Blockchains in the European Metrology Cloud

How this idea will impact digital transformation in Metrology

INMETRO

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In the next 20 minutes...

- The digital transformation in Metrology and its impact;

- Why cloud computing is so important;

- The European Metrology Cloud

- Why blockchains are important in this context

  - Immutable storage;

  - Workflow automation;

  - Security properties that protects data and software.

- Applications in Metrology involving blockchains

  - Case studies;

  - The Inter-NMI blockchain network.
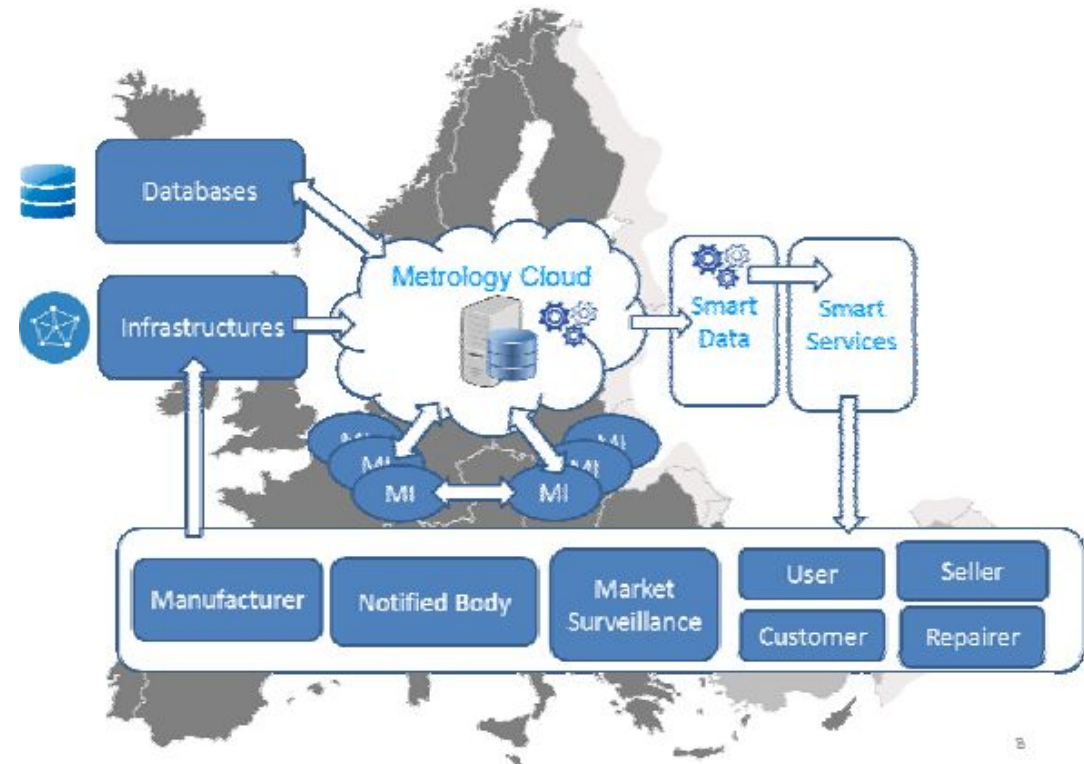
The digital transformation of Metrology

- The difference between digitalization and digital transformation
  - Digital transformation is the next step!
  - Who are not prepare will be left behind...

- Several technologies are involved
  - Industry 4.0 and their nine pillars: robots automation, horizontal and vertical integration, IoT, additive manufacturing, augmented reality, simulation, cybersecurity, big data, and **cloud computing**.
  - The cloud is a "basis" technology
    - It can provide the computational support and the proper environment to address the demands of other technologies.
    - The cloud can store data, provide computational power on demand, and also operationalize different platforms and services.

The Cloud and its properties

- According to Thiel et al. (2015), cloud systems can offer:
  - **On-demand self-service:** users have resources according to their needs.
  - **Rapid elasticity:** resources can be scaled to fit current demands.
  - **Measured service:** the quality of service is the same for all users.
  - **Broad network access:** services are available to a wide variety of devices.
  - **Resource pooling:** providers can pool resources and allocate them flexibly.
  - **Auditability and certifiability:** services keep logs of actions and policies.
- These aspects can be handy to metrology digital transformation
  - Measuring instruments already use cloud services to store information;
  - Cloud services can run legally relevant software;
  - Notified bodies can reduce costs and effort in activities as type approval and metrological surveillance.
  - Users (i.e., consumers, vendors) will have benefits from connected services.

The European Metrology Cloud (EMC) Project

- Defined as "a trustworthy, metrological core platform [...], designed to support and streamline regulatory processes by joining existing infrastructures and databases".
- Supported by NMIs in EU
  - The PTB leads the main efforts.
- The platform shall integrate
  - Manufacturers;
  - Notified bodies and repairers;
  - Users and their multiple instances.
- Measuring instruments (MI) are the main "information builders".
- Smart data extracted from the cloud will create new services and business models.

- Cloud-based measuring systems: physical MIs work as "dummy" sensors, while measurement processing, storage and services are done in the cloud (Opperman et al., 2018).
 - Reduction of costs with MI, including regulatory control activities.
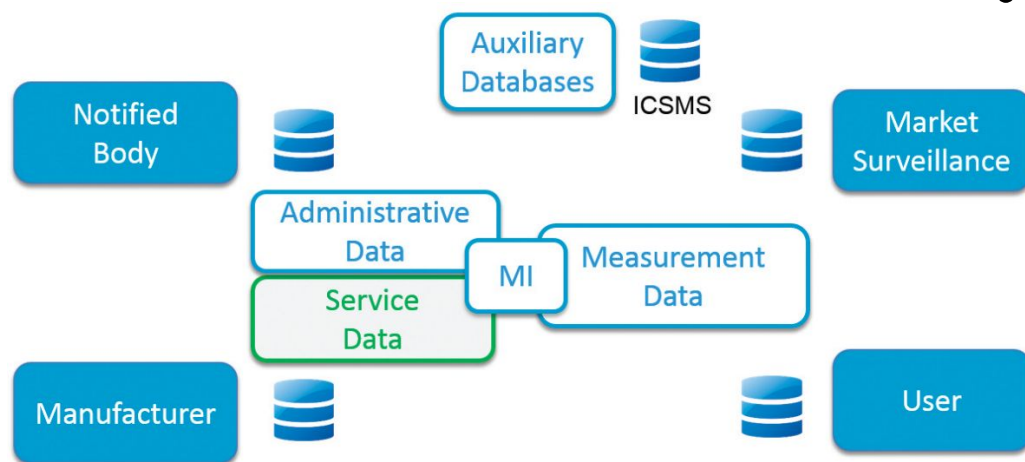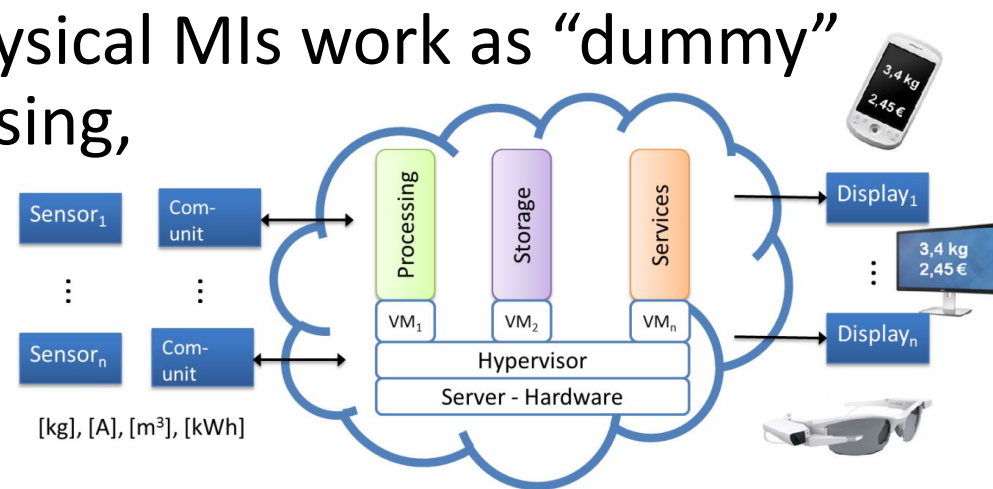
- Technology-driven and data-driven services result from the integration of administrative, measurement, and existing databases (Thiel et al., 2018).
  - New business models created from "smart" information;
  - Regulatory control improved by novel technologies and concepts.

And the EMC will need blockchains

- According to Thiel and Wetzlich (2019), the EMC faces challenges resulting from interactions in a complex, insecure environment.
  - There is not a Trusted Third Party (TTP);
  - Free movement of data across borders, different organizations feed and consume information from the cloud;
  - Need for a flexible platform where organizations can write code and provide their applications independently;
  - Multiple users need to access the cloud, consuming data that many times are sensitive.
- Blockchains can help by integrating the EMC platform
  - A permissioned blockchain that supports smart contracts and incorporates mechanisms to assure the privacy of sensitive data;
  - Intended use: decentralized IDs Administration and immutable logbook.

But what are blockchains and how they work?

- Basically, it provides trust among independent parties that do not need to trust each other:
  - Append only and immutable data structure, which uses a chain of blocks cryptographically linked;
  - Automation of workflows by using smart contracts - in practice, a platform of distributed services;
  - Strong properties regarding security.

- It has called the attention of different players in areas as finance, industry, business, government…

- And the Metrology is an area that also can take advantage from blockchains!

Replication

Cryptography

+

Consensus

Business logic
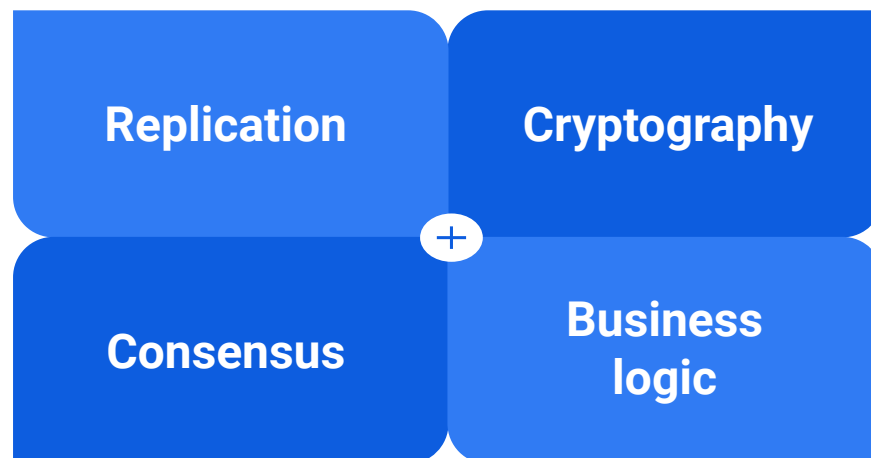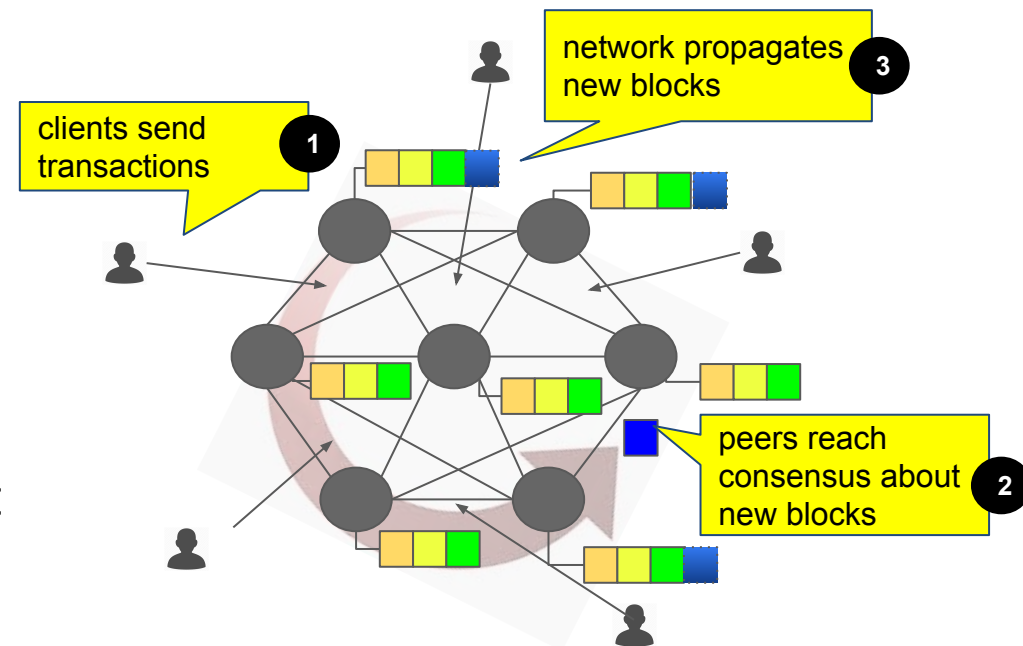
Examples of blockchain-based applications: Case #1

- **Distributed measuring systems**
  - Sensors send raw data to the blockchain.
  - Smart contracts perform LR software and processes.
  - We increase LR software protection
    - Software becomes immutable, since its hash is written in the ledger.
  - We reduce costs with MI legal control regarding software inspection
    - Type approval (activities 1 and 2);
   - Market/field surveillance (activite 3).

  - Publications:
    - IEEE-I2MTC Conference, 2019
    - IEEE-Transactions I&M, 2020
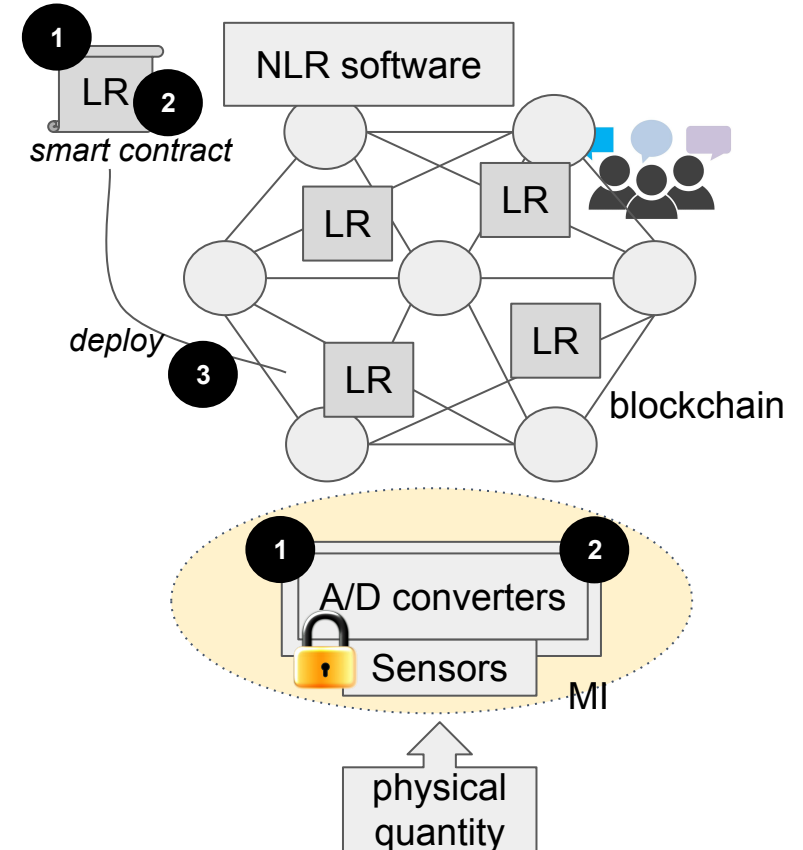
Examples of blockchain-based applications: Case #2

- Public Key Infrastructure (PKI) for smart meters:
 - The blockchain stores and attests public keys from smart meters;
  - Meters sign their measurements using the respective private key;
  - There is no cost with digital certificates;
  - Solution does not depend on a trust third part (TTP).

  - Publications:
    - [IEEE-MetroInd, 2020](#)
    - [Sensors Journal, 2021](#)
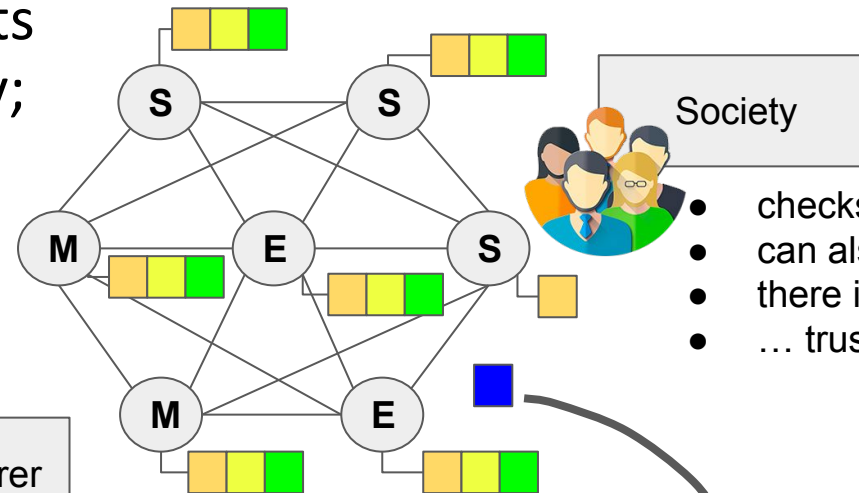
Society
- checks the blockchain
- can also take part on it
- there is no collusion...
- ... trusts the smart meter
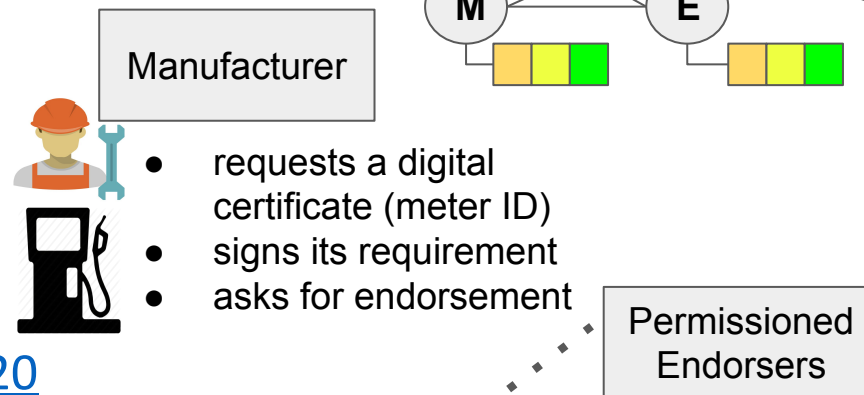
Manufacturer
- requests a digital certificate (meter ID)
- signs its requirement
- asks for endorsement

Permissioned Endorsers
- checks information
- inspects the smart meter
- endorses transactions

Examples of blockchain-based applications: Case #3

- Field surveillance of fuel dispensers
  - Vehicles' embedded sensors can monitor fuel dispensers' correct behavior;
    - One can use IoT devices (e.g., OBD interfaces) that are already available;
  - Vehicles write measurements into the blockchain;
  - Smart contracts perform data analysis (prevention against collusion)
    - Our approach is based on the Law of Large Number.
  - Independent organizations interested in fighting against frauds support the blockchain network
    - They do that providing pears voluntarily.
  - Our implementation uses Byzantine-fault tolerant consensus (BFT-SMaRt).

  - Publications:
    - Journal of Network and Computer Applications, 2021
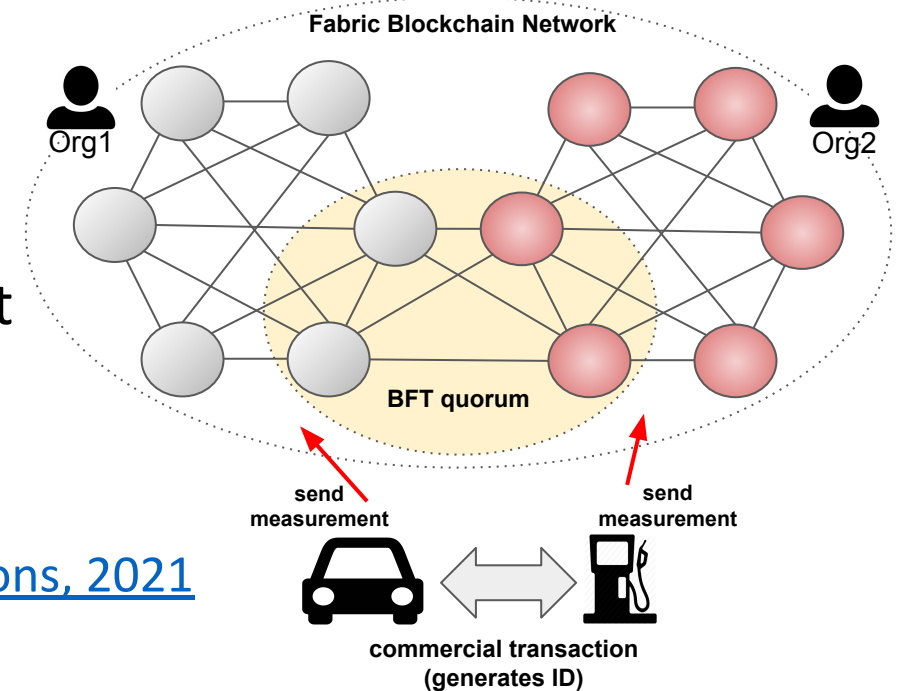
Proposal of an Inter-NMI blockchain network

- Since 2019, Inmetro and PTB are working together to specify a blockchain architecture to support applications in Metrology
  - A blockchain network hold by NMIs and interested research institutions.
- So far, we have four publications, proposals involving strategies for privacy, and the blockchain-based PKI prototype.
- Involved technologies:
  - Hyperledger Fabric;
  - Virtualization using docker containers;
  - Smart contracts write in Golang;
  - Client applications write in Python 3;
  - Code and setups are available in Github.
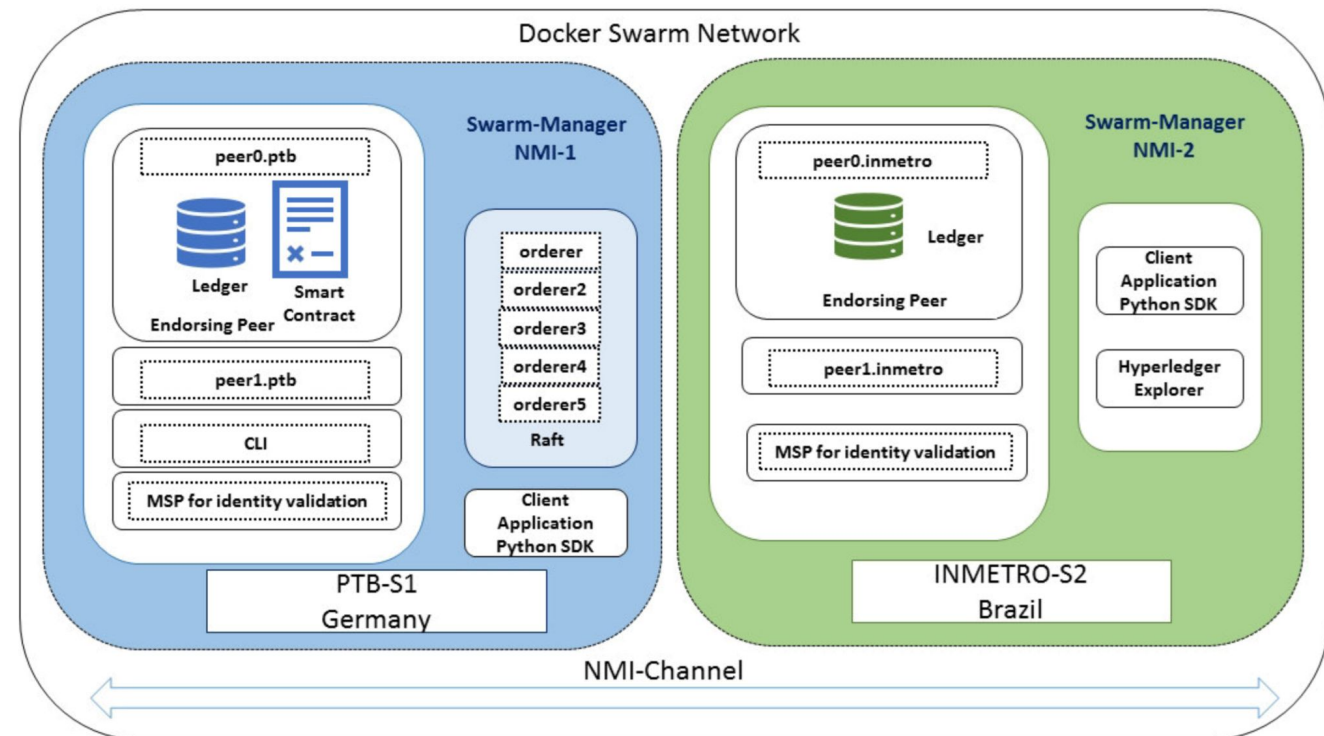
Conclusions

- Blockchains is a technology with potential so huge as was the Internet 20 years ago.

- Blockchains-based applications can accelerate digital transformation in Metrology, addressing several aspects related to information reliability, integration of systems, and workflows automation.

- The EMC project is aware of these possibilities and shall integrate a permissioned blockchain into its reference architecture.

- An inter-NMI blockchain network can constitute an important initiative to propagate these concepts among metrologists.

  - Your NMI is very welcome to join us!

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