From Blockchain to Cybersecurity and the EBSI

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Universidade de Aveiro, 7/20/2022

Several pictures @CEF Digital

inesc-id.pt

DE4A Digital Europe For All

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DEFINING TECHNOLOGY

TÉCNICO LISBOA

Motivation: vast interest world-wide

Outline

1. Blockchain
2. Bitcoin and cryptocurrencies
3. Ethereum and smart contracts
4. Permissioned blockchains

5. European Blockchain Partnership
6. European Blockchain Services Infrastructure
7. EBSI Use Cases
8. EBSI Early Adopters & DE4A

1. Blockchain

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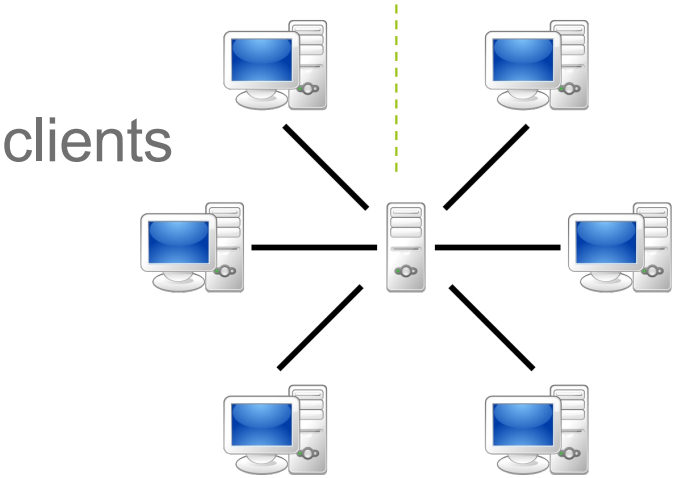
Decentralization: who shall we trust?

Client-Server

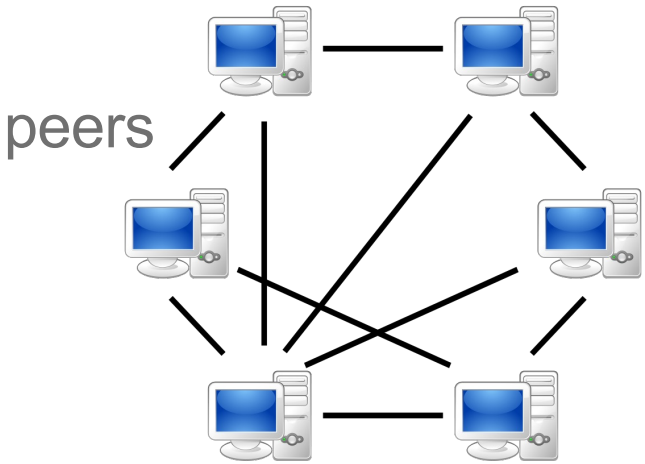
trust a server/provider



centralized

Peer-to-Peer

trust the community



decentralized

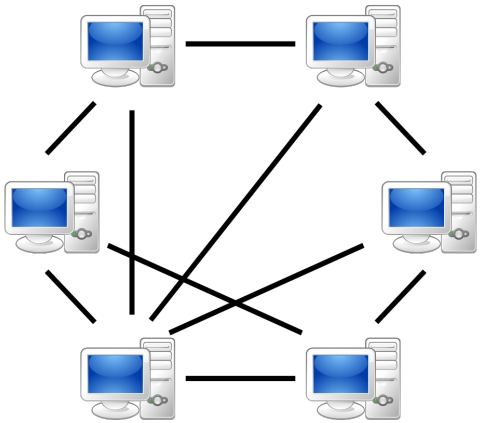
“Blockchain” has two meanings

1) Data structure – append-only, **chain** of blocks of transactions – **ledger**

“Blockchain” has two meanings

2) Distributed system – set of Internet nodes/peers

- They execute software and keep a copy of the chain
- They run a consensus algorithm to agree on the next block to append to the data structure

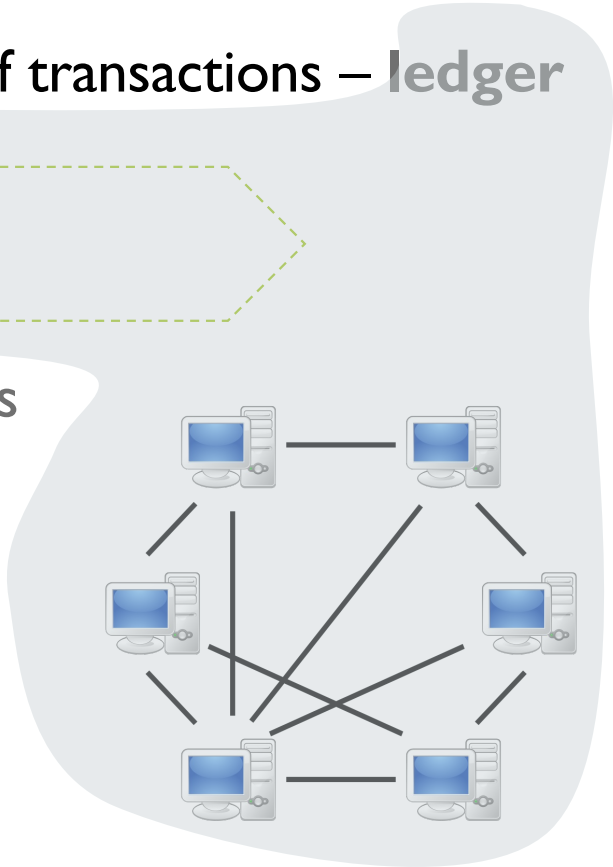


DLT – Distributed Ledger Technology

1) Data structure – append-only, **chain** of blocks of transactions – **ledger**

2) Distributed system – set of Internet nodes/peers

- They execute software and keep a copy of the chain
- They run a consensus algorithm to agree on the next block to append to the data structure



Blockchain relevant properties

- **Availability & integrity** – works even if some nodes are compromised
- **Auditability** – the ledger is visible to "everyone", so it can be verified
- **Immutability** – once a transaction is appended, it's not removed
- **Decentralization** – properties above without trust on a third party – this is what is new in Blockchain!

2. Bitcoin and cryptocurrencies

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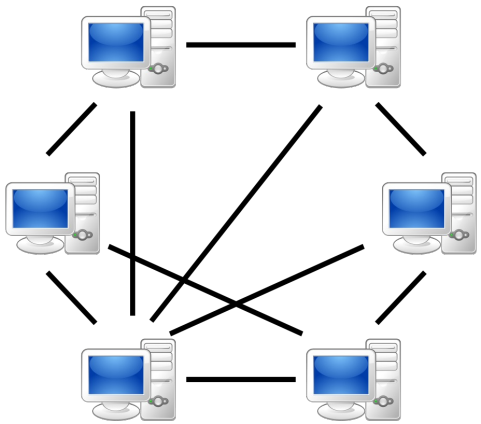
Bitcoin

- Bitcoin is a **cryptocurrency**
  - ~= fiat currencies (e.g., Euro), but not issued by a central bank
  - It's a digital asset

- Who issues the coin? Who ensures we can trust it?
  - A blockchain (system) that
  - that execute Bitcoin software
  - and contain copies of the blockchain (data structure)
  - Decentralized!



Bitcoin as a distributed system

REACHABLE BITCOIN NODES

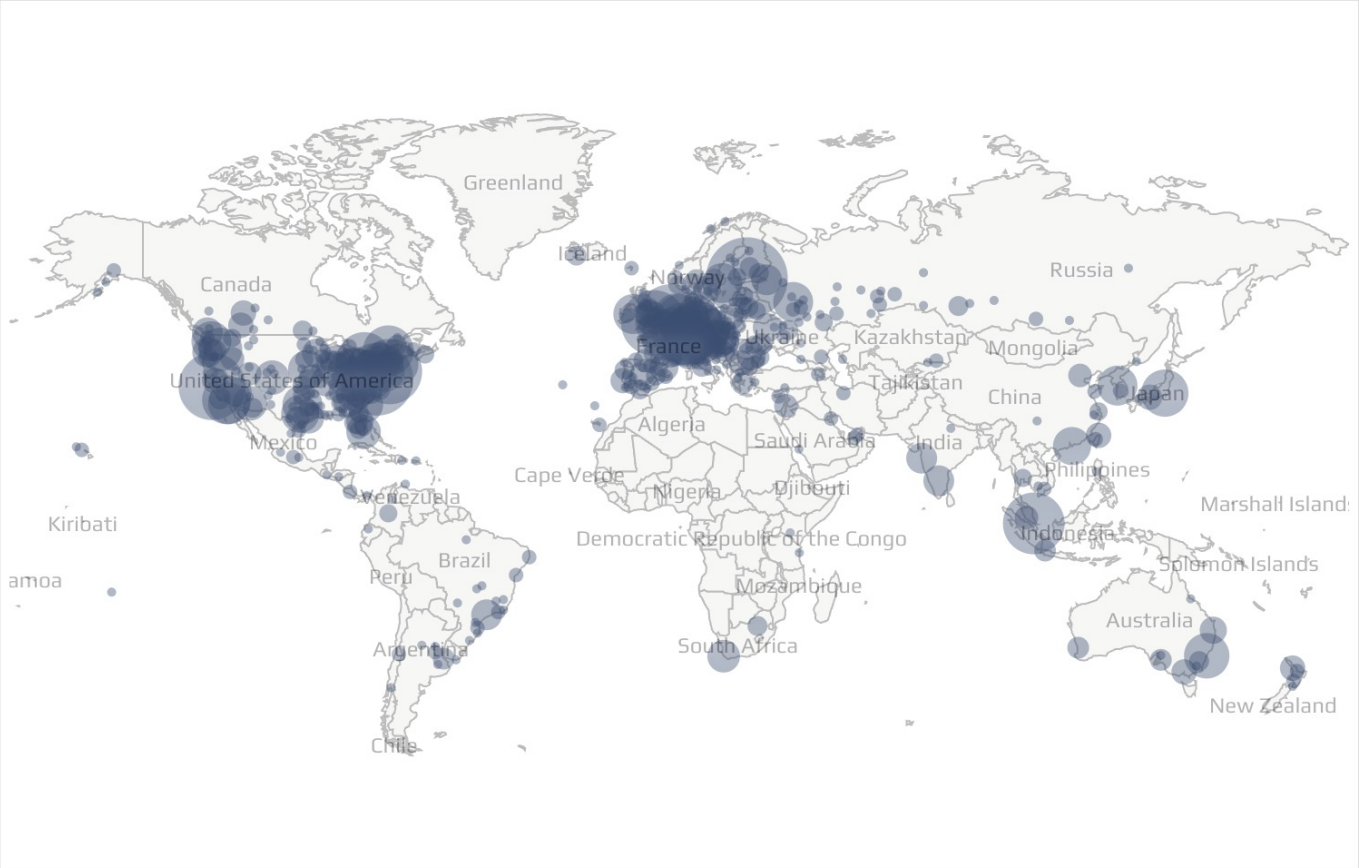
Updated: Wed Sep 28 17:43:29 2022 WEST

14394 NODES CHARTS

IPv4: -1.6% / IPv6: -1.9% / .onion: +2.8%

Top 10 countries with their respective number of reachable nodes are as follows.

RANK	COUNTRY	NODES
1	n/a	7426 (51.59%)
2	United States	1915 (13.30%)
3	Germany	1403 (9.75%)
4	France	431 (2.99%)
5	Netherlands	384 (2.67%)
6	Canada	313 (2.17%)
7	Finland	240 (1.67%)

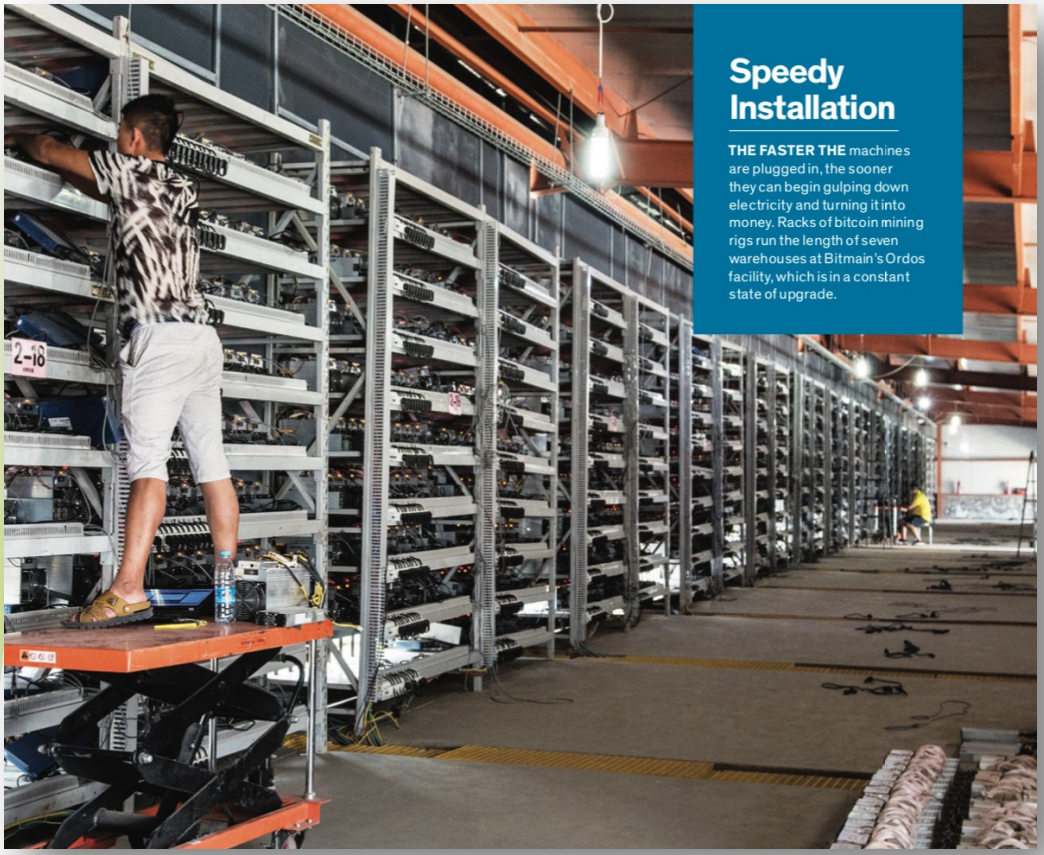


Bitcoin's service: currency transactions

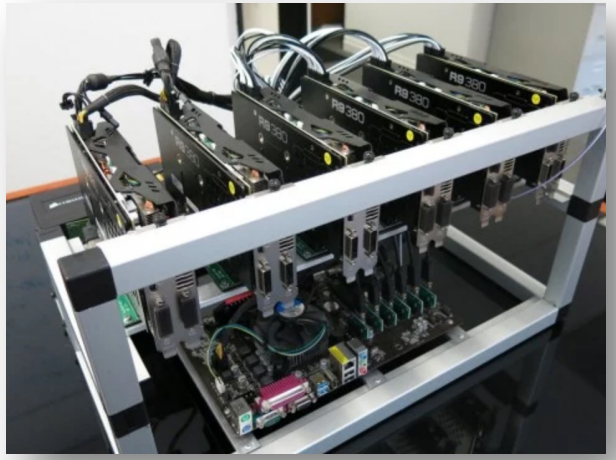
- **Service** = **transactions**, transfers of currency between accounts
  - Currency is associated to accounts (~bank accounts)
  - Another service is no transactions: storage of value

- The nodes keep a chain that stores all transactions of bitcoins
  - Solves the **double payment** problem, i.e., avoids that the same account uses the same coin in two transactions

Bitcoin components – miners



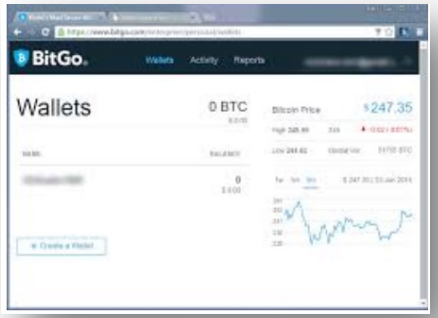
Bitcoin mining datacenter (China)

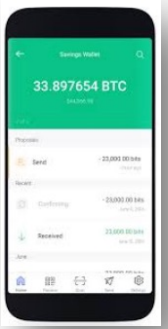


Mini-cluster of GPUs

Bitcoin components – wallets

- **Wallets** – store account info & request money transactions
  - Store private keys corresponding to user accounts; randomness and secrecy of these keys ensure owning of the account
  - Custodial wallets – a third party stores / manages the private keys
  - Non-custodial wallets – the users stores / manages the private keys





Bitcoin – authenticity / integrity

- How to enforce only the owner can do transactions on his account(s)?
- Using a cryptographic scheme: **digital signatures**
  - Alice's transactions **x** take a signature created with the **private key Kr** stored in her wallet
  - Bob can verify the signature with the public key **Ku**
  - Trudy can't forge the signature (doesn't have **Kr**)

users are anonymous
account address = hash(Ku)

Bitcoin – consensus mechanism

- Appending transactions / blocks to the chain:
  - Collect transactions and create a block
  - Try to solve the cryptopuzzle and find a **Proof-of-Work (PoW)**
  - If it finds a PoW before receiving a block+valid_PoW:
    - Send the block+PoW to all miners
    - Otherwise stop and try again for the next block
- Creator of the winning block gets a reward: 6.25+…BTC today
  - Why is it a PoW? Requires many tries; consumes much energy
  - Difficulty set for 1 success every ~10 minutes worldwide (!)

Bitcoin is the first of many

https://coinmarketcap.com/all/views/all/

#	Name	Price	1h %	24h %	7d %	Market Cap
1	Bitcoin BTC	$19,123.66	▼0.20%	▲1.04%	▼2.12%	$366,388,569,574
2	Ethereum ETH	$1,326.01	▼0.09%	▲2.52%	▼2.50%	$162,324,921,606
3	Tether USDT	$1	▼0.00%	▼0.01%	▼0.01%	$67,954,848,462
4	USD Coin USDC	$1.00	▲0.02%	▲0.01%	▲0.01%	$49,424,803,767
5	BNB BNB	$274.91	▲0.14%	▲0.14%	▲2.09%	$44,319,213,585
6	XRP XRP	$0.4723	▲0.20%	▼5.18%	▲22.81%	$23,535,006,108
7	Binance USD BUSD	$1.00	▲0.10%	▲0.05%	▲0.05%	$20,525,231,541
8	Cardano ADA	$0.4451	▼0.12%	▼0.11%	▼1.82%	$15,215,832,355
9	Solana SOL	$33.54	▼0.32%	▲3.10%	▲2.17%	$11,858,620,084
10	Dogecoin DOGE	$0.06093	▼0.14%	▼1.07%	▲4.18%	$8,083,967,494

#21,093
in Sep. 26, 2022

3. Ethereum and smart contracts

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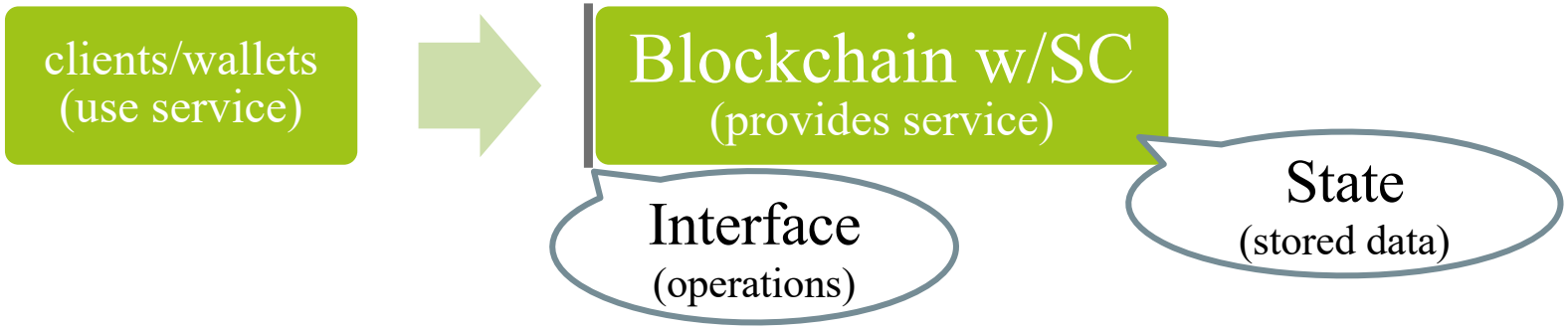
- Why provide only one service – transactions?

Smart contracts

- Notion introduced by **Ethereum**
  - another blockchain that also implements a cryptocurrency (ether)

- A **smart contract** is:
  - Software, i.e., a program
  - Stored in the blockchain nodes
  - Executed in those blockchain nodes
  - May involve money transfer (in ether)
  - Not smart, not contracts

Blockchain black-box model

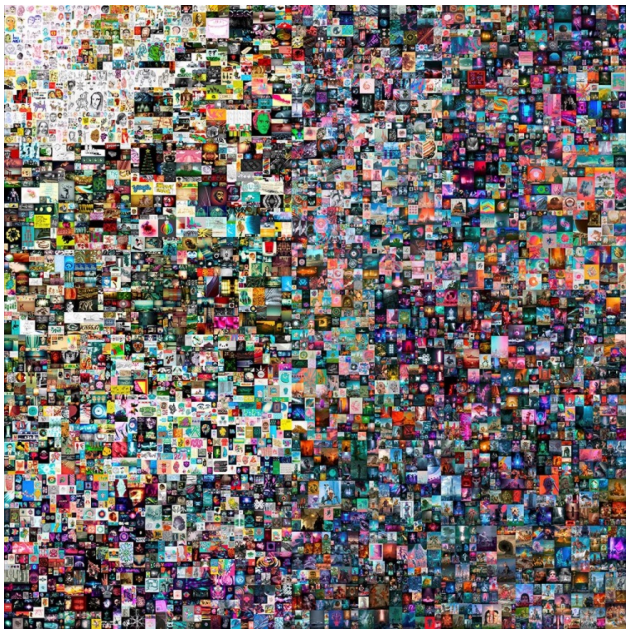


- Properties of the **Blockchain black-box:**
  - Availability & Integrity – provides **service** even if nodes fail / are corrupted
  - Auditability – visible to all
  - Immutability – appended data can't be changed
  - Decentralization – no central controller

Example: Non-Fungible Tokens (NFT)

- **NFT** – data that expresses ownership of a digital asset
  - An NFT is a token that is non-fungible, i.e., unique

- Implemented by a smart contract
  - Allows selling it and proving authenticity



Beeple, "Everydays: the First 5000 Days"
March 2021, Christie's, $69,346,250

Decentralized Applications – DApps

- **DApp** – a decentralized application based on smart contract(s)
  - Frontend – typically Web (HTML, JavaScript, CSS,…) or a mobile App
  - Backend – smart contract(s)
    - They store some data, typically only metadata (e.g., hashes)
  - Data storage – P2P, e.g., IPFS
    - For storing the bulk of the data, e.g., documents

28.9.2022

Blockworks

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4.5 million

The Punk 2924 was bought for 3,300 ETH ($4,451,633.94 USD)

4. Permissioned blockchains

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Blockchain variants

- 2014: financial institutions formed consortium to explore Blockchain (R3)
  - Barclays, Credit Suisse, Goldman Sachs, J.P. Morgan, …; GS and JPM left

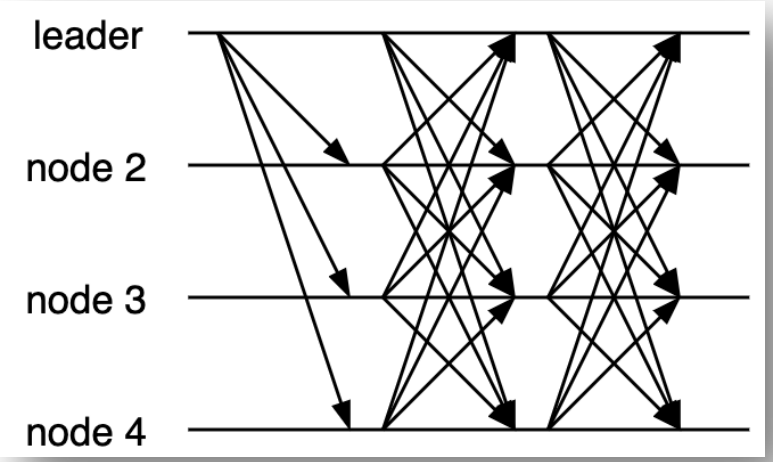
- Open blockchains were <u>not</u> what they needed:
  - Not interested in anonymous users
  - Not interested in showing the chain to the world

Blockchain variants

- **Permissionless** (i.e., no permission needed to be a member):
  - examples: Bitcoin and Ethereum
  - any server can enter, but to participate actively must provide proof-of-work
  - for **public** use
- **Permissioned** (i.e., permission needed):
  - examples: Hyperledger Fabric, Hyp. Besu, Quorum, Corda, Hyp. Burrow
  - servers must have permission; no proof-of-work needed
  - for **consortium** or **private** (?) use
  - *participants already have some degree of trust among them, but want to simulate the services of a neutral third party*

Consensus in permissioned blockchains

- PoW is really bad for consensus: probabilistic, forks, energy
- In **permissioned blockchains** the set of nodes is well-defined, which allows doing better
  - Problem solved since 1980 (Lamport et al.), fast since 1998 (Castro&Liskov)!



5. European Blockchain Partnership

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The Declaration

DECLARATION

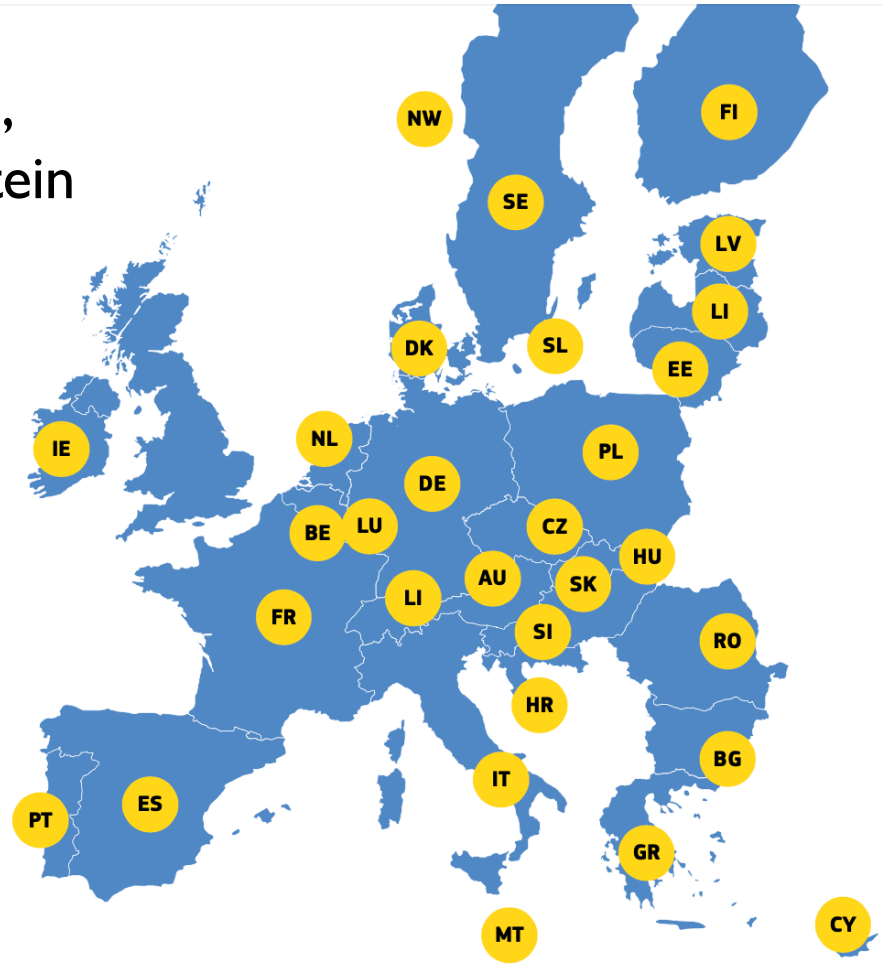
Cooperation on a European Blockchain Partnership

In order to harness the many opportunities of blockchain and avoid a fragmented approach, the signatories of this declaration agree to cooperate to establish a European Blockchain Partnership with a view to developing a blockchain infrastructure that can enhance value-based, trusted, user-centric digital services across borders within the Digital Single Market.

Done in Brussels on 10 April 2018 in one original in the English language

The Partnership today

- All EU Member States, Norway and Lichtenstein



CEF Building Blocks

CEF Digital
Connecting Europe

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Big Data Test Infrastructure
A free big data analytics sandbox to power your data-driven decision-making

eArchiving
Preserve, migrate and reuse data securely, according to European Standards

eInvoicing
Send and receive electronic invoices in line with the European Directive

Once Only Principle
Reduce administrative burden for individuals and businesses

Blockchain (EBSI)
Build the next generation of European Blockchain Services Infrastructure

eDelivery
Exchange electronic data and documents in an interoperable and secure way

eSignature
Create and verify electronic, paperless signatures

Context Broker
Make data-driven decisions in real time, at the right time

eID
Offer services capable of electronically identifying users from all across Europe

eTranslation
Enable multilingual public services and communication

APPLY FOR GRANTS

ensures legal validity of electronic documents (eIDAS regulation)

for EU-level, cross-borders, applications

6. European Blockchain Services Infrastructure

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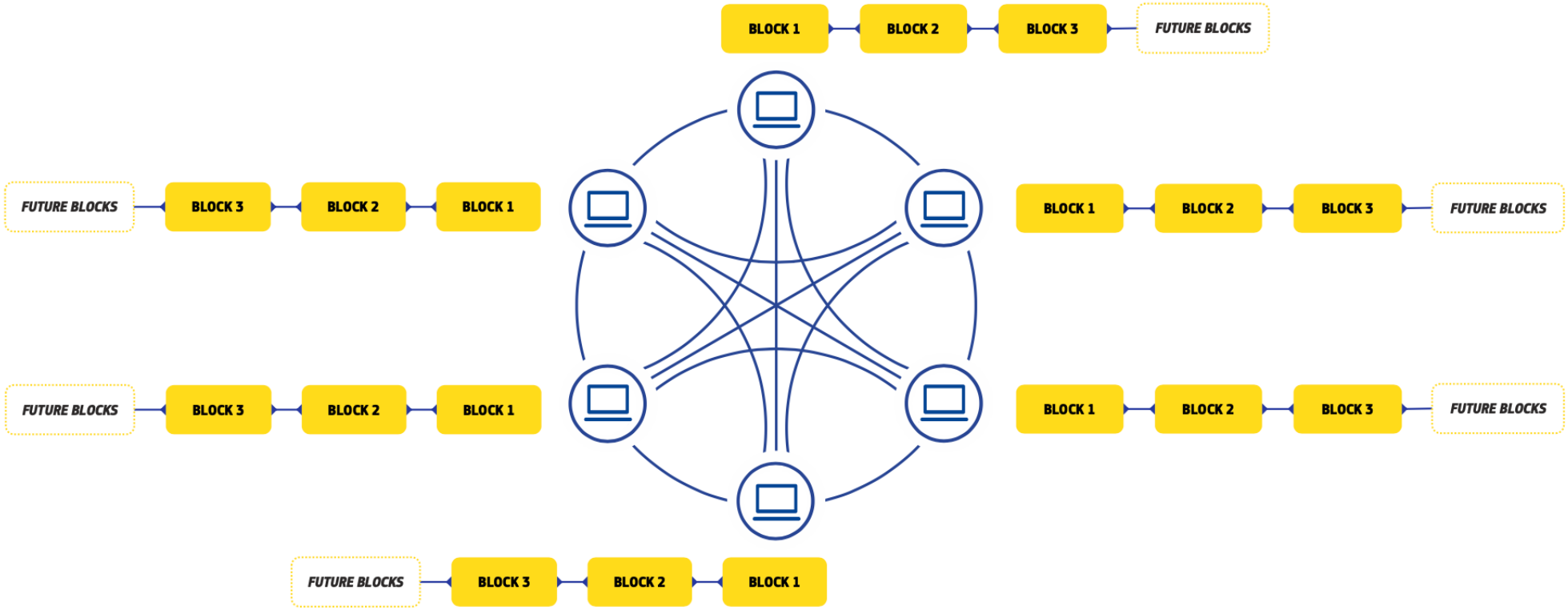
EBSI

- "a **network of distributed nodes across Europe** that will deliver **cross-border public services.**"

- Permissioned blockchain – target is to have nodes in all the countries and the EC

EBSI


BLOCK 1
BLOCK 2
BLOCK 3
FUTURE BLOCKS
FUTURE BLOCKS
BLOCK 3
BLOCK 2
BLOCK 1
BLOCK 1
BLOCK 2
BLOCK 3
FUTURE BLOCKS
FUTURE BLOCKS
BLOCK 3
BLOCK 2
BLOCK 1
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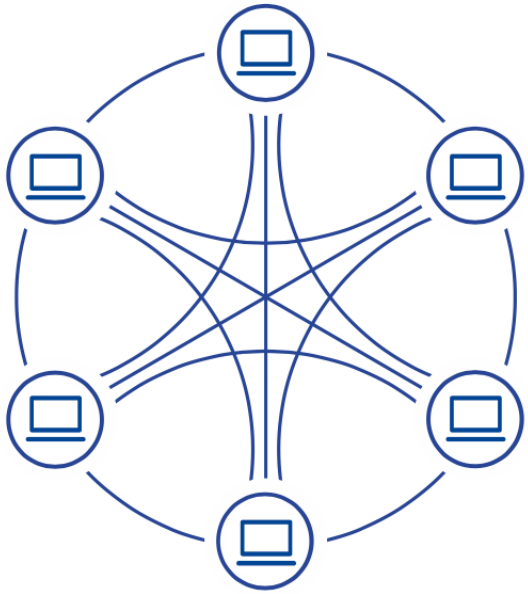
BLOCK 3
FUTURE BLOCKS
FUTURE BLOCKS
BLOCK 3
BLOCK 2
BLOCK 1

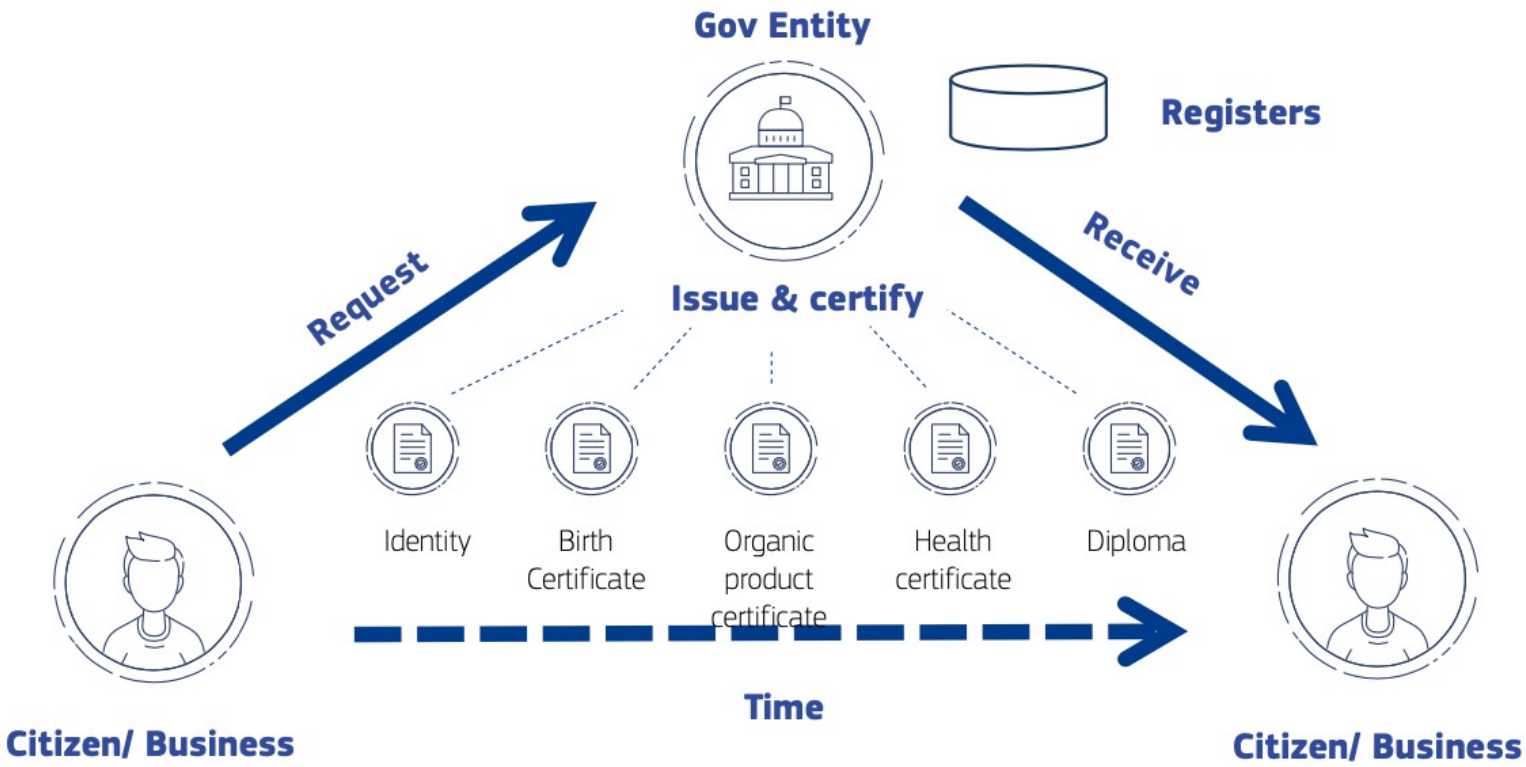
EBSI – technical details



A node is/contains:

- Minimum of 3 servers
- Hyperledger Besu and Hyperledger Fabric
- Core services: eIDAS bridge, management,…
- Smart contracts
- Use case software, business applications

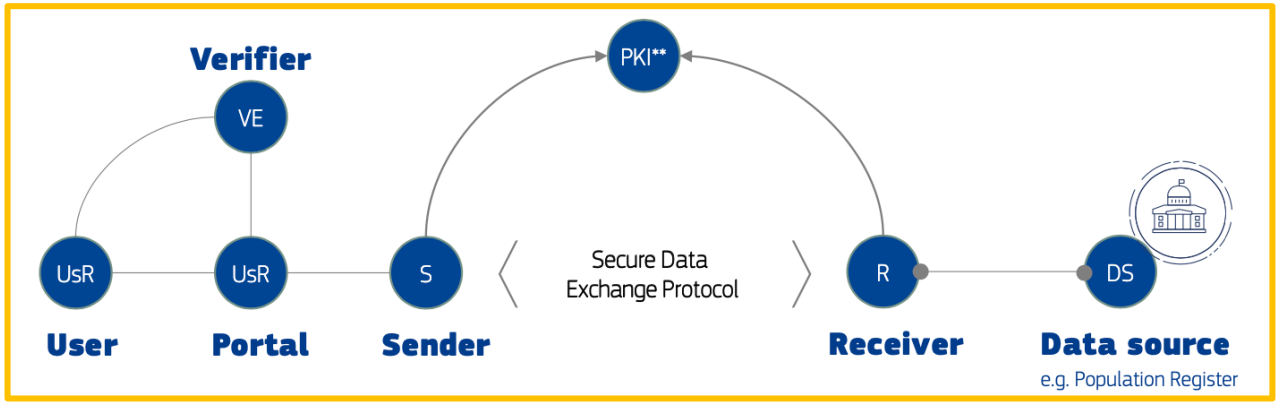
I st target: public services



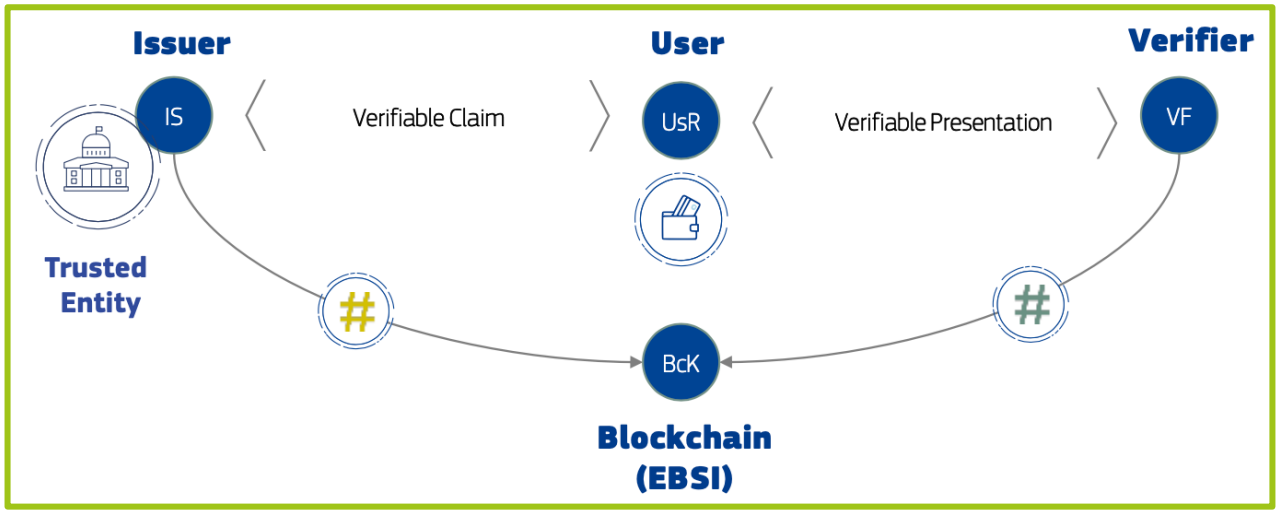
for EU-level, cross-borders, applications

How to share documents securely?

Old model – just in time evidence issuance



New model – verifiable credentials (stored in wallet)



Why is this interesting?

Data control by the citizen

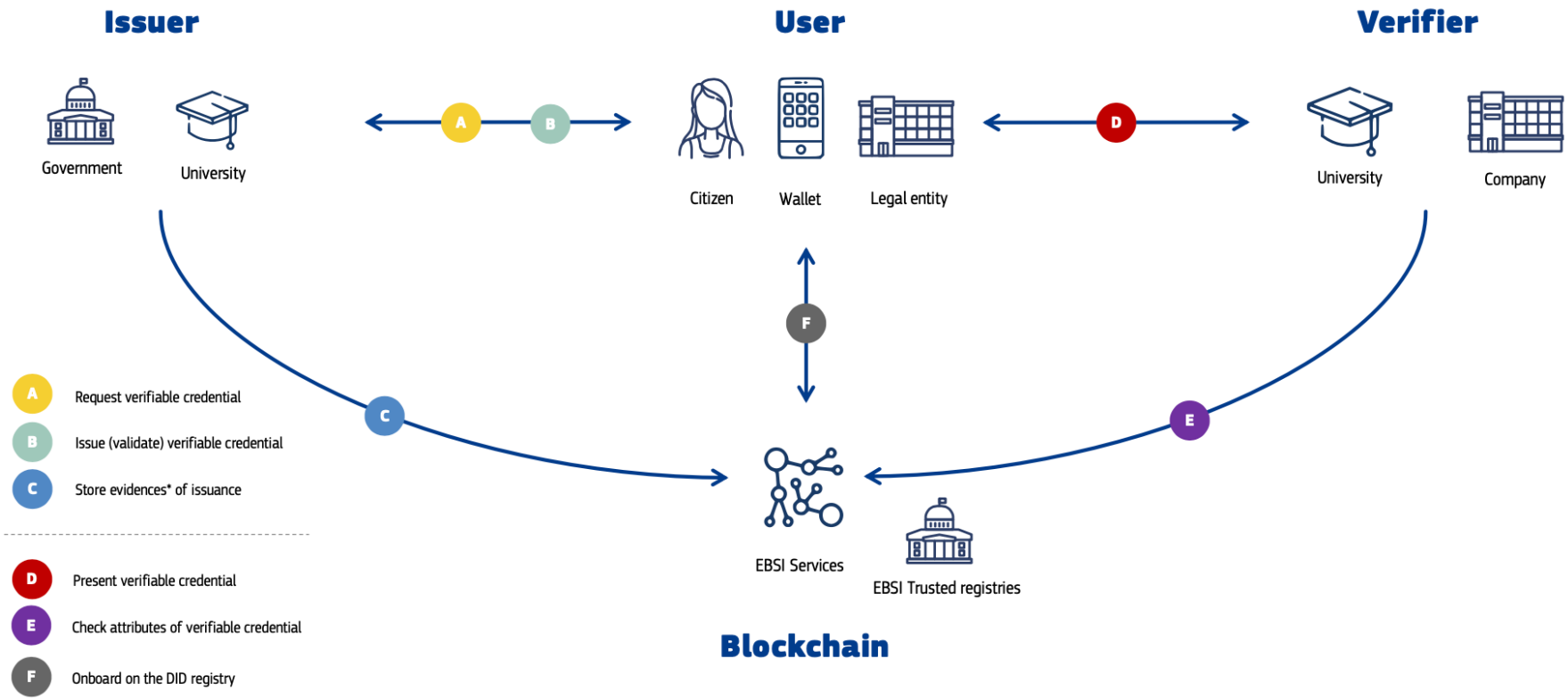
Enhanced selective data discloser

Improved traceability of the origin and of the recipient

Increased efficiency (no need of "just-in-time evidence issuance")

Reduced verification costs (once at scale)

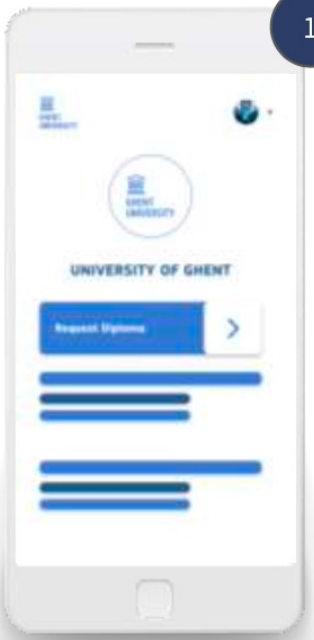
Example: trusted university diplomas
1. *Workflow*



Example: trusted university diplomas
2. *Obtaining the diploma with Wallet*

Eva initiates the request for the issuance of her Bachelor's Diploma

1



- Connect to University platform
- Initiate the action

Eva requests the issuance of her Bachelor's Diploma from the University of Ghent

2

- Select Verifiable ID
- Submit the request

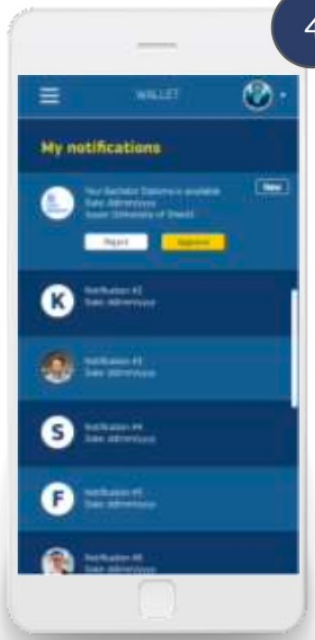
The University of Ghent issues the Bachelor's Diploma

3

- Check list of students
- Select the students
- Submit the credential

Eva receives and accepts the Bachelor's Diploma

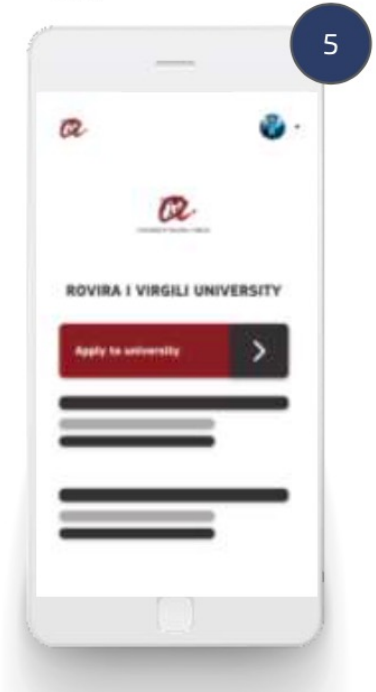
4



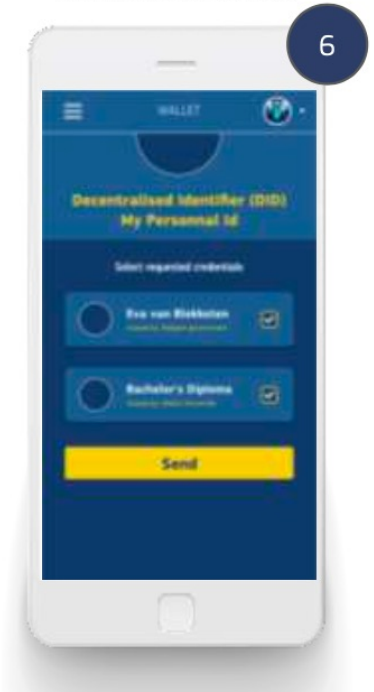
- Get notification
- Accept the credential
- Store in the wallet.

Example: trusted university diplomas
3. *Showing the diploma*

Eva initiates the application to the University of Rovira i Virgili



Eva shares her Bachelor's Diploma (VA) with the University of Rovira i Virgili



The University of Rovira i Virgili verifies the Bachelor's Diploma (VA) of Eva

Eva enrolls for a Master's Degree at the University of Rovira i Virgili

7. EBSI Use Cases

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Main use cases

European Self-Sovereign **Identity**

Diplomas management

Document Traceability

Trusted data sharing

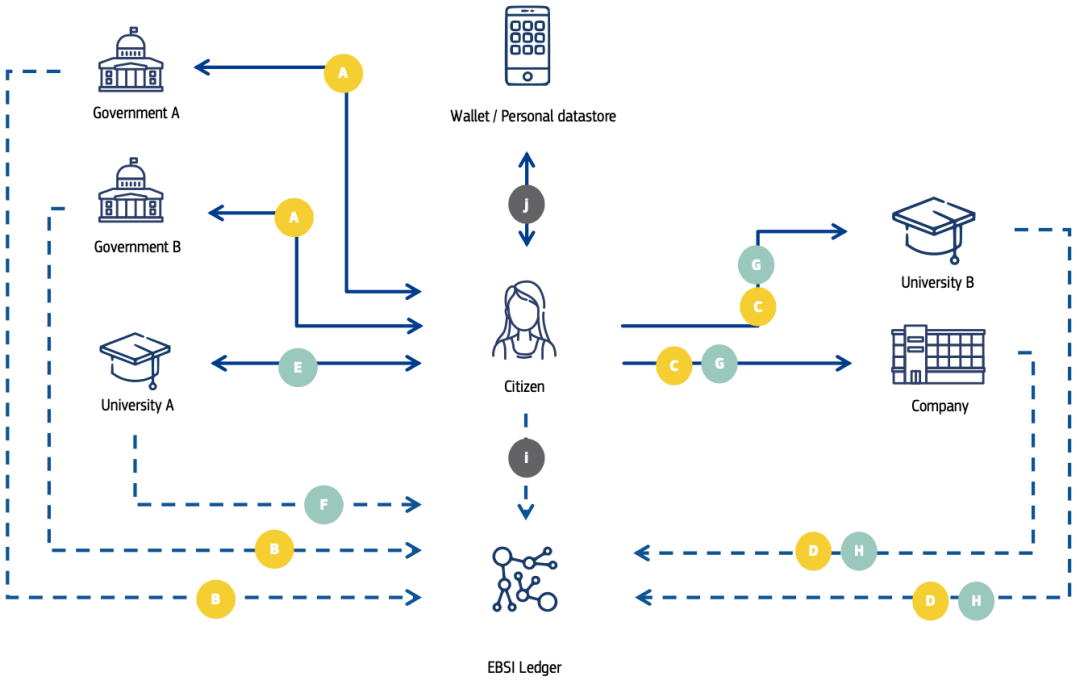
(Reserved for TAXUD's Community at this stage)

Use case 1: ESSIF

- **Self-Sovereign Identity** (SSI) allows a person/organization:
  - Create an identity (DID – Decentralized Identifier)
  - Get Verifiable Credentials (VCs) with claims about himself
  - Selective disclosure: only the desired claims are shown to each entity (to each online service)
  - Cross-borders identification
- European SSI Framework (ESSIF)
  - Supported by the EBSI
  - Connection to eIDAS to generate and verify VCs

Use case 2: Diplomas

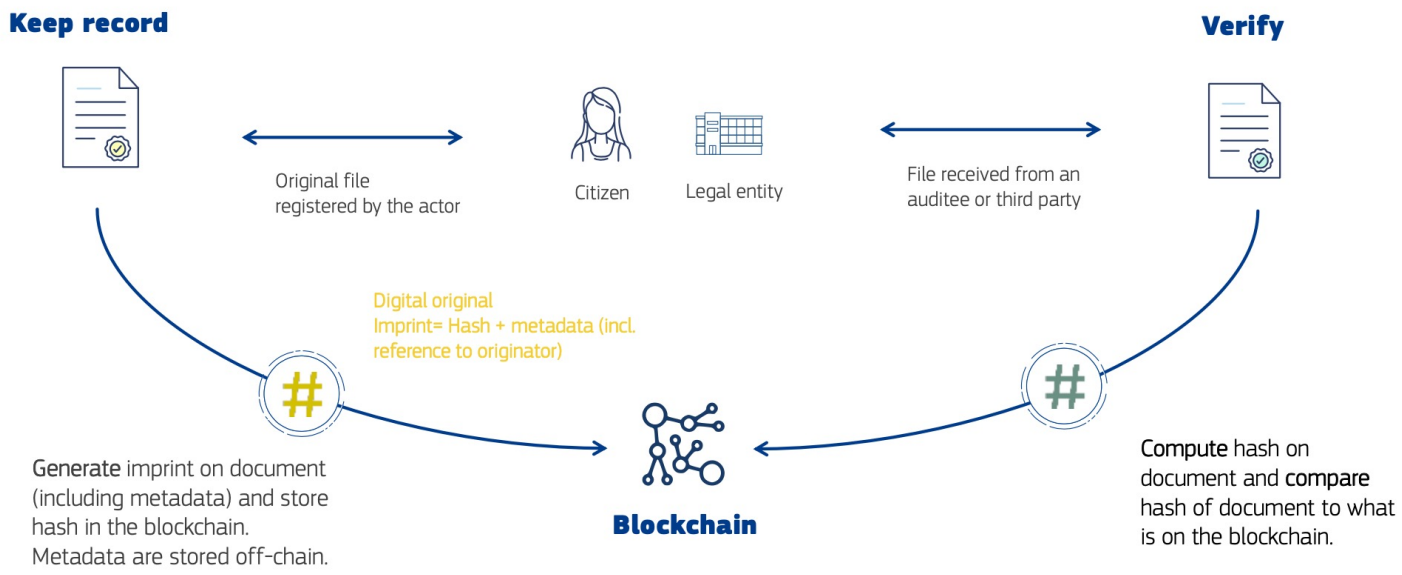
- The example we saw
- The objective is to create an ecosystem:



Use Case 3: Document Traceability

2 operations:

- Register: to record a data/document imprint in the EBSI
  - Imprint = hash + metadata of the data
  - Data = pdf, image, text message, action, etc.
- Verify: check authenticity/integrity of the data



New Use Cases

- SME financing
- European social security number
- Asylum demand

Road Ahead

- EBSI v2 entering production
  - Launched ~April 2021
- Governance
- Regulatory/legal

8. EBSI Early adopters & DE4A

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EBSI Early adopters programme

- Goal: jumpstart EBSI use
- Limitations:
  - Focus on current use cases (ESSIF, etc.)
  - Focus on pilots and production in public services
- Benefits:
  - Support and co-creation with EBSI experts
  - Open information sharing

DE4A

- H2020 EC project
  - Leader: ATOS | Participants: INESC-ID,…. (~22 partners)
- Goals
  - Contributing for the Digital Single Market, **simplifying cross-border exercise** by citizens and business
  - Simplifying migration towards European Digital Public Services co-delivered across borders
  - Full implementation of **once-only and digital-by-default principles**, **user centricity** and take into account new technologies (**blockchain**)

DE4A pilots

- Studying Abroad
  - Paperless procedures for students' mobility:
  - Application for Higher Education
  - Applying for Study Grant
  - Diploma/Certificate/Studies, professional recognition - **EBSI**
- Doing Business Abroad
  - Meet business needs retrieving and keep up-to-date company data from authentic sources: Starting of business; Digital Annual Reports
- Moving Abroad
  - Enabling citizens' mobility across EU enabling: Registering change of address; Civil Status Certificates; Retiring

Key Takeaways

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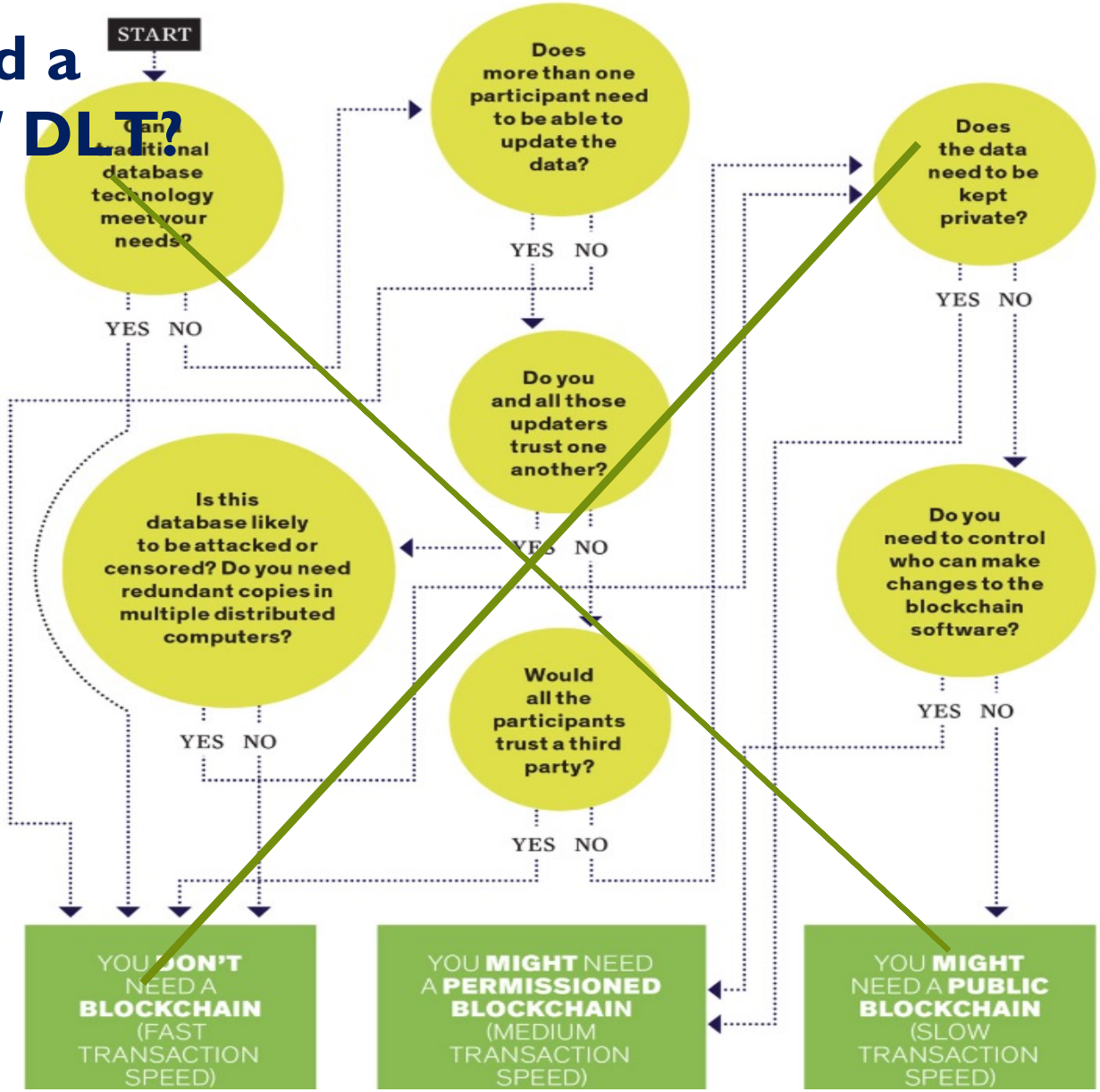
Do you need a blockchain / DLT?



Real question is: what applications can benefit from **decentralization** and the other blockchain **properties**? Where is the **added value**?

Blockchains

- Cryptocurrencies vs Programmable blockchains (smart contracts)
- Permissionless/public blockchains vs Permissioned blockchains
- Blockchains provide integrity, availability, auditability, decentralization
- Many relevant subtopics: tokens/NFTs, identity/SSI, traceability,…

What the EBSI is (not)

- It is <u>not</u> a:
  - Testbed / a Blockchain infrastructure to develop products
- It <u>is</u> a:
  - European-level blockchain infrastructure
  - For cross-border applications
  - For public services, at least for now
  - Pioneer initiative: 1st Blockchain created by set of countries
- Initial set of use cases + early adopters program

Thank you

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https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI

Several pictures @CEF Digital

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