Decentralized Blockchain-based Telecommunication Services Marketplaces

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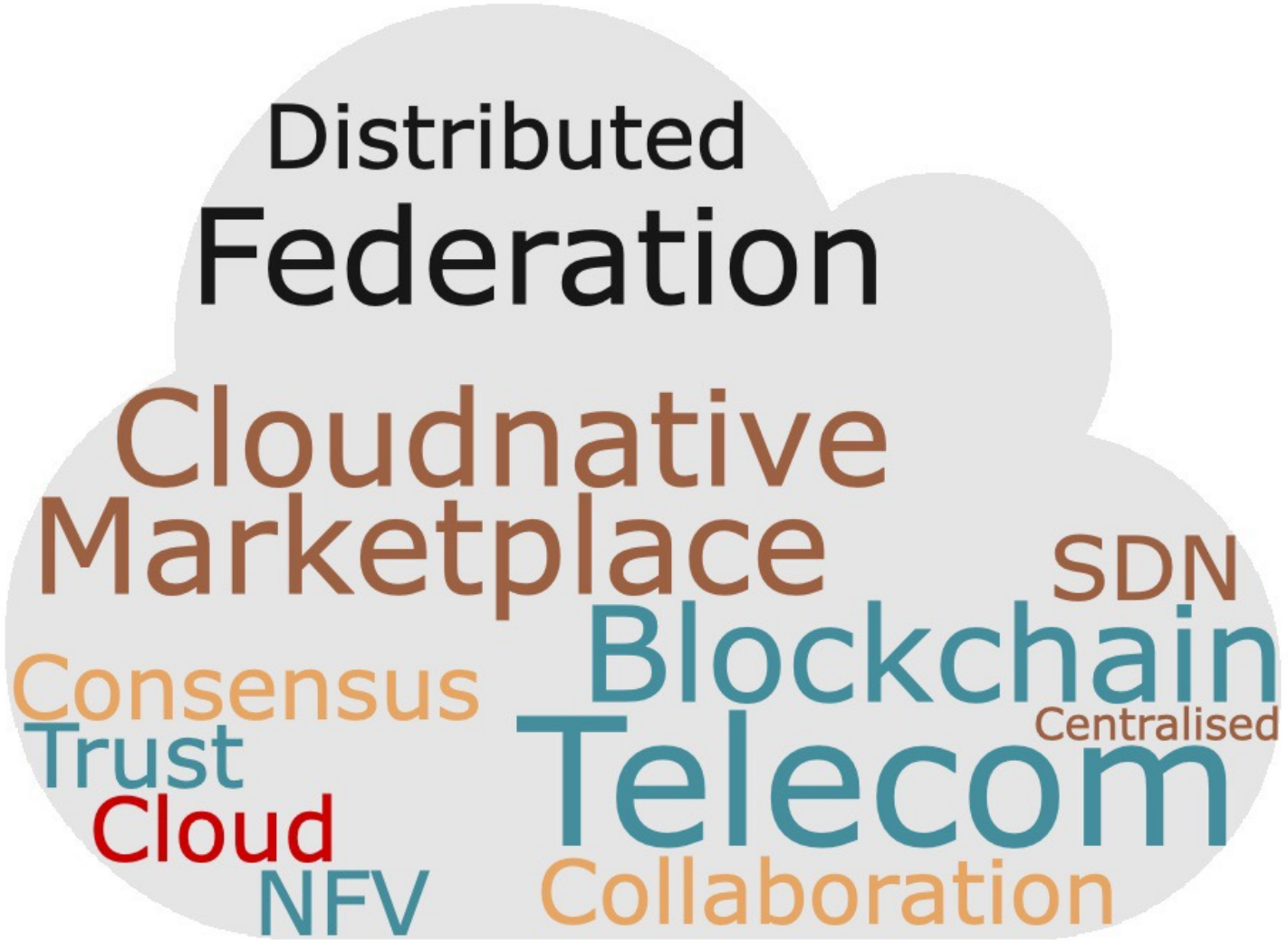
Funded by: KK-stiftelsen

Project partners: ERICSSON AFFÄRSVERKEN


Distributed
Federation
Cloudnative
Marketplace
SDN
Blockchain
Consensus
Centralised
Trust
Telecom
Cloud
NFV
Collaboration

Cloudnative Telecommunication Networks

- New pattern for organizing and operating telecommunication networks and services
- Takes advantage of Cloud techniques, e.g., decoupling of hard- and software, continuous deployment, containers and microservices
- Achieves elastic scaling, accelerates introduction of new (network) functionality and increased automation
- Permits federation of resources as well as them being distributed

Cloudnative Telecommunication Networks

- Challenges
  - How to engage stakeholder?
  - How to avoid too much centralization?
  - How to coordinate and orchestrate?
  - How to enable consensus and trust?

- Hypothesis:

  Apply marketplaces and Blockchains for stakeholder engagement and as trust-providing mechanisms!

Decentralized Blockchain-based Telecom-munication Services Marketplaces

- Aims of our tutorial
  - Introduce concepts and specify architectures
  - Detail how Blockchains enable trust in future CSP systems
  - Outline how marketplaces can engage stakeholders and establish business relationships
  - Discuss briefly standardization activities for TSMs using Blockchains
  - Demoing Blockchain capabilities for TSM and virtual P2P energy sharing

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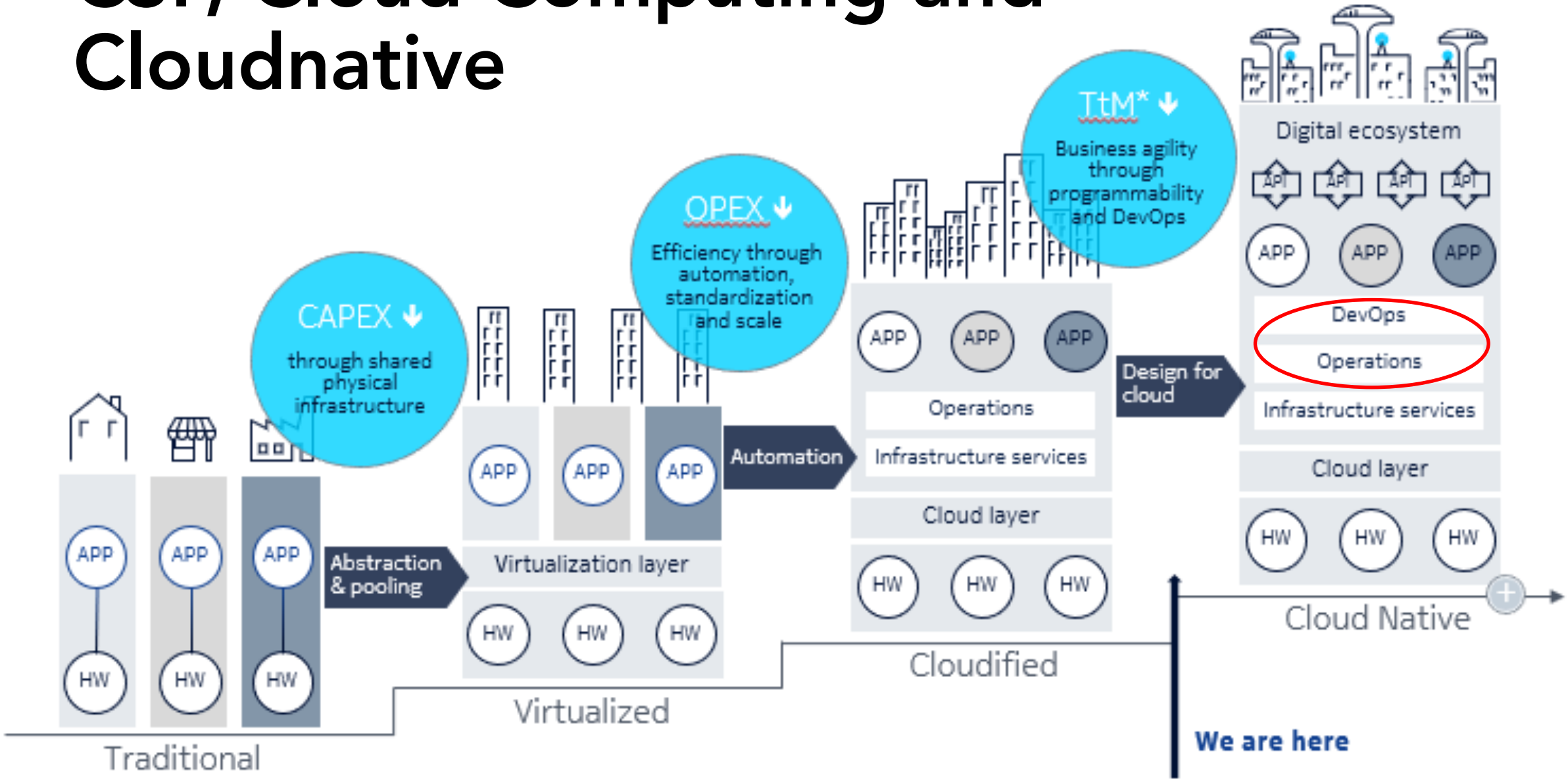
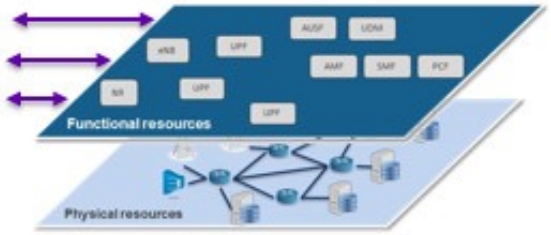
CSP, Cloud Computing and Cloudnative



Source: https://www.nokia.com/blog/how-to-start-your-cloud-native-journey-the-right-way/

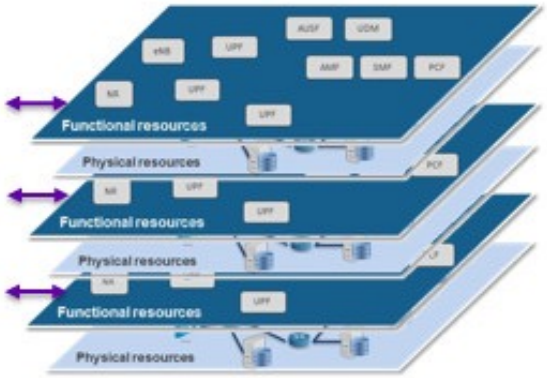
Sliced and Federated Network Architectures



Single Network

Shared functional layer

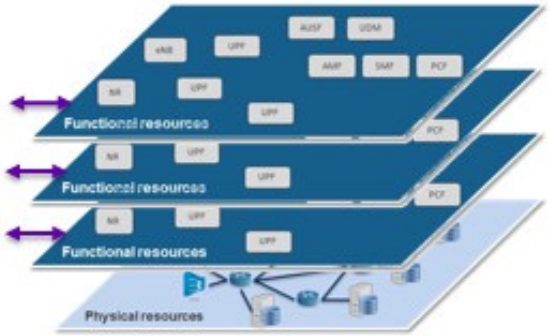
Shared physical resources



Separate Sub-networks

Dedicated functional layer

Dedicated physical resources



Network Slices

Dedicated functional layer

Shared physical resources

Slices with Edge / Crtl. / NFV Resource Federation

Dedicated functional layer with contributed and federated ctrl. resources

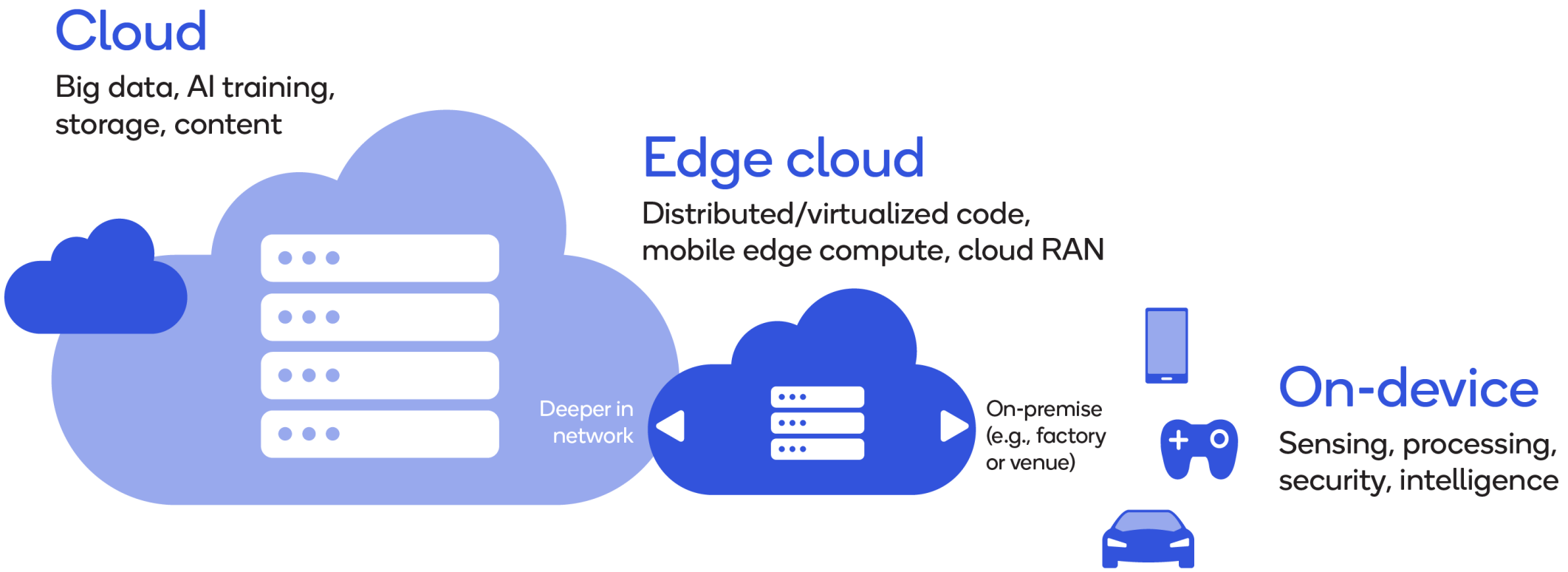
Shared (federated?) phyiscal resources

Functional resource layer

Physical resource layer

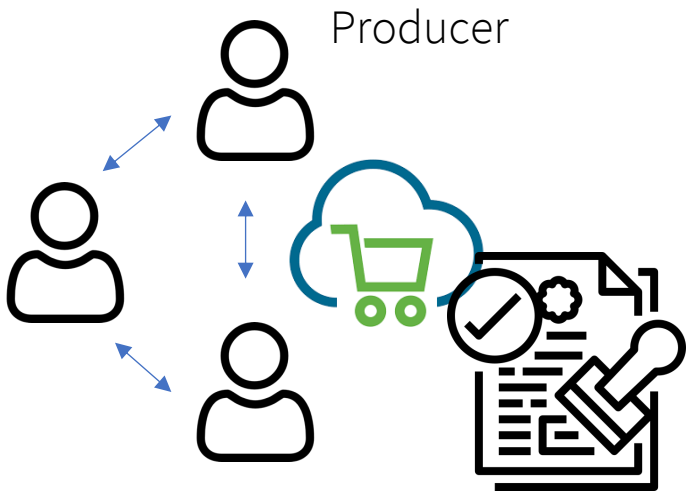
Source: https://sdn.ieee.org/newsletter/december-2017/end-to-end-network-slicing-opportunities-and-challenges-for-operators-a-view-from-bt

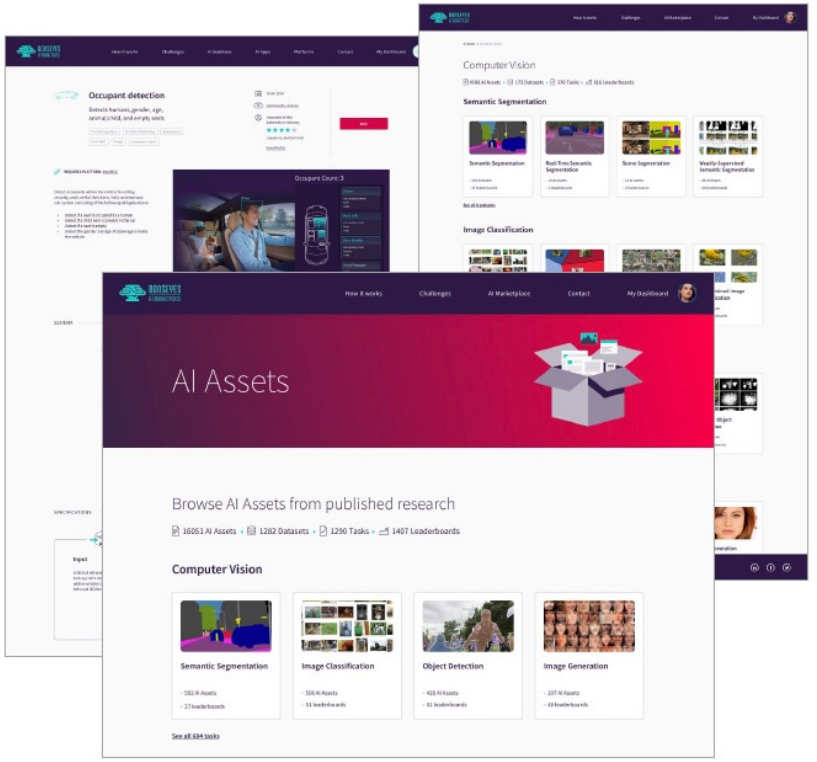
Services in the Cloud-to-Edge Continuum



Source: https://developer.qualcomm.com/blog/taking-your-development-wireless-edge

Marketplaces





Example: Bonseyes AI marketplace (www.bonseyes.com)

- Very popular in Clouds and Cloudnative app. development
- Not yet very popular in telecom. systems
- But: recent activities by CBAN, TM Forum, ETSI

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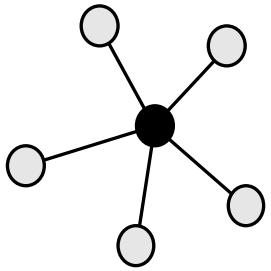
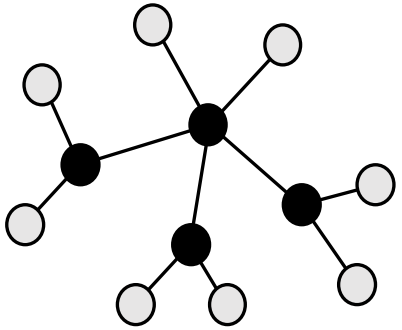
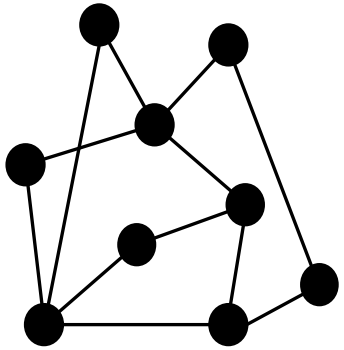
SYSTEM ARCHITECTURES



Centralized



Decentralized



Distributed

- System architectures from the two points of view:
  - **Control** over the computing infrastructure – by single or multiple entities (*centralized*, *decentralized*).
  - Physical **dissemination** of computing infrastructure that comprise system – whether resources are *distributed*.

DISTRIBUTED LEDGER TECHNOLOGY

- ***Distributed Ledger Technology (DLT)*** has gained attention due to its decentralized nature and trust-enabling capabilities.

- It acts as a distributed database:
  - *No central governing authority.*

- In DLT data is transmitted in a ***peer-to-peer network***.

DISTRIBUTED LEDGER TECHNOLOGY

- DLT has multiple implementations:

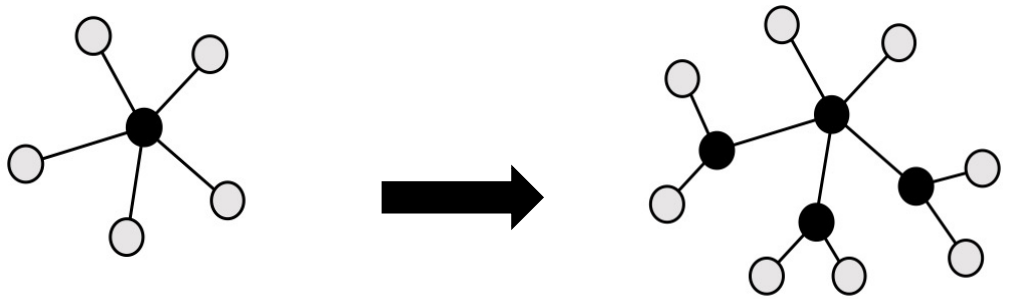
1. ***Blockchain.***

2. ***Direct Acyclic Graph (DAG) – based DLTs***.
   - The newly added transaction can reference multiple previously added ones.
   - Representative:
     - IOTA DAG-based ledger.

DISTRIBUTED LEDGER TECHNOLOGY: BLOCKCHAIN

- ***Blockchain*** bundles the pieces of data into blocks, where each block contains a reference to the previous one.

- ***Blockchain*** shifts from a classical centralized approach to a ***decentralized network of nodes***.



Centralized Decentralized

BLOCKCHAIN: ADVANTAGES

- Advantages:
  - ***Provenance.***
  - ***Accountability.***
  - ***Traceability.***
  - ***Transparency***.

- The decentralized nature makes ***highly difficult to alter ledger transaction history***.

BLOCKCHAIN: TRUSTLESS ENVIRONMENTS

- In a blockchain-based decentralized system, a computing environment is often referred to as ***trustless***.

- In order to achieve a trusted relationship, a ***third party has to be involved*** as an intermediary.

- To ***remove a need for a third party*** in blockchain-based decentralized systems, a secure and robust ***consensus mechanism*** is applied.

BLOCKCHAIN: ARCHITECTURES

- Depends on two things:
  1. **Public** or **private** access to the the information.
  2. **Permissioned** or **permissionless** consensus protocol execution.

- Main architectures:
  1. ***Public permissionless***.
  2. ***Private permissioned***.
  3. ***Public permissioned***.

BLOCKCHAIN: PUBLIC PERMISSIONLESS ARCHITECTURE

- ***Public permissionless blockchain*** – everyone is allowed to join the network and participate in the consensus process.
- Every node carries a copy of ledger.
- Participants retain a certain degree of anonymity.
- Representatives:
  - Bitcoin.
  - Ethereum.

BLOCKCHAIN: PRIVATE PERMISSIONED ARCHITECTURE

- ***Private permissioned blockchain*** – the ***governing node*** (or set of nodes) who decides whether a new participant can enter a blockchain network.
- ***Governing node*** decides who can participate in consensus.
- Representative - ***Hyperledger Fabric***.
- Three types of nodes:
  - Endorsement
  - Ordering
  - Validation

BLOCKCHAIN: PUBLIC PERMISSIONED ARCHITECTURE

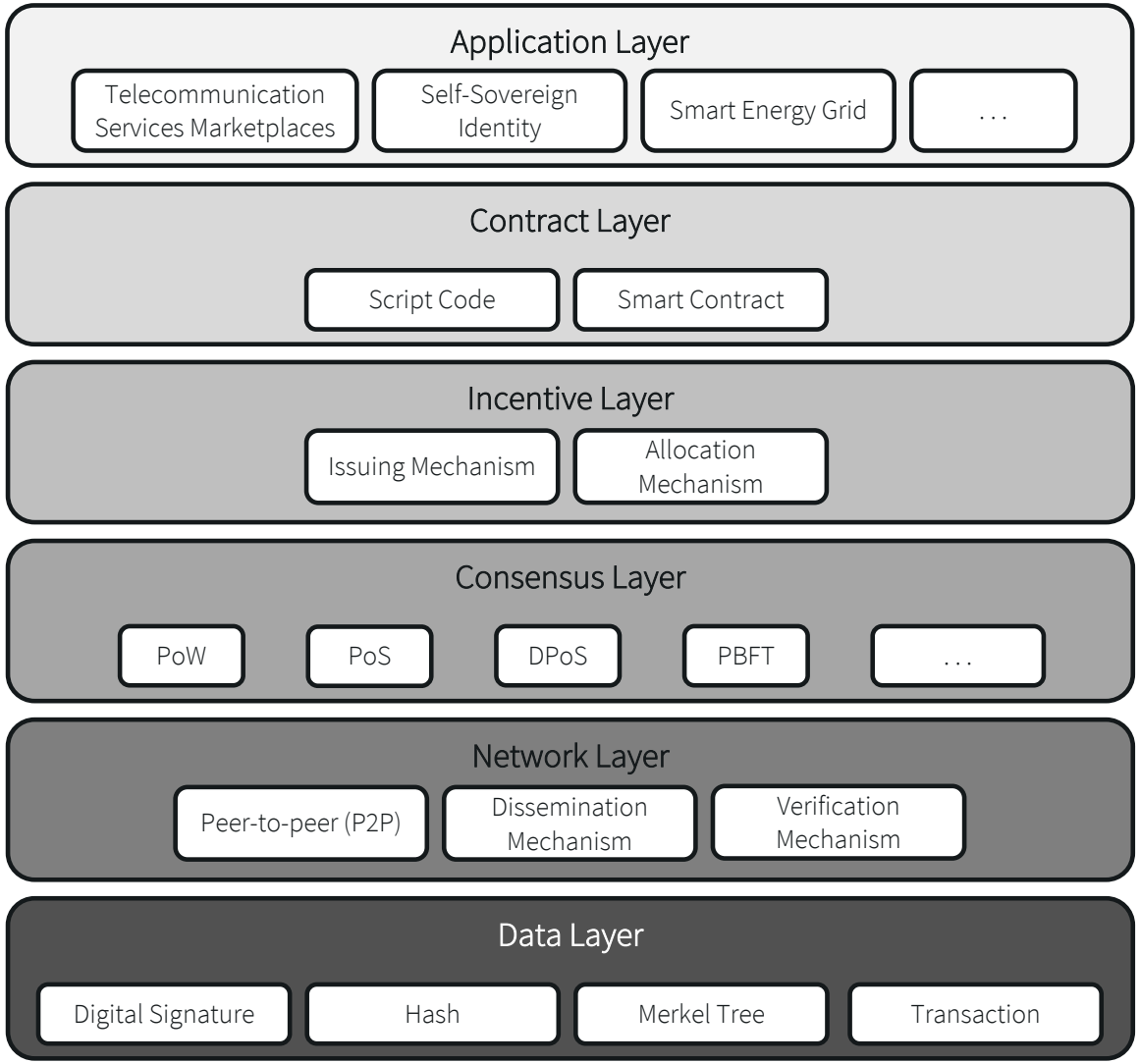
- ***Public permissioned blockchain*** – everyone can join the network, but only assigned nodes can conduct consensus.

- Allows initially non-trusting organizations to **establish a trust bridge** over a public yet permissioned system.

- Possibility for only a **specific group of nodes** to write new blocks to the ledger.

- This type of architecture was made popular by the ***Sovrin Foundation***.
  - Representative **– Sovrin Self-sovereign Identity Management** solution.

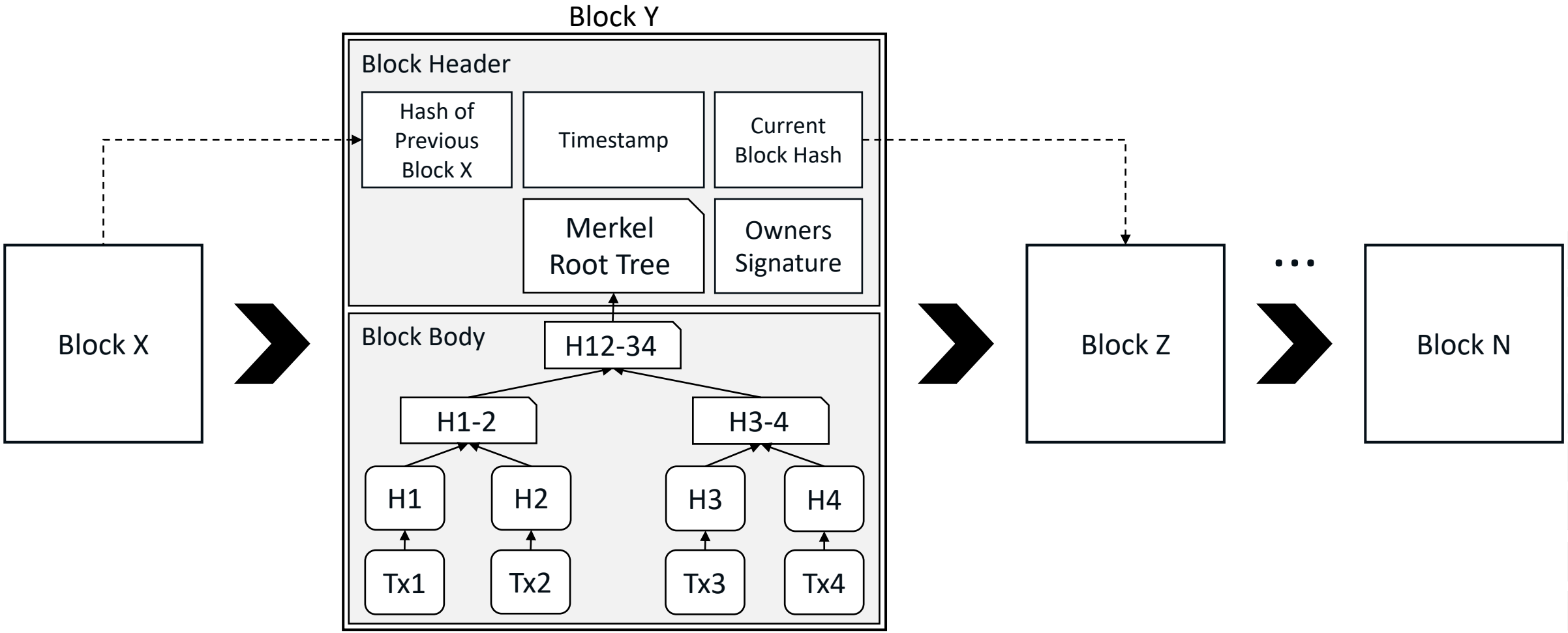
BLOCKCHAIN: INFRASTRUCTURE MODEL



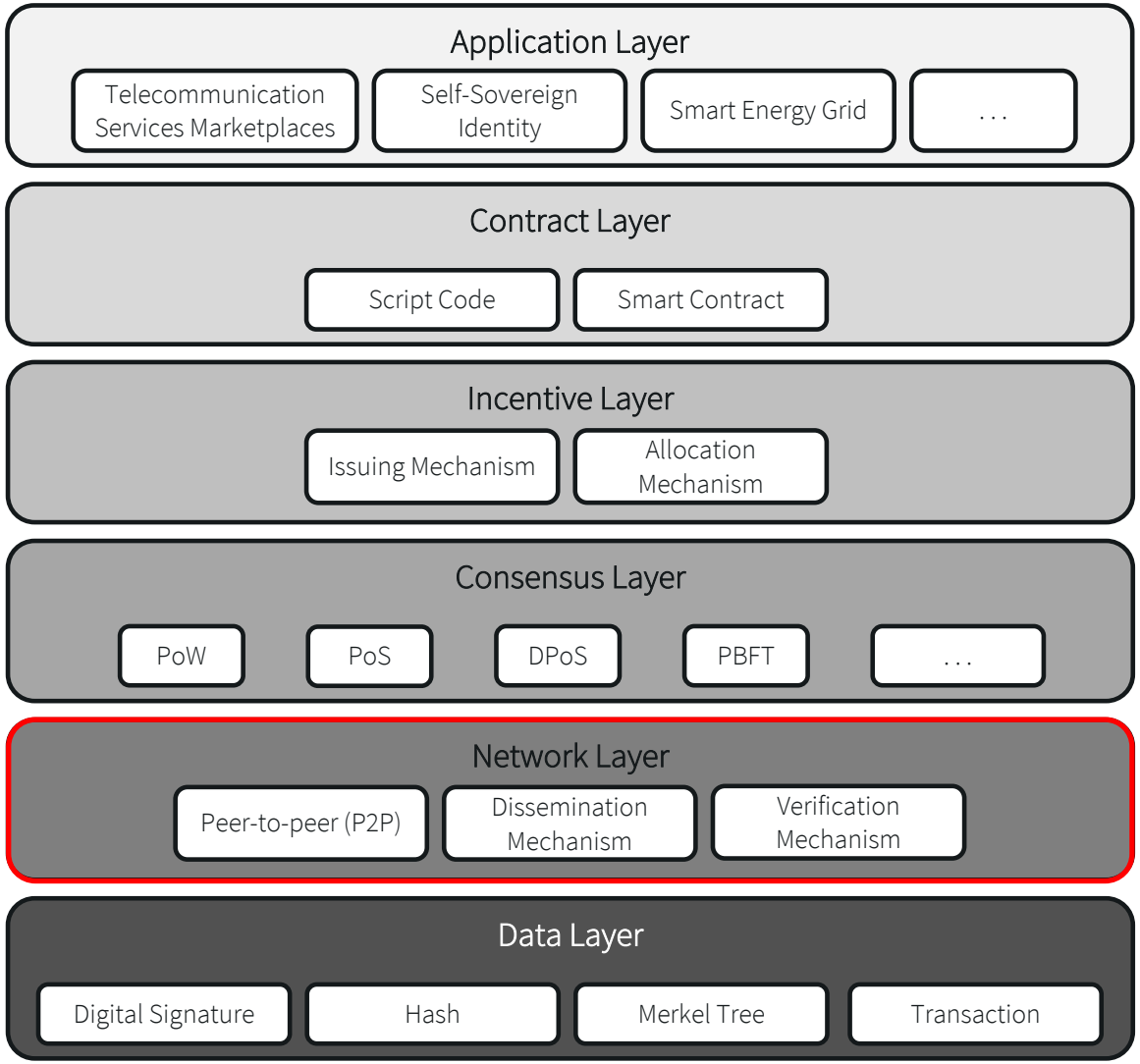
- Blockchain infrastructure model can be divided into six Layers:
  - Application
  - Contract
  - Incentive
  - Consensus
  - Network
  - Data

- Each layer represents a functional part of the blockchain

BLOCKCHAIN: DATA LAYER



BLOCKCHAIN: NETWORK LAYER



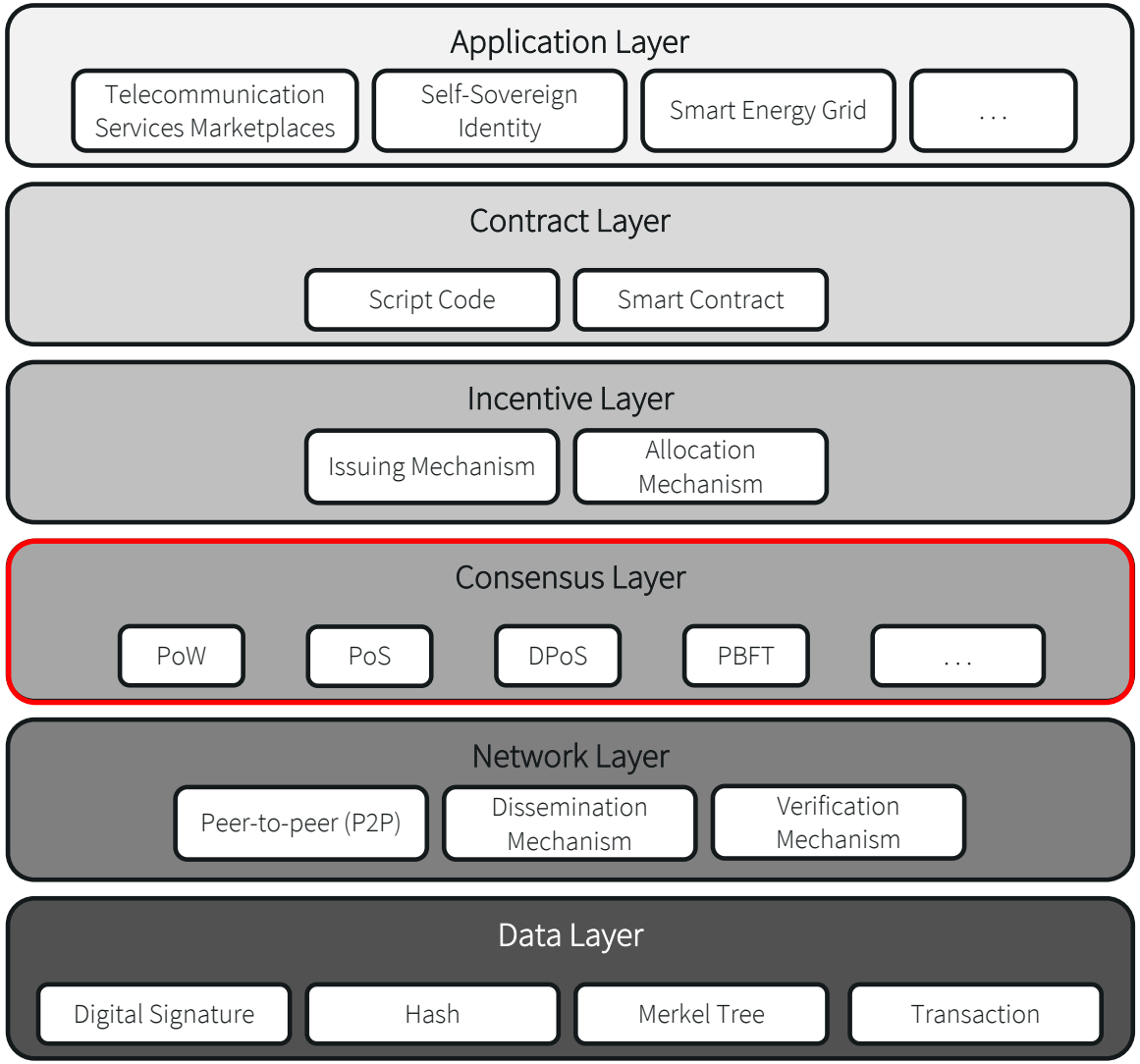
- Blockchain ***transactions are stored in a decentralized P2P network.***

- Advantages:
  - The data storage is ***replicated in every node***, thereby disabling potential data loss.
  - Each participant of the network is equal.

- The ***dissemination mechanism*** broadcasts transactions to all neighbouring nodes.

- The ***verification mechanism*** utilises public and private key of each node in the network

BLOCKCHAIN: CONSENSUS LAYER

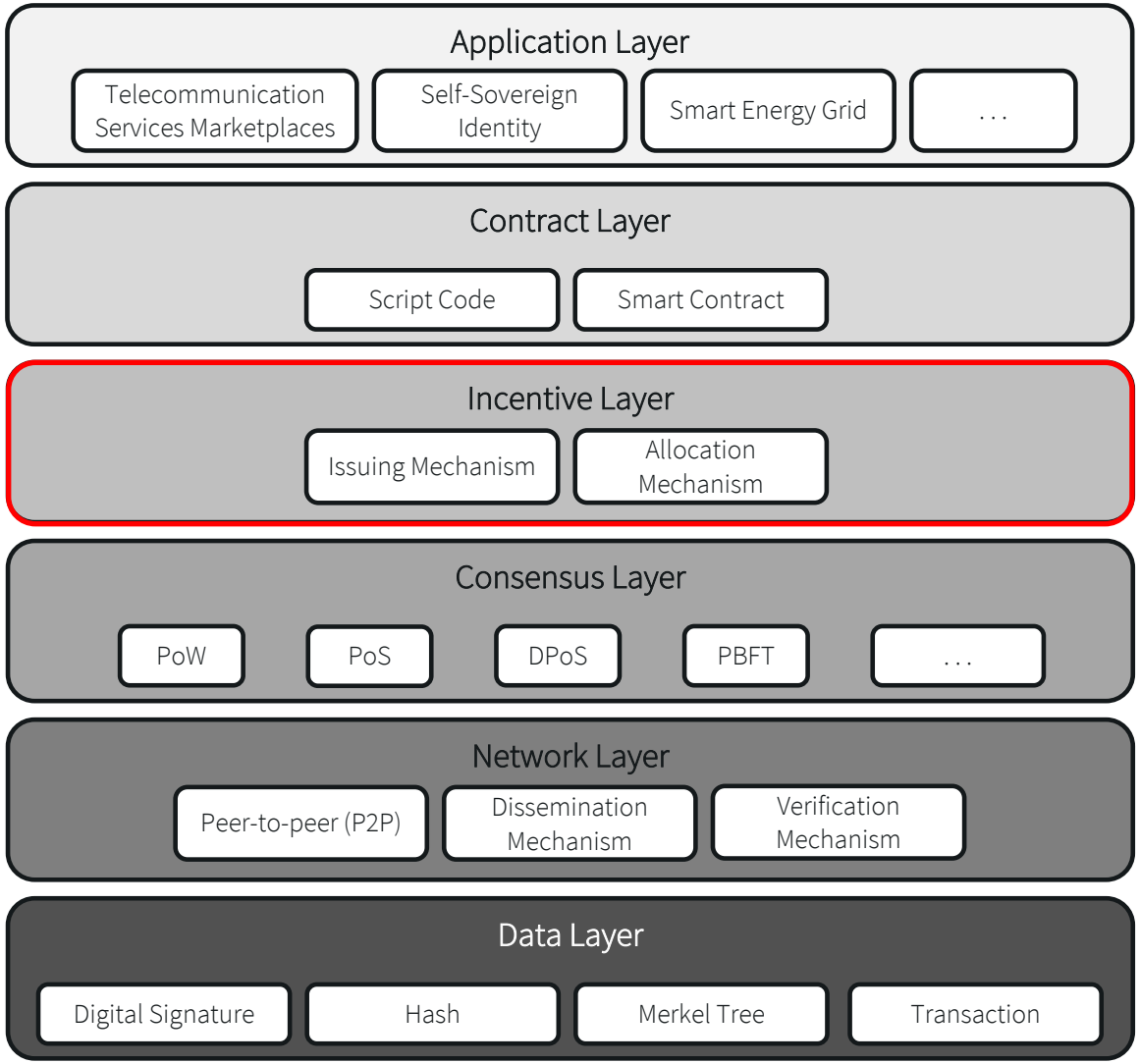


- ***Proof of Work (PoW)*** – is a consensus mechanism originally introduces by Satoshi Nakamoto in Bitcoin cryptocurrency.

- Consensus mechanisms which are based on PoW proved to be the most suitable for permissionless blockchain systems.

- ***Practical Byzantine Fault Tolerance*** related algorithms proved to be the most suitable for permissioned blockchain systems

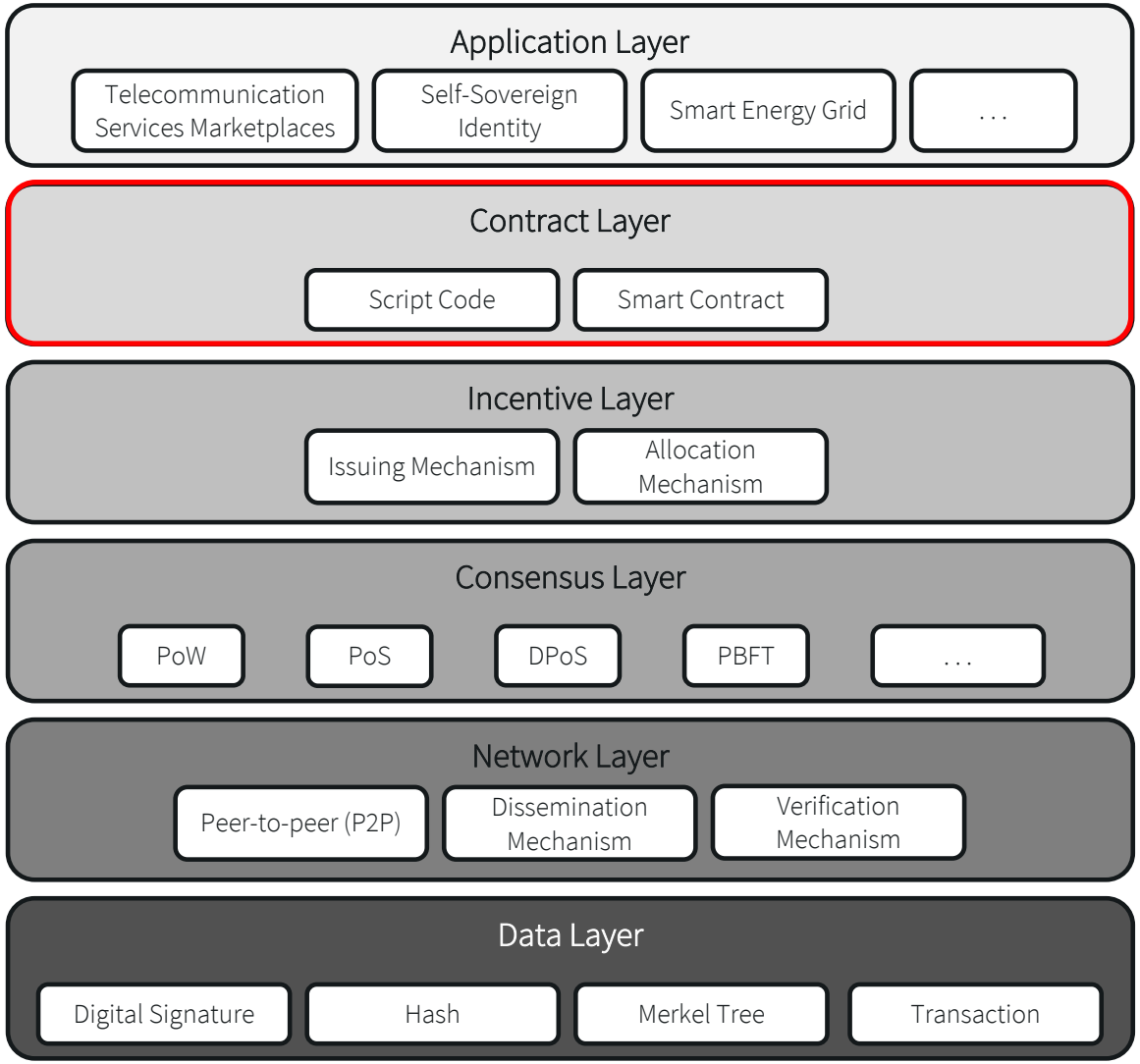
BLOCKCHAIN: INCENTIVE LAYER



- In most cryptocurrencies, the incentive ***issuing mechanism*** is called "mining".
  - ➢ The process of mining involves spending the computational power.

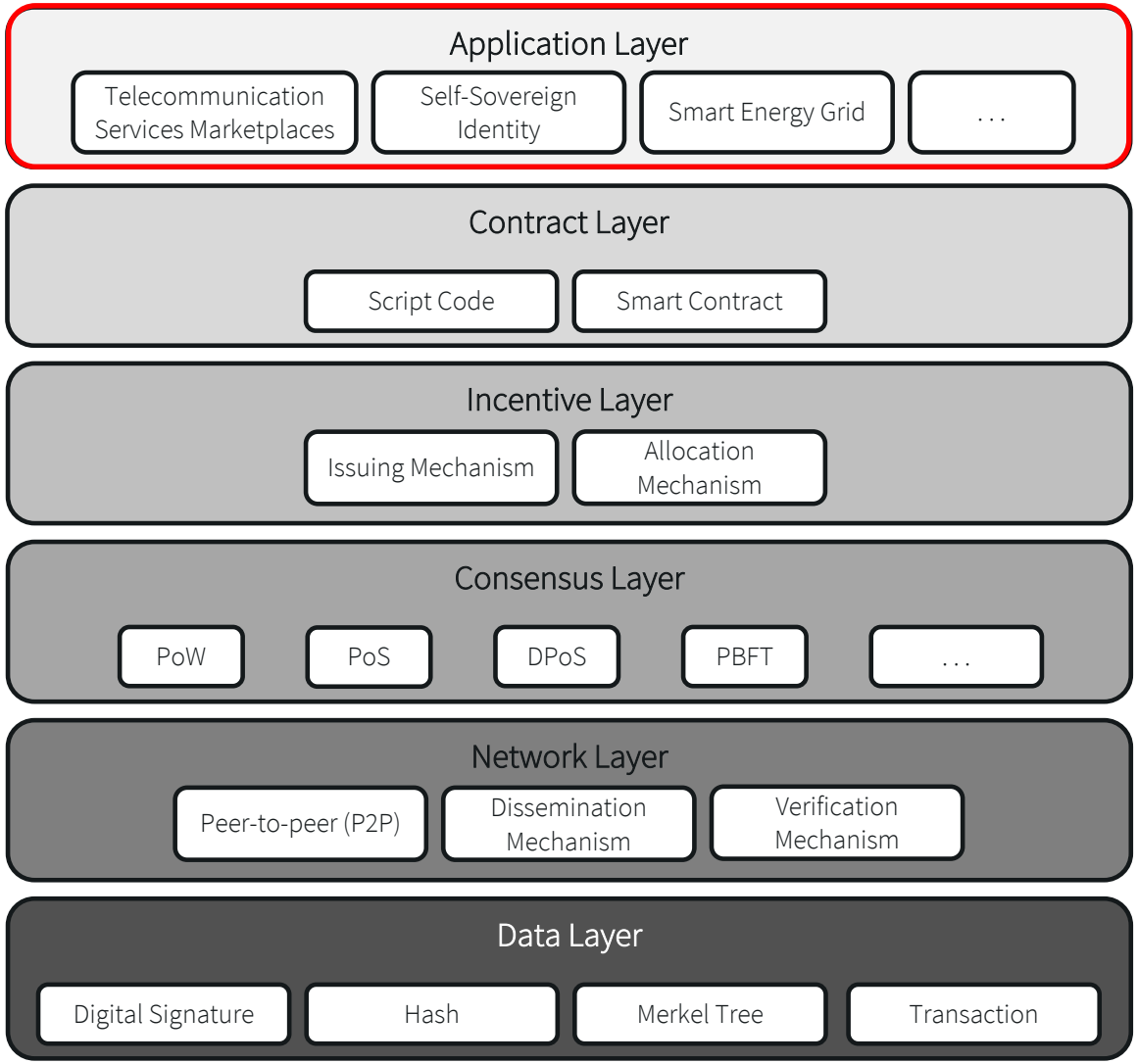
- According to ***allocation mechanism*** some economic incentives will be issued as a reward.
  - ➢ A portion of digital currency will be allocated to corresponding nodes.

BLOCKCHAIN: CONTRACT LAYER



- ***Scripts*** and ***smart contracts*** aim to make transactions in blockchain more flexible, complex, and automated.
  - ➢ Both scripts and smart contracts are securely stored on the ledger.
- ***Script*** is a piece of code that is embedded in a transaction.
- ***Smart contract*** is the evolution of the script.

BLOCKCHAIN: APPLICATION LAYER



- ***Application layer*** comprises different business applications.
- These applications aim to provide new services in decentralized systems.
- Blockchain technology is being researched by multiple communities.
- Also, adopted by multiple companies in the industry sector.

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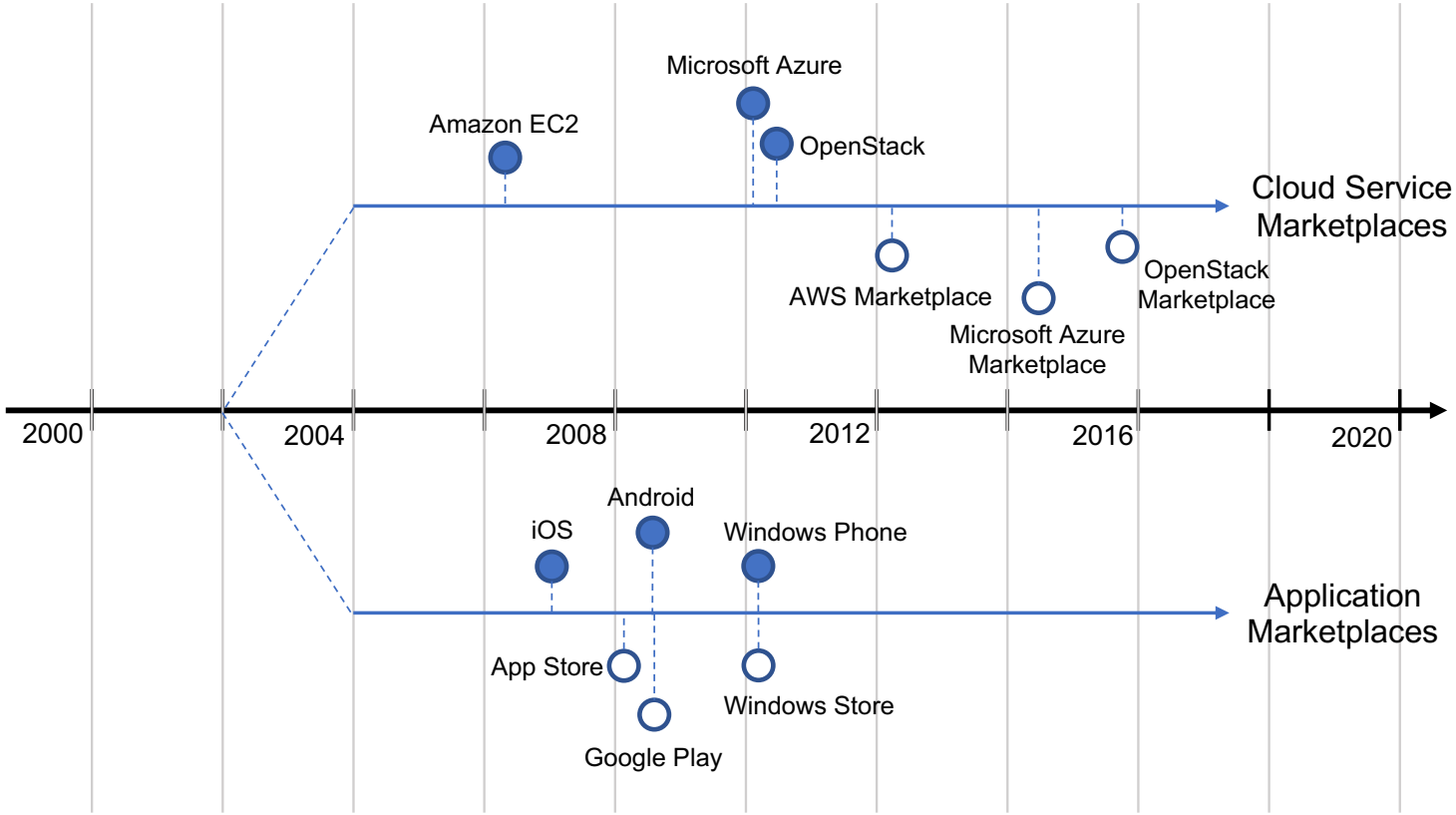
MARKETPLACES



- Digital marketplaces are a concept for the formation of **business opportunities**.

- Defined to meet the requirements of the concepts of ***supply and demand***.

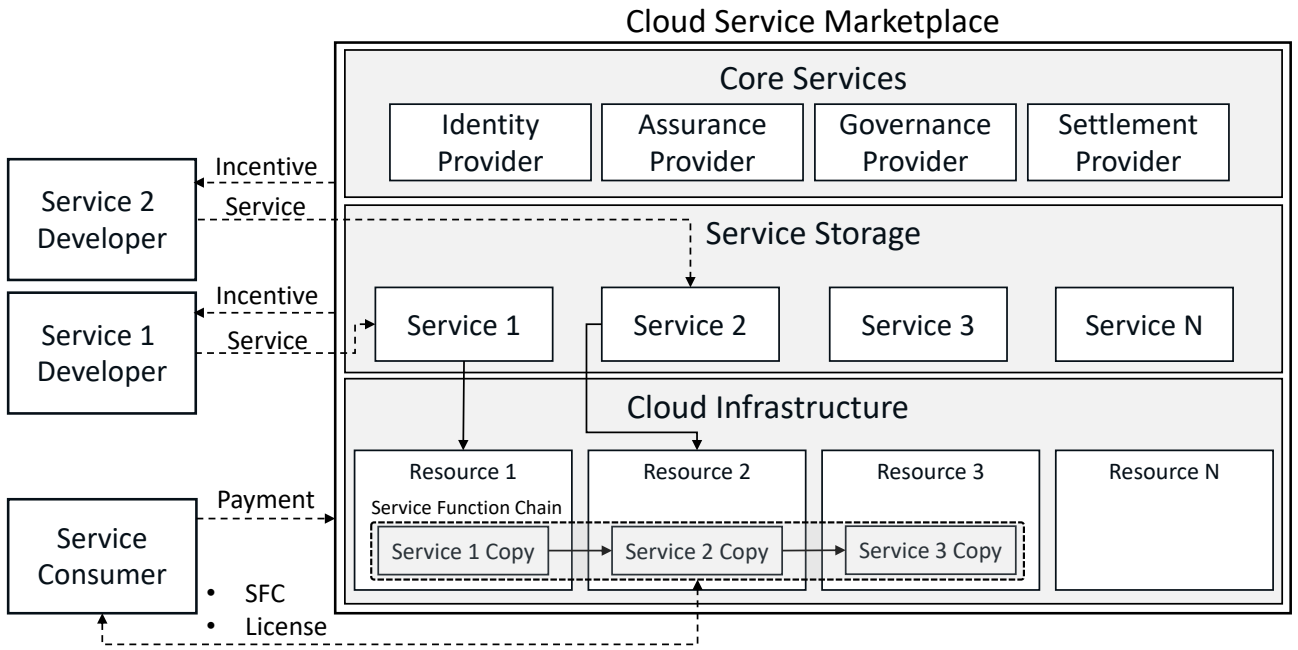
MARKETPLACES

- The business relations inside of the marketplace have to be regulated.
  - It is done through the ***licensing approach***.
- The supply concept also provides a ***payment*** for a software product.
- When centralized – it is the marketplace who ***dictates payment distribution***.

MARKETPLACES: CORE SERVICES

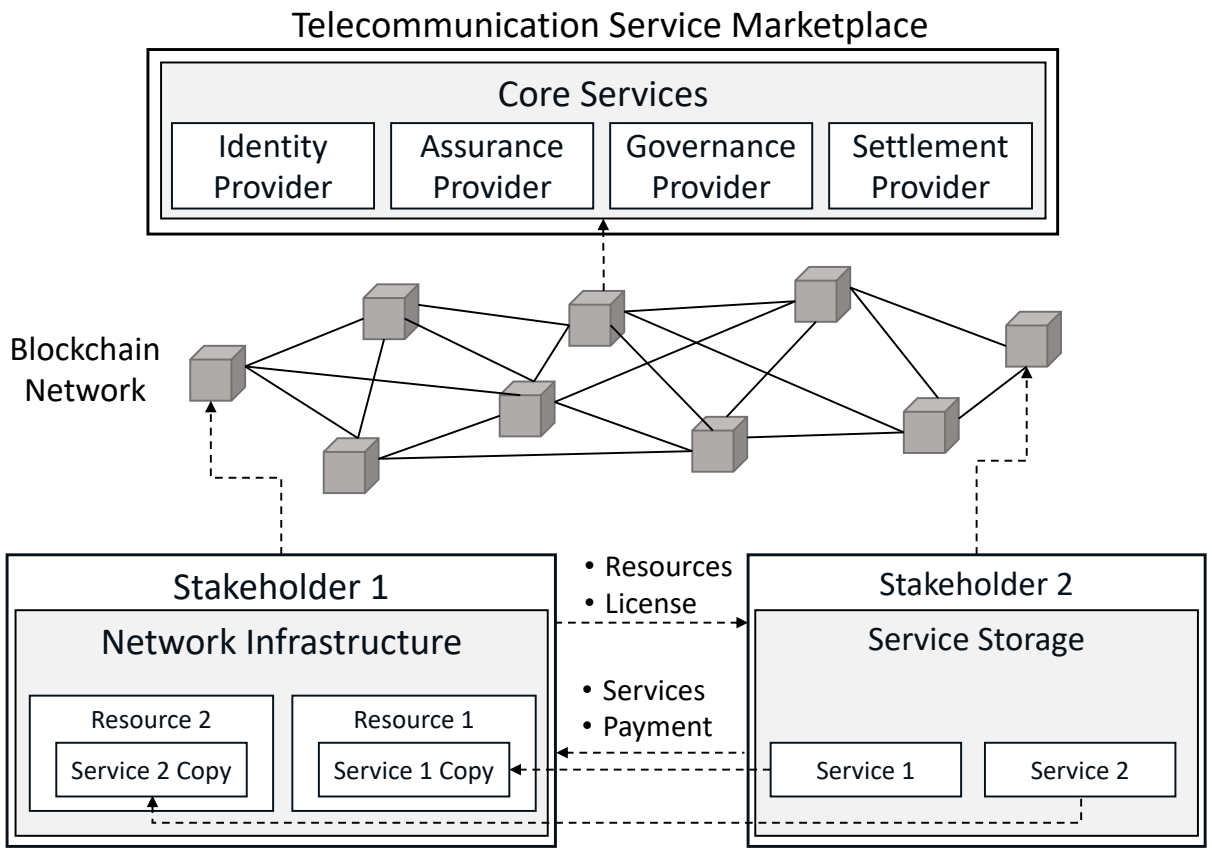
- Identity Management
- Assurance
- Governance
- Business Settlement

CENTRALIZED MARKETPLACES: CLOUD SERVICES



- ***Cloud Services Marketplaces*** (CSMs) are also build with a centralized server representing the ***trust provider***.
- The CSM provider acts as a ***assurance provider*** towards the customers.
- CSM is designed to distribute services that can become a part of the ***Service Function Chains***.

DECENTRALIZED MARKETPLACES:
TELECOMMUNICATION SERVICES



- ***Telecommunication Services Marketplaces*** (TSM) integrate multiple services offered by communication service providers.

- Blockchain allows to establish business relationship, ***without the need of a trusted third-party***.

- Core services of the TSM:
  - Identity Management
  - Assurance
  - Governance
  - Business Settlement

- It is essential to establish ***trust*** between actors within TSM.

TELECOMMUNICATION SERVICES MARKETPLACES:
USE CASE – SERVICE LEVEL AGREEMENT

- Communication Service Provider delivers network capacity.
- *Centralized approach* – third party involvement.
- *Decentralized approach* – network infrastructure is part of the TSM.
- Business Settlement – ***a blockchain smart contract with right and obligations of involved parties***.

TELECOMMUNICATION SERVICES MARKETPLACES:
USE CASE – INTER-CSP SETTLEMENT

- Large *Mobile Network Operators (MNO)* share network infrastructure with *Small Cell Providers (SCP)*.

- *Centralized approach* – SCP contacts MNO for negotiations of agreement.
  - Time-consuming and increased expense.

- *Decentralized approach* – MNO post their infrastructure via TSM.

- Business Settlement – ***a blockchain smart contract with right and obligations of involved parties***.

TELECOMMUNICATION SERVICES MARKETPLACES: STANDARDIZATION

- Communication Business Automation Network (CBAN).
- The European Telecommunications Standards Institute (ETSI).
- Global System for Mobile Communications (GSMA or GSM Association).
- Tele Management (TM) Forum.

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Symphony

- Scope: Cloud services for a virtual marketplace
- KKS-funded collaboration of BTH with Ericsson Research, Affärsverken Energy AB (project runtime: 2020 – 2023)
- Focus areas:
  - Service chains/meshes
  - Federated microservices
  - Compliance and provenance
  - Security and privacy
- Technical approaches:
  - Cloud-native
  - PKI
  - DPKI (distributed ledgers, blockchains)
- Use case:
  - P2P energy sharing

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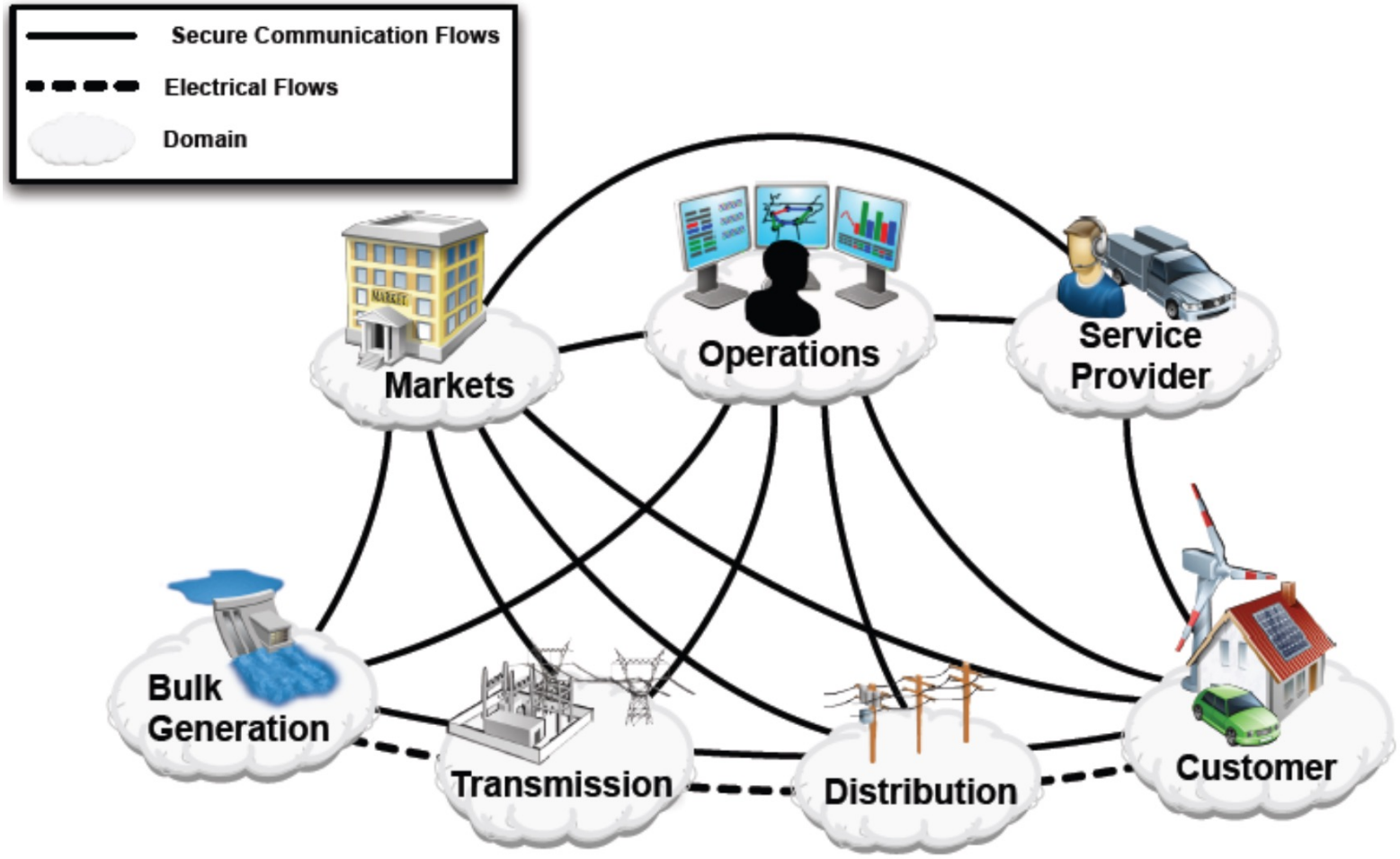
P2P ENERGY SHARING: NIST REFERENCE MODEL



NIST Smart Grid Framework 1.0 January 2010

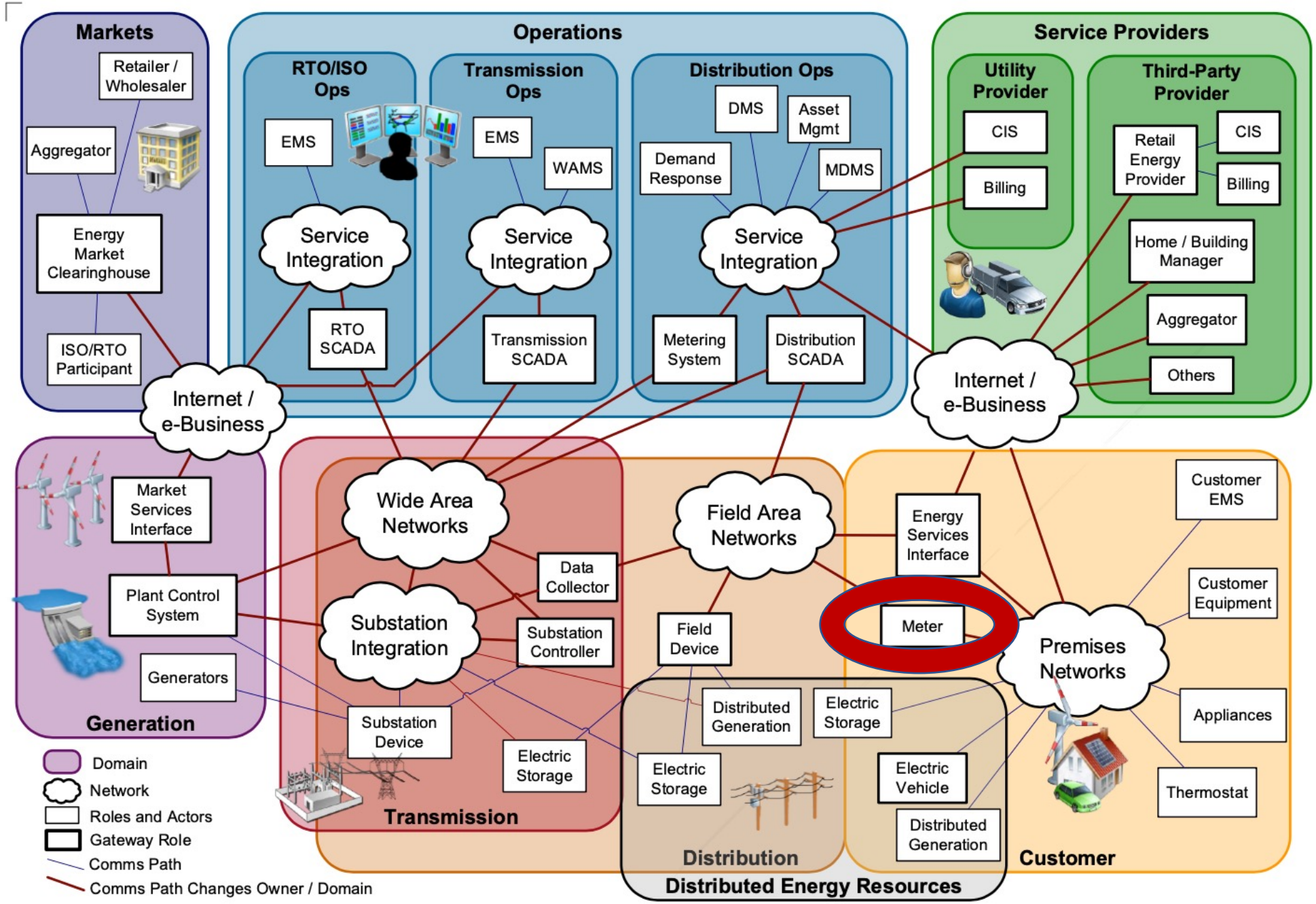
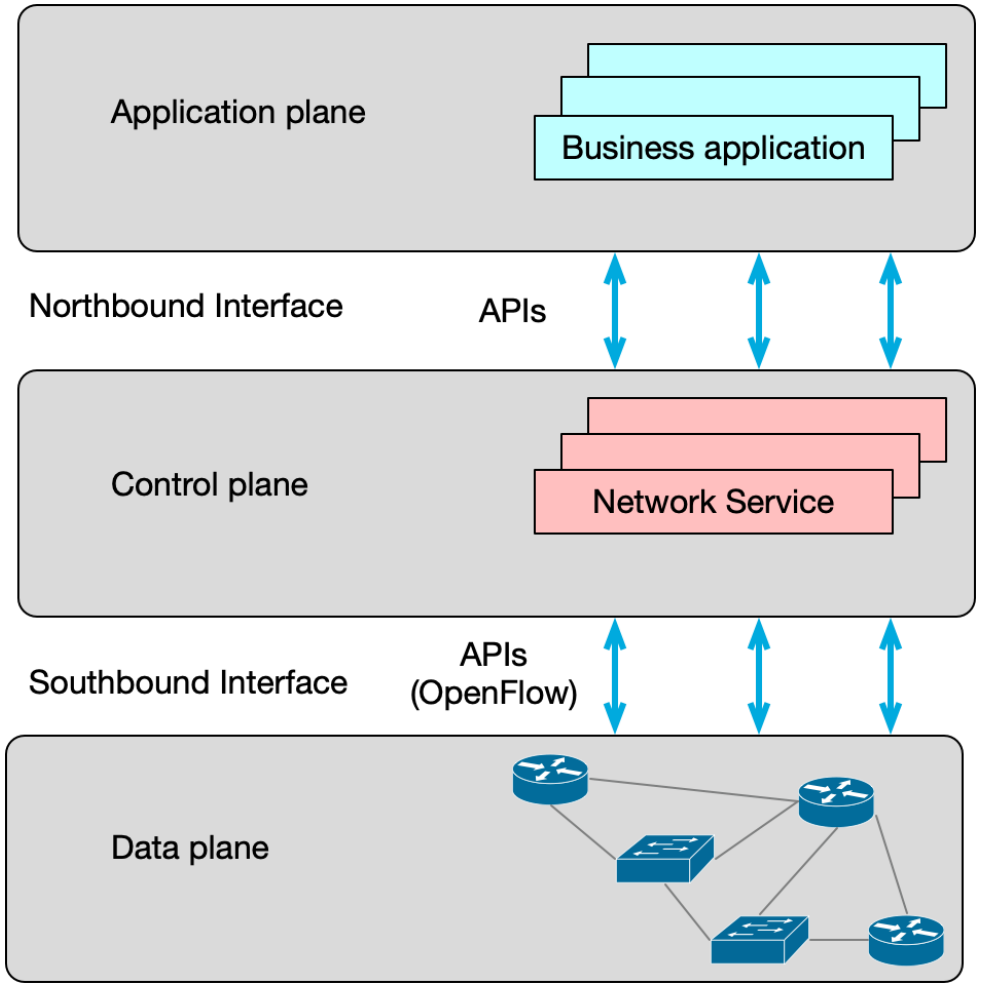
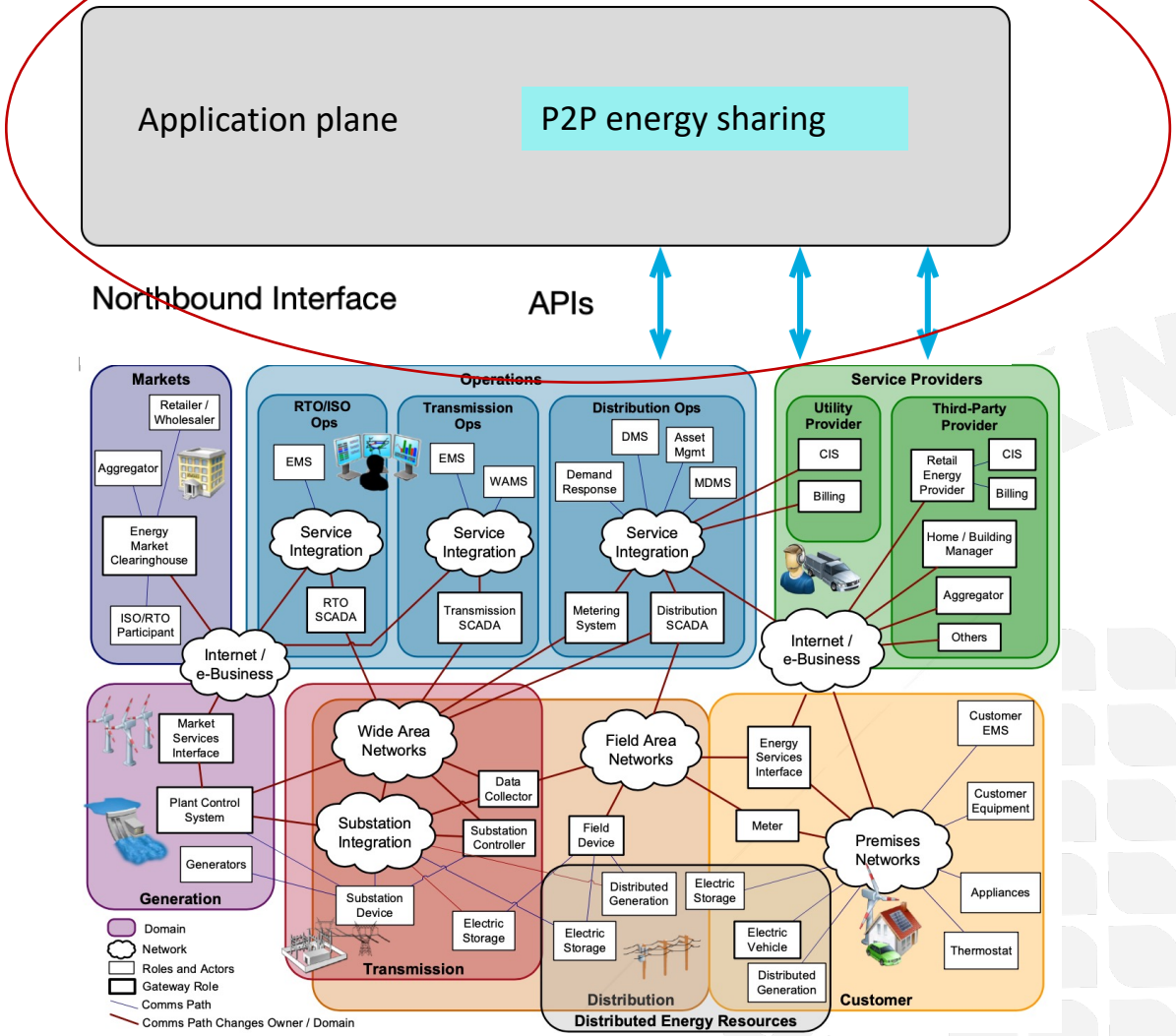


Figure 5-7. Logical Model of Legacy Systems Mapped onto Conceptual Domains for Smart Grid Information Networks

Logical mapping onto an SDN





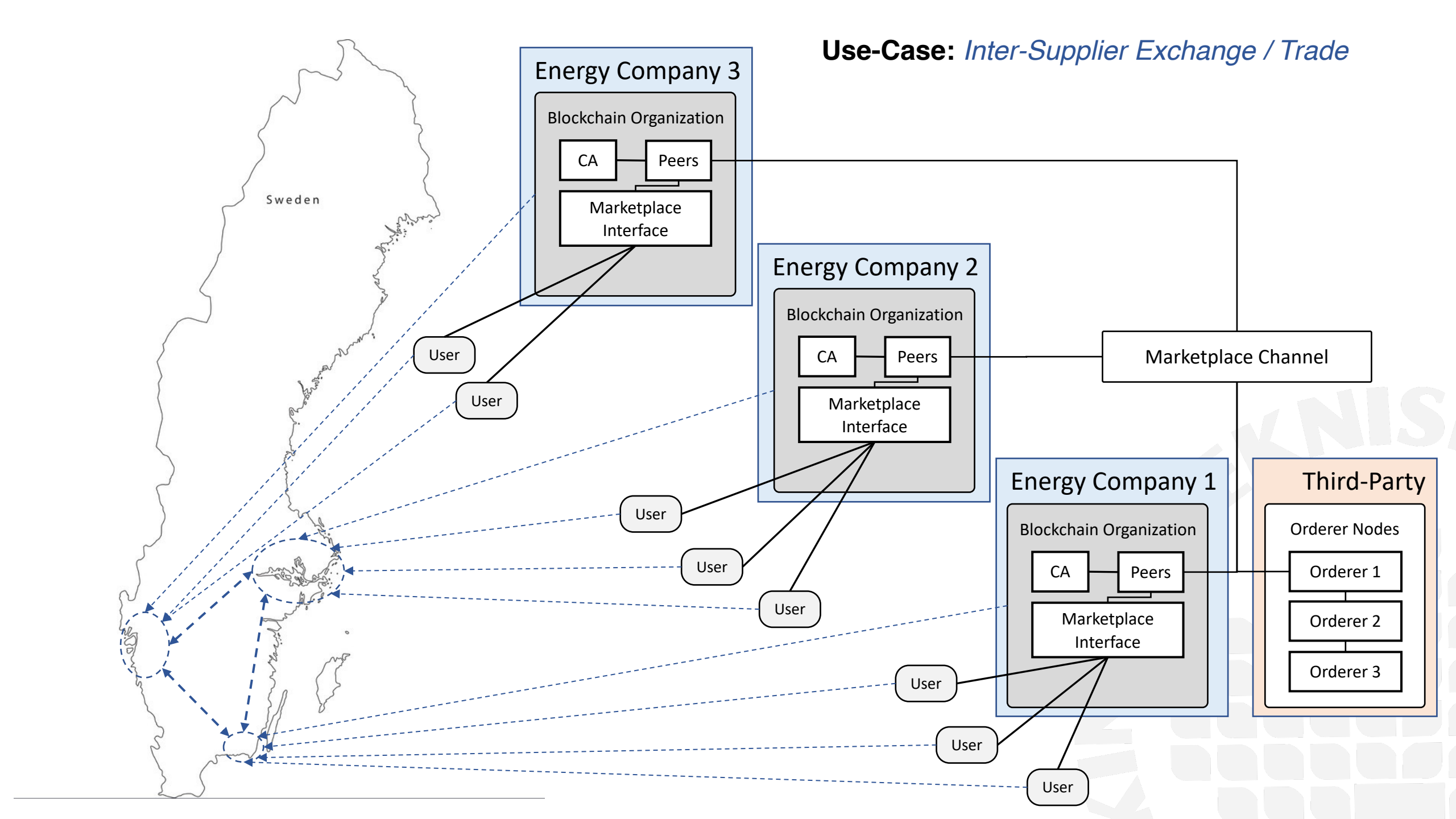
Assumptions (5-10 years span)

- Growing deployment of energy production equipment on customer premise
  - Solar panels
  - Wind mills
  - …
- Deregulations for energy production and sale
- Availability of energy cells for long-term energy storage

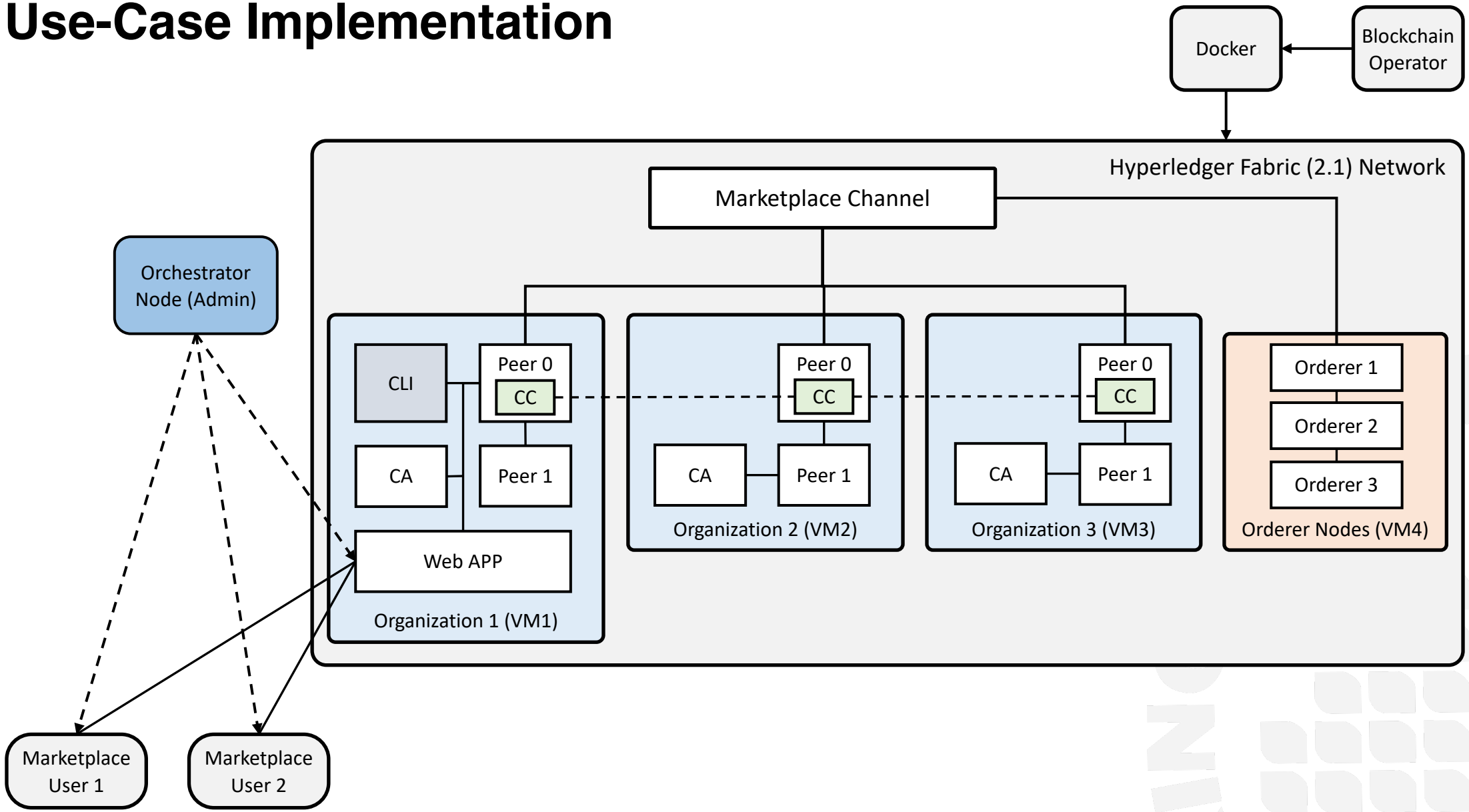
Types of P2P energy sharing

- Pure exchange between prosumers and consumers
  - Exchange of virtual kWhs
  - Prices decided by regulatory bodies
- Trading (like stock trading)
  - Prosumers advertise cost (cost range) for produced energy
  - Consumers advertise targeted purchase price (price range)
- Auction
  - Prosumer/consumer advertises interest in selling/buying at a start price
  - Consumers/prosumers bid and the best offer wins
- Feature: guarantee of origin (how green is the shared energy)

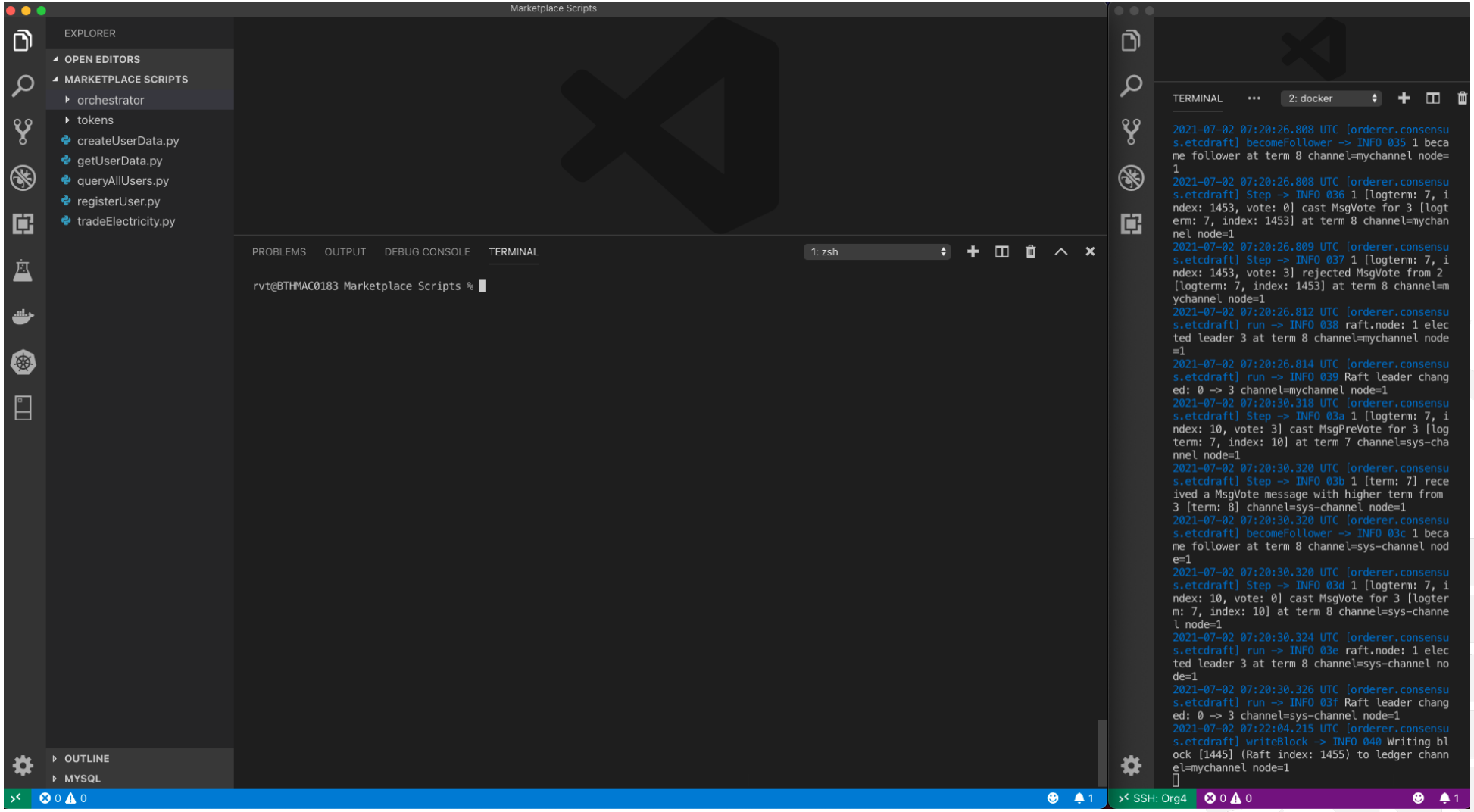
Use-Case: *Inter-Supplier Exchange / Trade*



Use-Case Implementation



DEMO


Marketplace Scripts
EXPLORER
OPEN EDITORS
MARKETPLACE SCRIPTS
orchestrator
tokens
createUserData.py
getUserData.py
queryAllUsers.py
registerUser.py
tradeElectricity.py
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
1: zsh
rvt@BTHMAC0183 Marketplace Scripts %
OUTLINE
MYSQL
TERMINAL
2: docker
2021-07-02 07:20:26.808 UTC [orderer.consensus.etcdraft] becomeFollower -> INFO 035 1 became follower at term 8 channel=mychannel node=1
2021-07-02 07:20:26.808 UTC [orderer.consensus.etcdraft] Step -> INFO 036 1 [logterm: 7, index: 1453, vote: 0] cast MsgVote for 3 [logterm: 7, index: 1453] at term 8 channel=mychannel node=1
2021-07-02 07:20:26.809 UTC [orderer.consensus.etcdraft] Step -> INFO 037 1 [logterm: 7, index: 1453, vote: 3] rejected MsgVote from 2 [logterm: 7, index: 1453] at term 8 channel=mychannel node=1
2021-07-02 07:20:26.812 UTC [orderer.consensus.etcdraft] run -> INFO 038 raft.node: 1 elected leader 3 at term 8 channel=mychannel node=1
2021-07-02 07:20:26.814 UTC [orderer.consensus.etcdraft] run -> INFO 039 Raft leader changed: 0 -> 3 channel=mychannel node=1
2021-07-02 07:20:30.318 UTC [orderer.consensus.etcdraft] Step -> INFO 03a 1 [logterm: 7, index: 10, vote: 3] cast MsgPreVote for 3 [logterm: 7, index: 10] at term 7 channel=sys-channel node=1
2021-07-02 07:20:30.320 UTC [orderer.consensus.etcdraft] Step -> INFO 03b 1 [term: 7] received a MsgVote message with higher term from 3 [term: 8] channel=sys-channel node=1
2021-07-02 07:20:30.320 UTC [orderer.consensus.etcdraft] becomeFollower -> INFO 03c 1 became follower at term 8 channel=sys-channel node=1
2021-07-02 07:20:30.320 UTC [orderer.consensus.etcdraft] Step -> INFO 03d 1 [logterm: 7, index: 10, vote: 0] cast MsgVote for 3 [logterm: 7, index: 10] at term 8 channel=sys-channel node=1
2021-07-02 07:20:30.324 UTC [orderer.consensus.etcdraft] run -> INFO 03e raft.node: 1 elected leader 3 at term 8 channel=sys-channel node=1
2021-07-02 07:20:30.326 UTC [orderer.consensus.etcdraft] run -> INFO 03f Raft leader changed: 0 -> 3 channel=sys-channel node=1
2021-07-02 07:22:04.215 UTC [orderer.consensus.etcdraft] writeBlock -> INFO 040 Writing block [1445] (Raft index: 1455) to ledger channel=mychannel node=1
SSH: Org4

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Decentralized Blockchain-based Telecom-munication Services Marketplaces

- Summary
  - Blockchains can be the trust-enabling technology in future CSP systems with federation of infrastructure and services
  - Fundamental Blockchain functions in TSMs: identity management, assurance, governance, and business settlement
  - Marketplaces are excellent platforms to engage stakeholders and establish business relationships
  - Demoed Blockchains capabilities for TSM and virtual P2P energy sharing which shows the significance of the concept

Decentralized Blockchain-based Telecom-munication Services Marketplaces

- Future developments
  - In depth investigation of the P2P energy sharing and Blockchains, e.g., different types of trading and application of smart contracts
  - Maintenance efforts for Blockchain based marketplace.
  - Performance characteristics of Blockchain-based marketplaces.
  - Decentralized systems consensus mechanisms investigation. How can the settlement be made smarter?

Thank you for your attention!

Questions?

For further information, please contact:

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Kurt Tutschku (ktt@bth.se)