Co-creation of composable network digital twins for autonomous control and management

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Gyu Myoung Lee (g.m.lee@ljmu.ac.uk)

Professor, Liverpool John Moores University, UK

LIVERPOOL JOHN MOORES UNIVERSITY

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Introduction

Introduction

- **Data**
  - From data to actionable knowledge for creating value
- **Connected Intelligence**
  - From Cloud Native to AI Native
  - Decentralized intelligence
- **Fully automated Infrastructure**
  - AI for networks and Networks for AI

Decentralized AI Platforms

SingularityNET

OpenMined

ALGORITHMIA

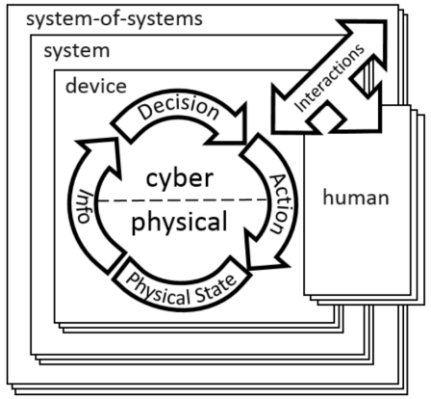
ocean

Self-X network

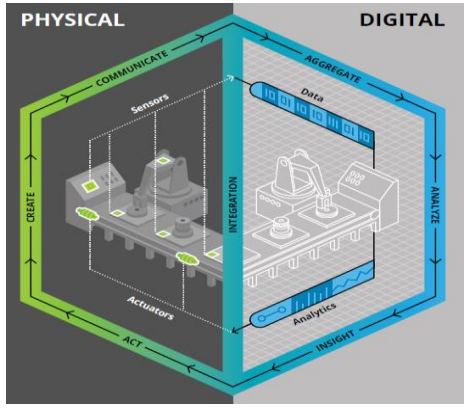
Intelligent Ecosystem of Ecosystems

Data-driven AIoT with Digital Twin Model

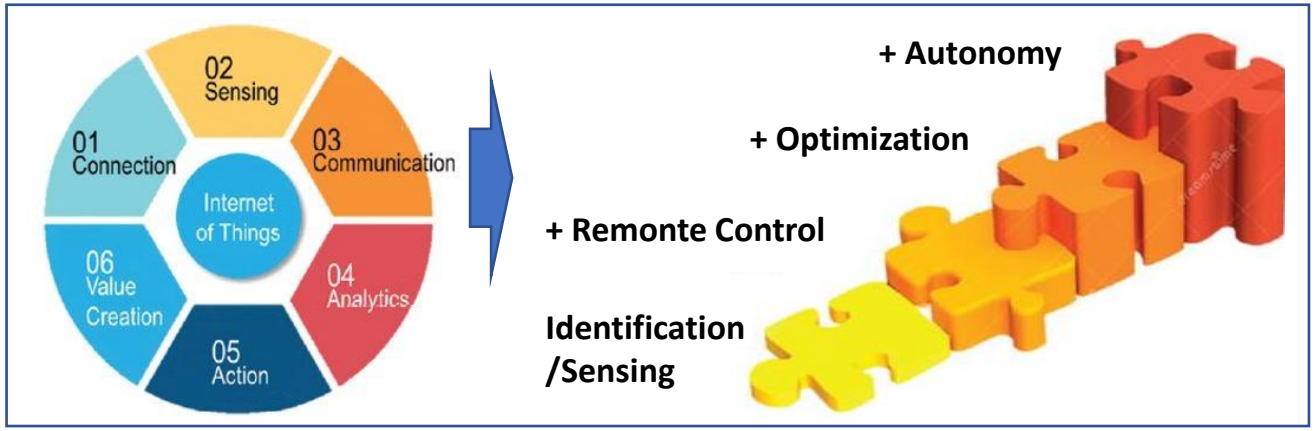
Internet of Things
Cyber Physical Systems



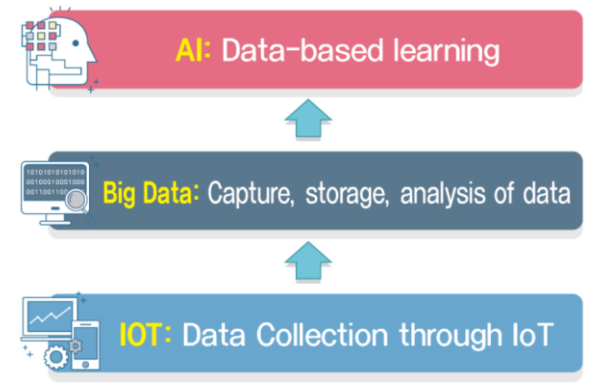
Digital Twin Model



From Connecting Devices to Creating Value

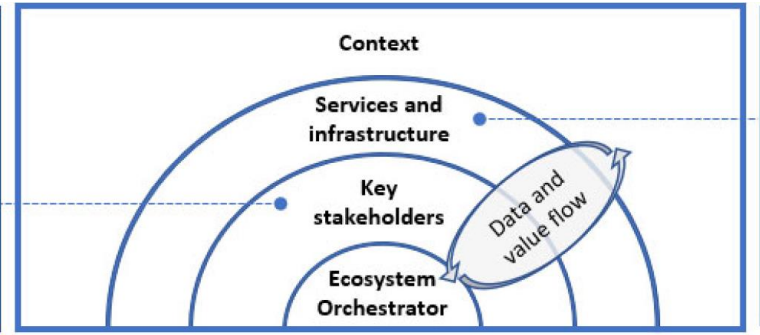


Artificial Intelligence of Things



- **The Ecosystem of ecosystems**
  - Technology ecosystems (e.g., 5G, Clouds, IoT, Big Data & AI, etc.)
  - Vertical domain specific ecosystems (e.g., industrial, health, energy, etc.)

Key stakeholders and their roles
Who are the key stakeholders? What are their roles in the data ecosystem?
Who is the Data Ecosystem Orchestrator?
Who are the Data Providers?
Who are the Data Consumers?

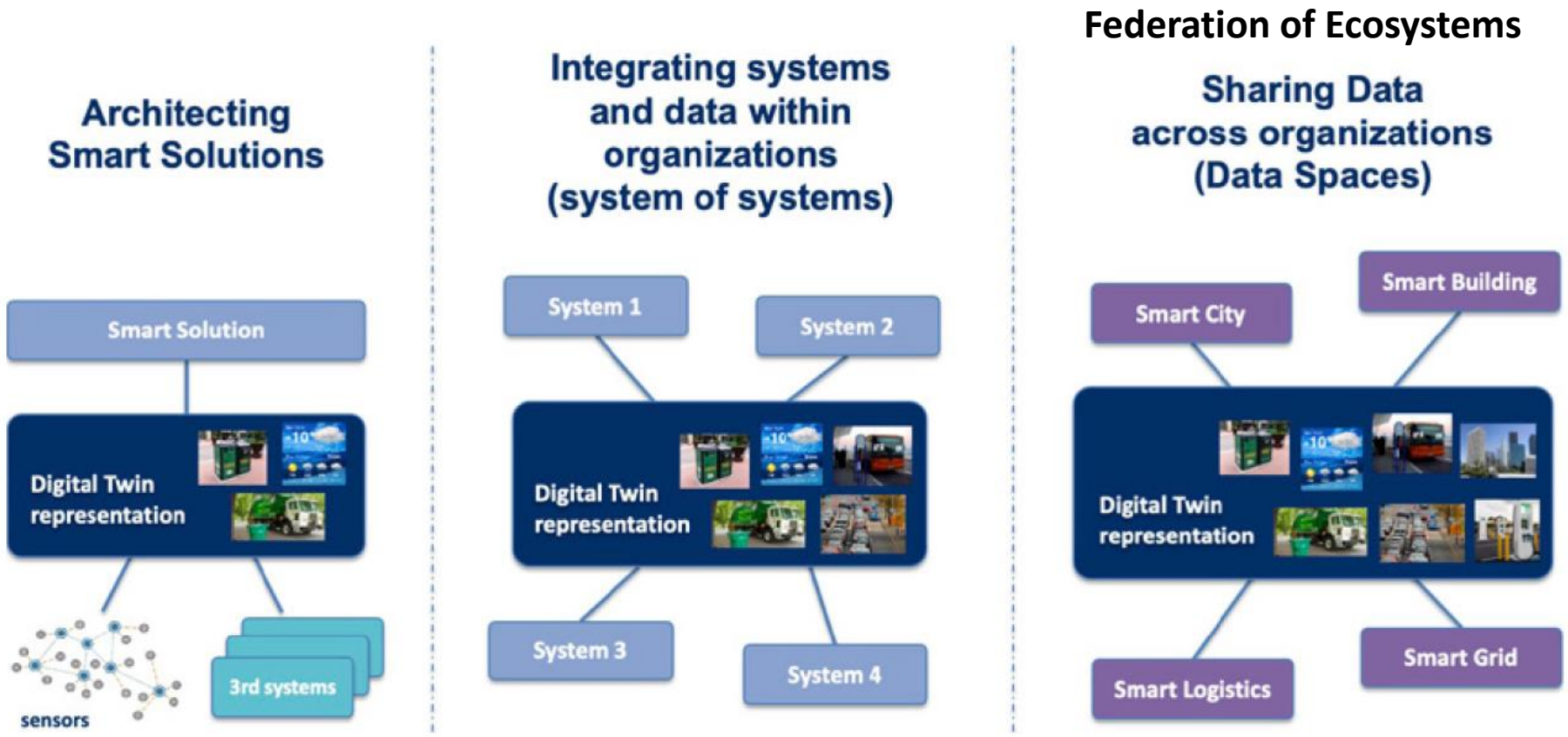


Services and infrastructure
What value adding services are needed in the ecosystem?
What infrastructure is required?
Who are the trusted intermediaries?

Scaling up – large scale virtual continuum

FIWARE
Digital Twin

cdbb
Centre for Digital Built Britain



Lessons from Microservices

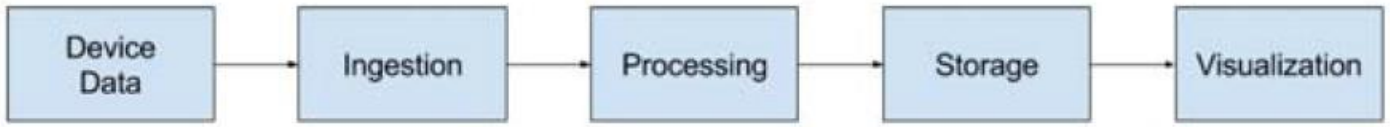
Microservices

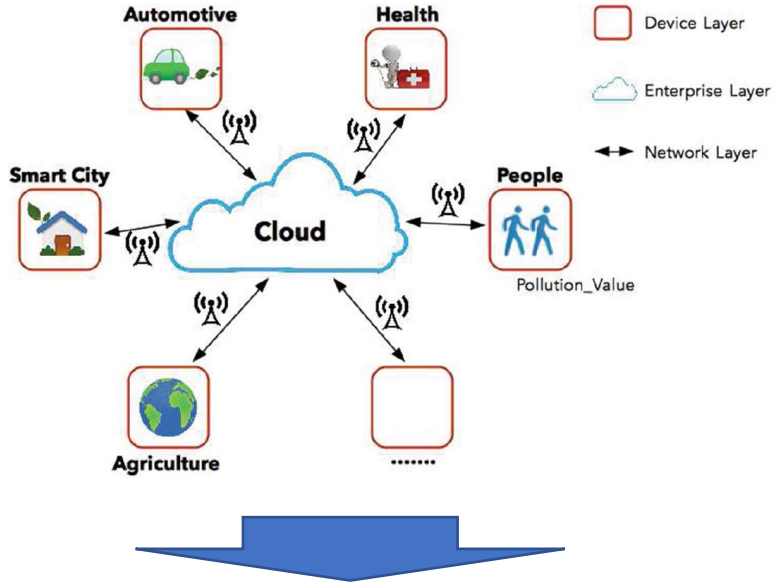
- The microservice architectural style
  - an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, often an HTTP(S) resource API.
- Microservices
  - Are small in size
  - Use message driven communication
  - Bounded by contexts
  - Autonomously developed
  - Independently deployable
  - Decentralized
  - Built and released with autonomous processes

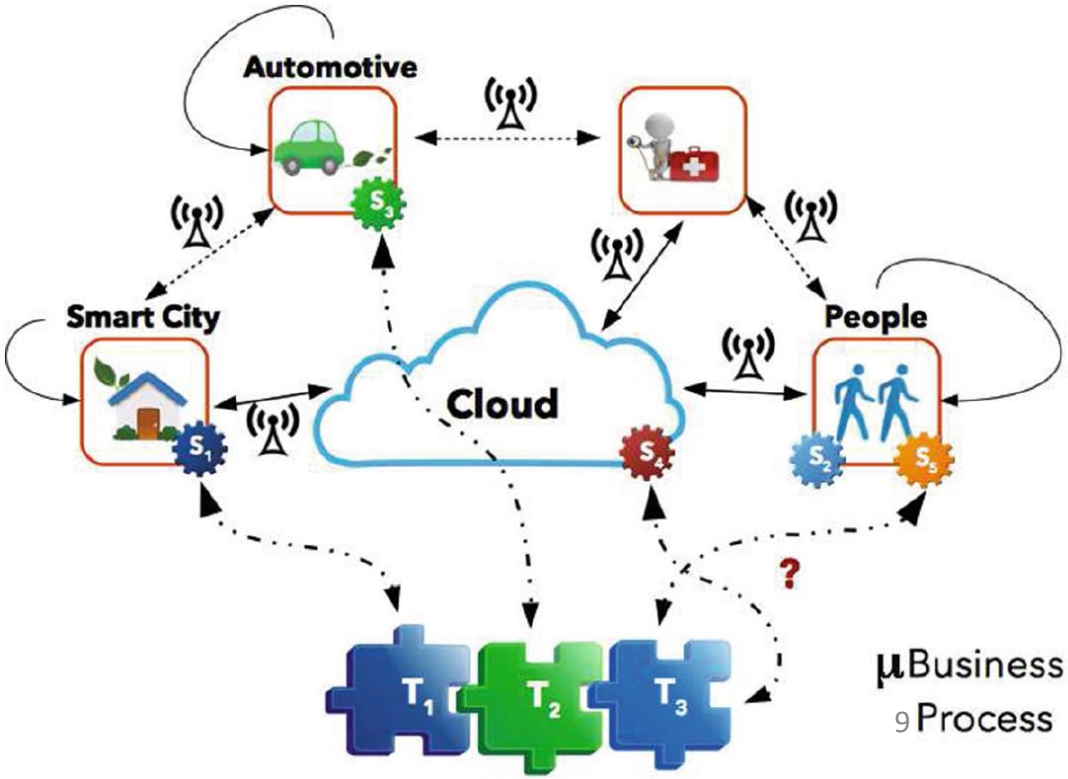
Composable IoT

Challenges for user driven service creation and composition

- Create applications from many different services (**Microservices** - **Containerization**)
  - Application is comprised of several smaller parts.
  - Microservices can be containerized such as Event Hubs or IoT Hubs.
- Data Pipeline
  - Applications work with IoT data
  - A series of steps

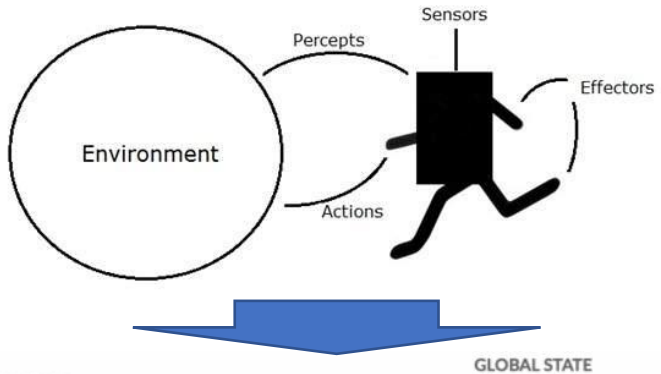


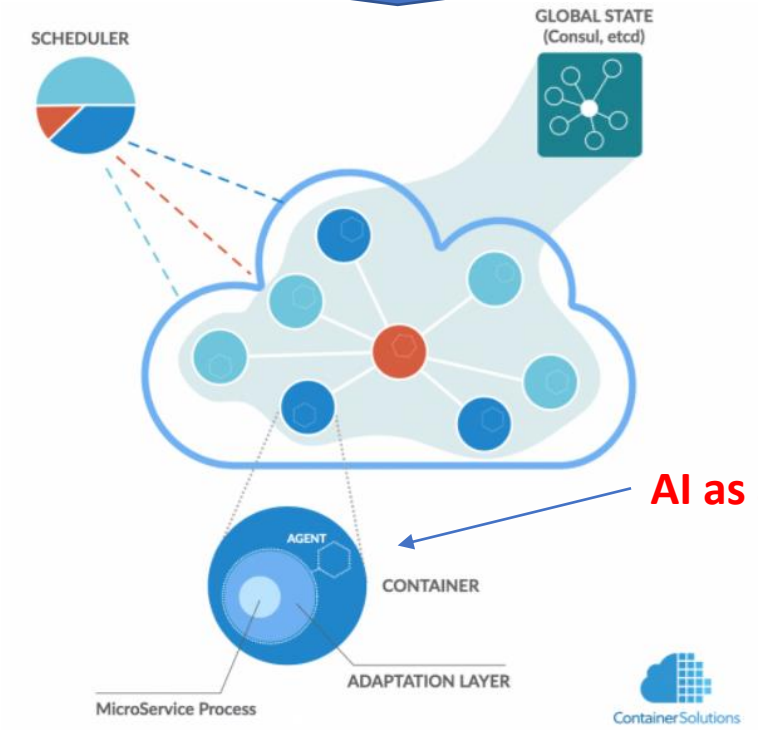




Embedded AI on Edge

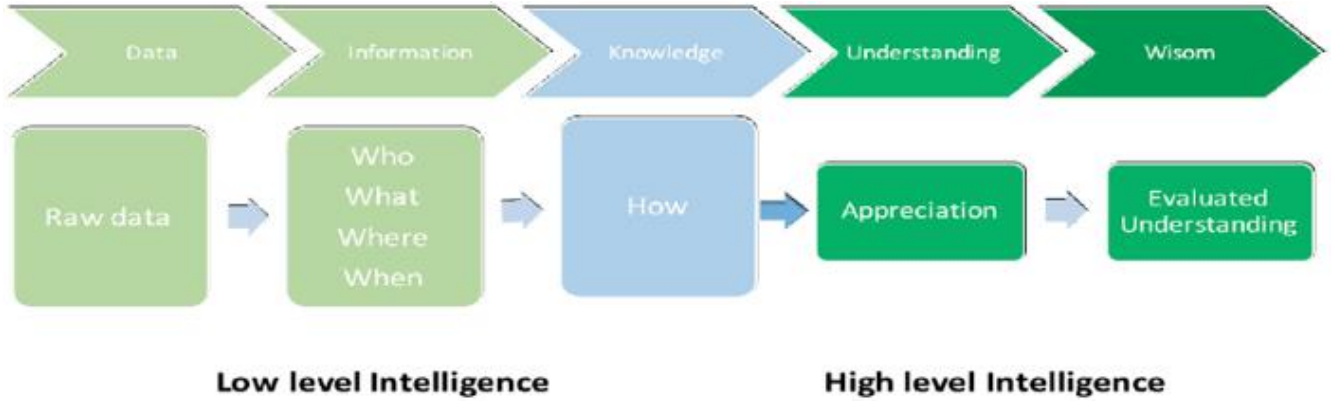
Lightweight Programmable AI Agents



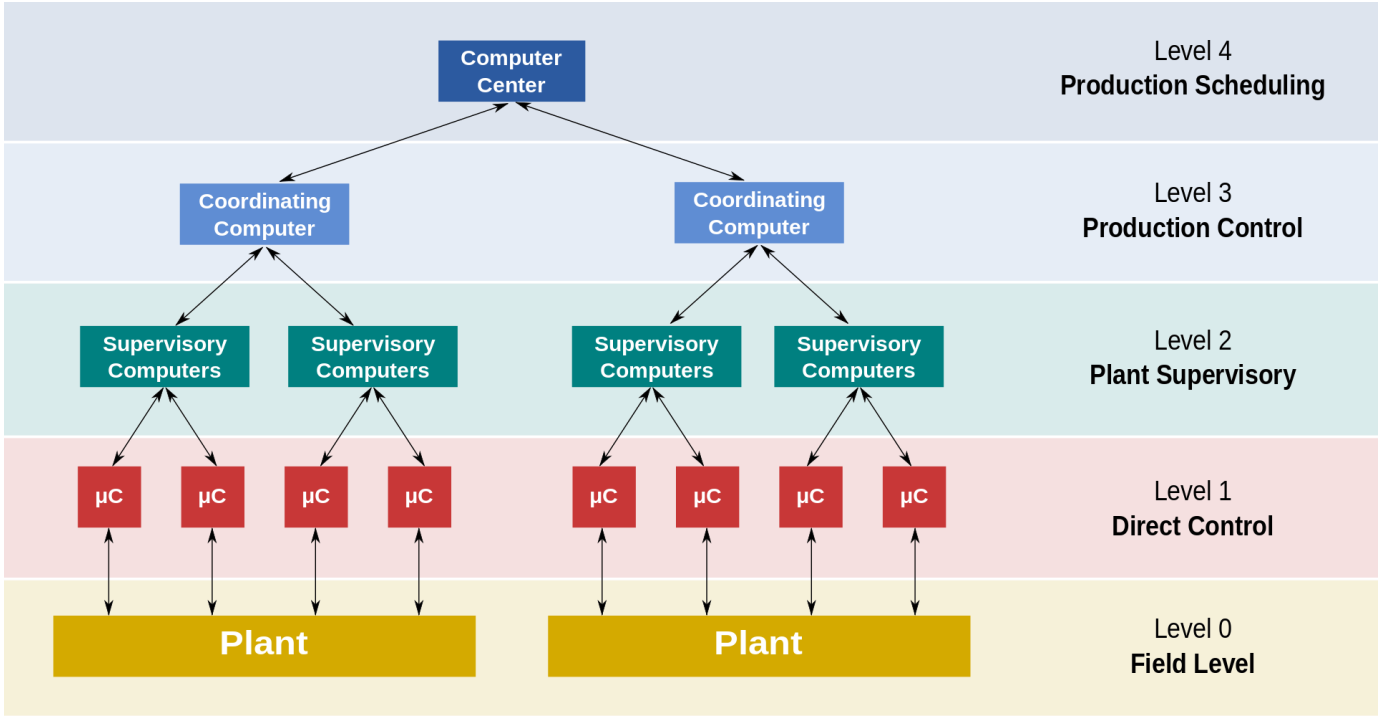


AI as a MicroService

Distributed Intelligence



Decision Making Hierarchy



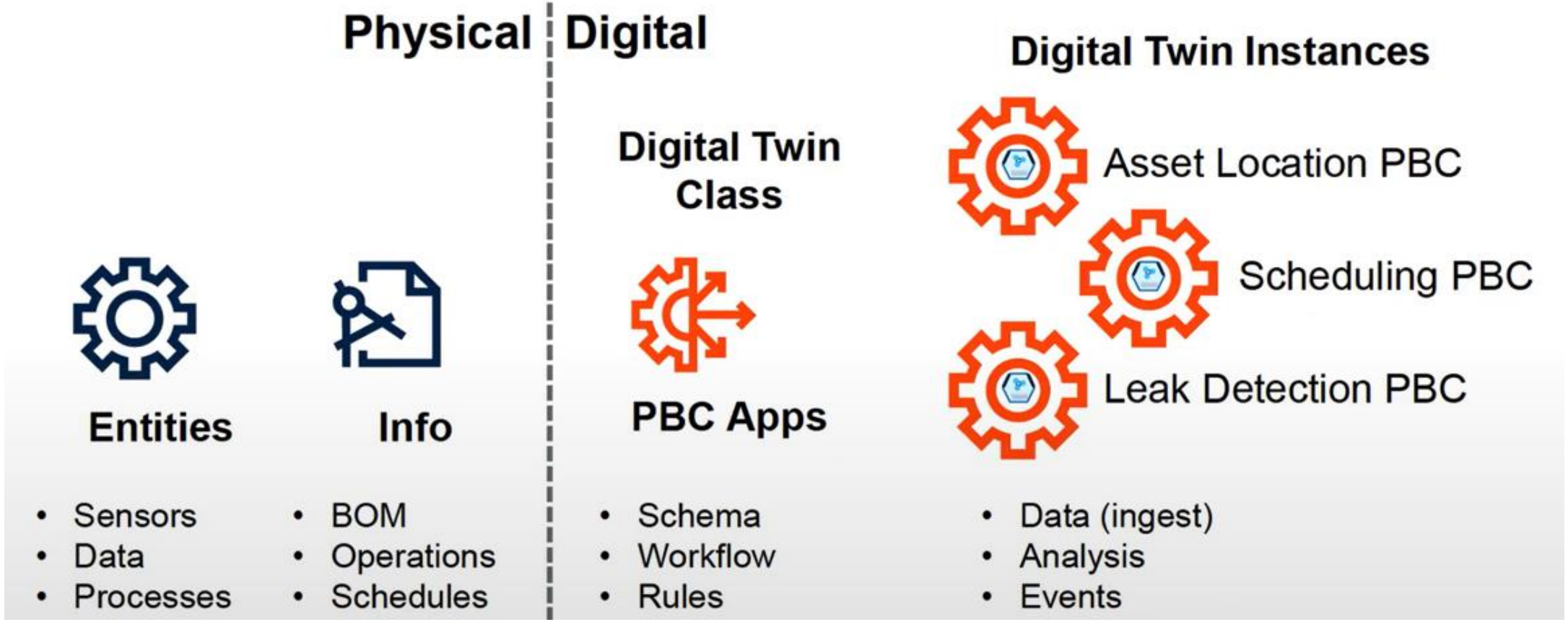
Example: Functional levels of a manufacturing control operation

Composable Digital Twins

Composable Business Applications (Gartner)

- Paradigm shifts from traditional monolithic applications
- Intelligent Composable Business Applications
  - Resilience require modular applications that can be recomposed on demand
  - Business and technology innovation must be closely aligned – empower business experts
  - Traditional solutions reduce business ability for fast, informed and contextualized decision making

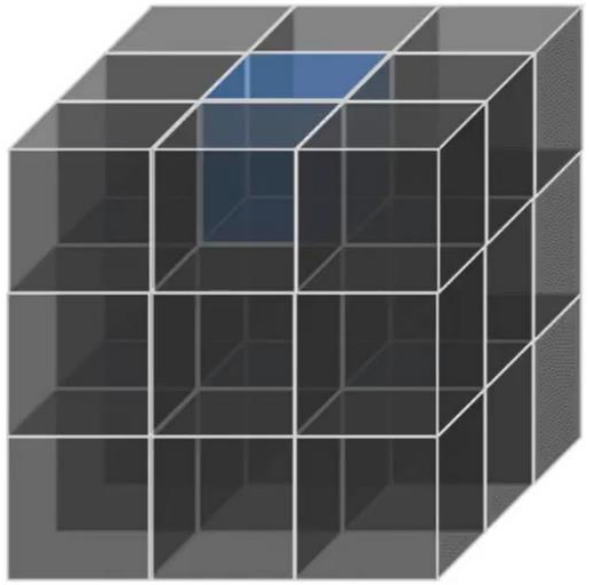
IoT and Digital Twin Enabled Packaged Business Capabilities (PBC)



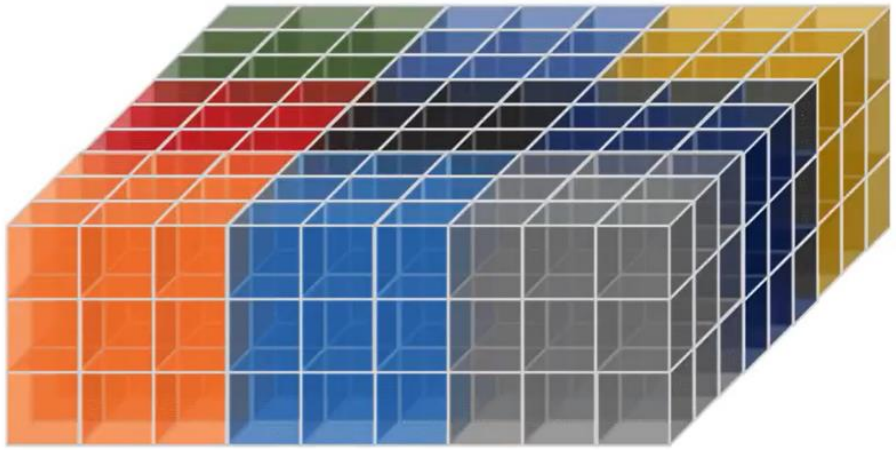
Source: Gartner

Complexity requires model-based approach

Discreet
Single/Atomic Entity
Gearbox



Composite Assembly of Twins
Ball Mill - Mining

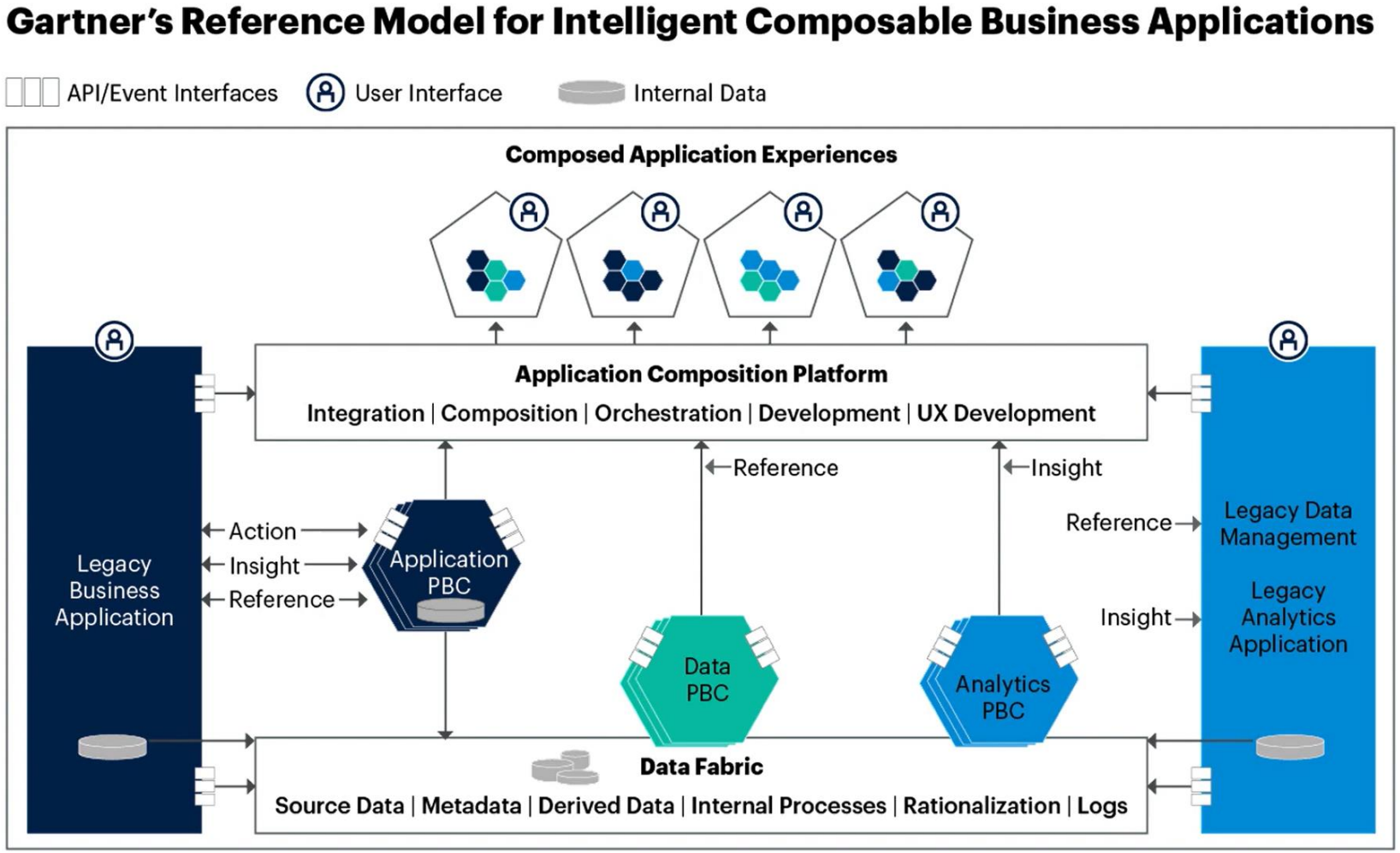


Composite System of Twins
Processing Plant or Factory

https://xmpro.com/digital-twins-the-ultimate-guide/

Composable architecture – Modular approach

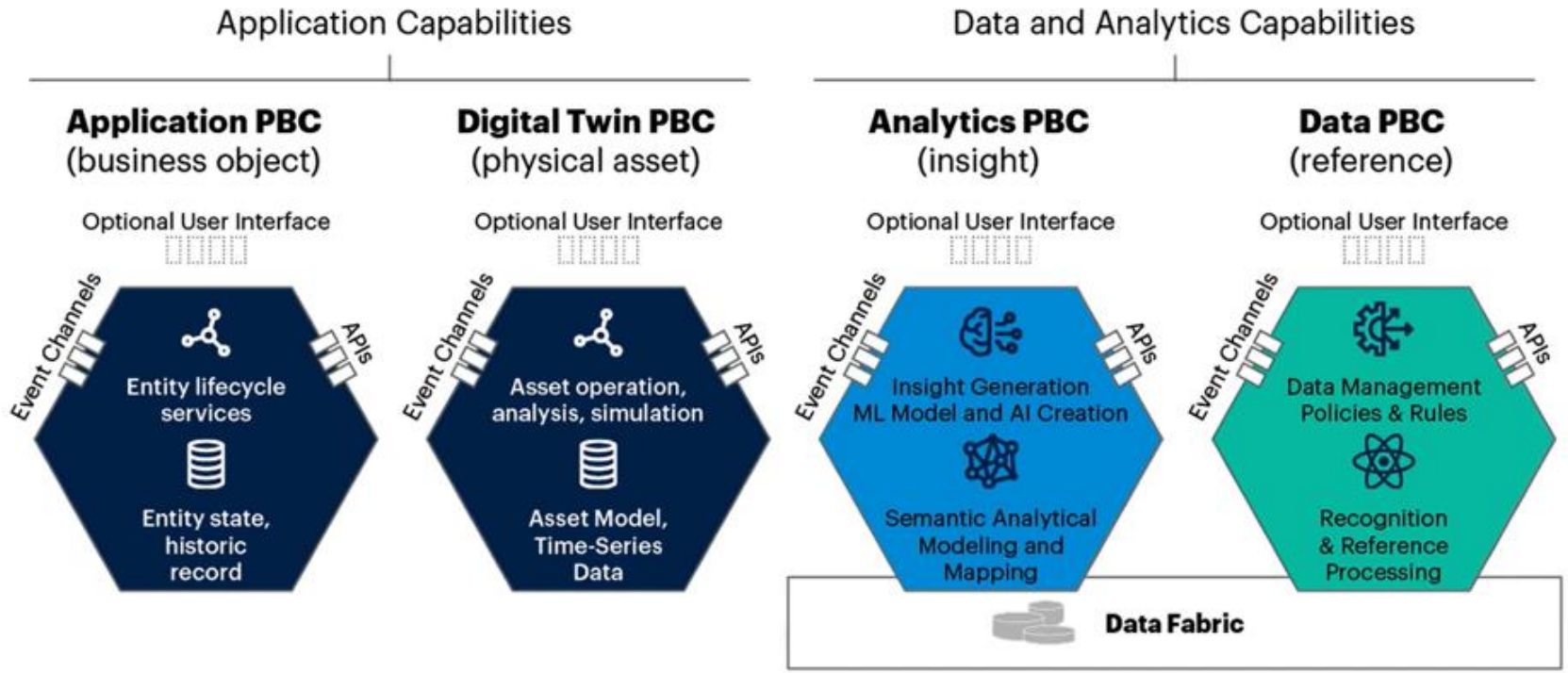
- Gartner
  - Super-apps (2023)
  - Composable Application (2022)
  - Intelligent Composable Business (2021)



Source: Gartner
720701_C

PBC: Package Business Capability

PBCs: The Building Blocks of Intelligent Composable Business Applications



Examples

- Patient
- Purchase order
- Product

Examples

- Infection detector
- Vehicle
- Turbine

Examples

- Infection rate prediction
- Credit rating
- Fraud detection

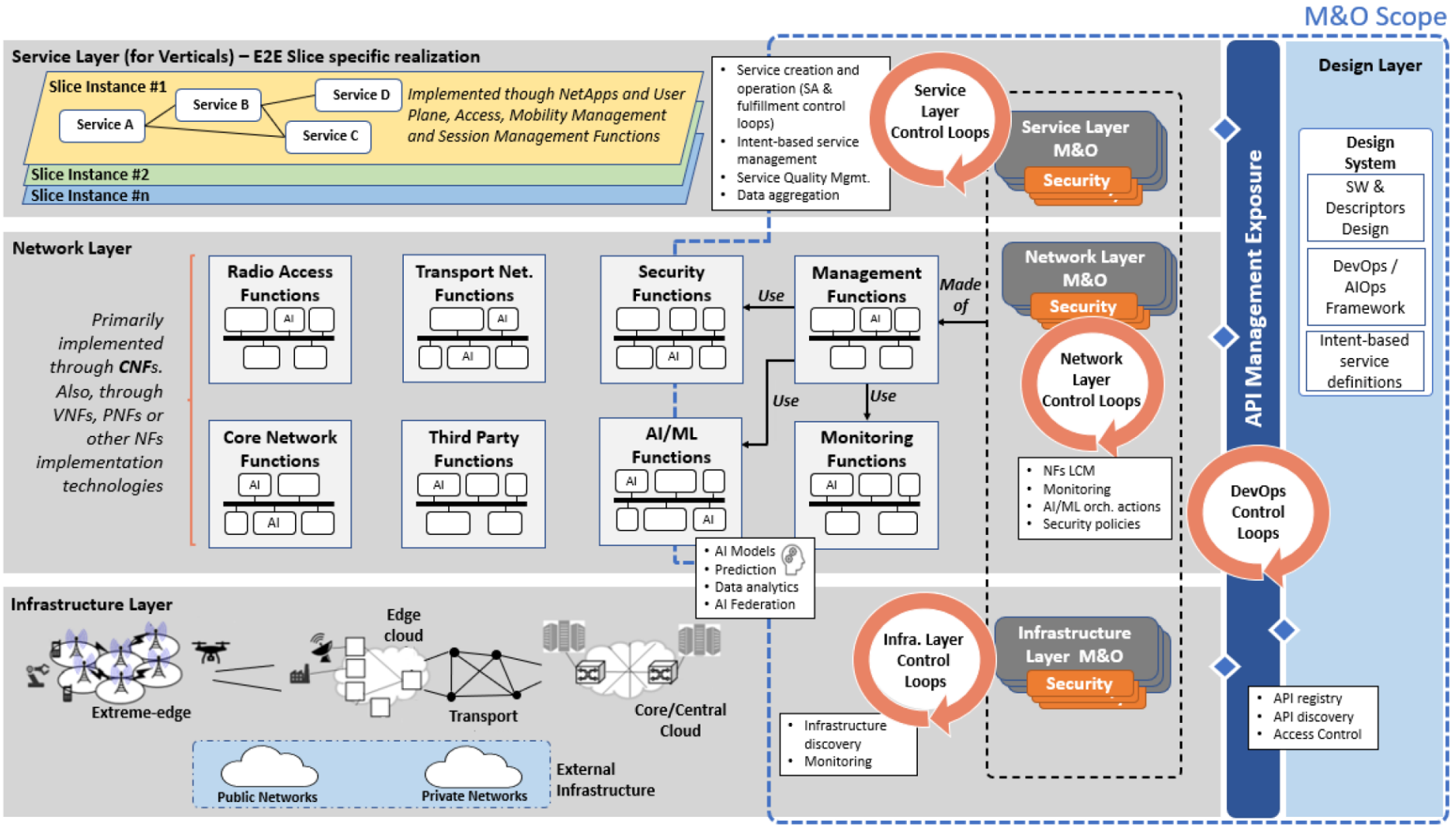
Examples

- Infection incidence collection
- Keyword search
- Knowledge graph management

Source: Gartner

Composable Network Digital Twins

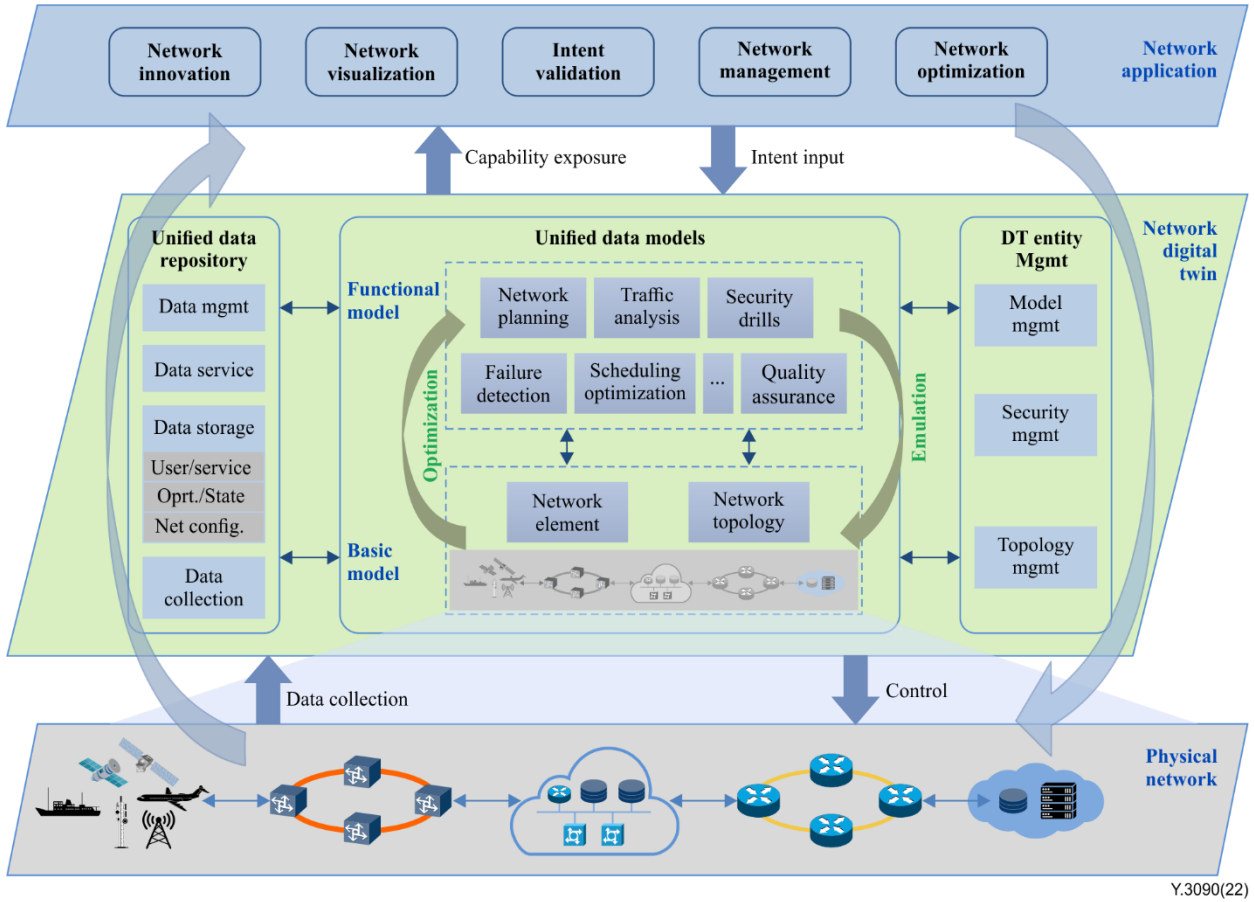
Intelligent control and management



Source: 5G-PPP

Network Digital Twins

- **A digital twin for networks (IETF)**
  - applying Digital Twin technologies to networks and creating a virtual image of real network facilities
  - an expansion platform of network emulation as a tool for scenario planning, impact analysis, and change management
  - achieve more simplification, automatic, resilient, and full life-cycle operation and maintenance
- **Digital twin network (ITU-T Y.3090)**
  - A virtual representation of a physical network.
  - It is useful for analysing, diagnosing, emulating and controlling the physical network based on data, model and interface, to achieve the real-time interactive mapping between the physical network and virtual twin network.



Vision for smart networks

- Future 6G networks will be fully integrated with all societal infrastructure towards smart networks and services
- The “data pipe” model used by the existing Internet protocol stack is no longer ideal for many emerging applications.

It is not about end-to-end transport any more

- **Fundamental cornerstone for the production of all services**

a distributed, virtual, tailored ICT services factory

Future network trends – Network platform

- The key drivers of network platform evolution
  - Trend #1: a collaborative, automated physical world
  - Trend #2: connected, intelligent machines
  - Trend #3: the internet of senses
- Critical enablers of the future network platform
  - Trend #4: omnipresent and nonlimiting connectivity
  - Trend #5: pervasive network compute fabric
  - Trend #6: trustworthy infrastructure
  - Trend #7: cognitive network

https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/technology-trends-2020

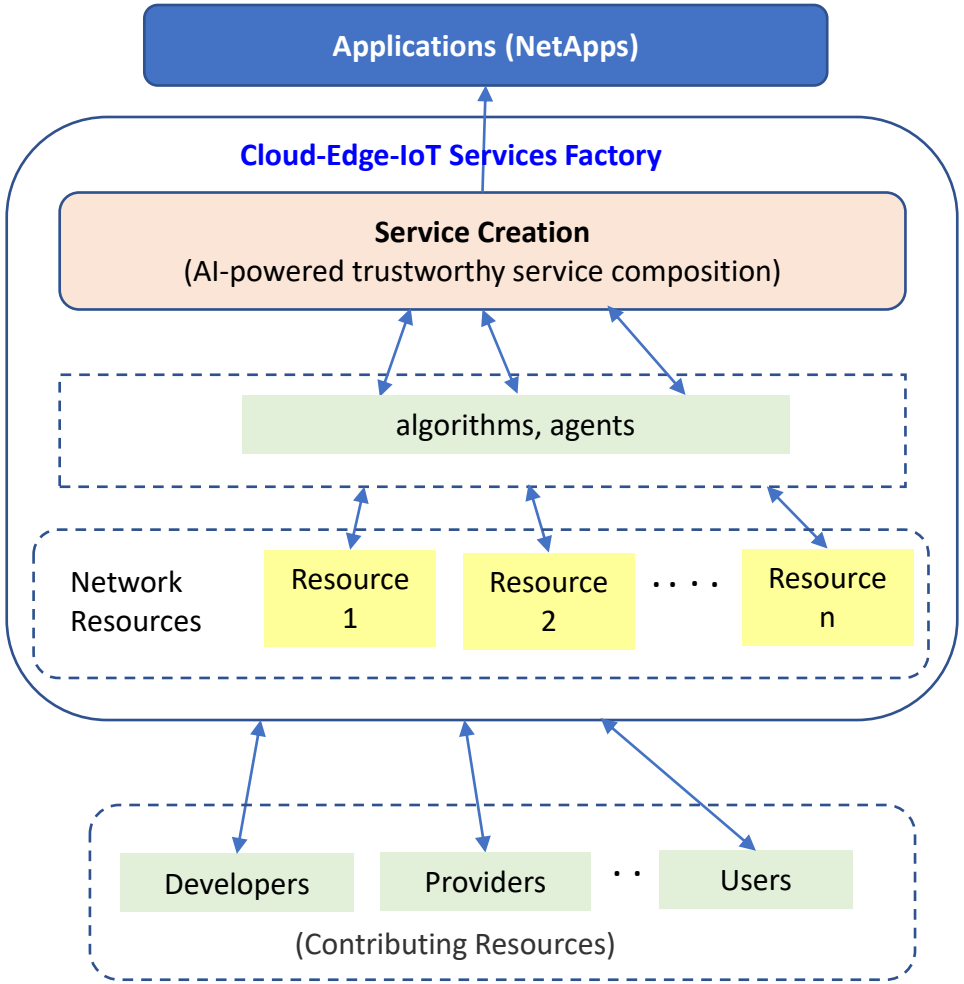
Network platform design

- From Cloud to Edge: Decentralization
- AI/Computing/Trust Native: In-network native and modular approach (energy efficient)
- Multi-tier heterogeneous resources: Minimizing complexity with AI
- Service Crowdmining: Crowd driven AI-powered Trustworthy Service Composition
- Trustworthy services: TrustChain (Lightweight distributed ledger with smart contract)
- Autonomous operations: SelfOps (Self-evolving and self-adapting service operations)
- Participation, Collaboration and Incentives: Collaboratively Evolving Platforms at Scale

Platform Characteristic	Business Characteristic
 OPEN	• Easily accessible for users, ecosystem partners, and businesses. • Host multiple independent businesses as tenants of the platform
 CONNECTED	Always-on, always connected
 INTELLIGENT	To use the data generated to enable efficient and meaningful transactions
 SCALABLE	Empowers businesses to scale the platform by number of users, segments, and geography.

Considerations

- Users (prosumers, contributors, creators)
  - Personalized services, user-centric service creation and management, rich experience, adding values to services
- Different types of resources
  - Data (digital assets, sensing data, trained data,…), computing, communication, learning (AI models, parameters,….), composable digital twins/microservices, ….
- Operation (Self-evolving and self-adapting)
  - Mining + service composition/chaining
- Optimization
  - Energy efficiency, minimize complexity
- Trust
  - Testing and validation, distributed ledgers



Multi-tier Federated Intelligence with Composable DTs

Core Networks
(Cloud DTs)

Cloud (AI Engine)

Access Networks
(Edge DTs)

Edge (AI Agent)

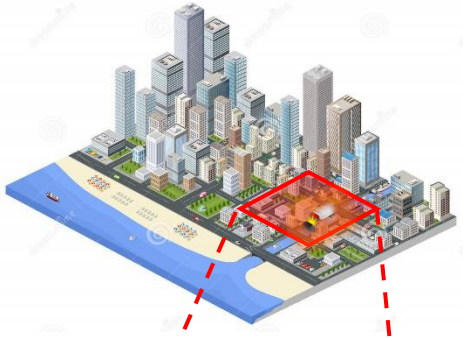
Users
(Atomic DTs)

IoT (Embedded AI)

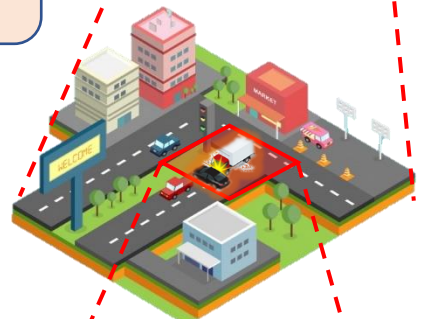
ICT Service Factory

Horizontal Composition

Vertical Composition



City Level Decision



Area Level Decision

Localized Decision

Deep AI

Medium level

Localized AI

Non Real-time

Real-time

The Challenge – Co-creation

- User-driven Composable Digital Twins using trusted and federated concepts
  - Creation of personalized atomic digital twin with data sovereignty and embedded intelligence
  - Composition of atomic digital twins
  - Building up large scale federated digital twins with AI capabilities
  - Supporting ICO (Interoperability, Composability and Orchestration)

Concluding remark

- Towards connected AI powered digital twins
  - **DTs for networks vs. Networks for DTs**

Standardization of Data-Driven ICT

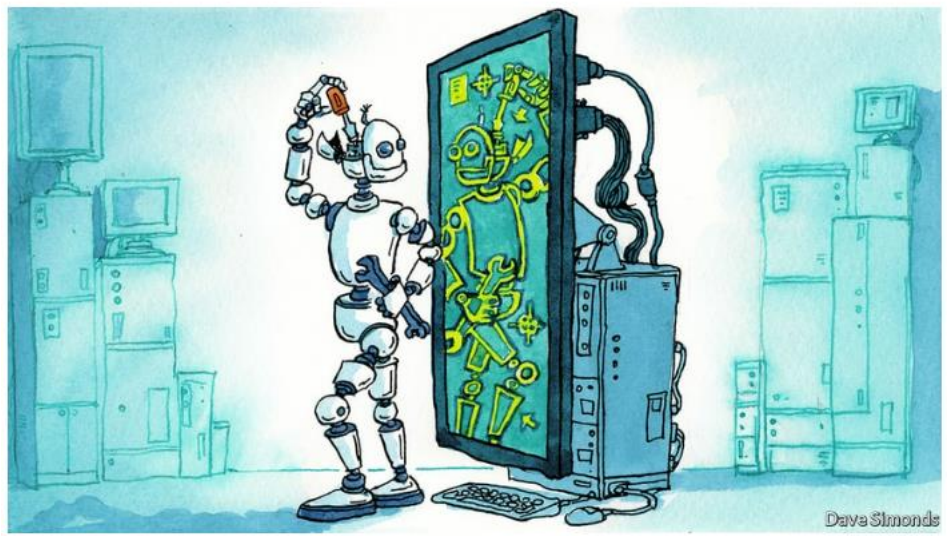
- Common features, but unlimited number of solutions

- Fregmentization
- Assembling

The Economist

Millions of things will soon have digital twins

From factories to cars to a range of consumer products



Jul 13th 2017

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