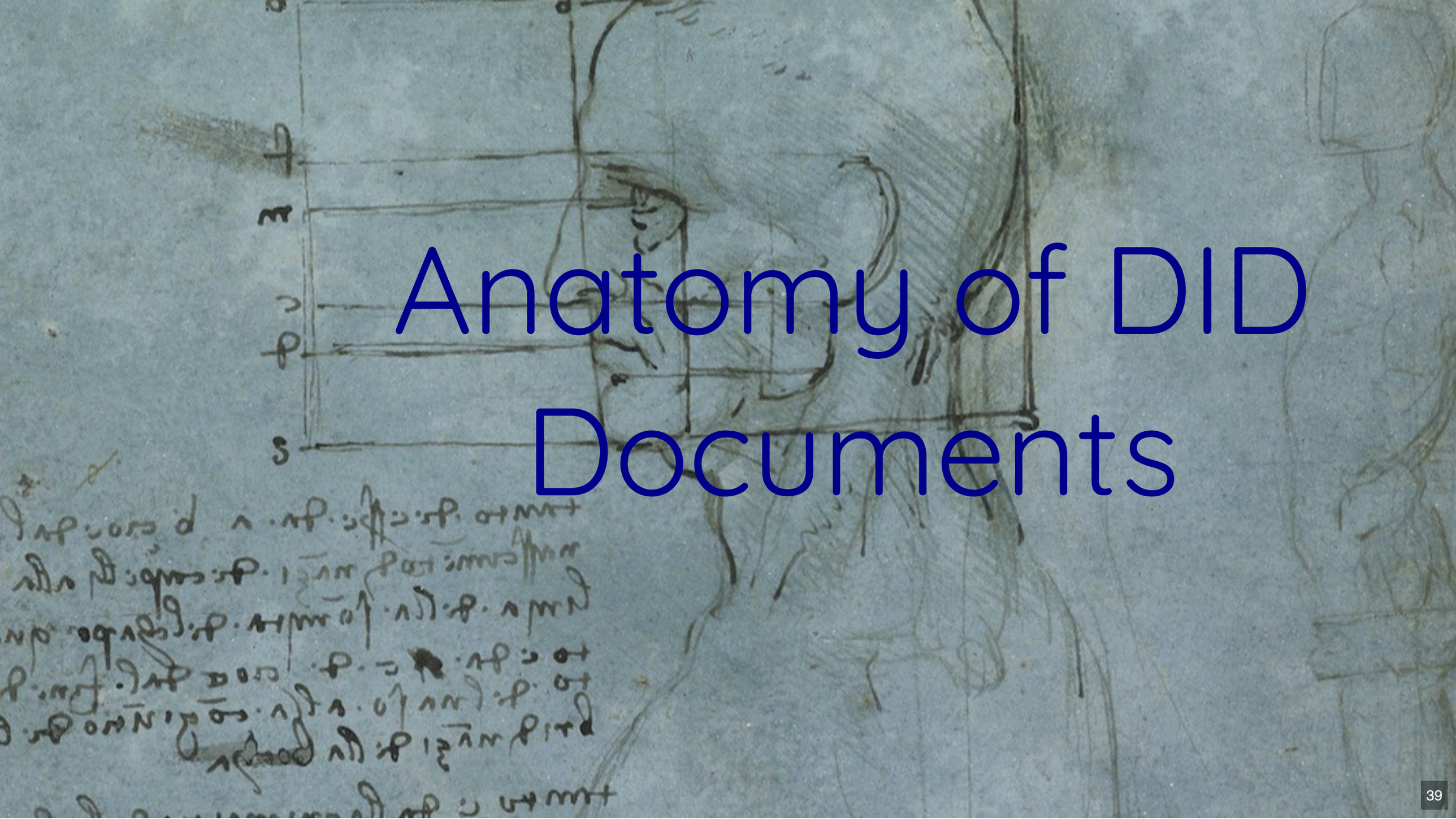
- There are other methods based on generic (e.g., Ethereum), or dedicated (e.g., Veres One) ledgers
- They are generally meant to be general solutions for identity, usable by various applications

Examples for special purpose methods

- `did:key:z6Mki7KaCeTufKQ6…NEv28PhP1PHF35btNN`
  - can be used for single, ephemeral interactions (e.g., IoT)
  - the method specific identifier is an encoded public cryptographic key
  - the DID documents aren't stored; they are generated on demand
- `did:peer:1zQmZMygzYqNwU6Uhmewx…LSwwgf2aiKZuwa`
  - interaction among a fixed number of "peers", e.g., business relationships
  - the method specific identifier is generated from the DID document
    - the document stores the user's public key(s)
  - all participants have access to the DID documents
  - information in the DID documents are used to exchange encrypted messages among peers

Methods in general

- Lots of experimentation is happening, exploring different methods
  - there is also a need to develop proper user interfaces, applications, etc, to store DIDs in personal wallets, for example
- We can expect to see a convergence of methods to only a few in the coming years



Anatomy of DID Documents

Abstract model of a DID document

- Uniquely related to the DID *subject*, i.e., the entity identified by the DID
- Includes a separate DID for the *controller*
  - identifies an entity that "in charge" of the DID document
- Expresses public cryptographic keys and other verification methods
- May include a separate "proof" section (typically a signature)
- May be extended to include application specific information

DID Document syntaxes

- The specification defines JSON, JSON-LD, and CBOR syntaxes
- The information can be converted from one syntax to the other in a lossless way
  - this means that, for example, only a subset of CBOR is used

Typical DID document structure

```
{
    "id":"did:example:abcedefgh",
    "controller":"did:example:xyzwvy",
    "publicKey":[{ ... }],
    "authentication":[{ ... }],
    "proof":[{ ... }],
    "service":[{ ... }]
}
```

Public Keys

- List of various public keys
- Their usage is not specified: can be used for DID verification but also for any other application

```
{
    "publicKey":[{
        "id":"keys-1",
        "type":"RsaVerificationKey2018",
        "publicKeyPem": "-----BEGIN PUBLIC KEY...END PUBLIC KEY-----\r\n"
    },{
        "id":"keys-2",
        "type":"Secp256k1VerificationKey2018",
        "publicKeyHex":"02b97c30de767f084ce30...16a3263d29f1450936b71"
    }]
}
```

Authentication

- Keys that can be used for the *authentication* of the controller:
  - can refer to a key listed separately in `publicKey`
  - can include a full key that can be used for authentication only

```
{
    "authentication":[
    "#keys-1",
    {
        "id":"#keys-3",
        "type":"Ed25519VerificationKey2018",
        "publicKeyBase58":"H3C2AVvLMv6gmMNam3uVAjZpfkcJCwDwnZn6z3wXmqPV"
    }]
}
```

Proof

- A cryptographic proof of the integrity of the document

```
{
    "proof": {
        "type":"LinkedDataSignature2015",
        "created":"2020-01-16T17:29:20Z",
        "creator":"did:example:12345#keys-1",
        "signatureValue":"QNB13Y7Q9...1tzjn4w=="
    }
}
```

Documents to read

Use cases and requirements

https://www.w3.org/TR/did-use-cases/

Core spec

https://www.w3.org/TR/did-core/

These slides

https://iherman.github.io/did-talks/talks/2020-evangelists/

https://iherman.github.io/did-talks/talks/2020-evangelists/index.pdf

Some more documents to come

Registry

Registry for various terms: crypto terms, methods, additional terms,…

Rubric

Documenting what criteria to look for when choosing a specific method

Implementation guide

Today's Status

- Draft specification was developed in a W3C CG
- Working Group started in September 2019
- Plan is to be technically ready (i.e., Candidate Recommendation) by summer 2020
- Recommendation should be available by summer 2021

Thank you for your attention!

ivan@w3.org

These slides: https://iherman.github.io/did-talks/talks/2020-evangelists/