Alliance for IoT
and Edge Computing
Innovation

Webinar • 8 September 2023

Presentation of the IoT-DLT-AI Technological Convergence

Alfredo Favenza, AIOTI Web3 TF Co-Chair, LINKS Foundation
Silvio Meneguzzo, PhD in Blockchain & DLT, University of Turin – LINKS Foundation

AIOTI

Opening and Welcome

Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead, Links Foundation

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Agenda

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15.00 Opening and Welcome (10 min)

Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead, Fondazione Links

15.10 Presentation of the convergence and use cases

Silvio Meneguzzo, PhD in Blockchain & DLT, University of Turin, Fondazione Links

16.10 Questions from the audience (15 min)

Moderated by Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead

16.25 Wrap up and end of Webinar (5 min)

Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead

Outline

- Introduction
- Webinar's Objectives
- Technology Stacks
  - IoT, DLT, AI
- Convergence Matrix
  - DLT-IoT
  - DLT-AI
- Convergence Prism
  - IoT-DLT-AI
- Use Cases
- Conclusions

Introduction

Background

- In **2020** and **2021** Links Foundation released two studies proposing a methodology for the analysis of **areas of convergence** lying at the **intersection of DLT and AI technologie**s.
  - "Exponential Technologies Convergence: Can AI help Shaping a New Breed of DLTs?" (Medium.com, 2020)
  - "12 Areas of Convergence in Which Blockchain Can Foster Better AI" (Medium.com, 2021)

- The proposed **methodology** included:
  - A proposals for **DLT and IoT technology stacks**
  - The concept of «**Convergence Matrix**» as a tool to unveil possible areas of application where the different layers of the two proposed stacks could interact to solve **DLT and IoT mutual challenges.**

Background

- In **2022 AIOTI** released the «**Report on DLT-IoT Convergence"**, led by LINKS Foundation with the collaboration of members from the AIOTI DLT Interest Group including Nearcom, Vicomtech, Nydor System Technologies, Verses, BovLabs, VizLore Labs, Blue Future Organisation, BEIA)

- The report exploited the **same methodology** of the previous work on DLT-AI, but this time focusing on the possible **convergence between DLT and IoT technologies**.

Background

- **2023.** The AIOTI established a roadmap for the evolution of the Technology Convergence Topic to extend the analysis to the opportunity lying at the intersection of three technology stack, IoT, DLT and AI.

- This work is still **in progress**, but the first results have highlighted the **high potential** for the emergence of **new services and applications** that will be able to exploit the joint full potential of these disruptive technologies.

Webinar's Objectives

- Grasp the main characteristics and nuances of **IoT, DLT and AI technologies.**
- Explore opportunities lying at the **intersection of IoT, DLT and AI** by connecting the different layers of the three technological stack.
- Discover promising **areas and topics of convergence** where DLT IoT and AI can help solving respective challenges.
- Stimulate the emerging of **innovative solutions for real world challenges leveraging on IoT, AI and DLT** technologies.

Technology Stacks

Silvio Meneguzzo, PhD in Blockchain & DLT, University of Turin – Fondazione LINKS

IoT technology stack

- **Sensors and Actuators.** Devices exposing either an analog or a digital interface. Most sensors are coupled with an embedded hub device in which case an internal bus technology is used to link both systems, such as I2C, RS232, RS485, SPI, SDI 12, 20mA etc.
- **Hub Device.** Enables the collection of data from sensors through a multitude of standards and configurations. It creates a bridge between the IoT Gateway and the sensors and actuators. The Hub device presents two Communication Interfaces (both bidirectional): one towards sensors and a second wireless one towards the IoT Gateway. The goal of this devices is to group several sensors/actuators in a first level of processing power.

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Ref: «Report on DLT-IoT Convergence», AITOI, 2022

IoT technology stack

- **Gateway.** Provides the means to bridge the gap between devices in the field (factory floor, home, etc.), the (enterprise) Cloud where data is collected, stored and manipulated by enterprise applications, and the user equipment (smart phones, tablets etc.). The IoT Gateway, provides a communication link between the field and the network and can also offer local processing and storage capabilities to provide offline services and if required.
- **Computation servers.** These types of system are designed to deal with Big Data and provide complex computations on them, like Machine Learning algorithms. The amount of processing power expected at this level corresponds to CPD clustering systems or more frequently Cloud platforms. Communications between the gateway and the computation server is usually done through TCP/IP protocols.

Ref: «Report on DLT-IoT Convergence», AITOI, 2022

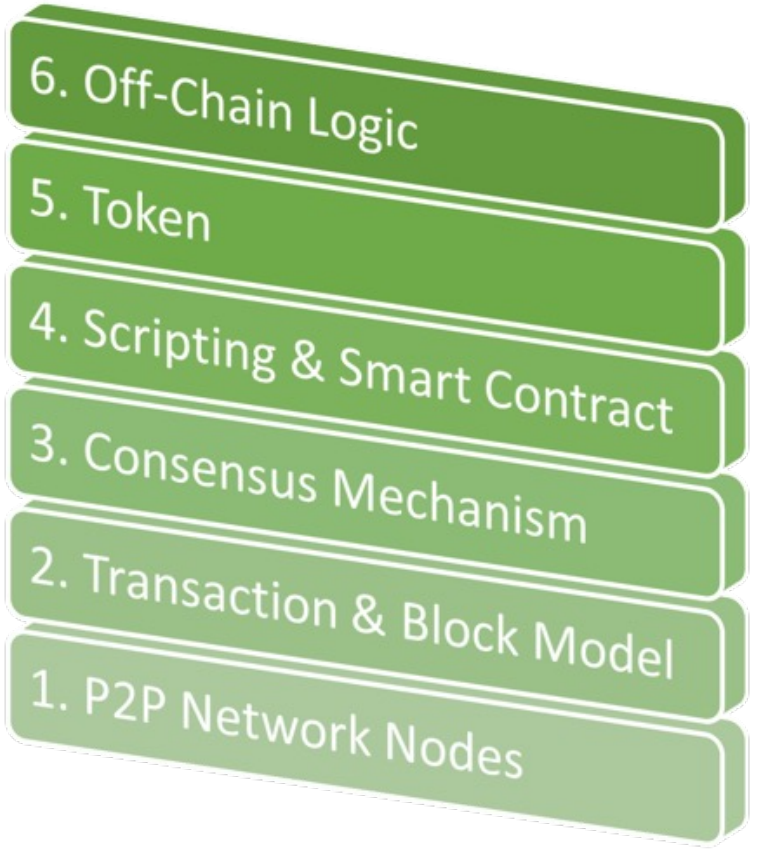
IoT technology stack

- **Services.** This level covers the interaction between servers and users, representing man-machine interface technologies. Services provide a virtual/direct link between people and data, using infrastructure as a transparent tunnel. The exploitation of information can be based on web technologies, or visualization on mobile devices. Quality of service is a key concept here in the sense of access to processed data, but also taking into account their temporal validity.

Ref: «Report on DLT-IoT Convergence», AITOI, 2022

DLT technology stack

- **P2P Network of Nodes**. A network of physical or virtual machines (peers) maintaining a local copy of the ledger communicating over the internet (TCP/IP protocol). Peers are equally privileged, equipotent participants in the application. They share resources without a centralized administrative system or control in an untrusted environment.
- **Transaction & Block Models**. The representation of the distributed ledger data replicated across nodes on the P2P network, usually a cryptographically secure linked list of blocks where each block contains an ordered list of transactions.



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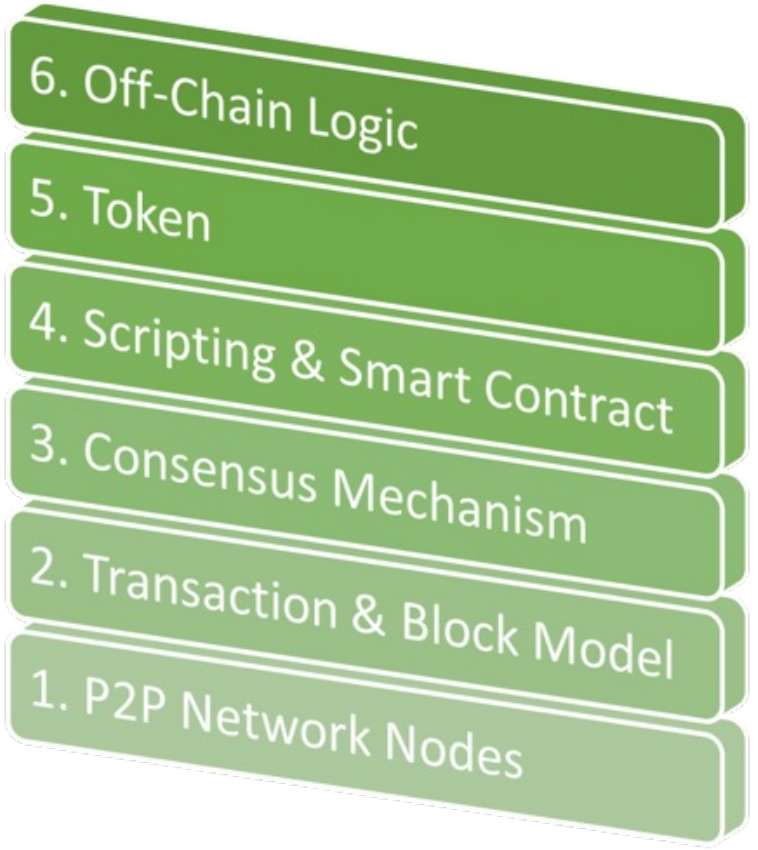
DLT technology stack

- **Consensus Mechanism.** A network protocol that defines rights, responsibilities, and means of communication, verification, validation, and consensus across the nodes in the network. This layer includes ensuring authorization and authentication of new transactions and incentive mechanisms (if needed).

- **Scripting & Smart Contract (On-chain Logic).** Scripts (code) deployed as data in the ledger and executed throughout sending transactions to the network. Smart contracts can hold and transfer digital assets managed by the DLT and can invoke other smart contracts. Smart contract code is deterministic and immutable once deployed.



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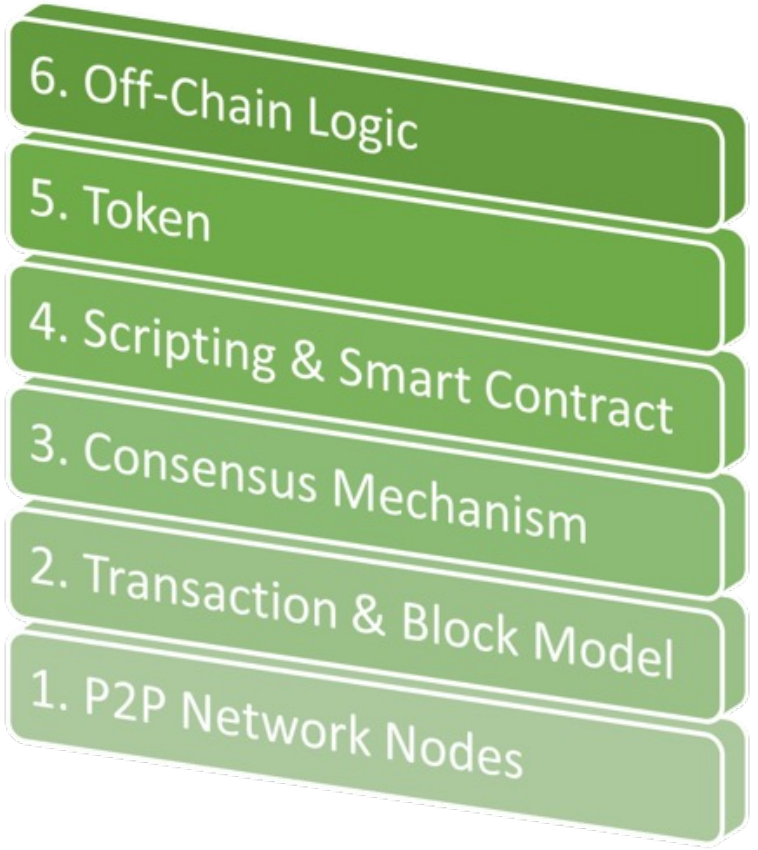
DLT technology stack

- **Token.** Tokens allow to digitalize (tokenize) fungible (i.e., money) and non-fungible (i.e., work of arts) assets. Tokens can represent shares in a company, the right to benefit from future earnings, grant voice power for voting systems, etc. Tokens can be created and exchanged, usually using smart contracts.

- **Off-chain Logic.** Includes all parts of the data, and computation kept off-chain. As for the data, usual practices are to store large or private sets of data off-chain (e.g., replicated databases, sidechain, cloud) and to keep hashes, metadata, and small-sized public data on-chain. For logic, due to the "closed-world" logic of smart contracts (i.e., SC can usually only examine state stored on the ledger), oracles are invoked to interact with the external world and to bring the external knowledge into the ledger.



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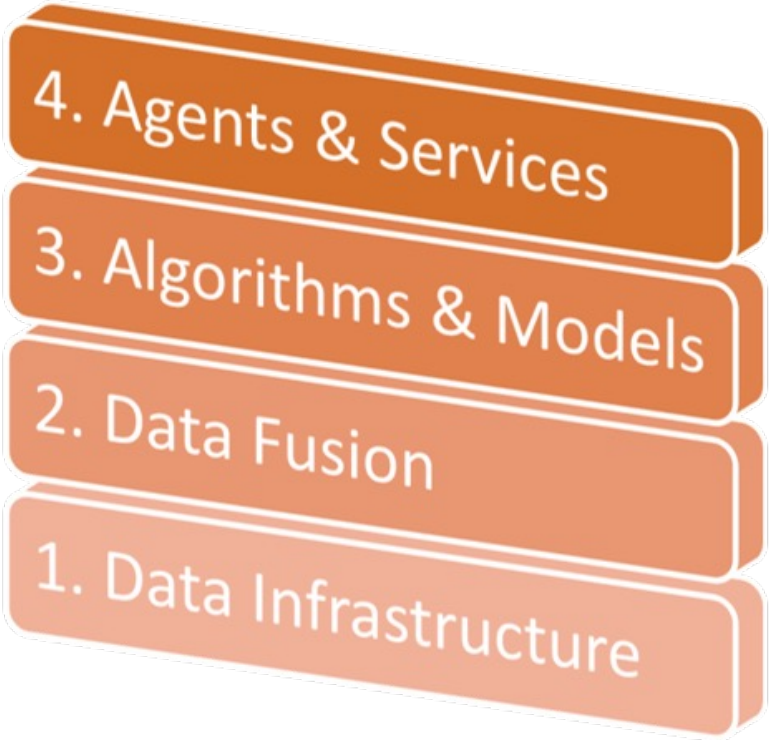
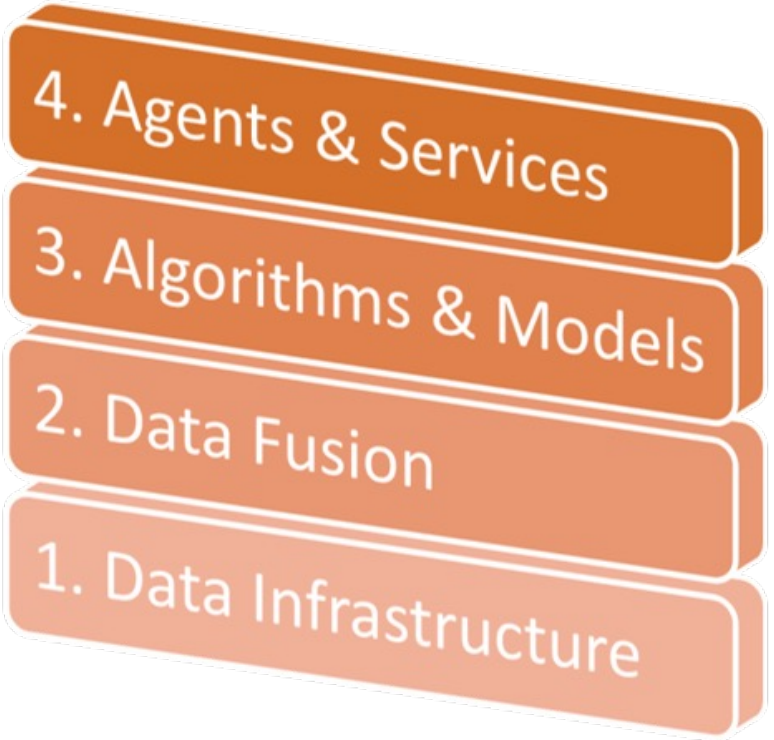
AI technology stack

- **Data Infrastructure.** Hardware resources, physical or virtualized, which are made available for the storage of data (e.g., Hadoop, big data storage, etc.) and subsequent processing (VMs Containers, CPUs, GPUs, etc.).
- **Data Fusion**. Software tools to interface with the storage and processing resources (e.g., SQL, NoSql, Spark, etc.). They provide the functionalities to implement raw data cleaning and labeling to provide quality datasets to the upper layer of learning models.



AI technology stack

- **Algorithms and Models.** Tools and libraries of algorithms to train the learning models on the provided datasets. Examples: features selection, Models, Training (e.g., supervised, unsupervised, reinforcement, etc.), TensorFlow, Caffe, Torch, Scikit-learn, CNTK.
- **Agents and services**. Applications that leverage the results of the models' analysis to perform data analysis operations (e.g., NLP, Image processing, prediction, classification, clustering).

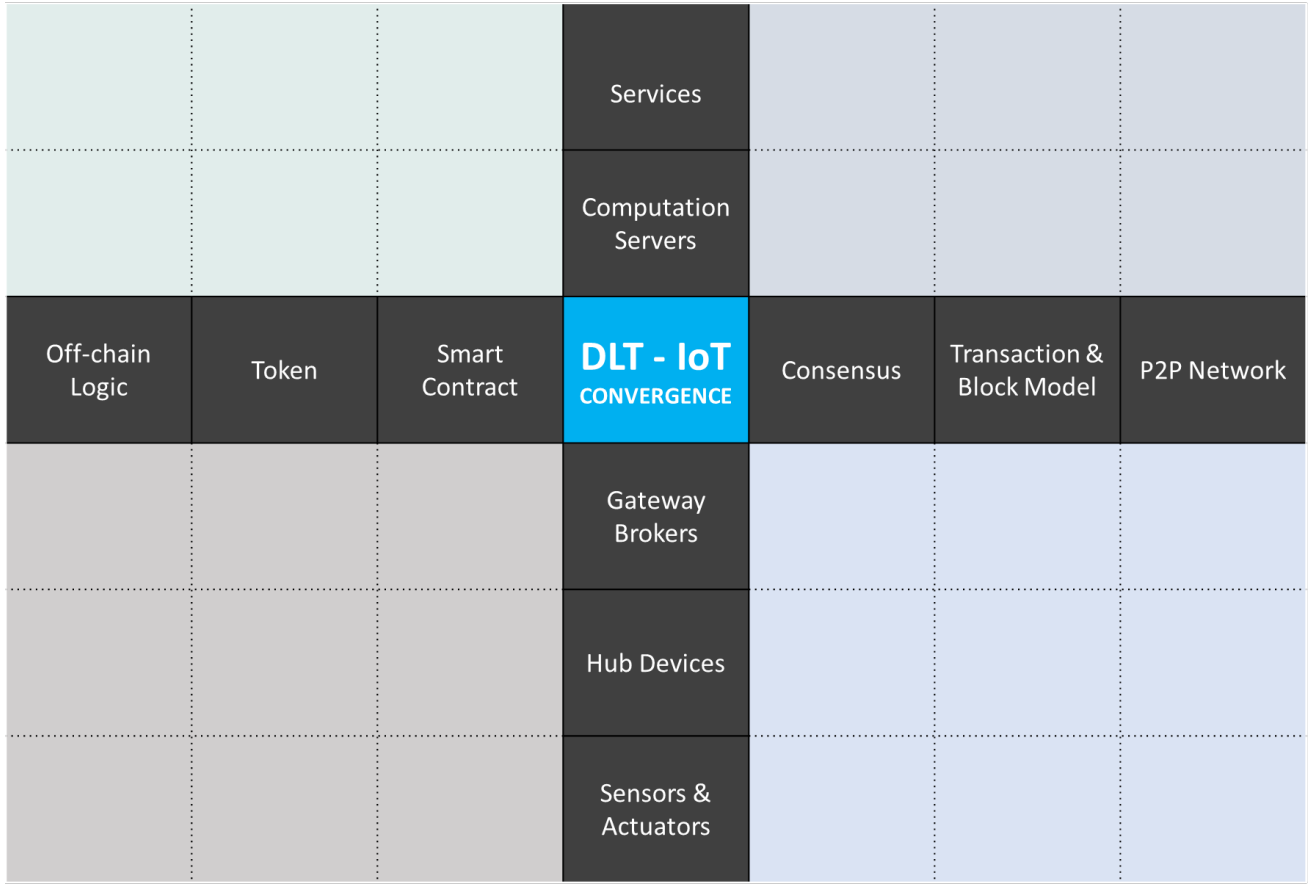


Convergence Matrix

Silvio Meneguzzo, PhD in Blockchain & DLT, University of Turin – Fondazione LINKS

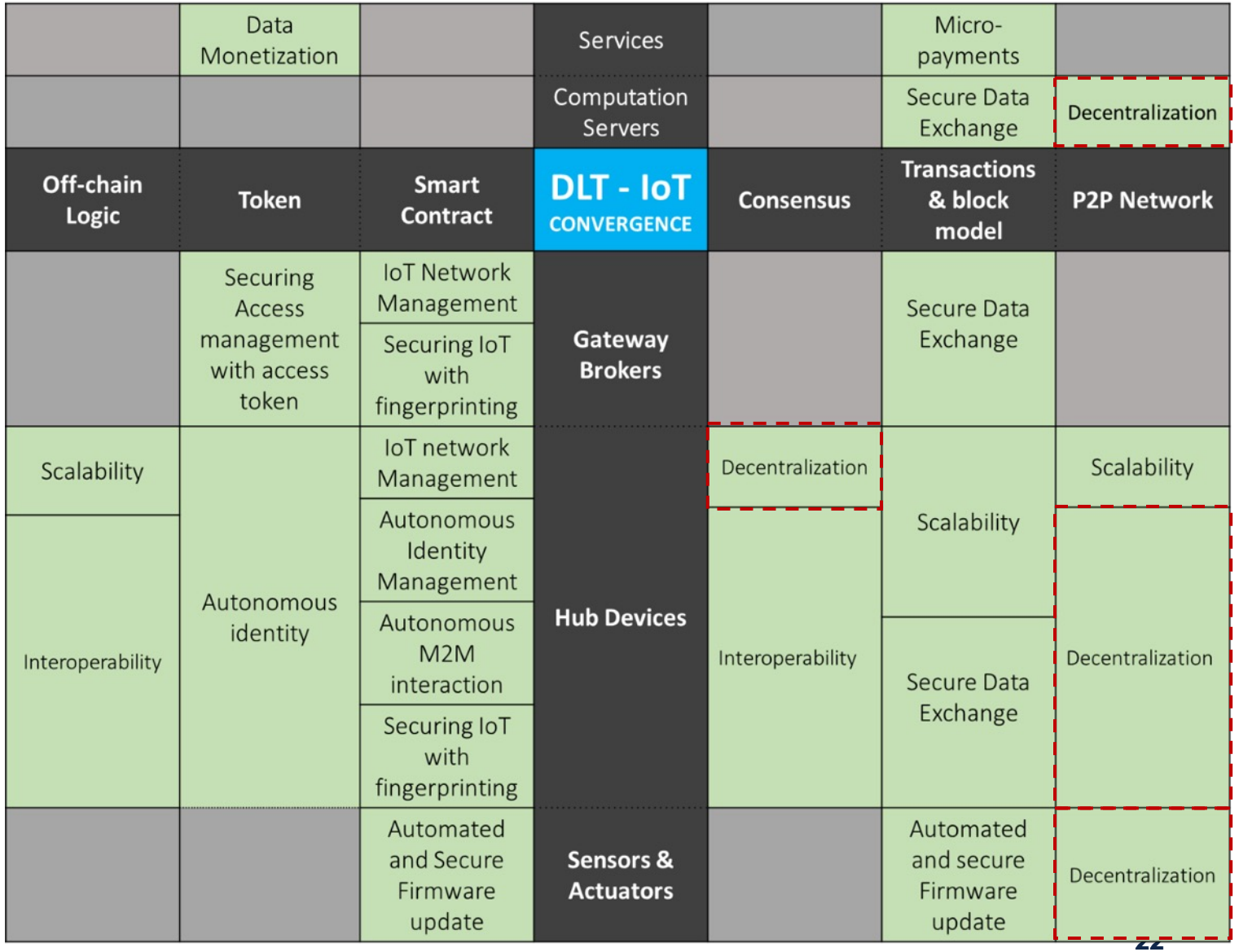
DLT-IoT Convergence Matrix

- **Report on DLT-IoT Convergence** (AIOTI, 2022)
- Highlights the possible **areas and topics of convergence** lying at the **intersection of the building blocks** of the DLT and the IoT stacks.



DLT-IoT Convergence Areas

- Decentralization
- Interoperability
- Scalability
- Secure Data Exchange
- IoT network security and Identity management
- Autonomous M2M interaction
- Data monetization
- Micro-payments
- Voting & Negotiation



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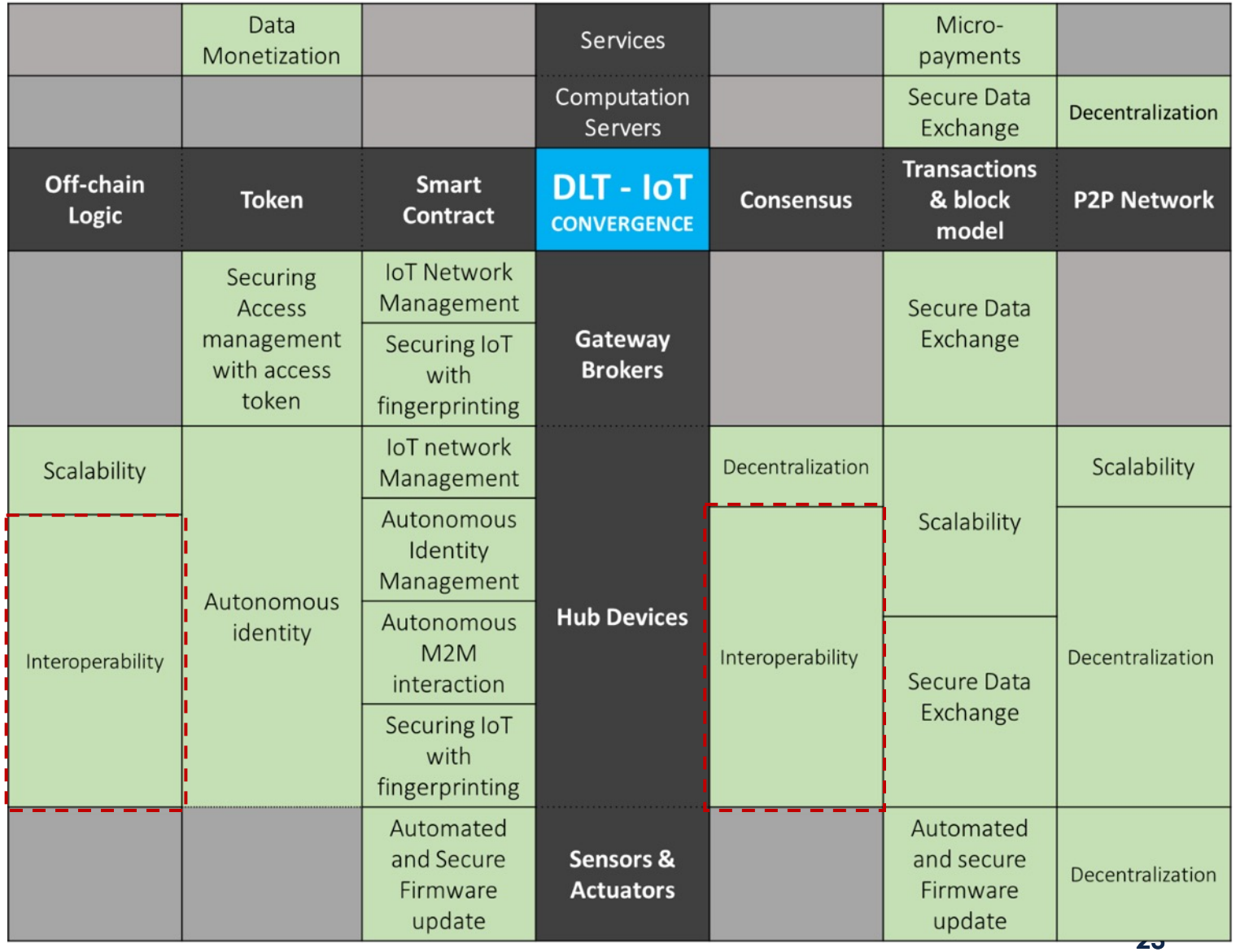

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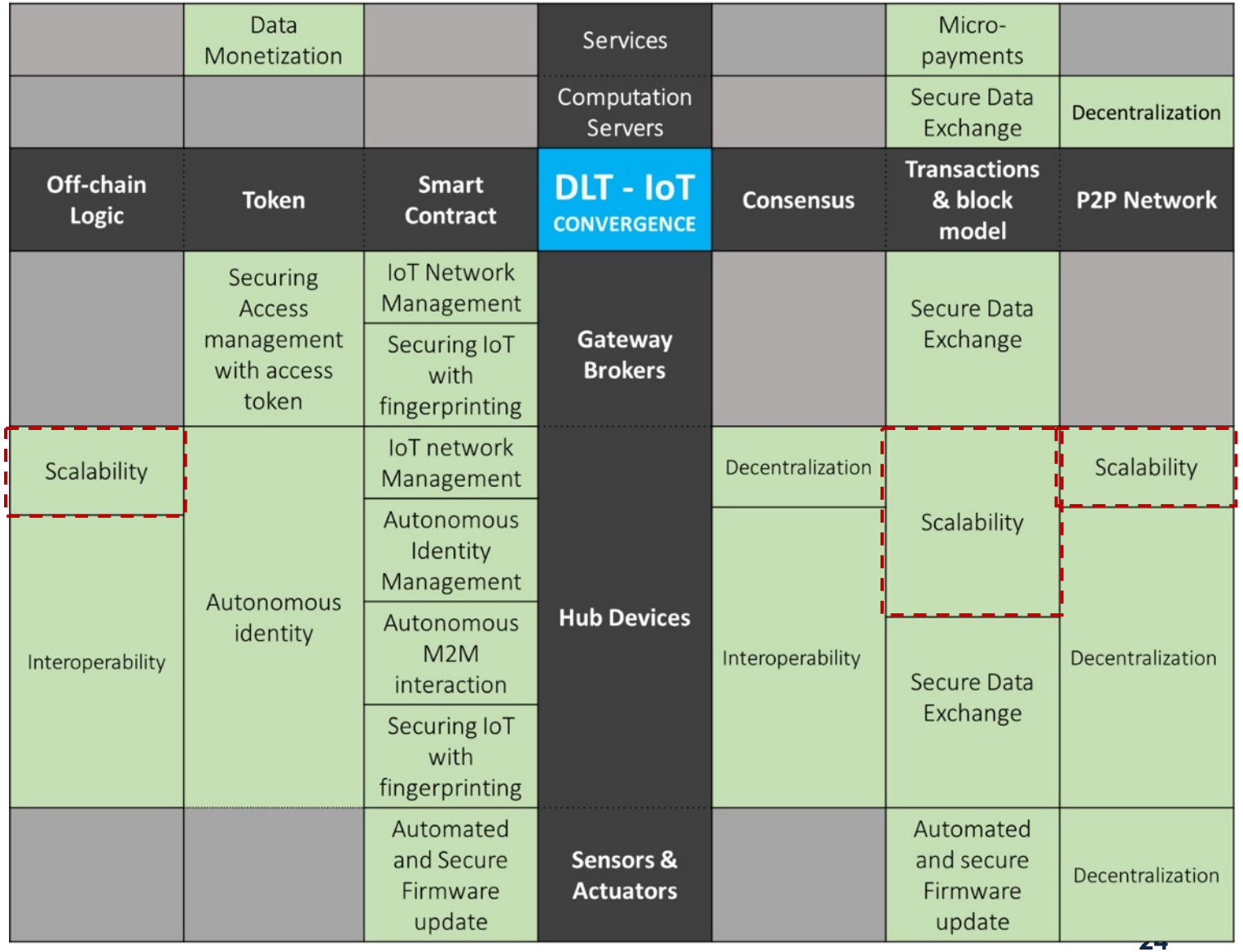

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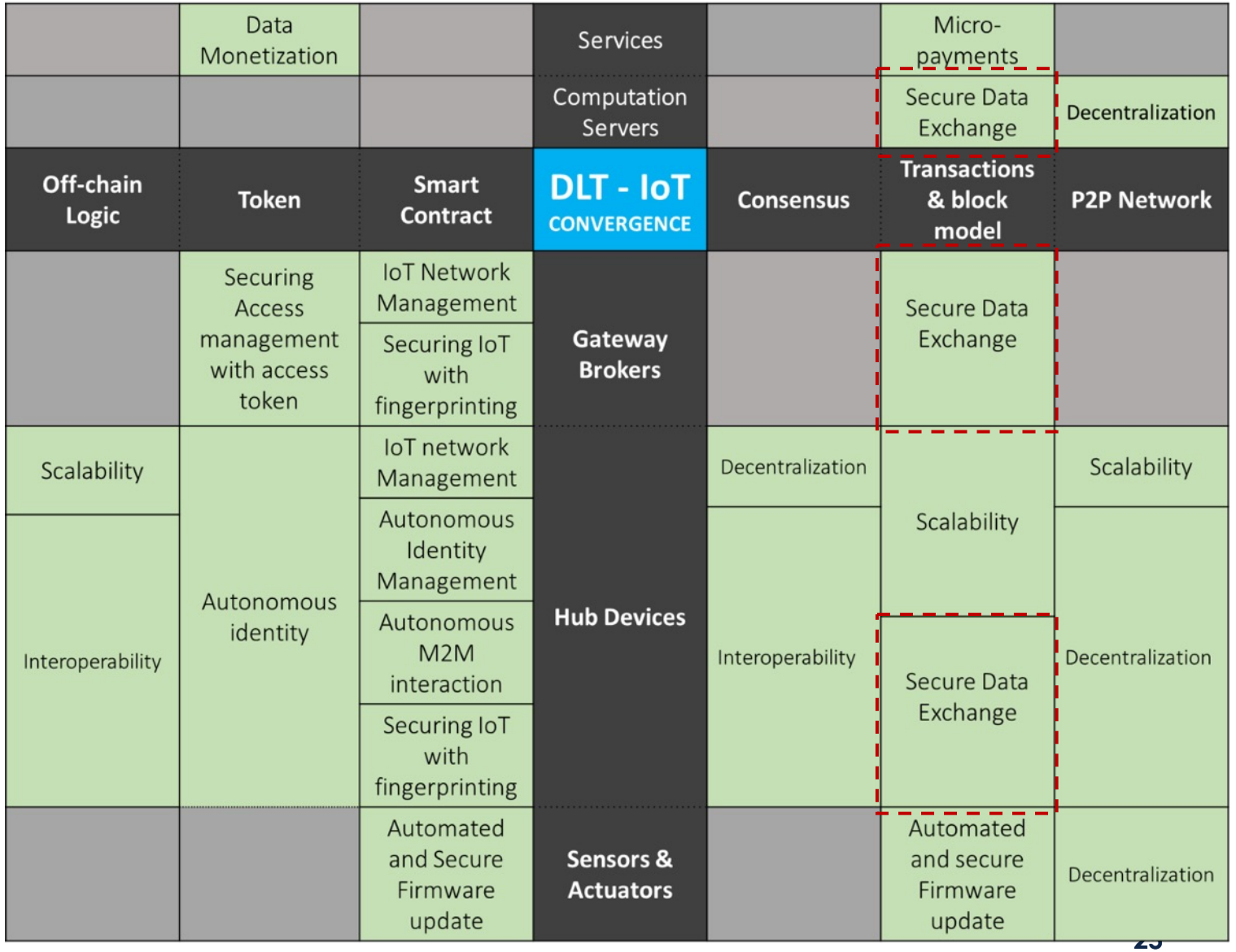

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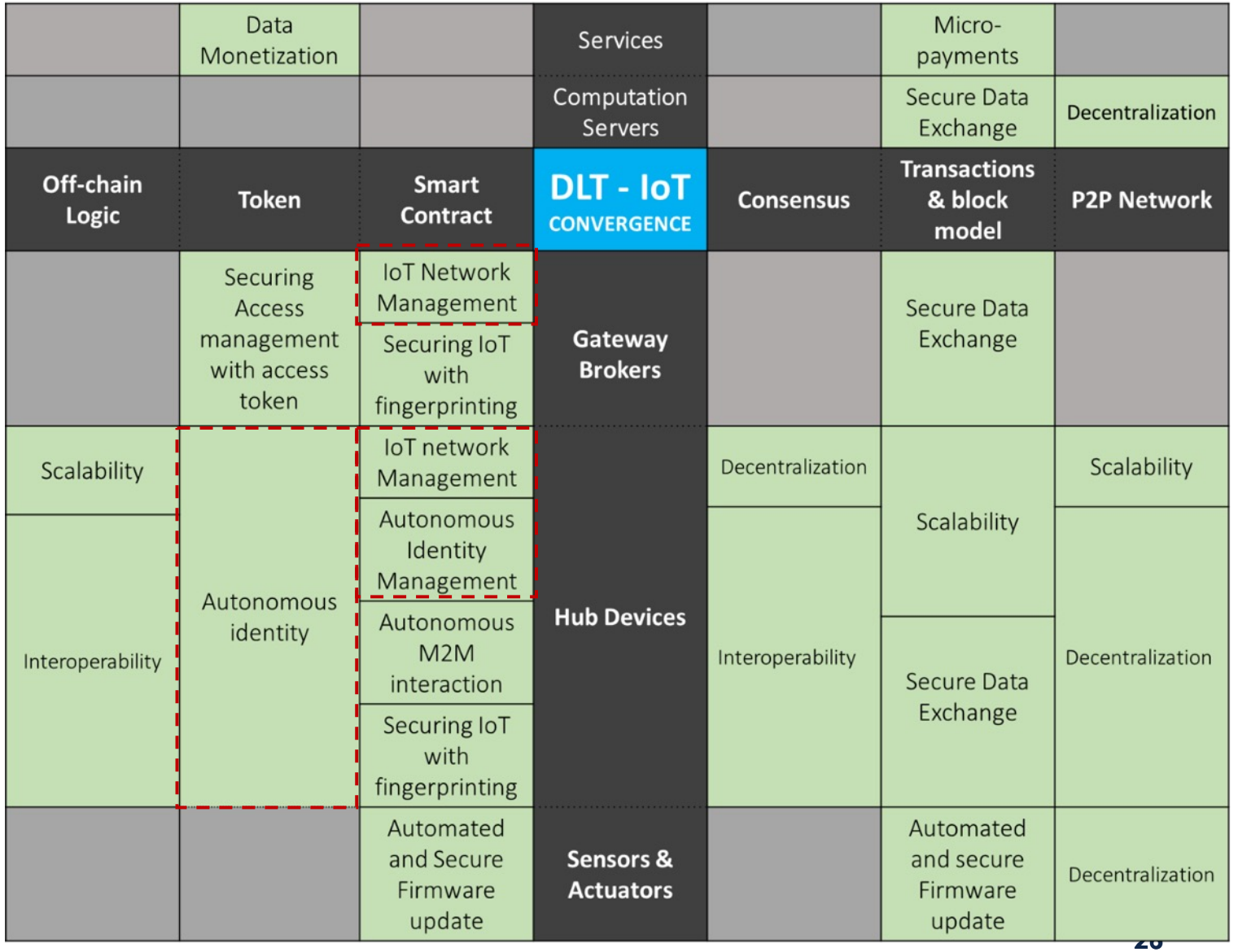

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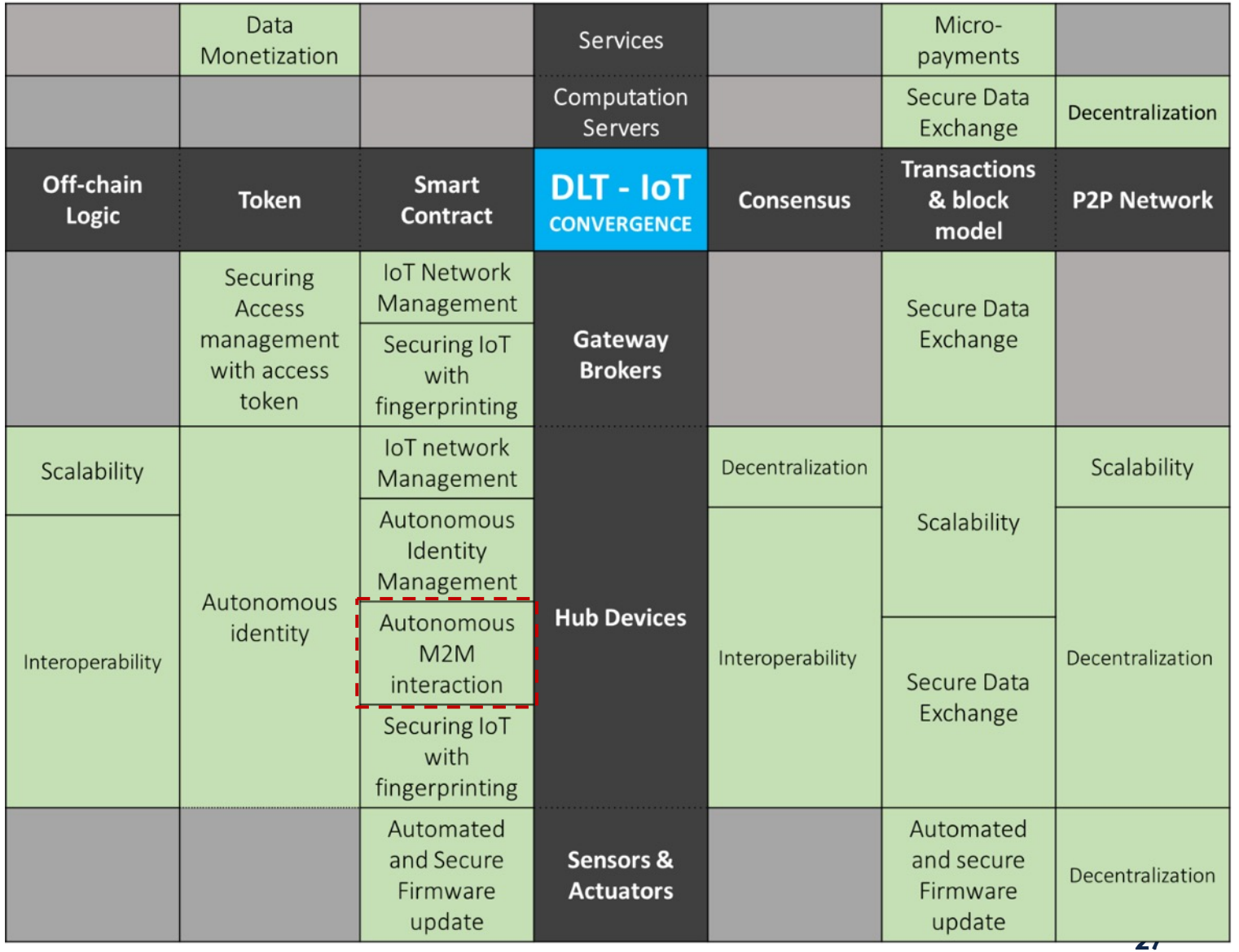

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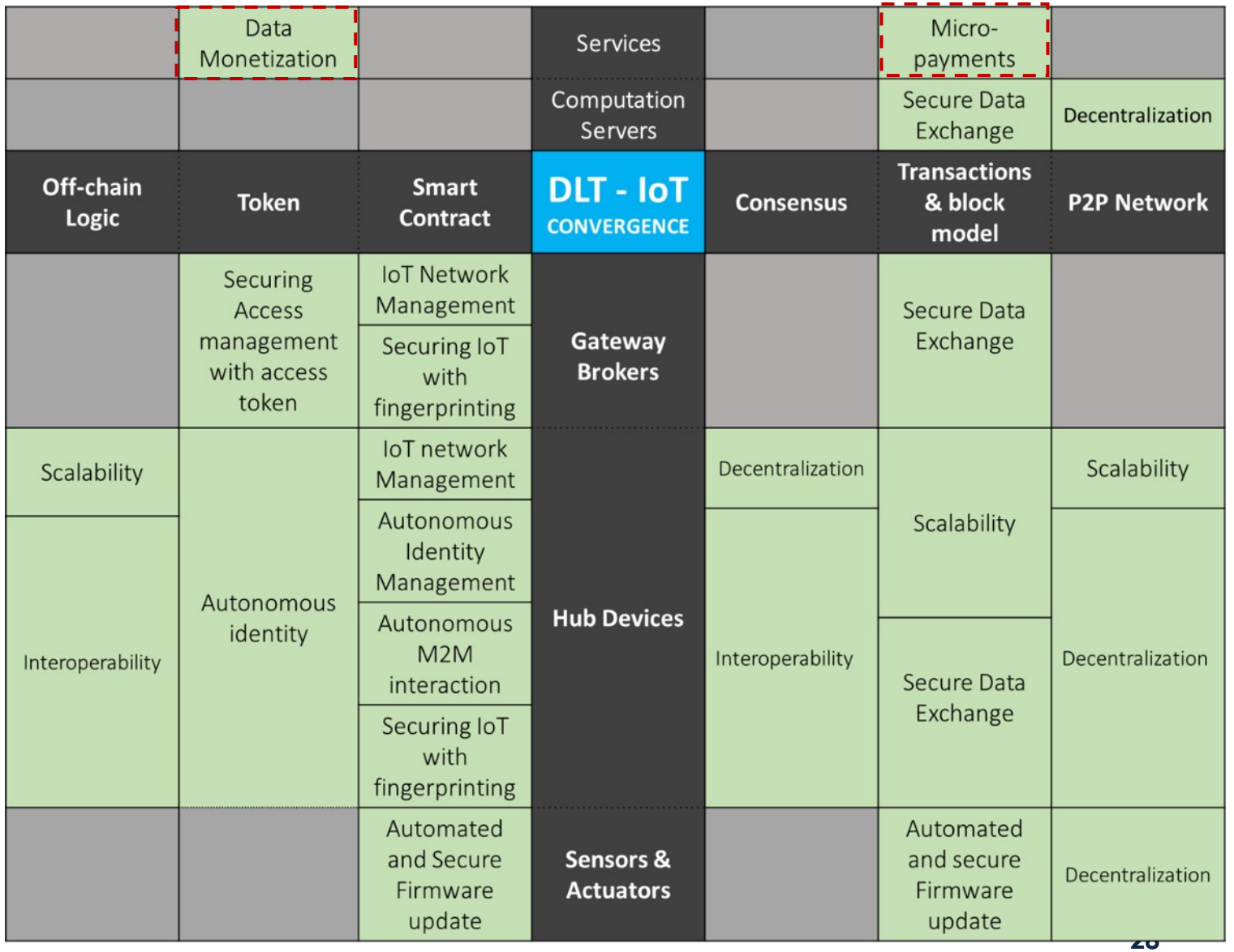

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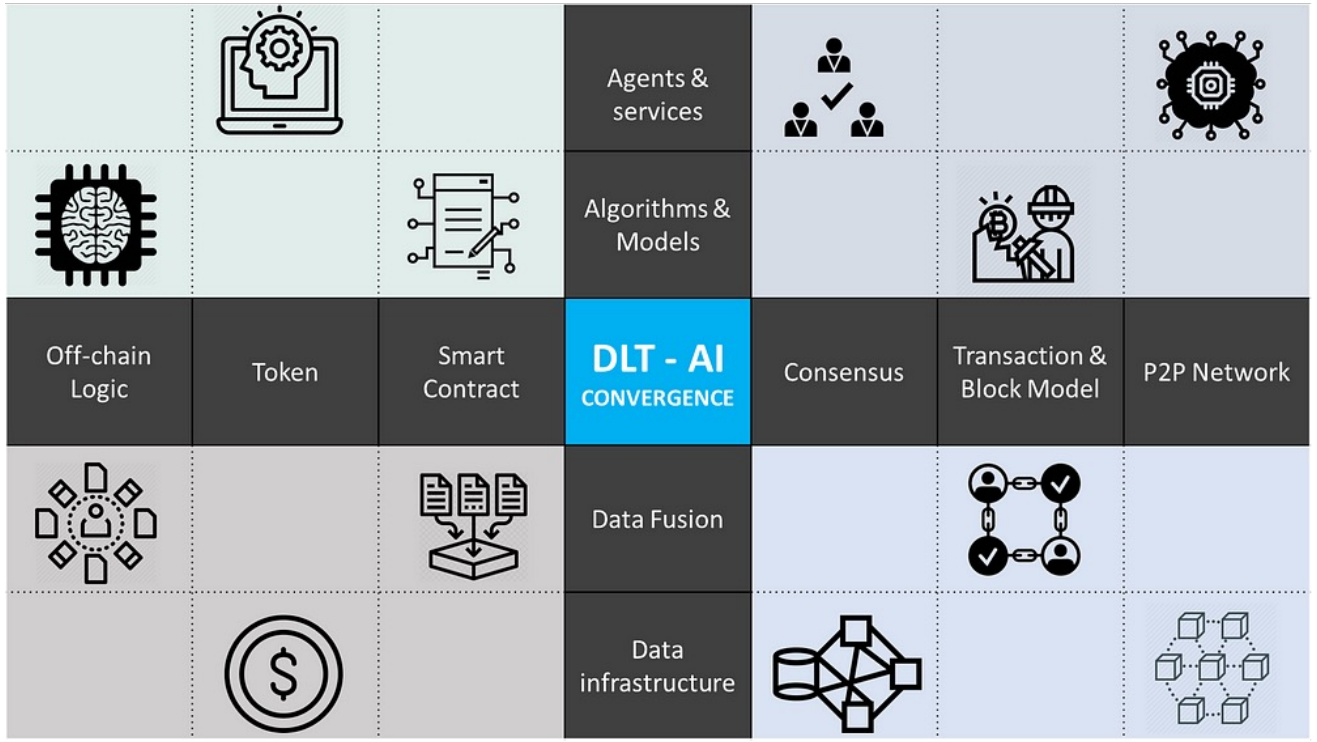
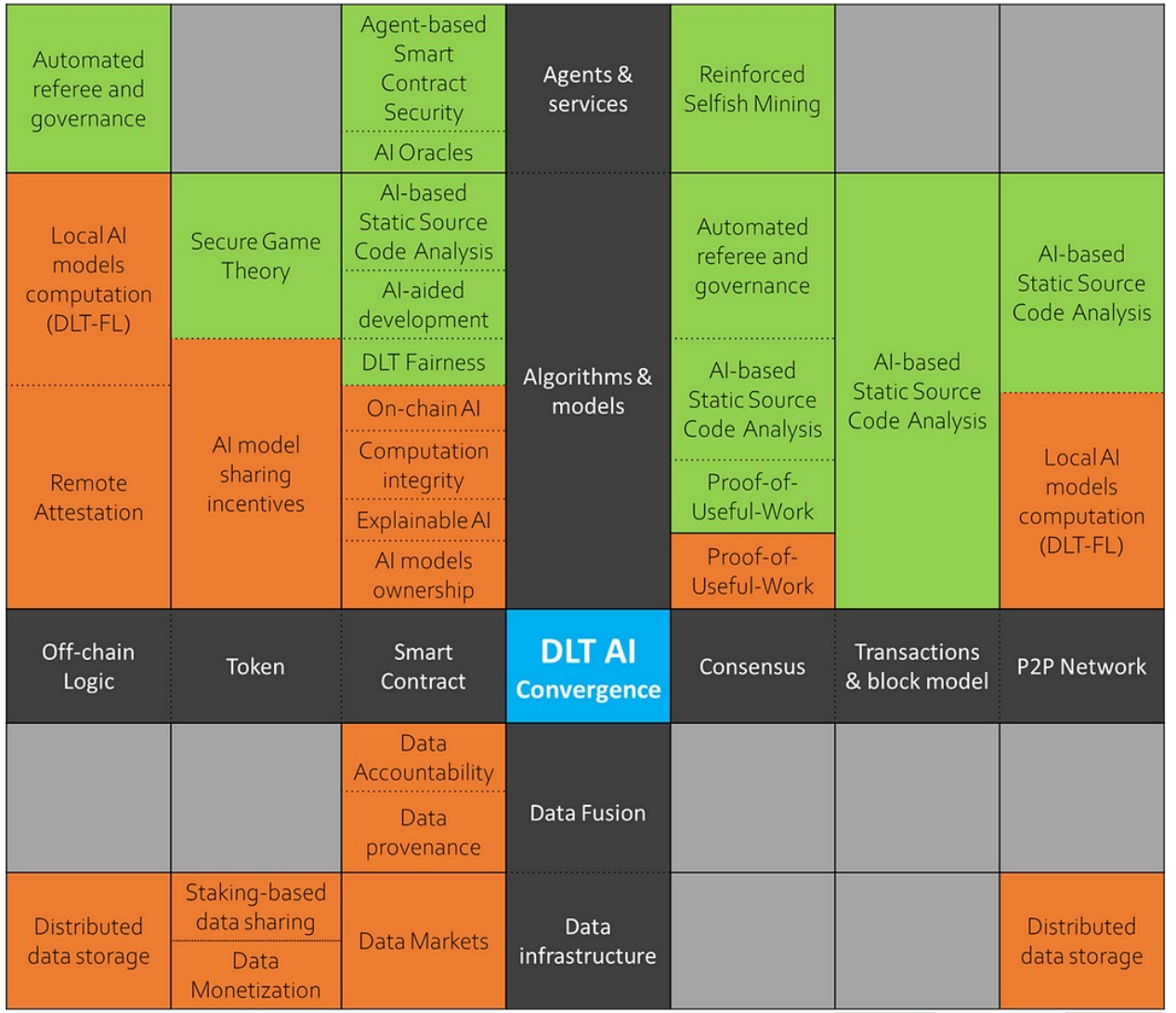


DLT-AI Convergence Areas

DLT -> AI

- AI models sharing incentives
- On-chain AI
- Data accountability & data provenance
- Remote attestation on Trusted Execution Environments
- Computational integrity
- DLT-based federated learning for AI models computation
- Data markets and data monetization
- AI Pipeline explainability, traceability and audibility
- Staking-based data sharing
- Distributed data storage
- AI models ownership
- Proof-of-Useful-Work



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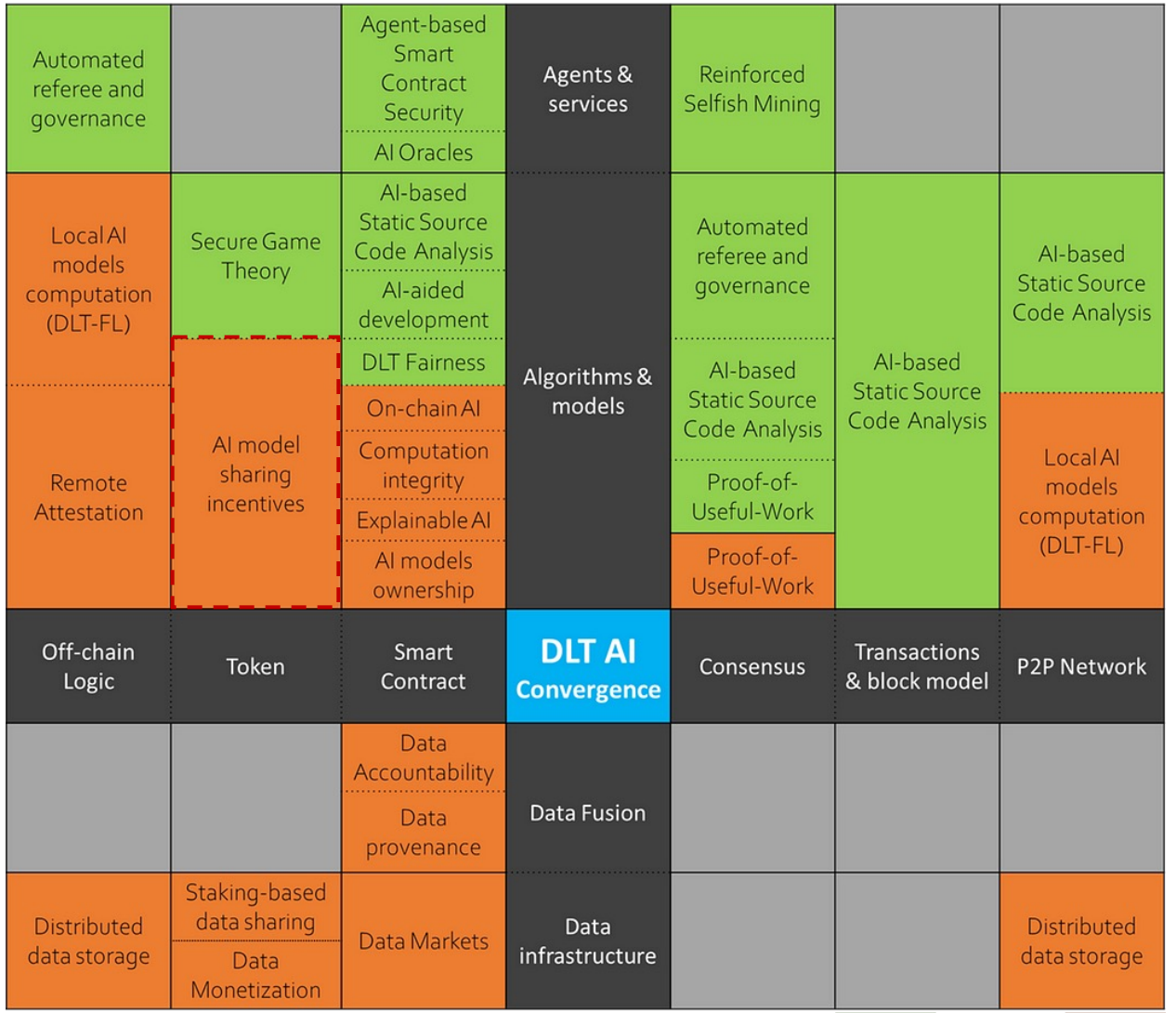

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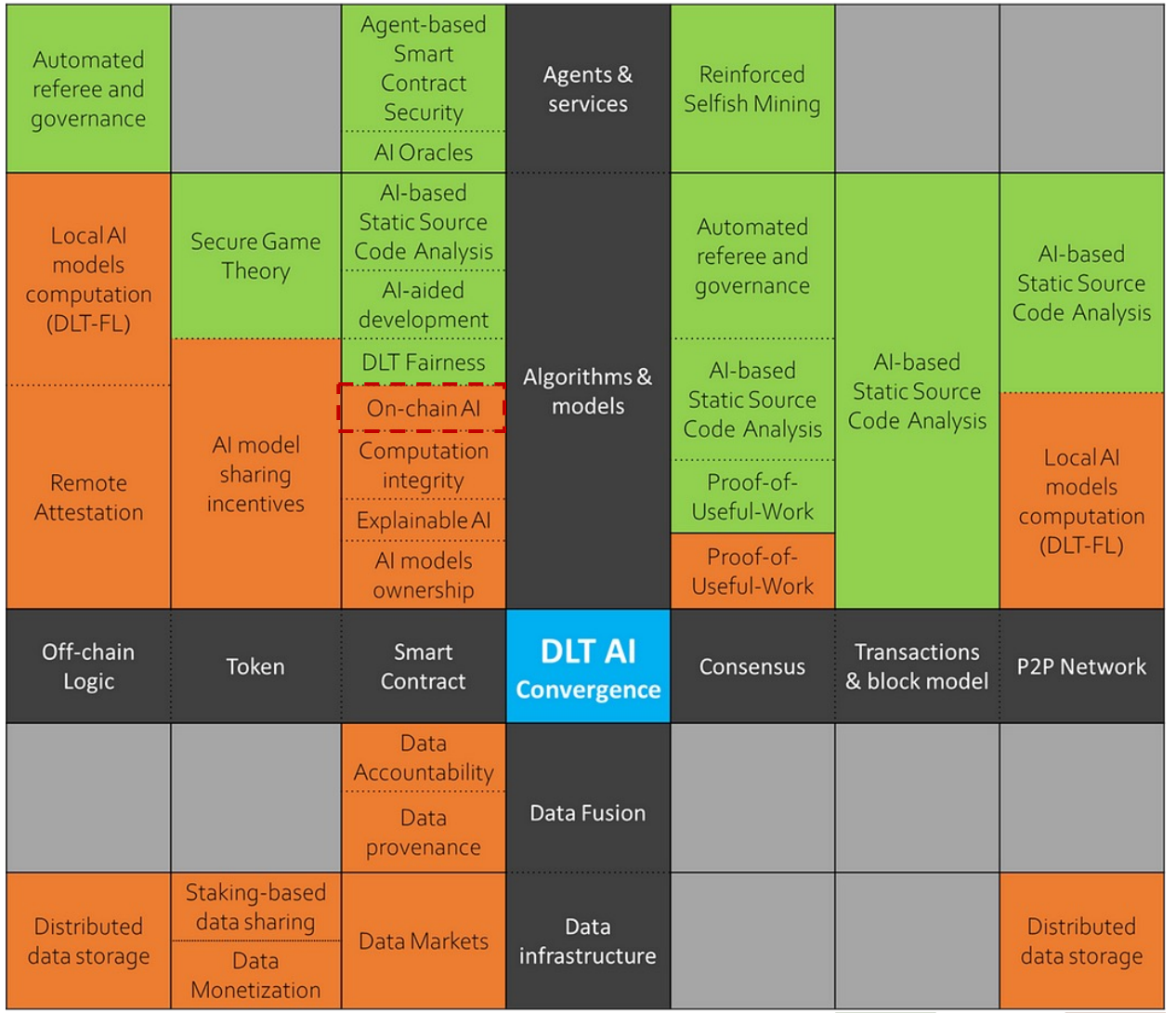

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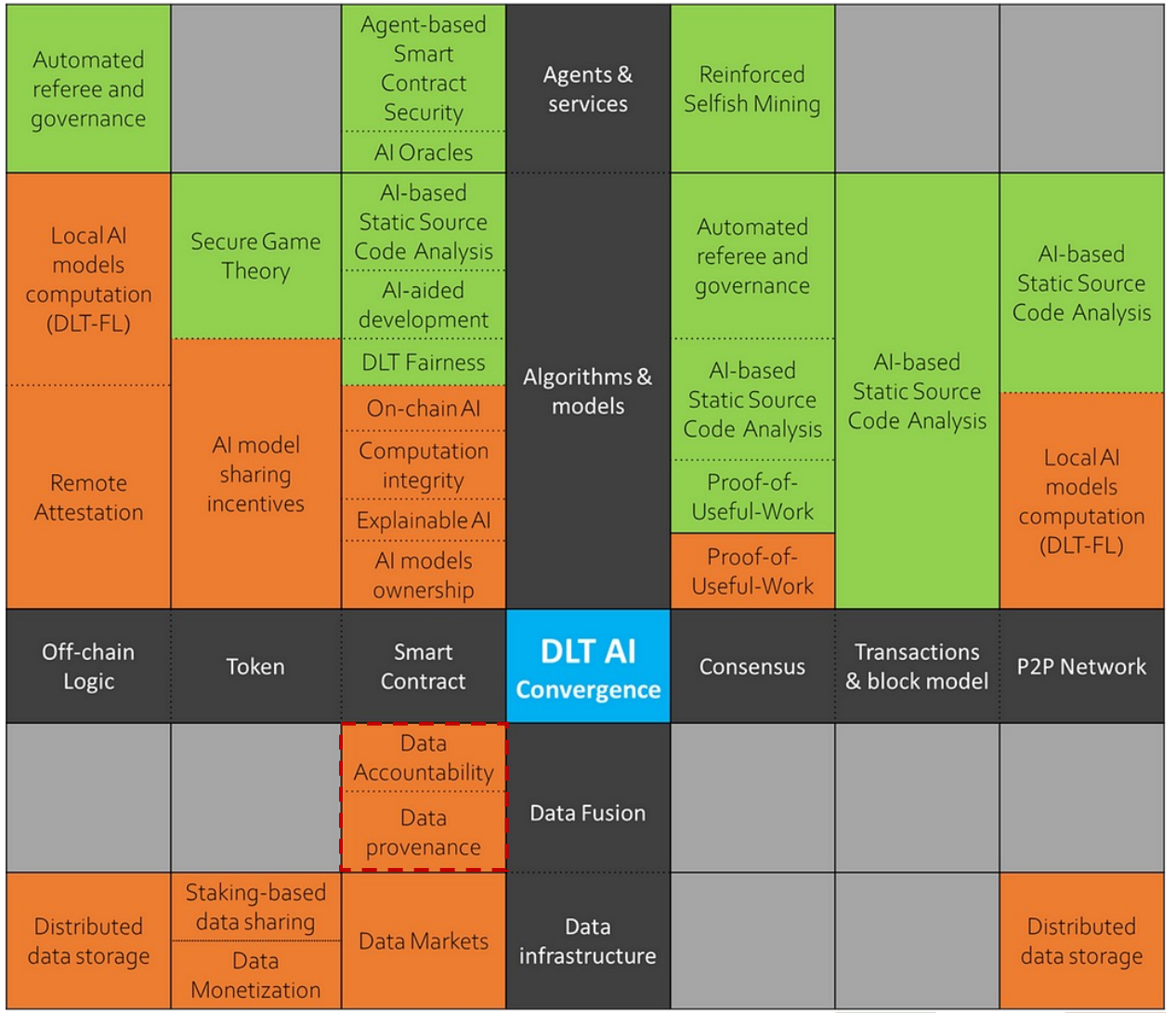

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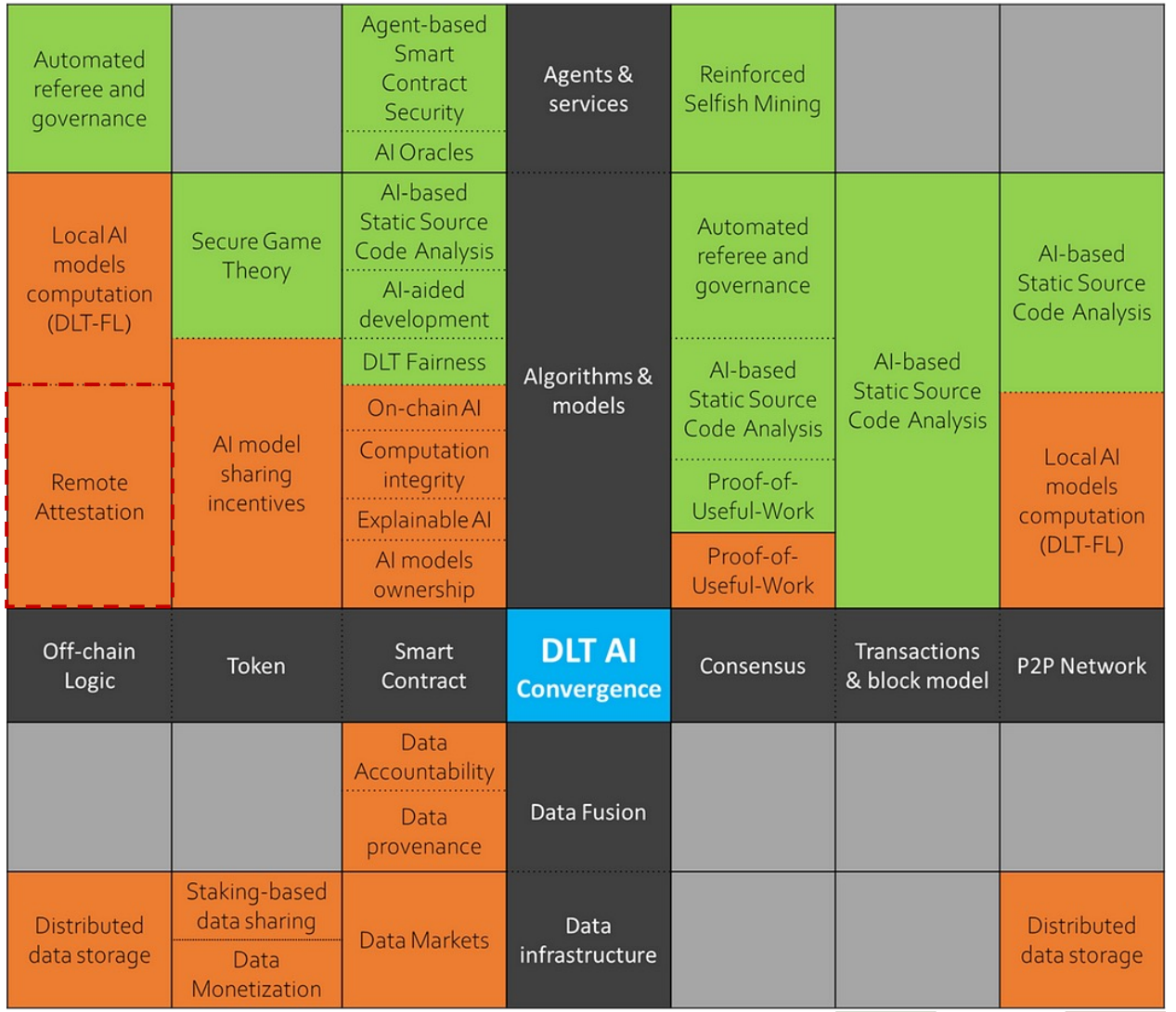

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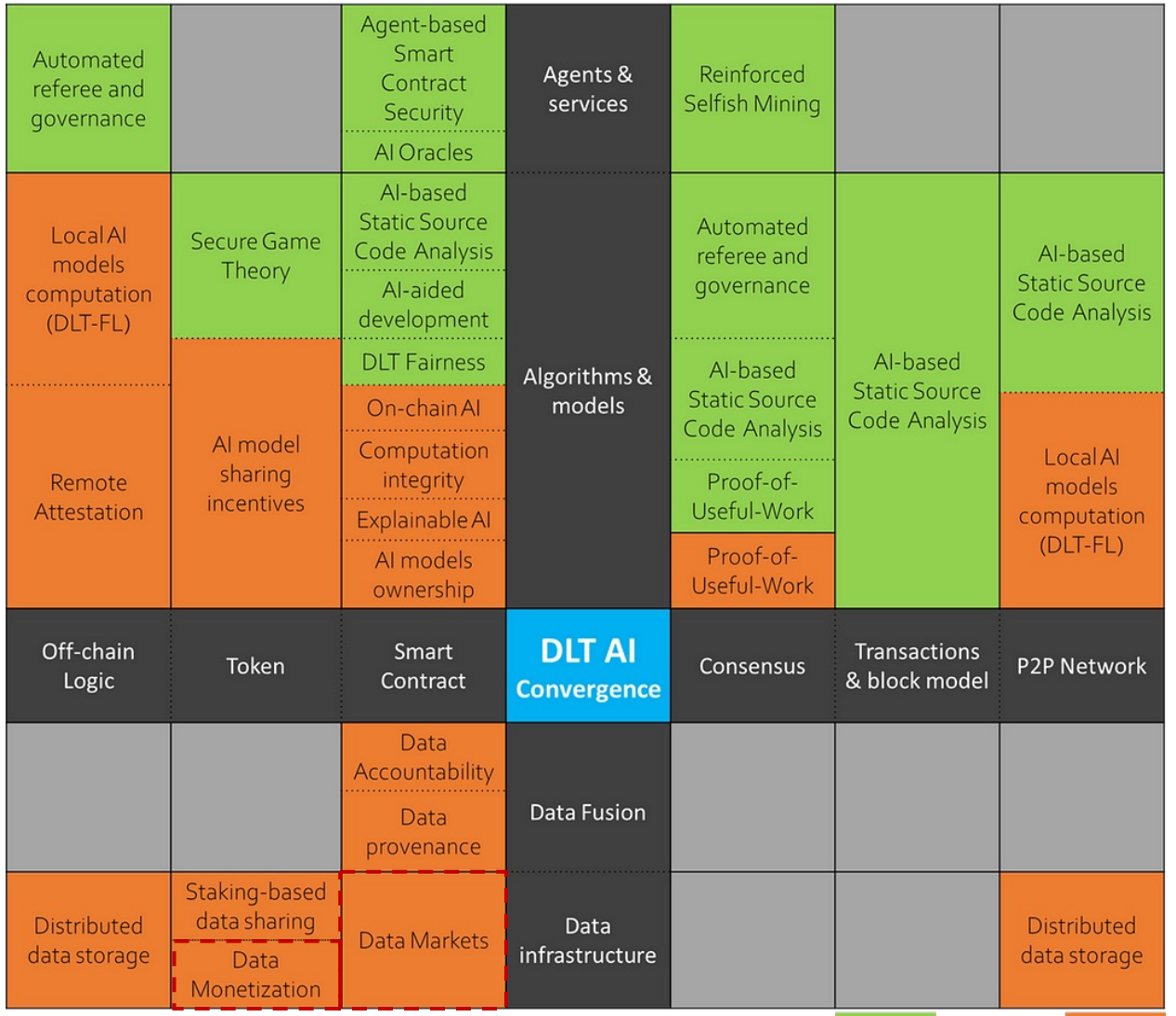

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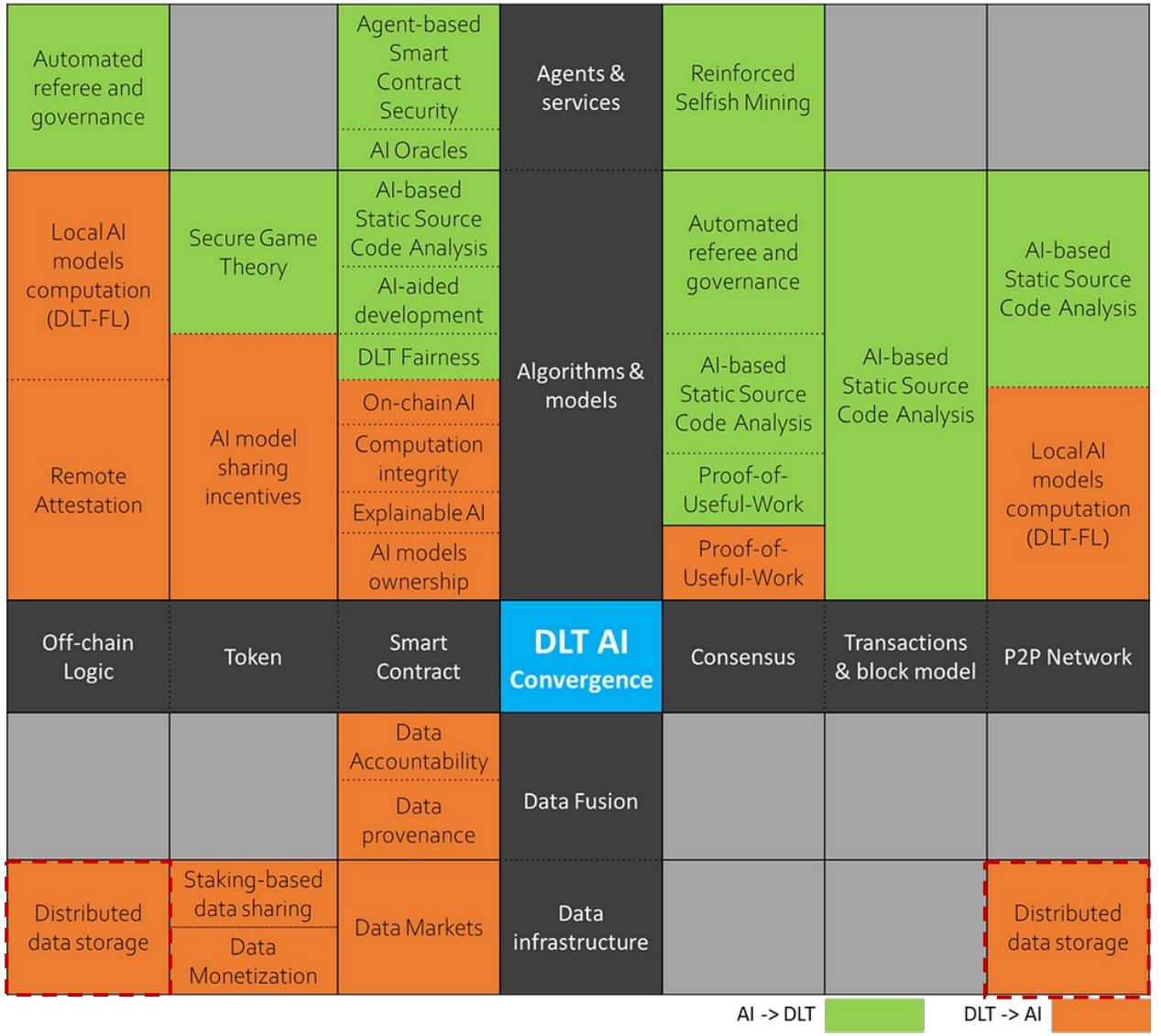

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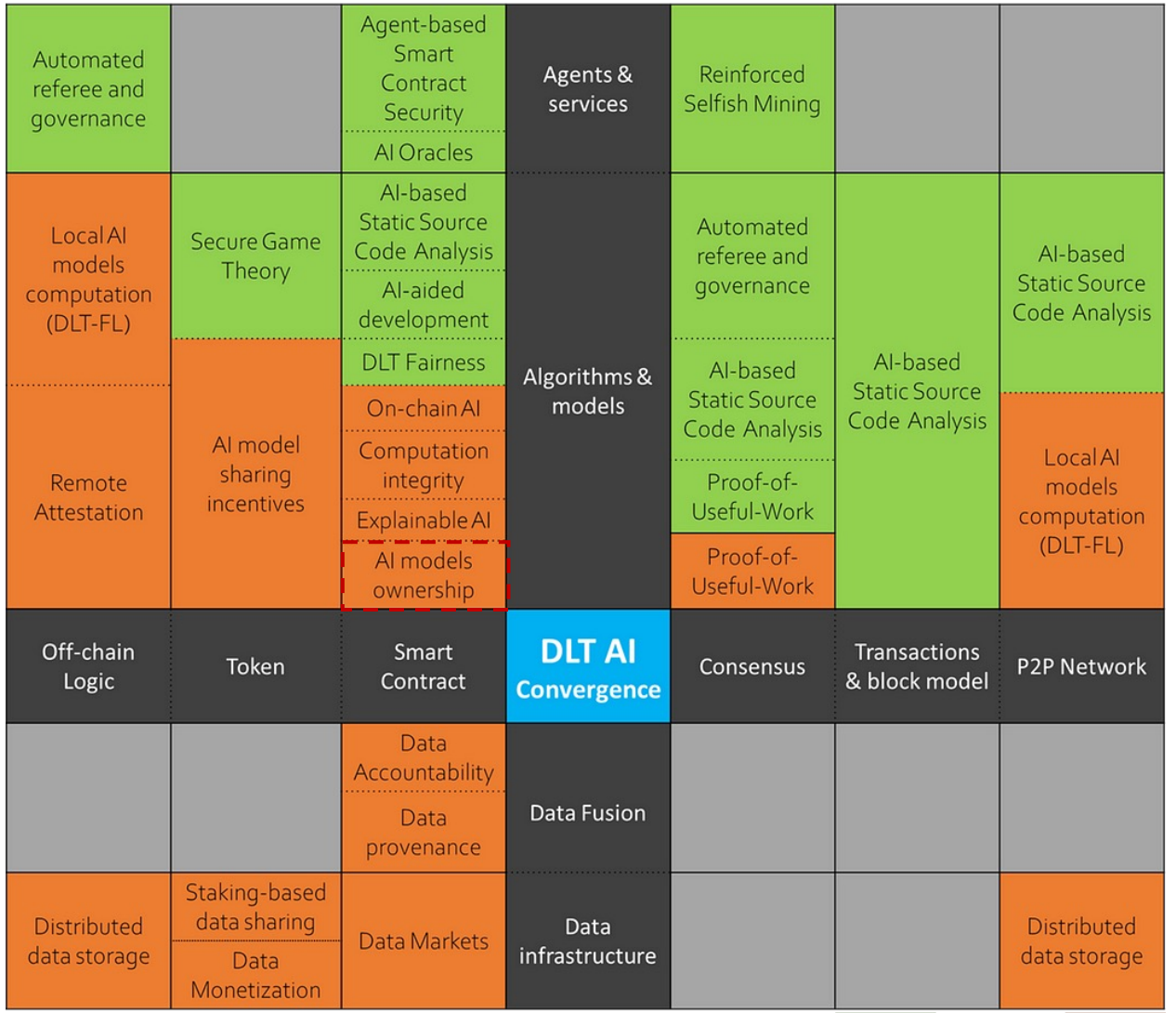
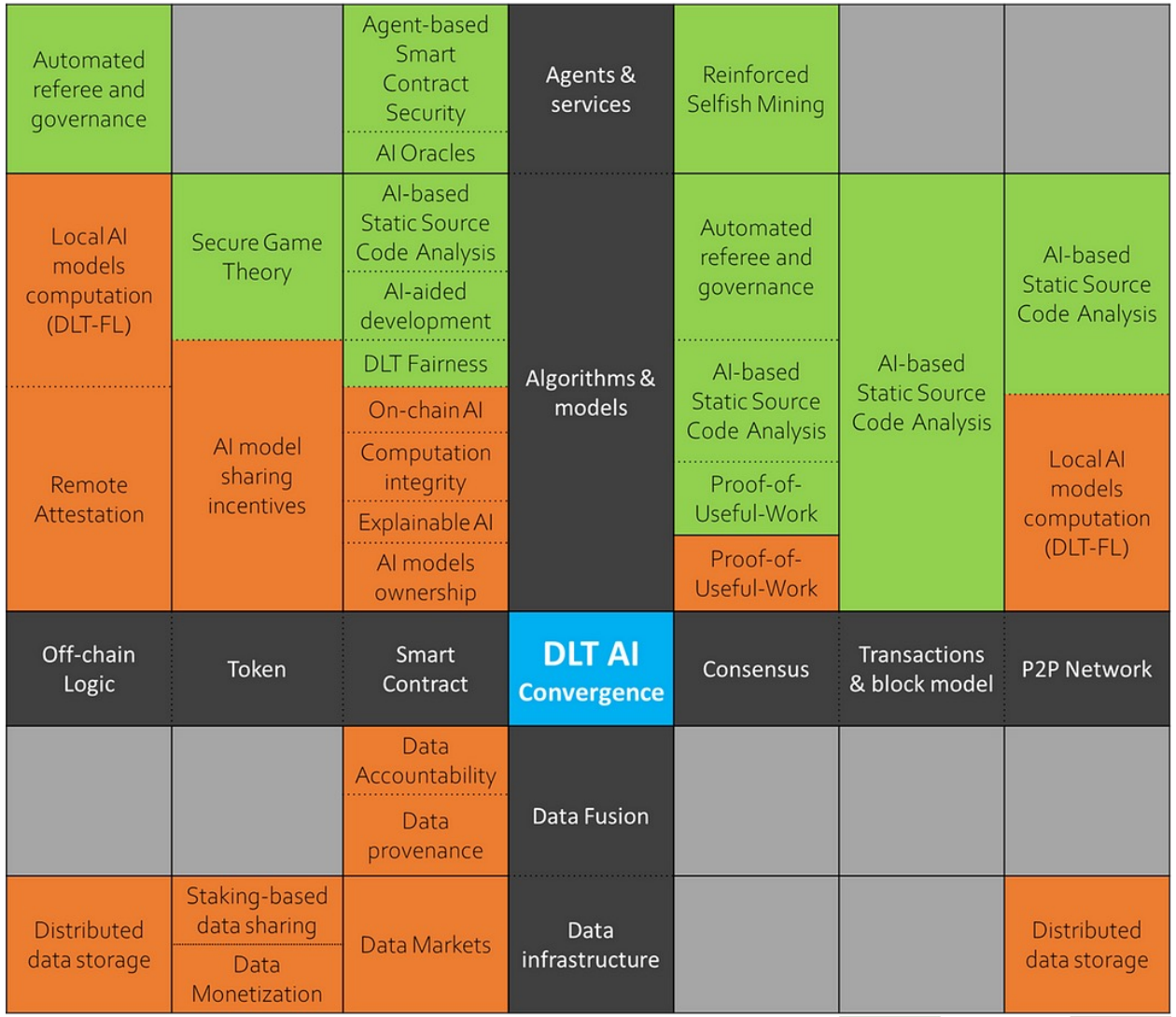


DLT-AI Convergence Areas

AI -> DLT

- AI-based Static Source Code Analysis
- Automated Referee and Governance
- Proof-of-Useful-Work
- AI-Aided Development
- DLT Fairness
- Secure Game Theory
- Reinforced Selfish Mining
- Agent-based Smart Contract Security
- AI Oracles



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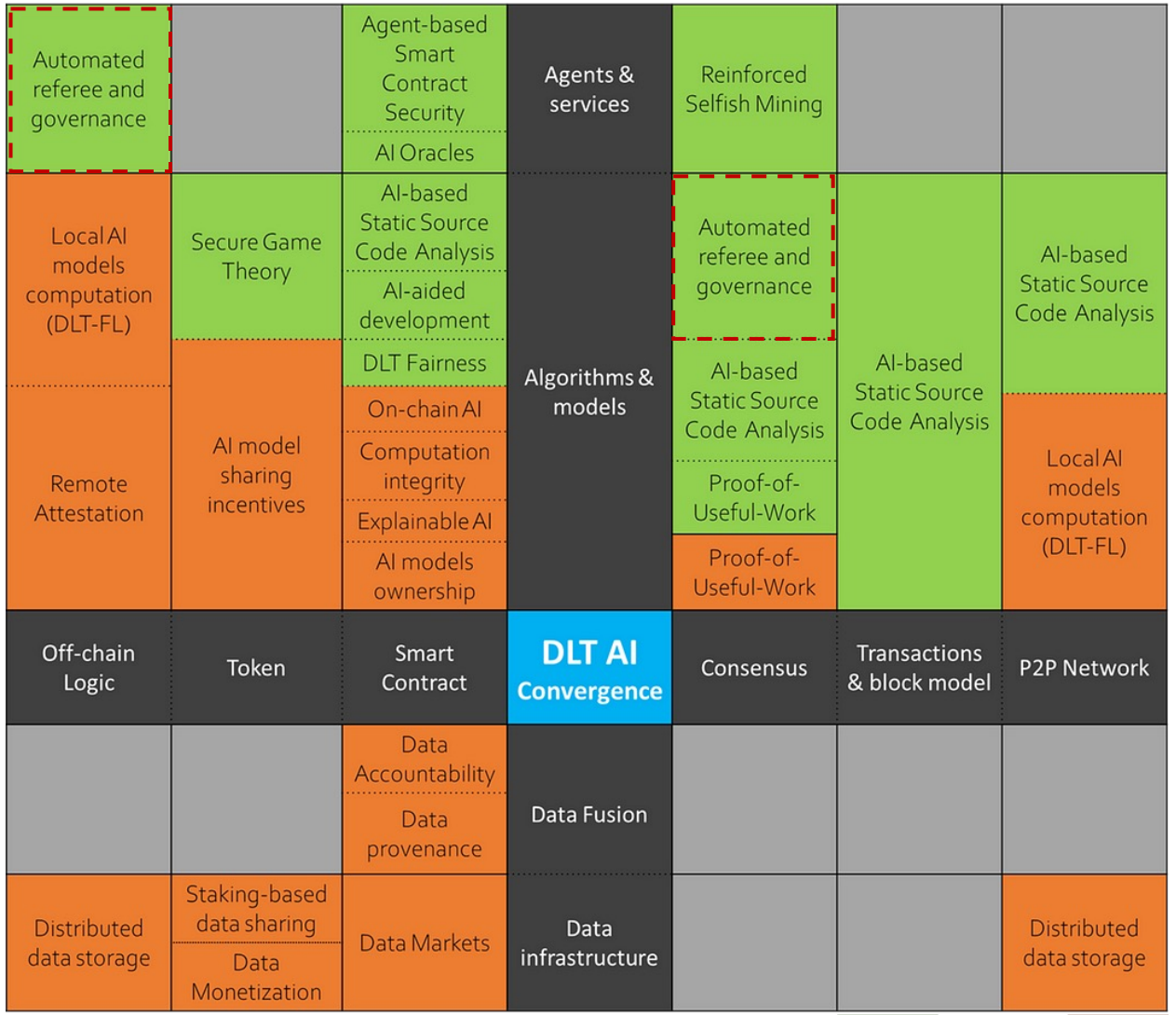

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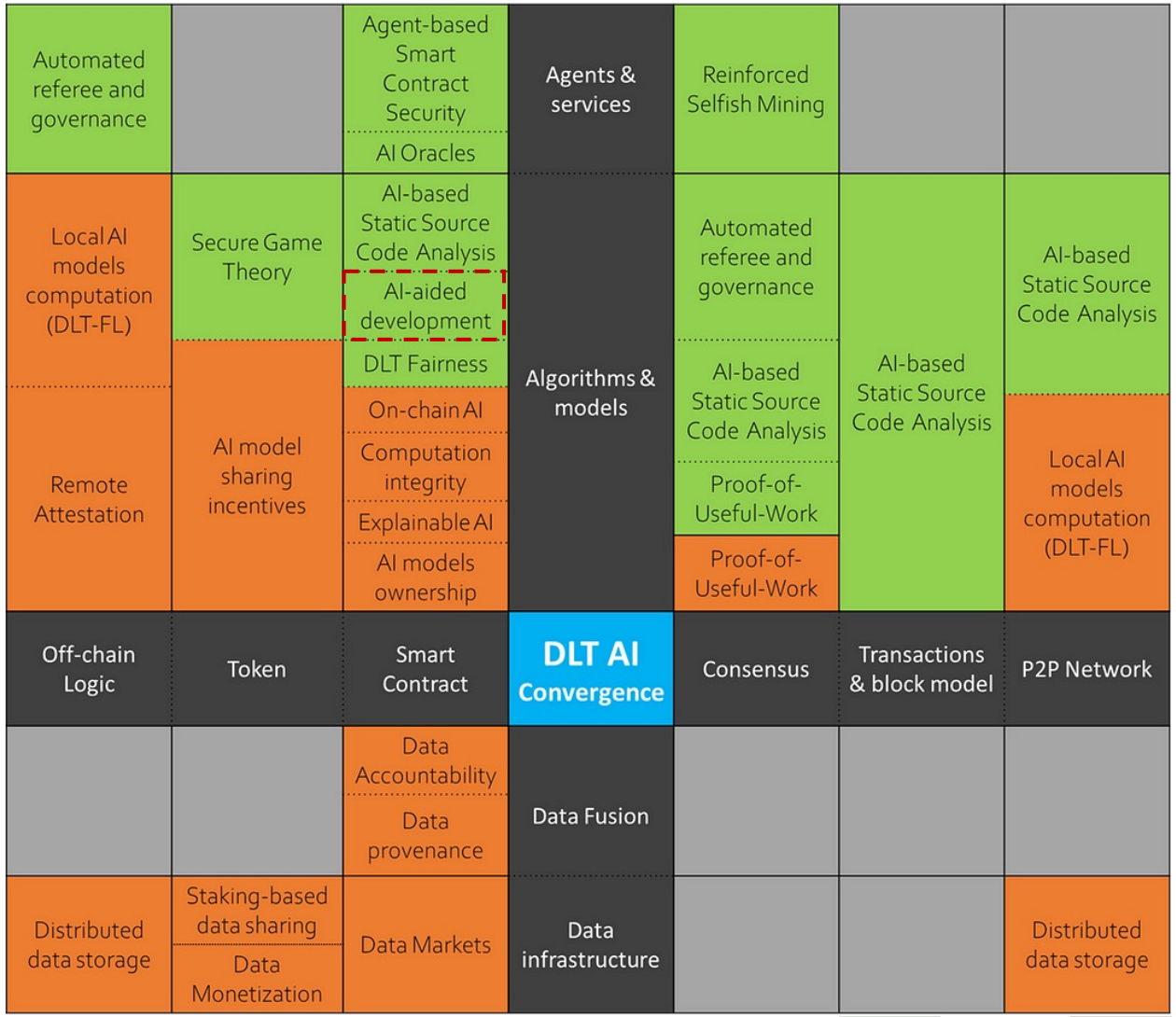

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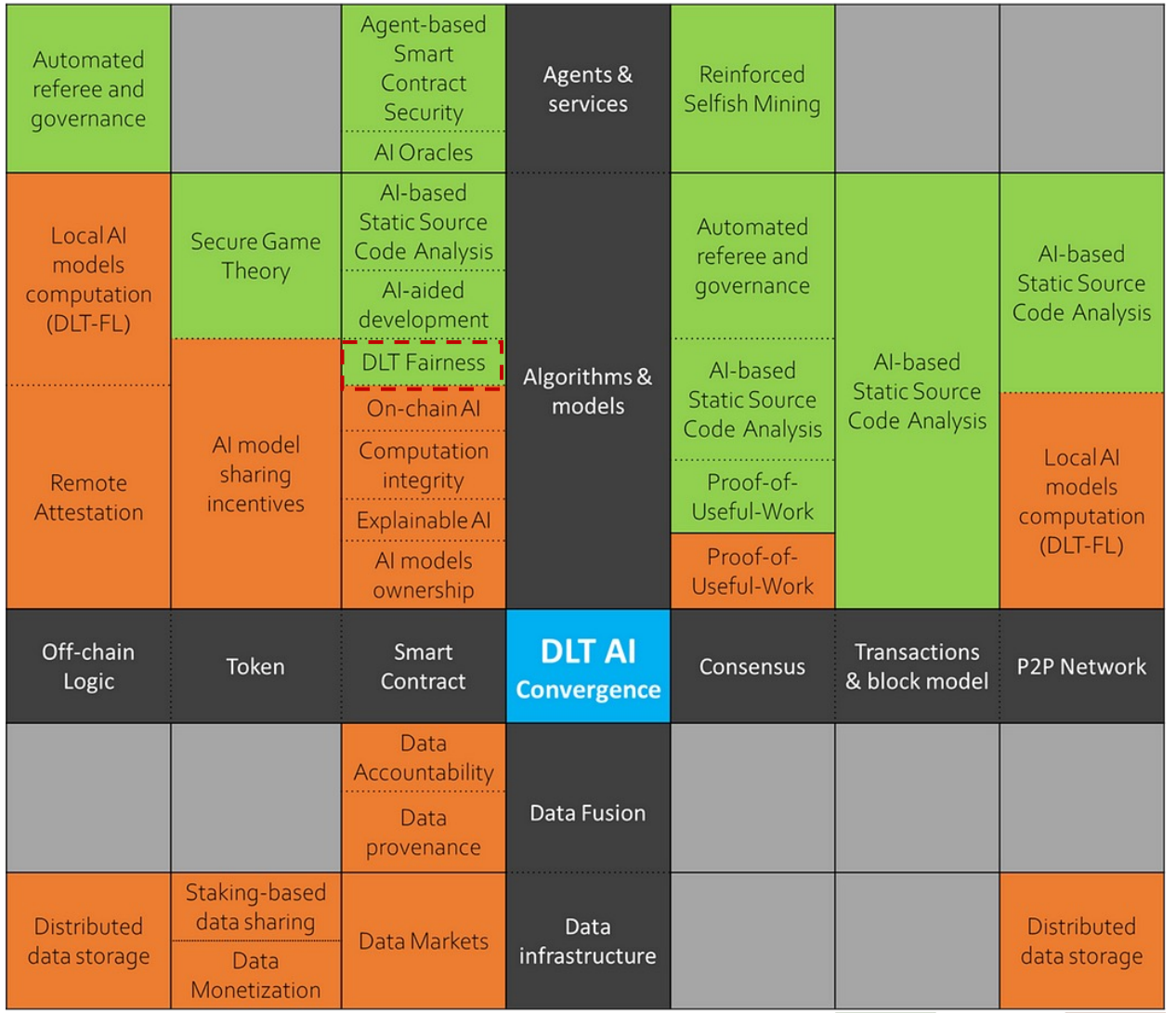

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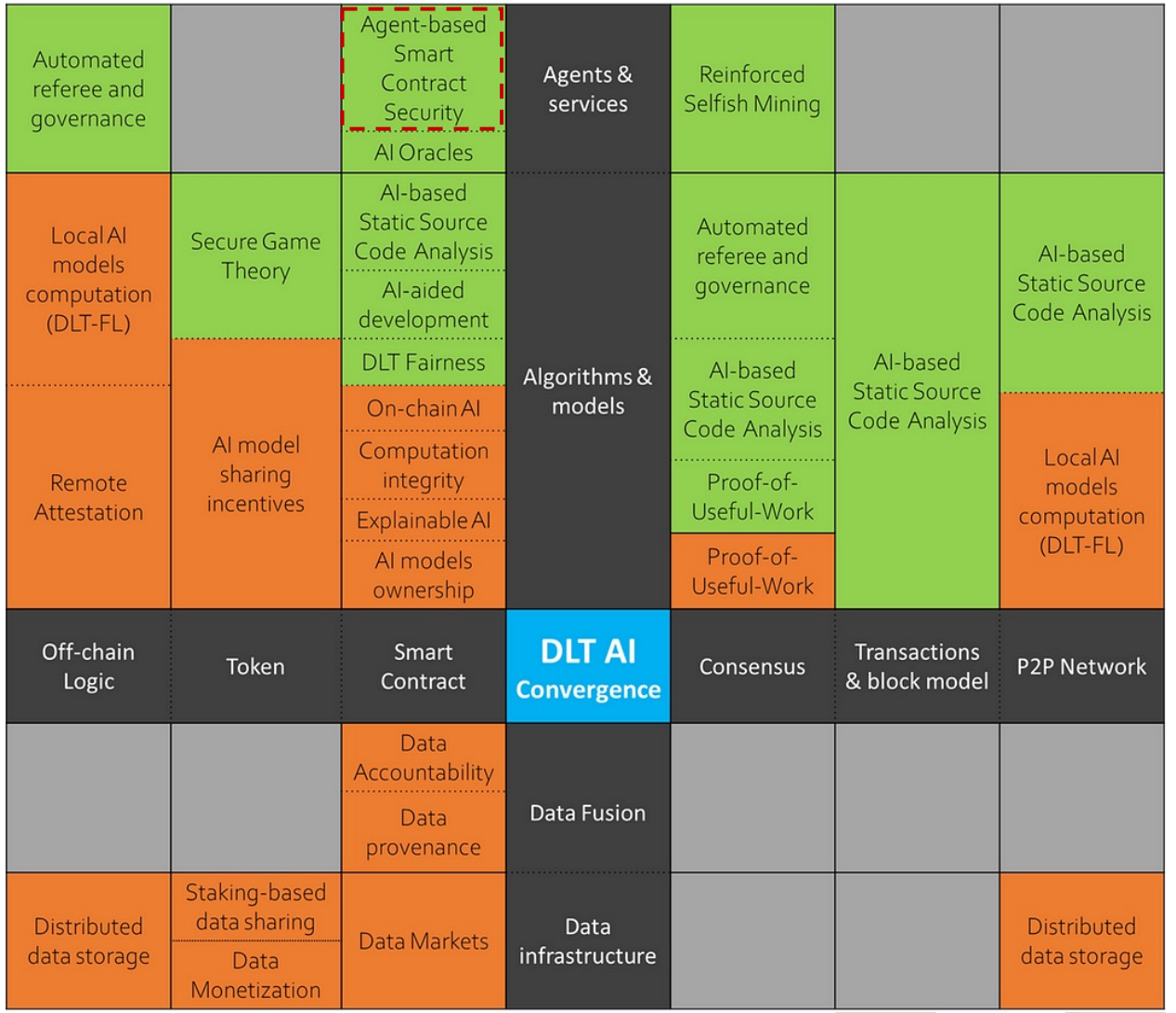

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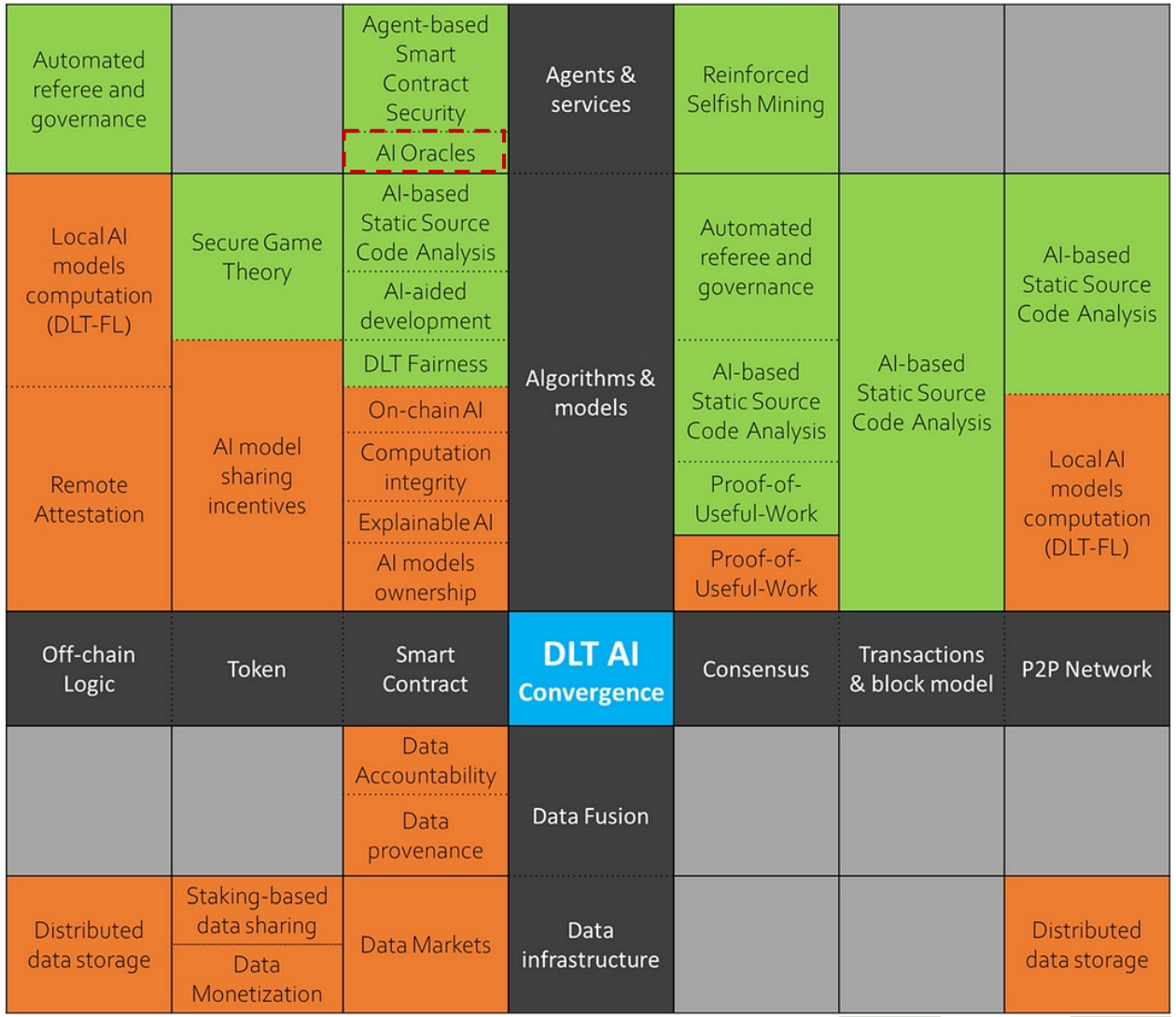


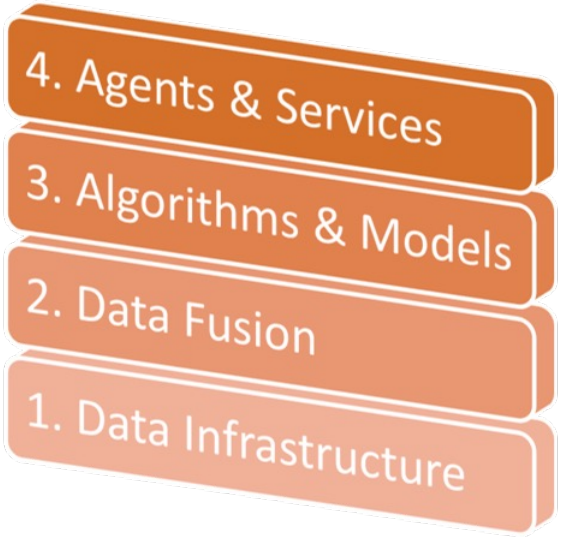
IoT-DLT-AI Convergence Prism

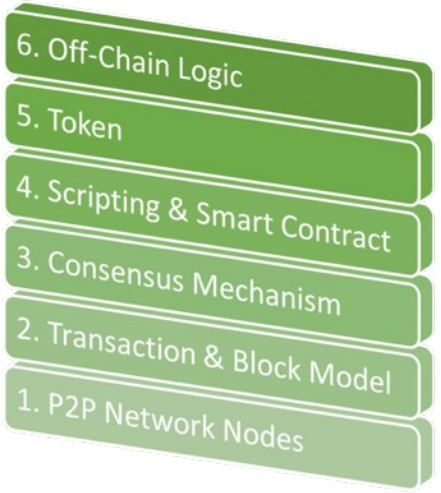
Silvio Meneguzzo, PhD in Blockchain & DLT, University of Turin – Fondazione LINKS

AIOTI

DLT-IOT- AI Convergence Prism

Highlights the possible **areas and topics of convergence** lying at the **intersection of the building blocks** of the DLT, IoT and the AI stacks.





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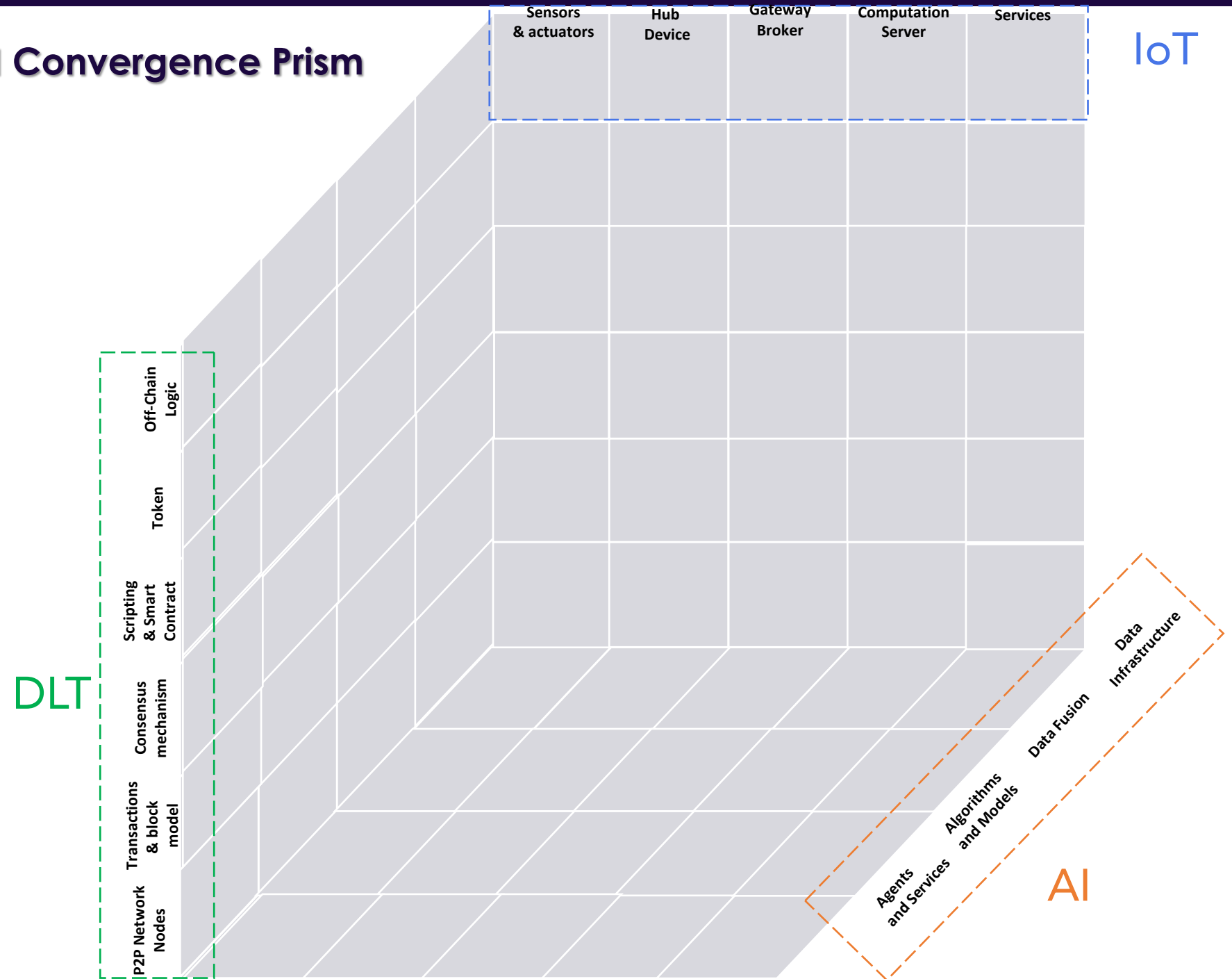
IoT-DLT-AI Convergence Prism



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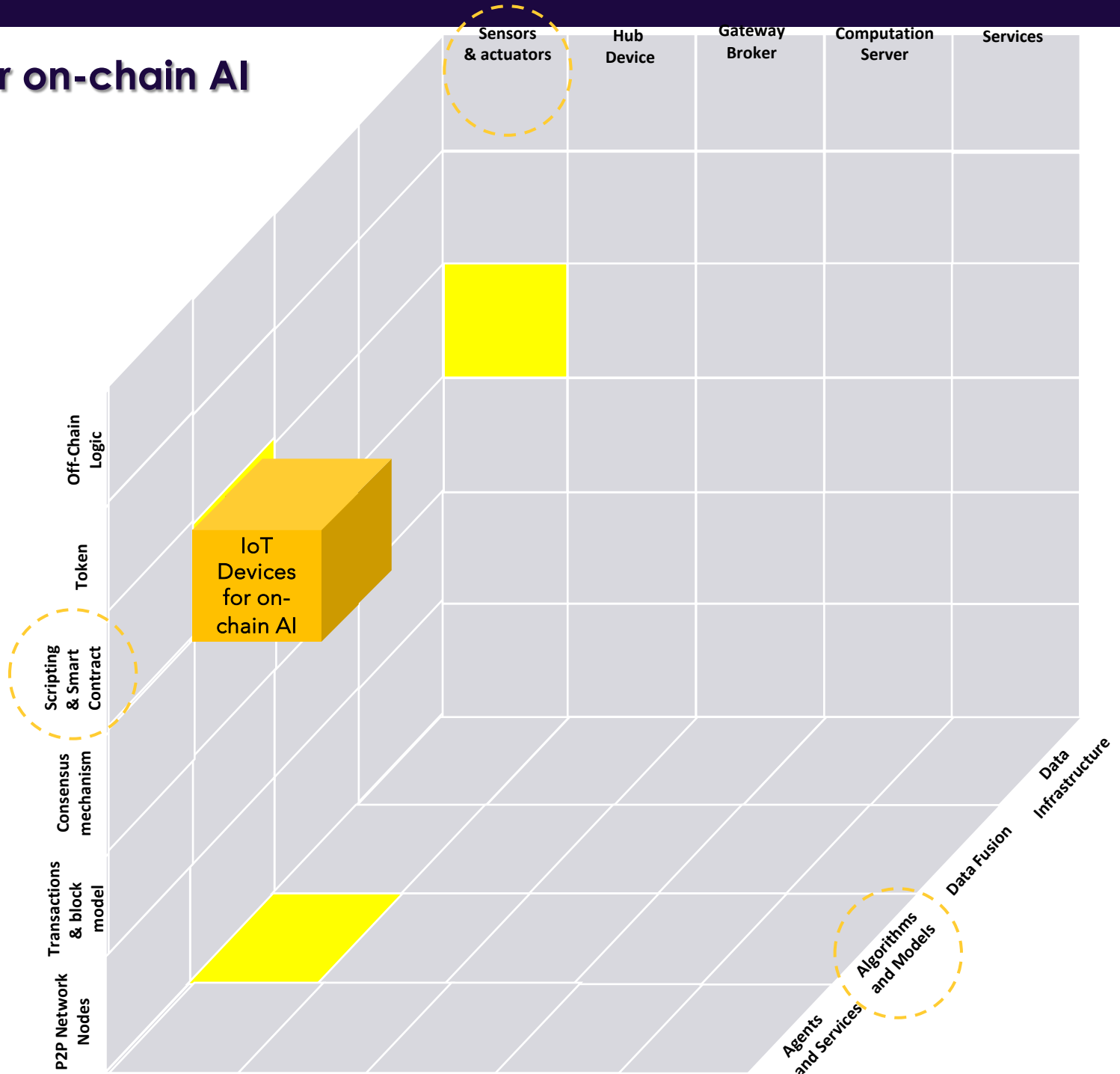
IoT Devices for on-chain AI



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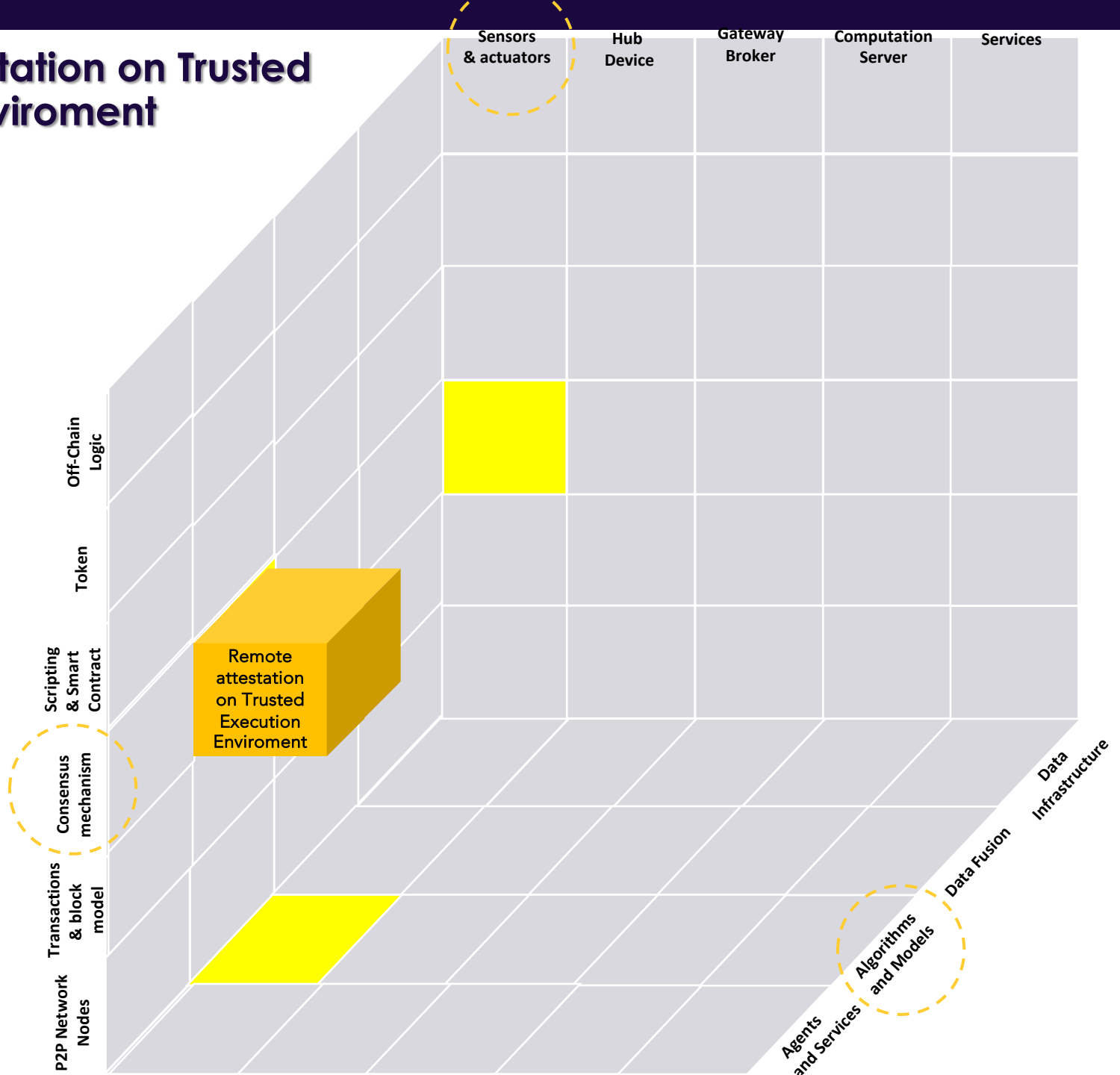
Remote attestation on Trusted Execution Enviroment



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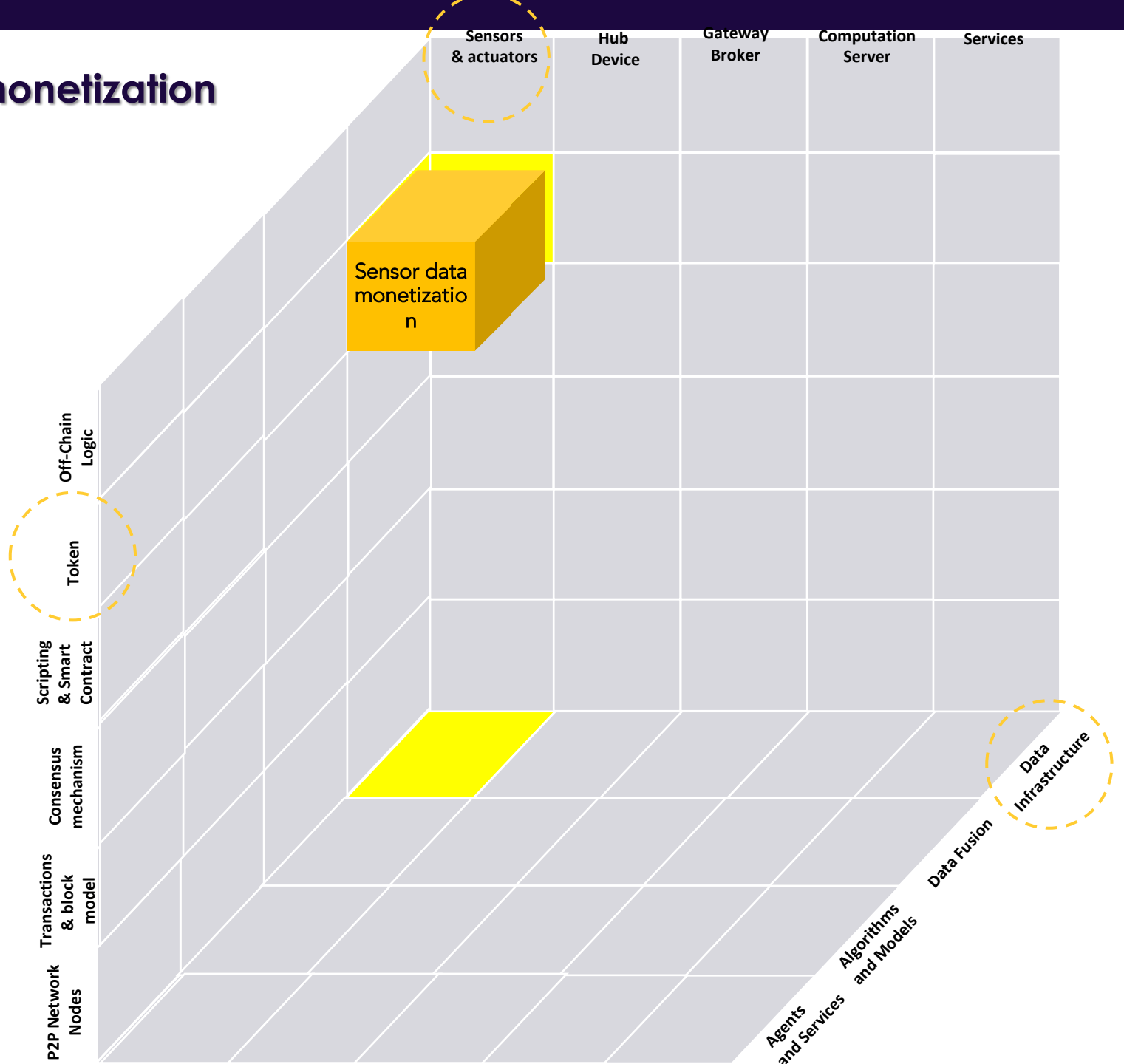
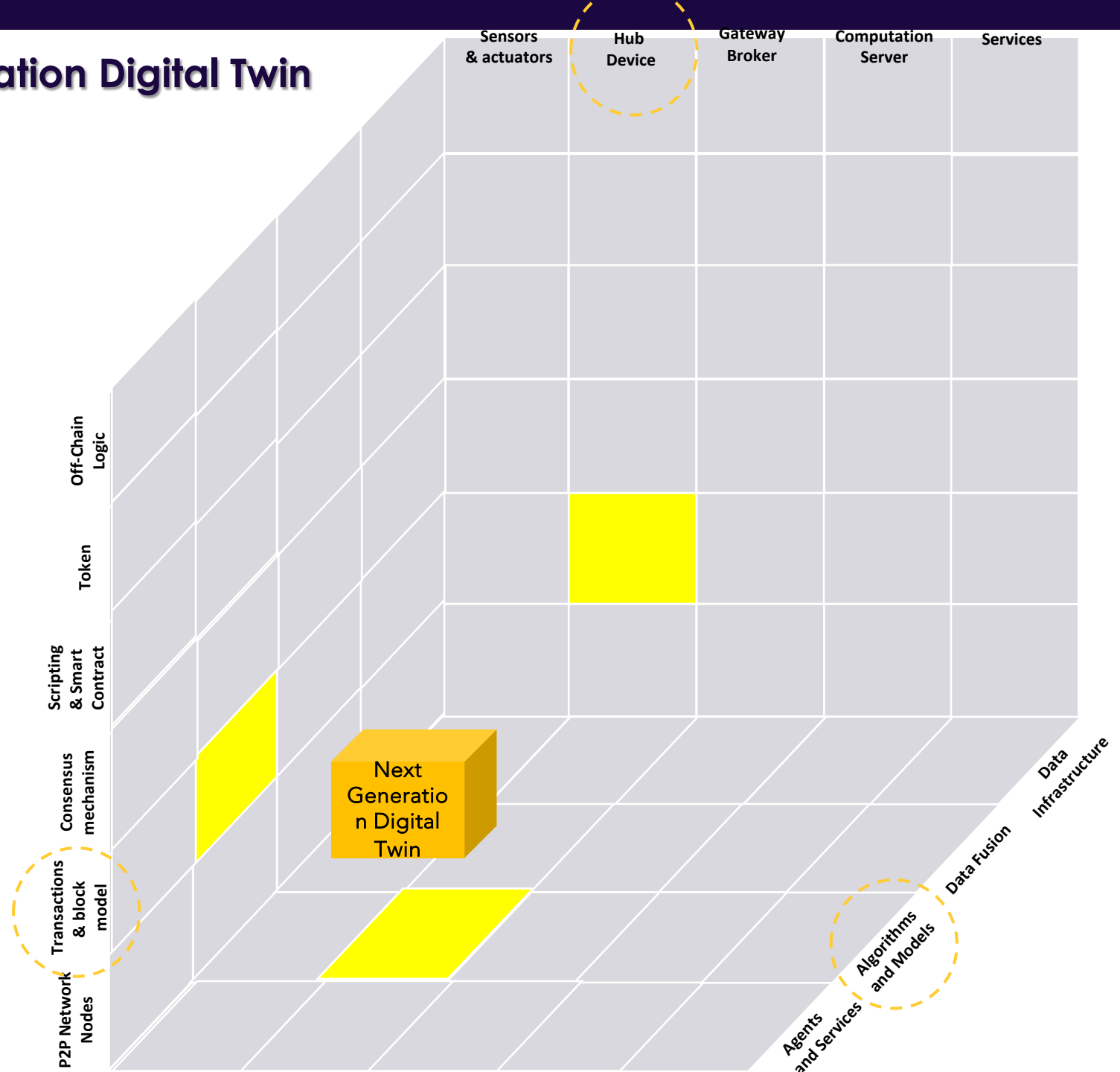
Sensor data monetization



Next Generation Digital Twin



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AI Oracle based IoT data

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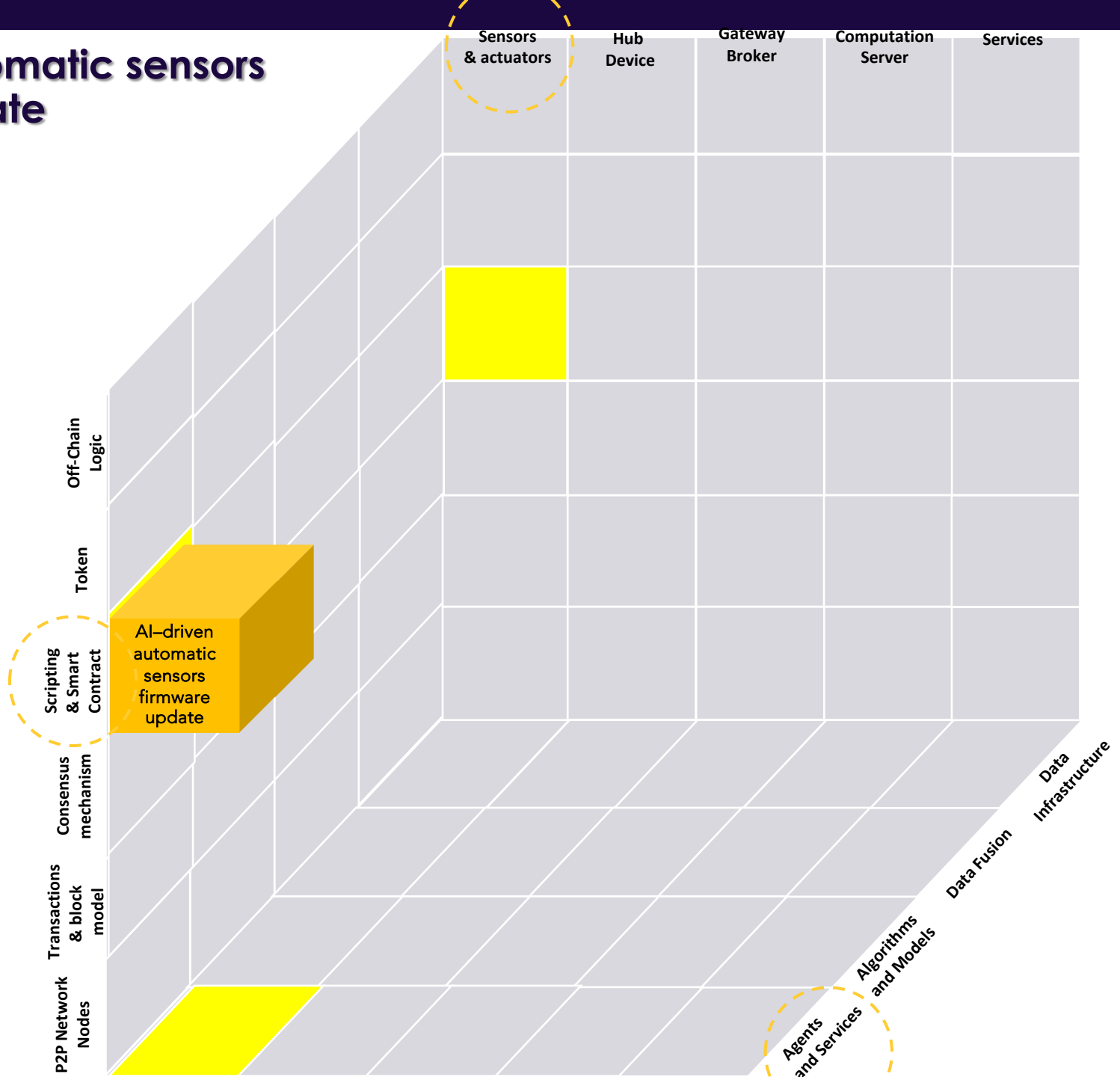
AI-driven automatic sensors firmware update



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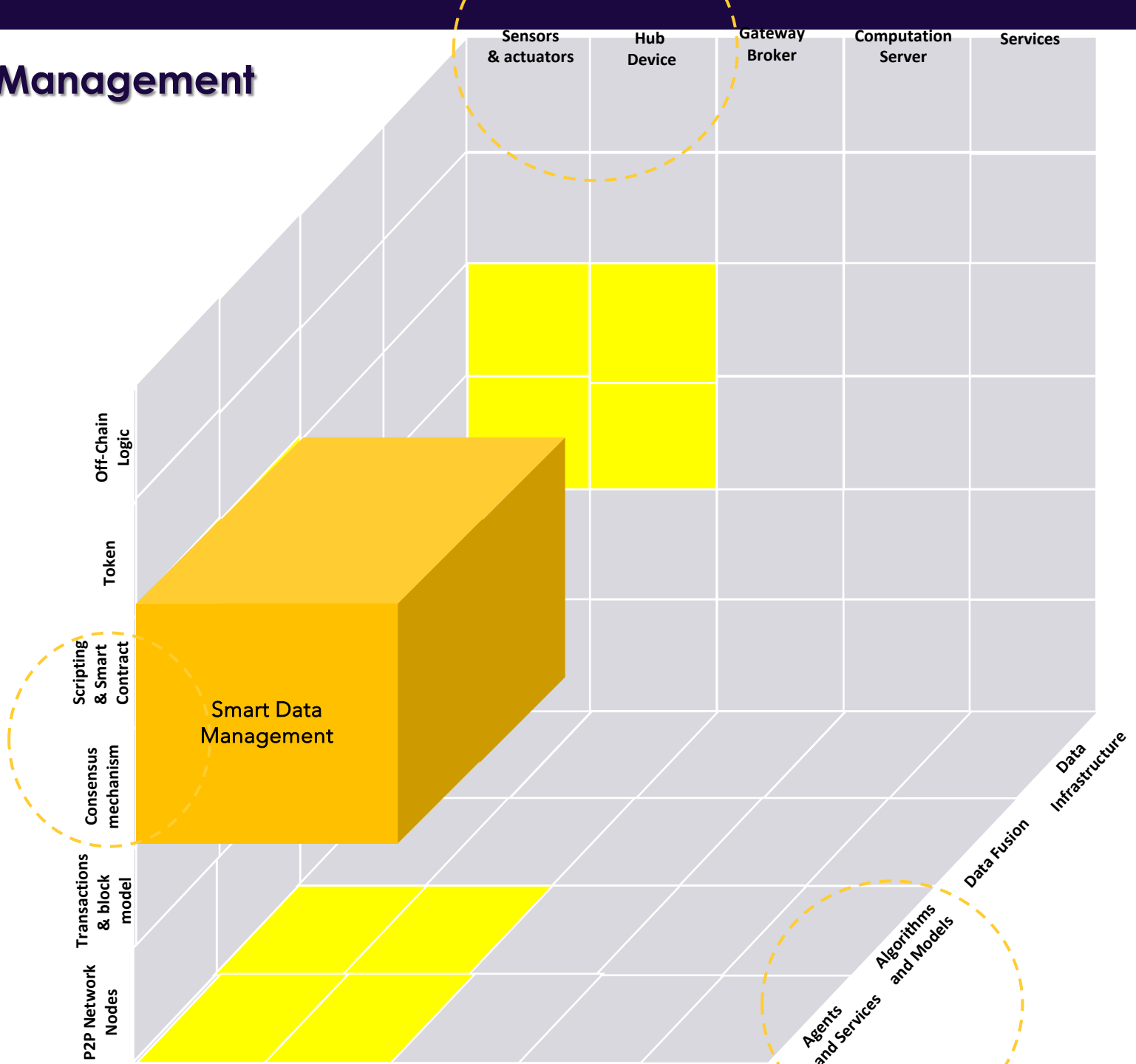
Smart Data Management



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Summary of IoT-DLT-AI Convergence Areas

- IoT Devices for on-chain AI
- Remote attestation AI alg. on Trusted Execution Enviroment
- Smart Sensor data monetization
- Next Generation Digital Twin
- AI Oracle based IoT data
- AI-driven automatic sensors firmware update
- Supply Chain Transparency and Optimization Platform
- Smart Data Management

Use Cases

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Use Case 1 - Walmart's food safety initiative

Area/topic of convergence: enhance food safety and traceability throughout its supply chain

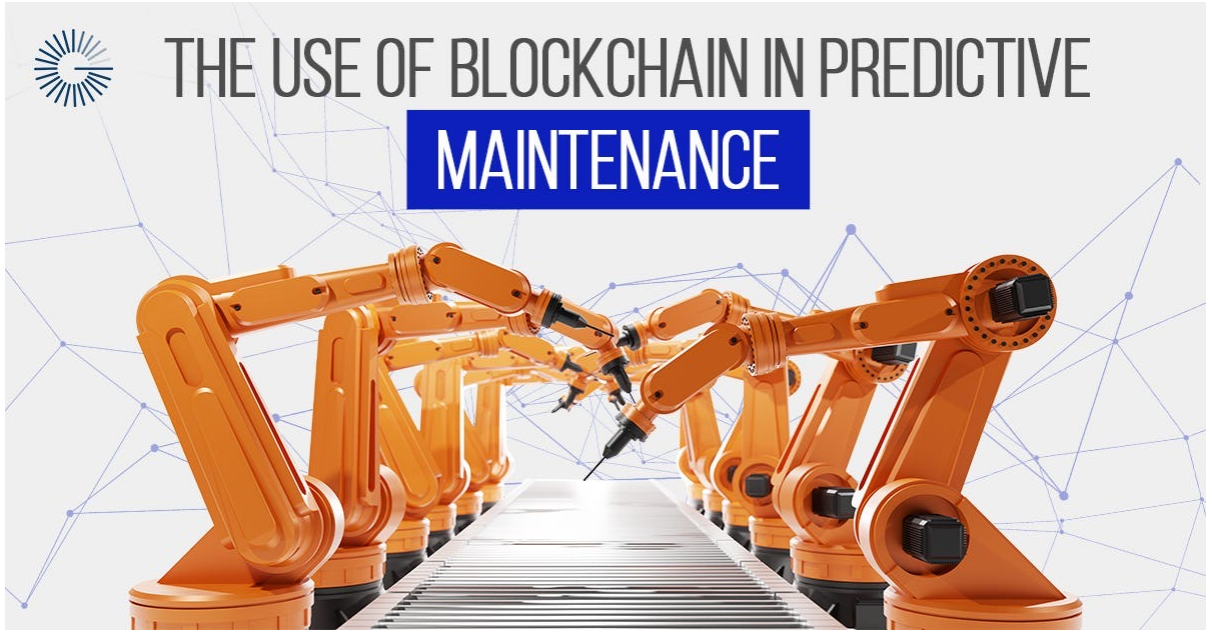
- **Role of IoT:** IoT sensors to keep tabs on the humidity and temperature of fresh food
- **Role of DLT:** secure data collection, notarization and monitoring
- **Role of AI:** AI to forecast the likelihood of food contamination and take preventative action

https://medium.com/@VishalPatil070404/the-blockchain-iot-and-ai-convergence-highlights-and-challenges-4ce6890c6ea6

Use Case 2 - Predictive Maintenance Solution

Area/topic of convergence: construct a system that can forecast when machinery or equipment will break down

- **Role of IoT:** securely communicate data to a blockchain-based system
- **Role of DLT:** track the performance and condition of machines in real time
- **Role of AI:** analyzed using AI algorithms to spot patterns and trends that can reveal when maintenance is required



Use Case 3 - GE Aviation's blockchain-based supply chain platform

Area/topic of convergence: track the movement of airplane parts and guarantee their authenticity and quality

- **Role of IoT:** IoT sensors to keep an eye environmental conditions throughout storage and transportation, including temperature and humidity
- **Role of DLT:** A transparent and tamper-proof record of all supply chain transactions
- **Role of AI:** analyze the sensor data and identify any quality problems

Use Case 4 - Smart Homes

Area/topic of convergence: Smart Homes

- **Role of IoT:** smart devices keep an eye environmental conditions
- **Role of DLT:** protection from unauthorized access and manipulation
- **Role of AI:** analyze the sensor data

Use Case 5 - Energy Sector

Area/topic of convergence: Empowering the Green Revolution: Transforming the Energy Sector

- **Role of IoT:** Smart meters, Remote monitoring, Demand response
- **Role of DLT:** Energy trading, Supply chain management, Grid management
- **Role of AI:** Predictive maintenance, Energy management, Grid management

https://www.linkedin.com/pulse/empowering-green-revolution-ai-iot-blockchain-energy-sector-salehi/

Conclusions

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Conclusions

Opportunity

Are we capable of being part of the "next thing" and take advantage of technology convergence to invent new applications that currently do not exist?

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Presentation of the convergence and use cases

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Questions from the Audience

Moderated by:
Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead

Wrap up and end of the Webinar

Alfredo Favenza, AIOTI Task Force Web3 Accelerator Co-Lead

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Thank you for listening

Any questions?

You can email sg@aioti.eu

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