Fakultät für Informatik
Facoltà di Scienze e Tecnologie informatiche
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SOFTWARE
AND SYSTEMS
ENGINEERING
research group

IoT in cloud and fog computing

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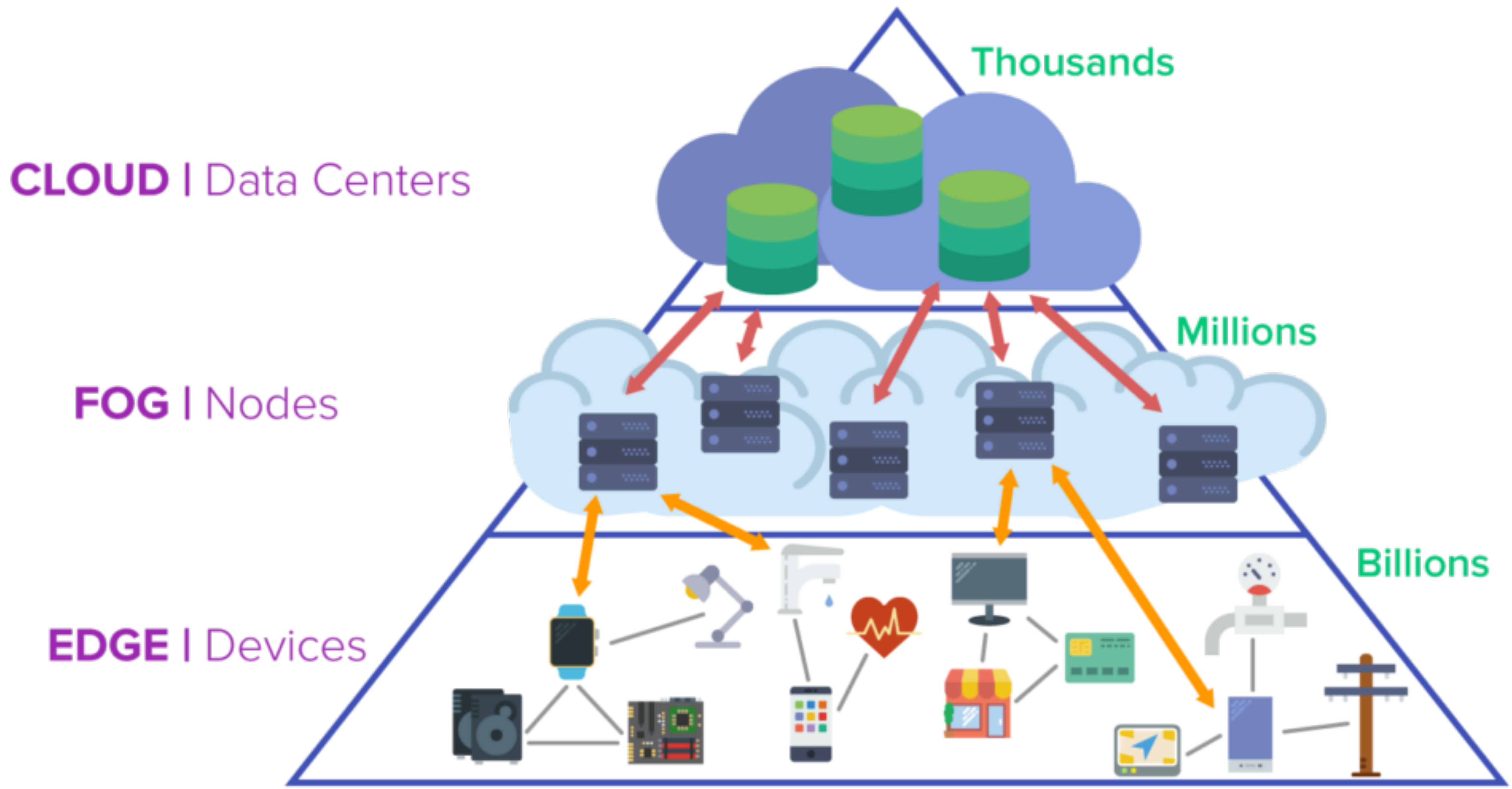
Internet of Things
E BLOCKCHAIN:
Analisi Interdisciplinari

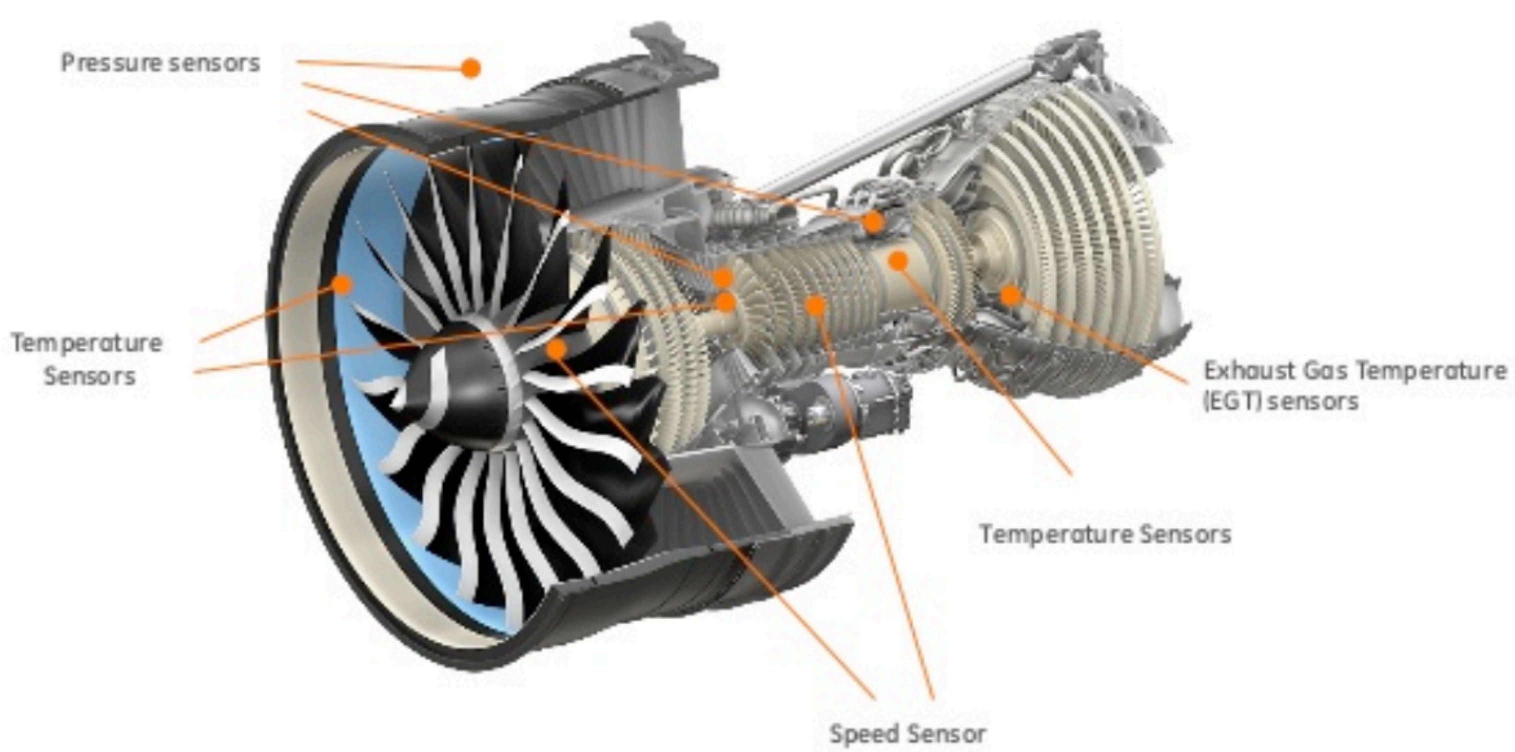
Introduction

- Cloud computing models are not designed to handle “the volume, variety, and velocity of data that the Internet of Things generates”



Need for Edge

- Huge volumes of data are generated (Analysis)
- Keep data near users/devices (Storage)
- Limits cloud bandwidth, latency (Response time)



Each GE jet engine can generate 1TB of data of data from a single flight

Edge computing

- Computing and storage resources are placed at the Internet edge (in close proximity to mobile devices or sensors)

Edges computing devices/ IoT Devices

- Do not operate in isolation
- Crowds of devices
  - Distributed
  - Belong to different providers

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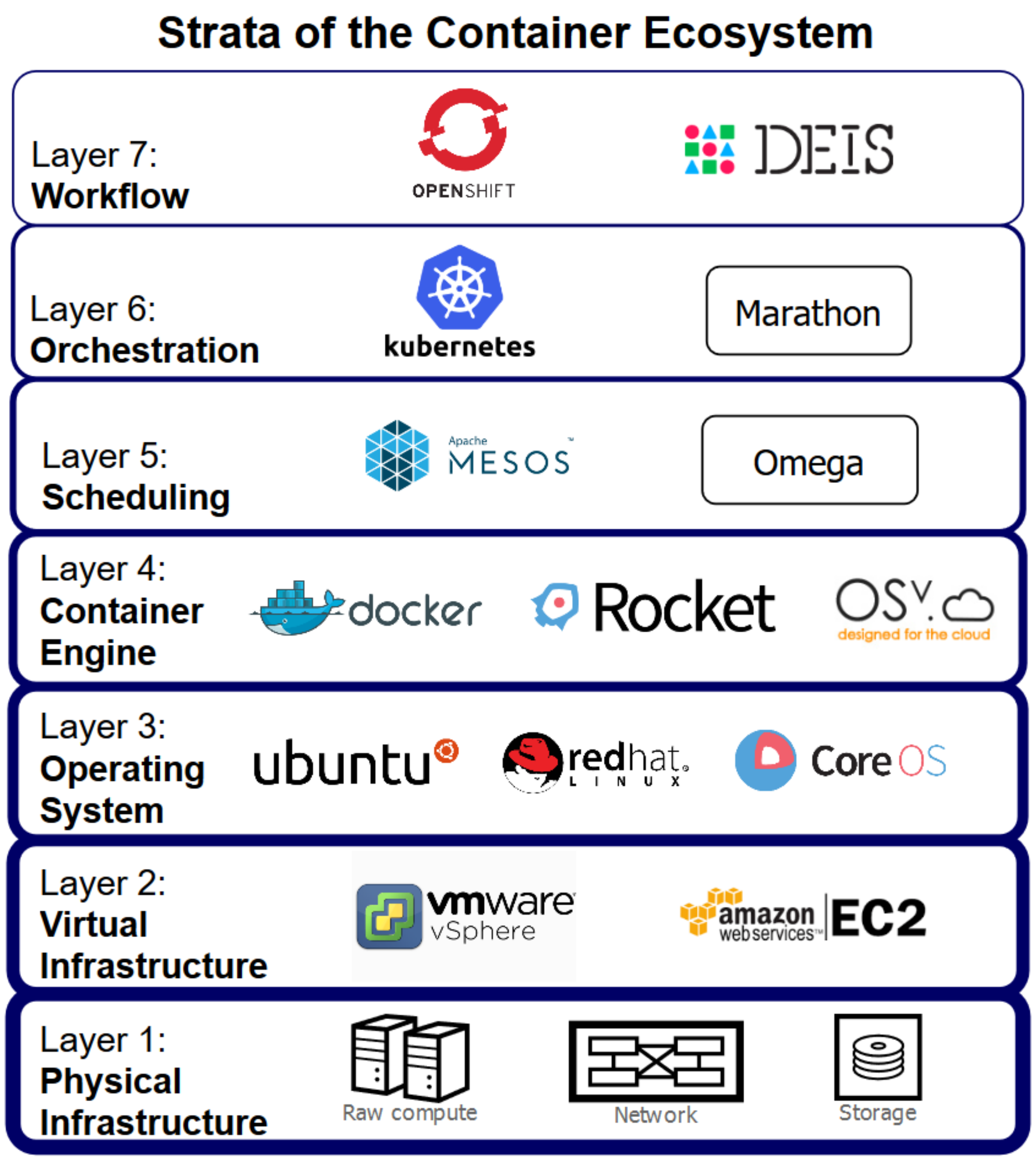
Need for orchestration

Container-based Edge Cloud Deployment

- Cluster architecture for edge cloud scenarios:
    - Cloud deployment on resource-constrained devices



Research Challenges

- The collaboration of multiple SPs and mobile edge applications vendors are posing new challenges
    - Trustworthiness: verification of client/edge software & hardware
    - Tradeoff: Local vs. Global architecture, Distributed vs. Centralized

Goal

- Investigating the blockchain technology as a platform for edge computing orchestration
  - Identification
  - Provenance
  - Orchestration

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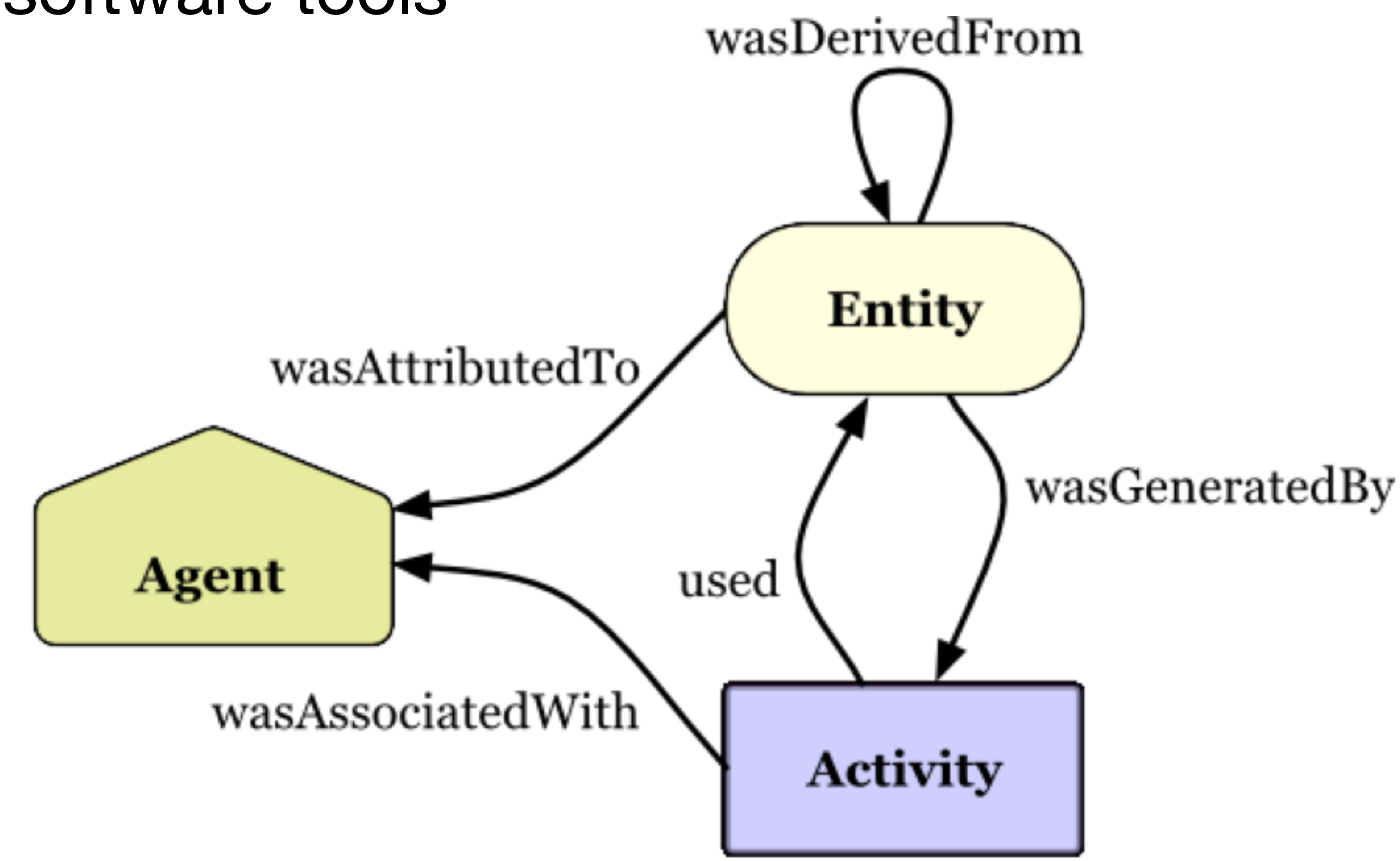
No Third party

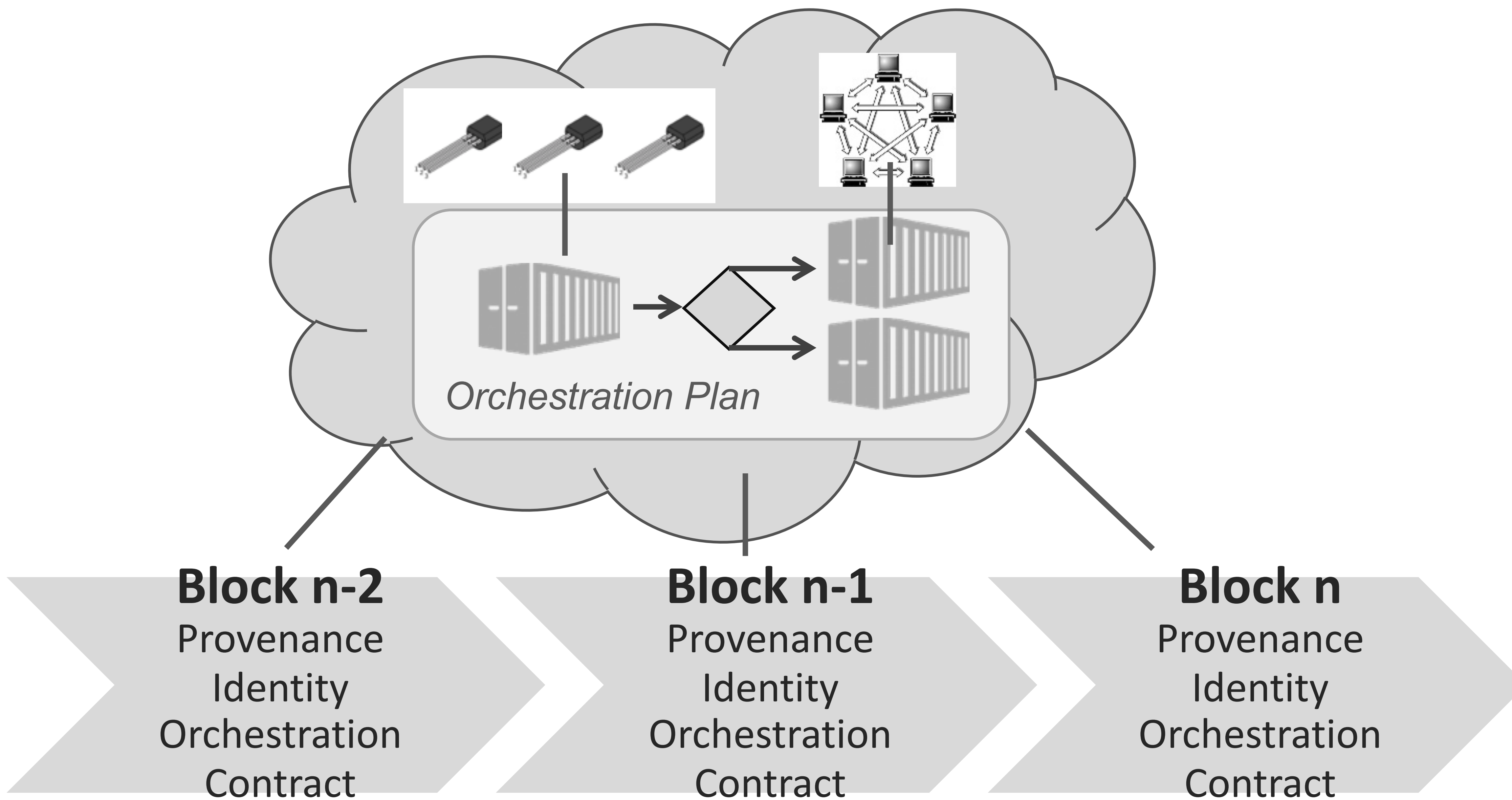
Trust Tax

PROV standard

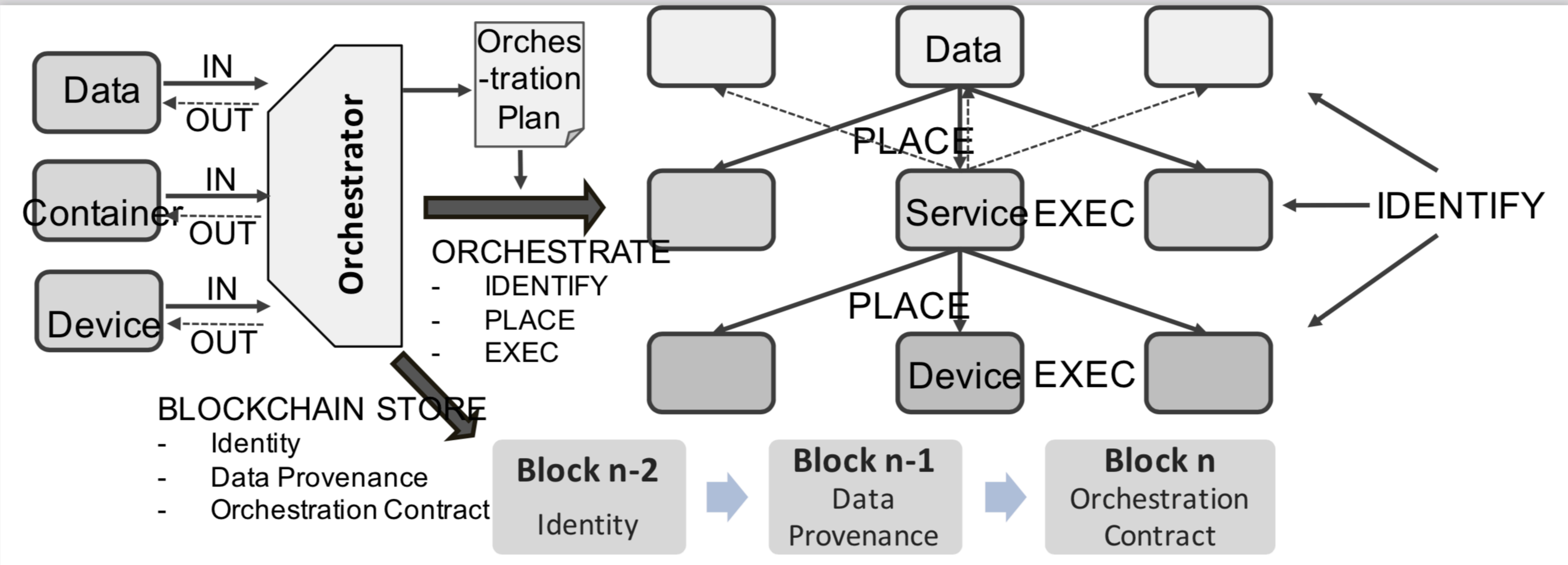
- W3C PROV outlines a generic model for Provenance
- Defines the architecture and the compliance requirements for software tools



Trusted Orchestration Management (TOM) for the Edge with Blockchain



Architecture



Example

- **Agricultural domain**
  - Devices: RPi clusters in remote, exposed areas (assumed to be in fixed locations)
  - Sensors: rain, temperature, sun, humidity
  - Actuators: irrigation system
  - Containers: regular sensor data collection, data filtering and analysis, local storage, maintenance and testing
  - Data: sensor data (raw, filtered), analysis results, actuator instructions
  - Orchestration: scaling up services, check data provenance, container identification, container orchestration on devices (contract execution).

Design Decisions

- Block size
- Consensus protocol
- On/off-chain
- Public/private chain
- Single/multiple chains
- Internal/external validation oracle
- Permissionless/ permissioned

Blockchain Design Decision 1
Mechanisms of improving transaction processing rate Larger block size; Off-chain transactions; Smaller transaction without signature; Scalable protocol
Blockchain Design Decision 2
Mechanisms of selecting the next block included in the blockchain Proof-of-work, Proof-of-stake, Proof-of-burn, Proof-of-retrievability
Application Design Decision 1
Scope: on-chain Enable verification of computational result, limited computation power and data storage Examples: Metadata (V-A), Negotiable value (V-B). **Scope: off-chain** More computation power and data storage, less cost, additional trust required Examples: Raw personal data (V-A), Sensitive information (V-B)
Application Design Decision 2
Public chain Information transparency, growth potential to larger scale, trustworthy, existing user base Examples: V-A **Private chain** Easier management, better privacy Examples: Consortium blockchain (V-B)
Application Design Decision 3
Single chain Easier chain management and permission management, harder data management and isolation Examples: V-A, V-B **Multiple chains** Information isolation, harder chain management and permission management
Application Design Decision 4
External Validation oracle Introduce a third party trusted by the whole network Examples: Arbitrator (V-A) **Internal Validation oracle** Periodically injecting external state into the blockchain might introduce latency issues. The source of external state also needs to be trusted.
Application Design Decision 5
Permissionless vs. Permissioned blockchain Trade-offs: Performance, cost, censorship, reversibility, finality, flexibility in governance Permissions: Read/Join network, submit transaction, mine, create assets Example: Permissioned (V-A, V-B)

Xu, Xiwei, et al. "The blockchain as a software connector." Software Architecture (WICSA), 2016 13th Working IEEE/IFIP Conference on. IEEE, 2016.

Edge computing Marketplace

- Raspberry Pis market to run docker containers
- All transactions related to renting/releasing are recorded in a blockchain
- Raspberry Pis operate autonomously

Thank you