# Use-Case Showcase

**Yongsheng Liu**

**WG1 Chair, ITU-T Focus Group on Autonomous Networks**

**Principal Researcher, China Unicom Research Institute**

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**liuys170@chinaunicom.cn**

# Agenda

# Overview-Use case outcome from FG-AN (1/2)

**China unicom** 中国联通

☐ **Document (FGAN-I-157) is a collection of use cases presented and elaborated during FG-AN meetings.**

International Telecommunication Union

## ITU-T Technical Specification

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(28 October 2021)

ITU-T Focus Group on Autonomous Networks

**Technical Specification**

**Use cases for Autonomous Networks**

ITU
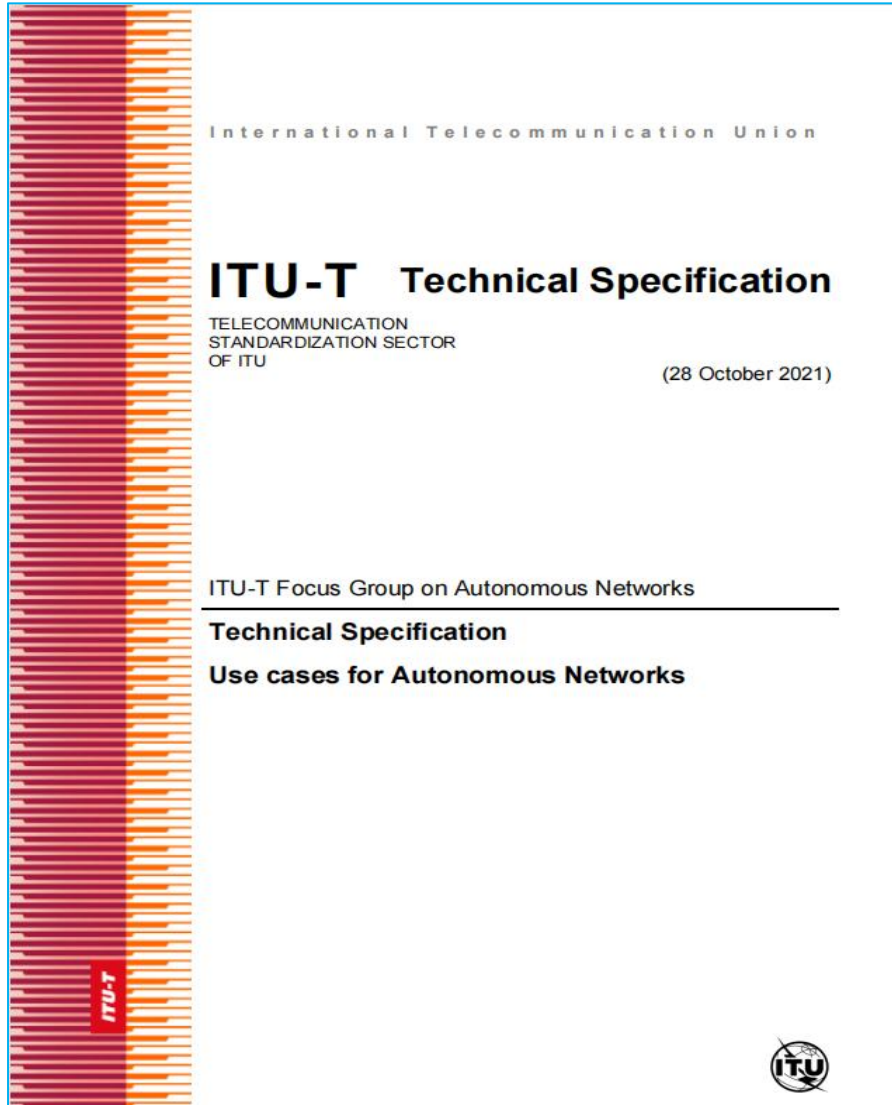
## FG-AN

ITU-T Focus Group on Autonomous Networks was established by ITU-T Study Group 13 at its virtual meeting, 17 December 2020. The Focus Group will draft technical reports and specifications for autonomous networks, including exploratory evolution in future networks, real-time responsive experimentation, dynamic adaptation to future environments, technologies, and use cases. The Focus Group will also identify relevant gaps in the standardization of autonomous networks.

The primary objective of the Focus Group is to provide an open platform to perform pre-standards activities related to this topic and leverage the technologies of others where appropriate.

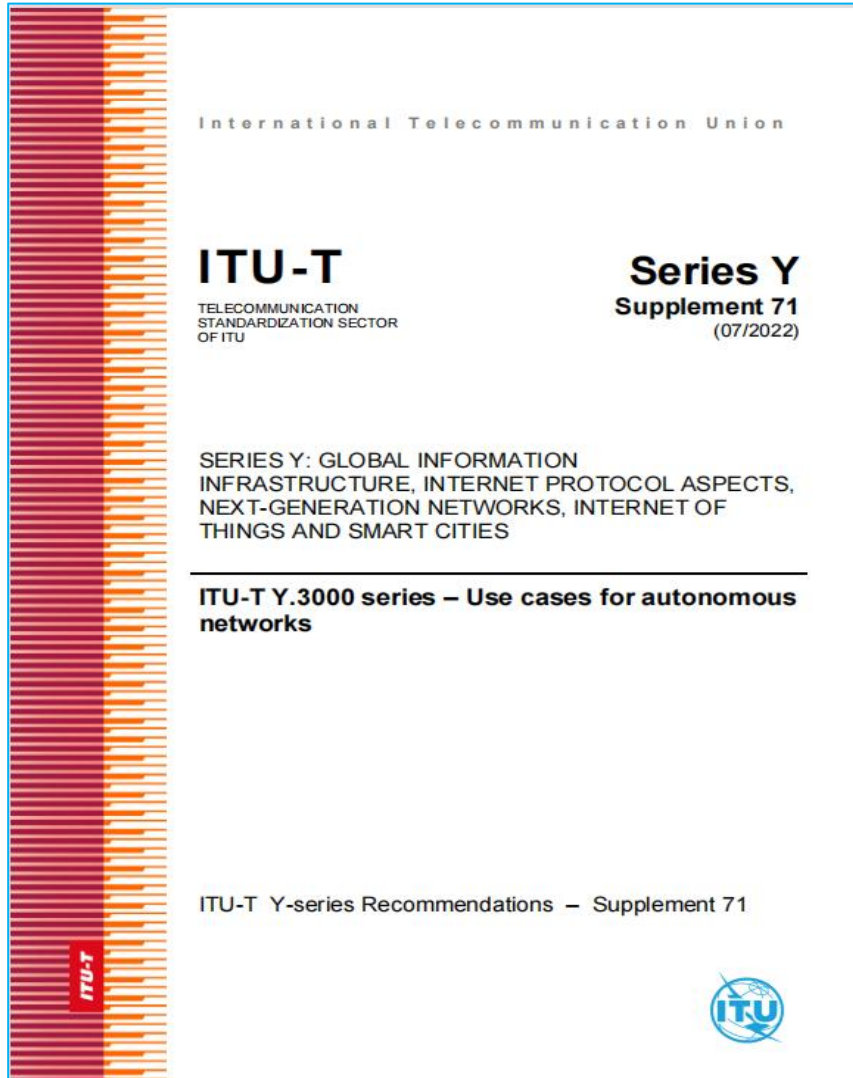**ToR:** Terms of reference          **Parent group:** ITU-T Study Group 13

**Deliverables:**

▸ **Use cases for Autonomous Networks**

▸ **Architecture framework for Autonomous Networks**

▸ **Trustworthiness evaluation for autonomous networks including IMT-2020 and beyond**

▸ **Proof of Concept (PoC)**

▸ **Gap analysis**

▸ **Definitions glossary**

https://www.itu.int/en/ITU-T/focusgroups/an/Pages/default.aspx

□ **Deliverable of use cases transmitted to ITU-T SG13, and published as ITU-T Y.Suppl 71.**



International Telecommunication Union

**ITU-T**
TELECOMMUNICATION
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**Series Y**
Supplement 71
(07/2022)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

**ITU-T Y.3000 series – Use cases for autonomous networks**

ITU-T Y-series Recommendations – Supplement 71

**[2022-2024]** : **[SG13]** : **[Q20/13]**

**[Declared patent(s)]** - **[Associated work]** - **[Publication]**

| | |
|---|---|
| Work item: | Supplement 71 to ITU-T Y.3000-series Recommendations (ex Y.Supp-AN-Use Cases) |
| Subject/title: | Use Cases for Autonomous Networks |
| Status: | Agreed on 2022-07-15 [Issued from previous study period] |
| Approval process: | Agreement |
| Type of work item: | Supplement |

**ITU-T Recommendations by series**

Y series: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

⊟ Y series: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

⊞ Y supplements: Supplements to the Y-series Recommendations

Y Suppl. 70: ITU-T Y.3800-series – Quantum key distribution networks - Applications of machine learning

Y Suppl. 71: ITU-T Y.3000 series – Use cases for autonomous networks

Y Suppl. 72: ITU-T Y.3000-series – Artificial intelligence standardization roadmap

Y Suppl. 74: ITU-T Y.3800-series – Standardization roadmap on quantum key distribution networks

https://www.itu.int/itu-t/recommendations/index.aspx?ser=Y

# Overview-Use cases statistics

中国联通 China unicom

**10** Months

**30** mentors

**40** use cases

**90** Pages

**143** Requirements

**19** Category 1

**21** Category 2

Category 1 describes scenarios related to the autonomous behaviours themselves.

Category 2 describes scenarios related to applications of autonomous behaviours in the network.

Summary

This is a deliverable of the ITU-T Focus Group on Autonomous Networks (FG-AN).

This document analyses use cases for autonomous networks. It provides use case descriptions and indicates the basic set of possible requirements for each use case. The use cases are divided into categories, priorities are indicated, and actor-interaction diagrams are added.

Keywords

Artificial Intelligence, autonomous networks, components, machine learning, requirements, use cases

Contributors:
Abhay Shanker Verma
TEC, Ministry of Communications
India
Email: as.verma@gov.in

Abhishek Dandekar
Fraunhofer HHI
Germany
Email: abhishek.girish.dandekar@hhi-extern.fraunhofer.de

Abhishek Thakur
Institute for Development and Research in Banking Technology (IDRBT)
India
Email: AbhishekT@idrbt.ac.in

Albert Cabellos-Aparicio
Barcelona Neural Networking
Universitat Politècnica de Catalunya
Barcelona, Spain
Email: alberto.cabellos@upc.edu

Albert López-Brescó
Barcelona Neural Networking
Universitat Politècnica de Catalunya
Barcelona, Spain
Email: alopez@ac.upc.edu

Alfons Mittermaier
Highstreet Technologies GmbH
Germany
Email: alfons.mittermaier@highstreet-technologies.com

Ammar Muthanna
SPbSUT
Russian Federation
Email: ammarexpress@gmail.com

Andrey Kucheryavy
ITU-T SG11 Chairman
Email: akouch@mail.ru

Ashish S Sharma
Fraunhofer HHI
Germany
Email: ashish.sanjay.sharma@hhi.fraunhofer.de

Bing Qian
China Telecom
China
Tel: +8618511588556
Email: qianbing@chinatelecom.cn

Chi Wang
Microsoft
Email: wang.chi@microsoft.com

# Overview-A list of use cases

☐ **Four use cases (two for each category) are elaborated on in the following slides.**

| ID | Name of Category 1 |
|-----|---------------------|
| **001** | **Use of knowledge in autonomous network** |
| 002 | Configuring and driving simulators from autonomous components in the network |
| 003 | Peer-in-loop (including humans) |
| 004 | Configuring and driving automation loops from autonomous omponents in the network |
| 006 | Automation and intelligent OAM(operation, maintenance and management) of radio network |
| 009 | Network resource allocation for emergency management based on closed loop analysis |
| 012 | Signalling flows for autonomous IMT-2020 network |
| 013 | Plug/play of network instance |
| 014 | "Generative adversarial Sandbox": (or hybrid closed loops) |
| 016 | Compose-able, hierarchical closed loops |
| 019 | Analysis-driven evolution in virtualized RAN based on devops |
| 020 | Evolving Edge applications for verticals using Private 5G |
| 021 | Experimentation and "fire-drills" for public safety networks |
| 028 | Evolution from scenario-specific, explicit-coordination to coordination-free interoperability (achieved using data-driven approaches) |
| **031** | **OpenCN: An open repository of intents for controllers and modules** |
| 032 | AI enabled Game theory based mechanism for resource allocation |
| 033 | Service automation using workflows |
| 034 | Disaggregation and Placement of In-Network Programs |
| 035 | FLAML: A Fast and Lightweight AutoML Library |

| ID | Name of Category 2 |
|-----|---------------------|
| 005 | Domain analytics services for E2E service management |
| 007 | Intelligent Energy Saving for Data Centers |
| 008 | Autonomous Massive MIMO |
| 010 | Inter-domain service automation (IDSA) - for microfinance |
| 011 | Autonomous vertical-driven edge service and middle-mile connectivity for rural financial inclusion (FI) |
| 015 | Open, integrated, log analysis |
| 017 | Quality of Experience (QoE) Prediction as-a-Service (QPaaS) |
| 018 | Autonomy applied to CDNs |
| 022 | Machine Learning for Network Automation |
| 023 | Autonomous agents (with varied competence) in networks |
| 024 | Automated, adaptive acceleration for AI @ edge |
| 025 | Assistive networks: Adaptation of communication system based on changing user accessibility needs |
| 026 | Ev-as-a-service: Achieving zero touch evolution in a delegated autonomy case |
| **027** | **Experimentation as a service: Digital twins as platforms for experimentation** |
| **029** | **Intelligent Maintenance Assistance System** |
| 030 | Demand forecasting and live service migration methods in edge computing systems |
| 036 | Connected AI (CAI) testbed: Testbed for 5G Connected Artificial Intelligence on Virtualized Networks |
| 037 | Negotiated boundaries in AN for seamless network sharing |
| 038 | AN enabled end-to-end supply chain |
| 039 | Towards Openness in AN |
| 040 | Awareness in AN |

# Overview-Process and structure of a use case

☐ **As shown in the process, a contribution is revised at least three time, ensuring the quality for a use case.**

☐ **Besides basic fields, more information including context and open issue is provided for better understanding.**

Submit use case contributions

↓

Appoint mentors

↓

Refine it and derive requirments

↓

Publish in template

↓

Review and finalize

| Use case id | |
|---|---|
| Use case name | |
| Created by | |
| Mentor | |
| Creation date | |
| Use case context | A very short description on the context in which the use case was created. |
| Use case description | A detailed description of the use case. May include figures, Description of the relation (if any) of the use case with autonomous behaviour or the key technical enablers. |
| Open issues (as seen by the proponent) | • At this point, open issues helps to understand the view of the proponent better and on a case-by-case basis invite/request details from other bodies via LS.<br>• At a later point, open issues may point to "gaps" in existing work in related areas which may point to a need to study them further. |
| Notes on use case category | • Cat 1: describes a scenario related to core autonomous behaviour itself.<br>• Cat 2: describes a scenario related to application of autonomous behaviour in the network. |
| Notes on priority of the use case | |
| Reference | Articles, papers, etc |

# Agenda

# Selection of specific use cases

☐ **Four use cases are selected for knowledge base subsystem, experimentation subsystem, dynamic adaptation subsystem and application, respectively.**

**FG-AN-usecase-001**

Use of knowledge in autonomous network

**FG-AN-usecase-027**

Experimentation as a service

**FG-AN-usecase-031**

OpenCN

**FG-AN-usecase-029**

Intelligent Maintenance Assistance System

**Knowledge Base subsystem**

Information Bases

**Autonomy Engine**

Exploratory Evolution subsystem

Evolution controllers

Experimentation subsystem

Experiment controller

AN Sandbox

AN Orchestrator

E2E Network Orchestrator

**Dynamic Adaptation subsystem**

Curation controllers | Selection controllers | Operation controllers | Service endpoint

**Underlay network**

Hardware components | Software components | Orchestrator | Controllers

High-Level Framework for Autonomous Network

☐ **To satisfy the key concepts of autonomous networks while minimizing human intervention requires knowledge.**

**Purpose**

To satisfy the key concepts of autonomous networks while minimizing human intervention requires knowledge.

**Solution**

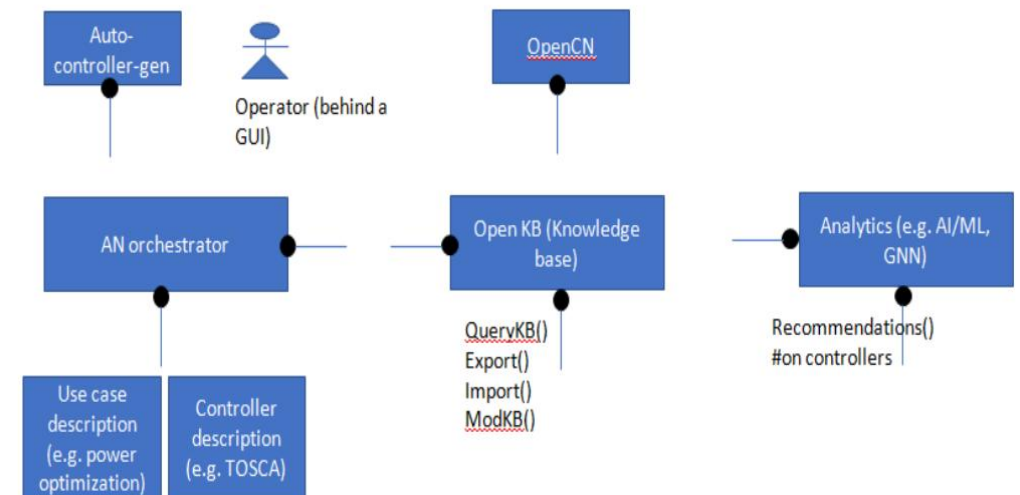This use case concerns use of knowledge in the actors in the AN.

**Detailed description**
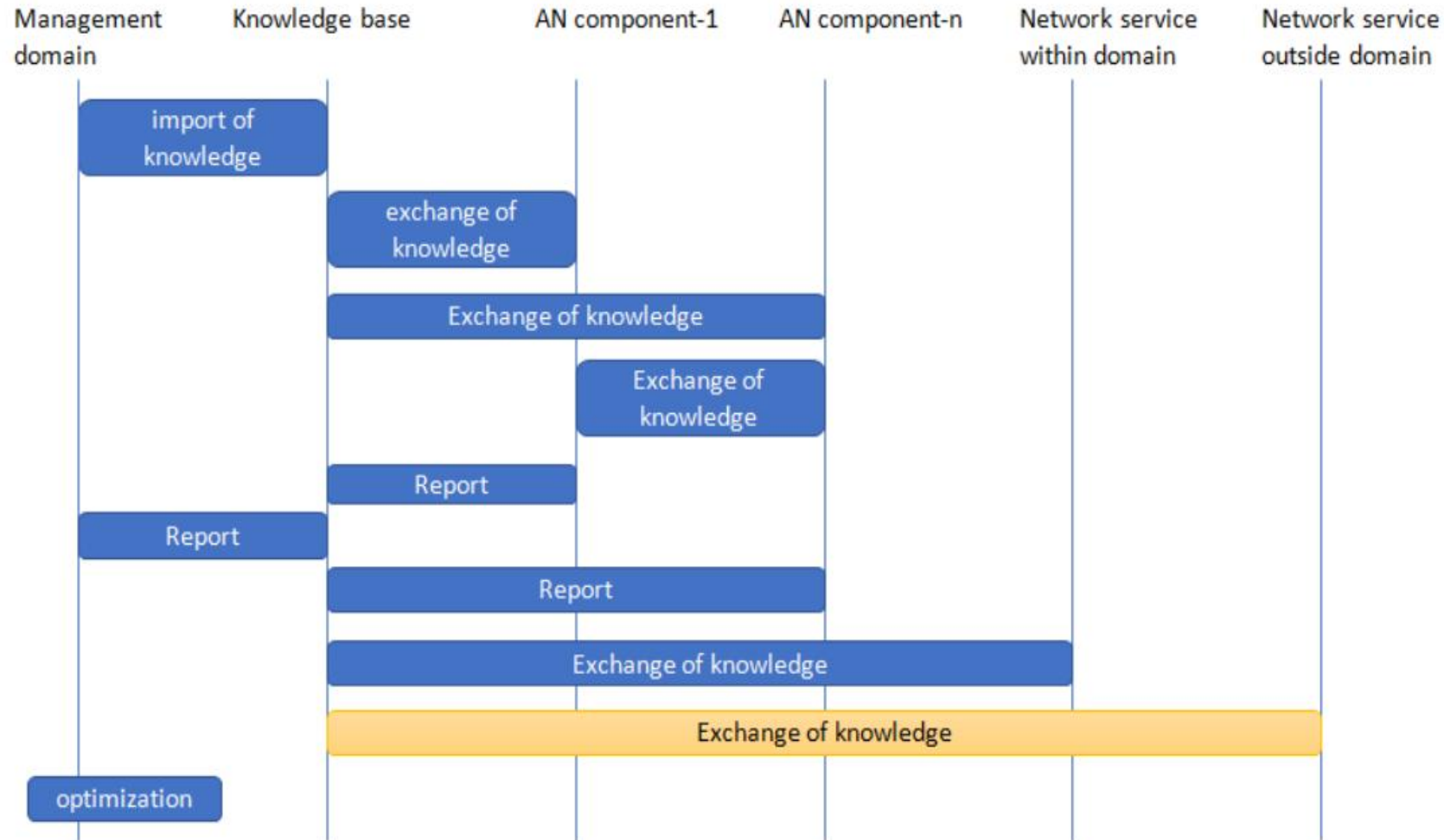
This knowledge may include:
- representation of data about the environment in which the autonomous system is operating;
- possible actions and consequences
- key configuration options
- potential parameter indices
- other types of logic.

Components in use of knowledge in AN is shwon in the right figure.

☐ **Actor interaction for Use of knowledge in autonomous network**



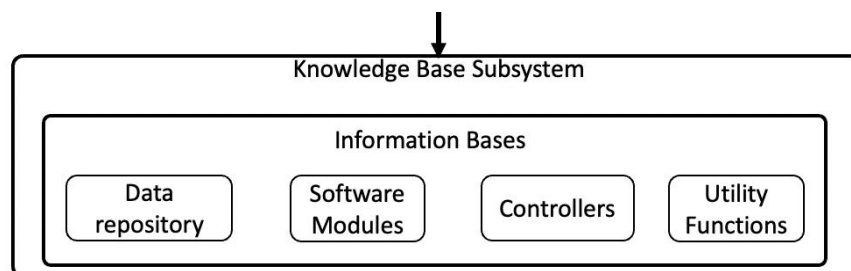Following steps in this use case scenario:

1. Knowledge is imported from outside or peer entities of autonomous network components

2. Knowledge is referred internally in autonomous network components.

3. Generate report for human consumption

4. Knowledge is stored and updated within the autonomous network components

5. Knowledge is exported from autonomous network components to outside or peer entities.

☐ **Lession learnt: knowledge base component of AN**

**Critical requirements of the use case:**

- AN-UC01-REQ-001: It is critical that AN enable **exchange of knowledge** between the various components in the AN implementing the various key AN functionalities like evolution, exploration and adaptation.

- AN-UC01-REQ-002: It is critical that AN enable **optimization of knowledge bases**.

- AN-UC01-REQ-003: It is critical that AN enable creation of **reports** on the use of knowledge bases, for consumption of humans and machines.

- AN-UC01-REQ-004: It is critical that AN enable exchange of knowledge between various components in the AN, and other network services in the same administrative domain.

- AN-UC01-REQ-005: It is critical that AN **use knowledge base** for mapping high level use case description to controller description.

- AN-UC01-REQ-006: It is expected that AN enable exchange of knowledge between various components in the AN, and entities in other administrative domains.

- AN-UC01-REQ-007: it is of added value that AN use Auto-controller generators that are functions which generate controller specifications, using the existing repository in openCN, the knowledge base and an analytics function aided by AI/ML e.g., GNN, recommendation engine.

**Knowledge Base Subsystem**

**Information Bases**

| Data repository | Software Modules | Controllers | Utility Functions |

**Definition**

➢ **Knowledge base:** A subsystem which manages **storage, querying, export, import and optimization and update knowledge**, including that derived from different sources including structured or unstructured data from various components or other subsystems.

☐ **Digital twins as platforms for experimentation**

| | |
|---|---|
| **Purpose** | AN aims to remove the human from the control loop, which poses hard challenges to offer 100% guarantees once the AN products are deployed in networks. |
| **Solution** | Digital twin can be used to estimate accurately the resulting network performance of an experimentation approach and the effect after applying the actions produced the AN, thus determining what network scenarios are well-supported by the product. |
| **Detailed description** | The contribution proposes to build digital twins of computer network infrastructures. Some examples of the (hypothetical) questions which could be answered using digital twins are listed:<br>• Which is the best network upgrade given a budget?<br>• Which is the best link upgrade to accommodate a new customer?<br>• Can we support a new customer SLA with the current network capacity? |

☐ **Components of use of DT (Digital Twin)**
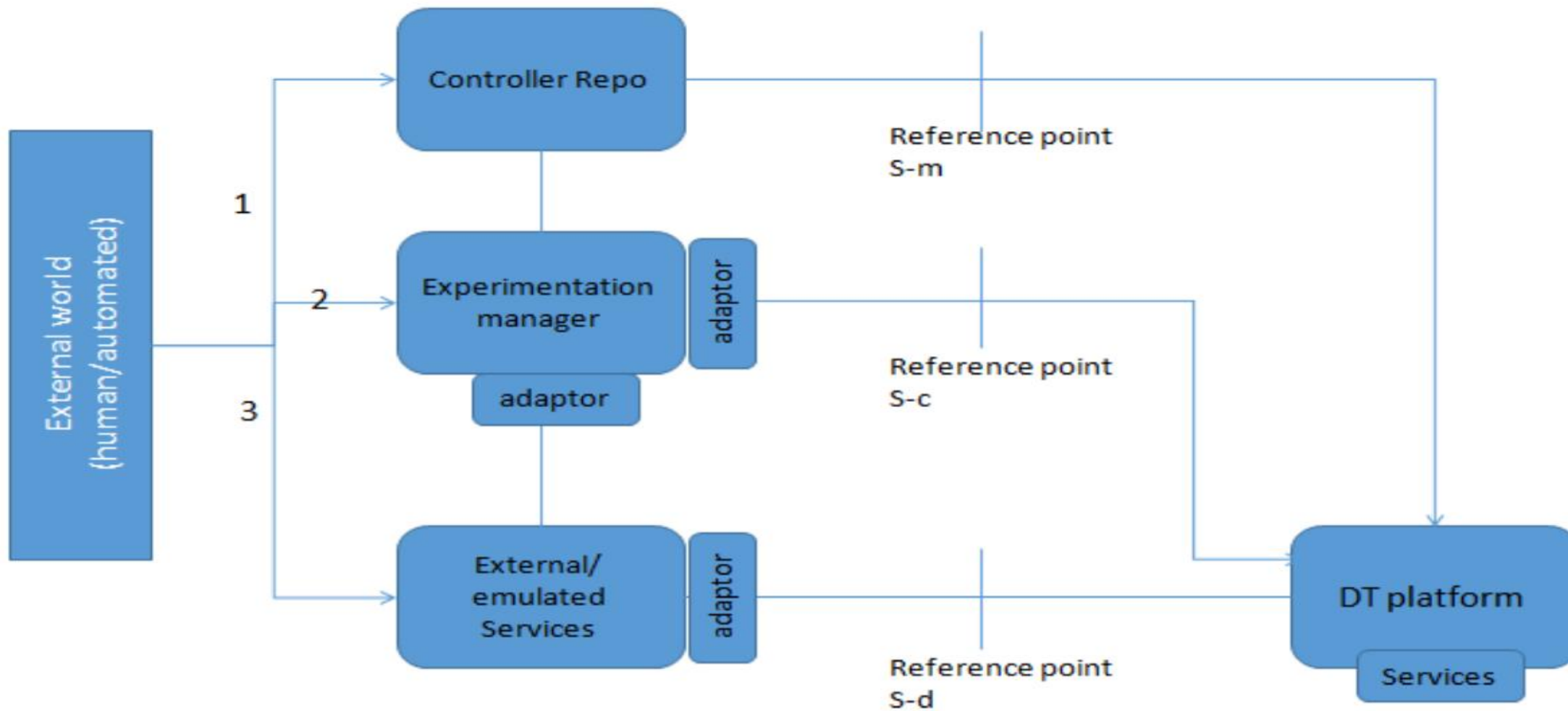
☐ **Lession learnt: Experimentation component of AN**

**Critical requirements**

- AN-UC027-REQ-001: It is critical that AN enable **import of simulation environment** into digital twin, **trigger simulations** in digital twin and **validate the results**, especially the use case specific closed loops.

- AN-UC027-REQ-002: It is critical that AN-triggered experiments and adaptations are **tested** using corresponding simulator settings in digital twin and the impact in simulated environment is **evaluated**.
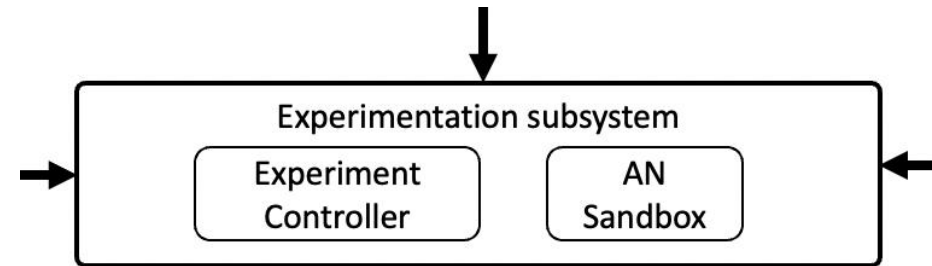


**Definition**

- ➤ **Experimentation Controller:** A controller which generates potential scenarios of experimentations based on controller specifications and additional information as provided by the knowledge base, executes the scenarios in the AN Sandbox, collates and validates the results of the experimentation.

- ➤ **AN Sandbox:** An environment in which controllers can be deployed, experimentally validated with the help of (domain specific) models of underlays, and their effects upon an underlay evaluated, without affecting the underlay.

-15-

☐ **Controller respository**

| | |
|---|---|
| **Purpose** | As controllers (closed loops) evolve to solve practical problems in the networks, controllers need to be resuable in AN. |
| **Solution** | This use case aims to provide a baseline repository (called OpenCN) of intents for different forms of controllers. |
| **Detailed description** | ➢ An open repository will form a baseline for reusable definitions for controllers, provide components for composing and chaining together controllers.<br>➢ Not only does the baseline intents allow stakeholders to reuse, extend and interoperate controller implementations, but it also allows the development of an ecosystem of services around it – providing customizations (adaptations), integrations (post experimentations) and finally evolutions. |

☐ **Actor interaction for open repository of intents**
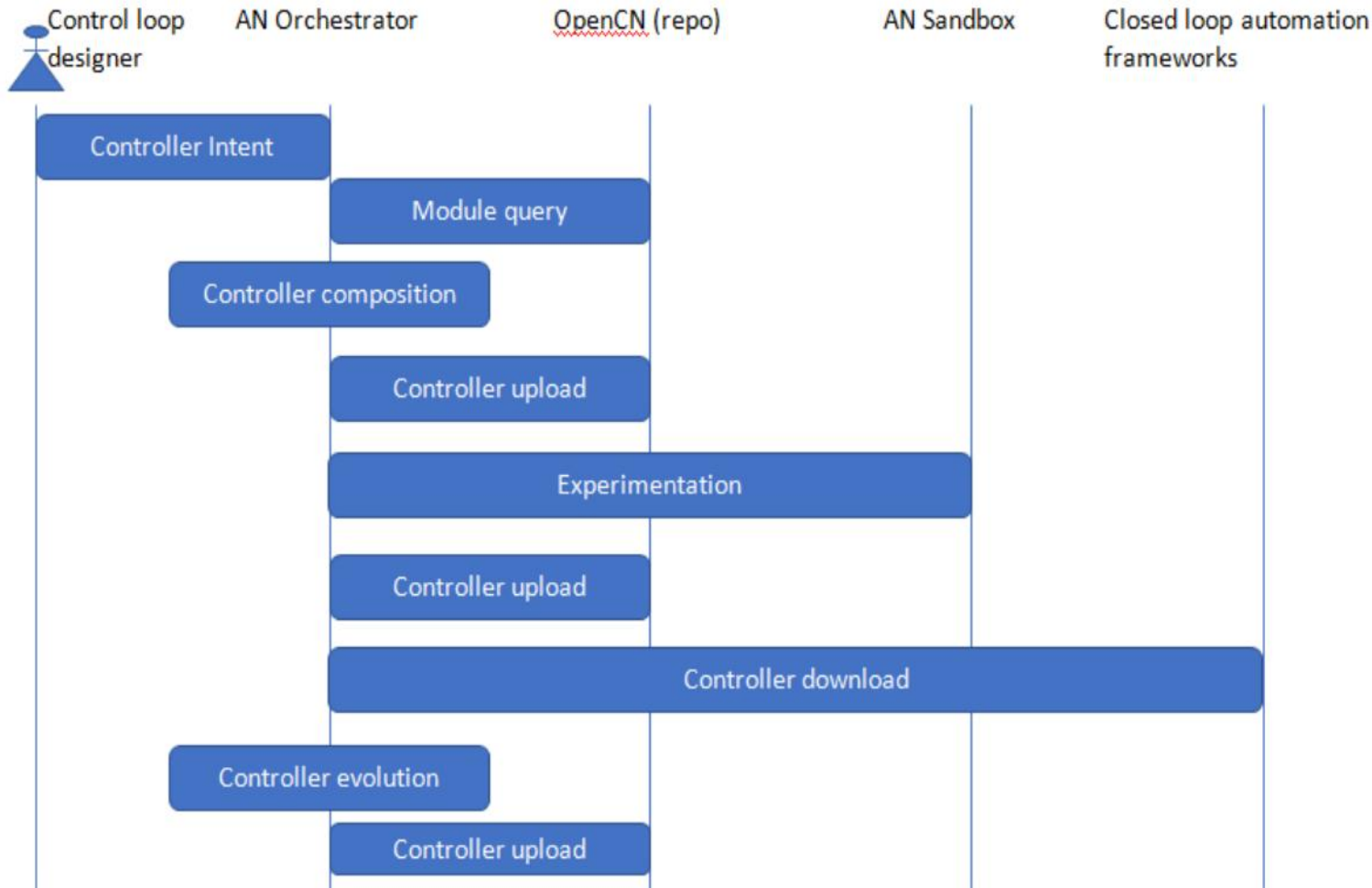


Steps in the use case are as follows:

- Initial version of controllers are formed from intent or composition from modules.

- These may be stored in the repo labelled as "untested" or candidate controllers

- Experimentation manager pulls the candidates from the repo and evaluate and test and compare the controllers

- Evolution manager uses the open repo to pull and apply strategies

- Operational controllers are stored in the open repo and pulled and deployed in underlays .

☐ **Lession learnt: Dynamic adatation component of AN**

**Critical requirements**

- AN-UC031-REQ-001: it is critical that AN enable storage of controllers in an open repository.
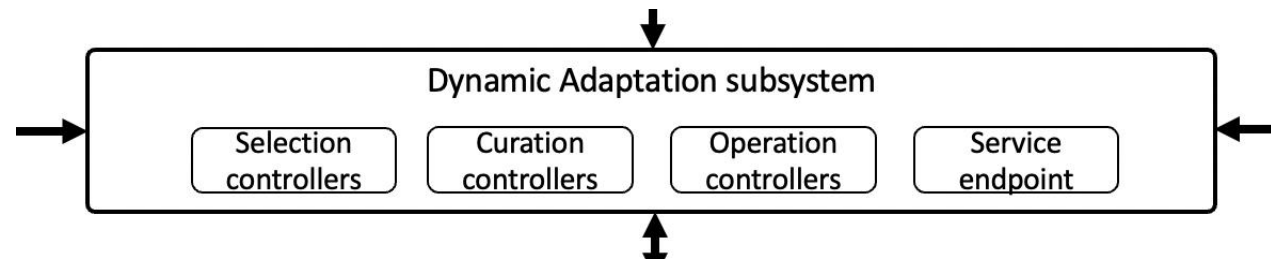


**Definition**

➢ **Selection Controller**: A controller responsible for the selection of a services' operational controller from the curated controller lists.

➢ **Curation Controller**: A controller responsible for the selection and maintenance of the controllers within the curated controller lists from the evolvable controllers.

➢ **Operation Controller**: A controller responsible for the operation of a managed entity.

# Agenda

# Timeline of AN in China Unicom

| China Unicom Autonomous Network White Paper V1.0 | China Unicom Autonomous Network White Paper V2.0 | China Unicom Autonomous Network White Paper V3.0 | China Unicom Autonomous Network White Paper V4.0 |
|---|---|---|---|
| **June 2020** | **December 2021** | **December 2022** | **End of 2023** |

China unicom中国联通
创新·改变世界

中国联通自动驾驶网络白皮书

V1.0

中国联合网络通信有限公司
2020年5月

中国联通自智网络白皮书

2.0

中国联合网络通信有限公司智网创新中心
中国联合网络通信有限公司研究院
联合发布
2021年12月

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中国联通自智网络白皮书
3.0

Autonomous Networks

中国联合网络通信有限公司智网创新中心
中国联合网络通信有限公司研究院
联合发布
2022年12月

**4.0**

**Expecting**

# AN goal of China Unicom
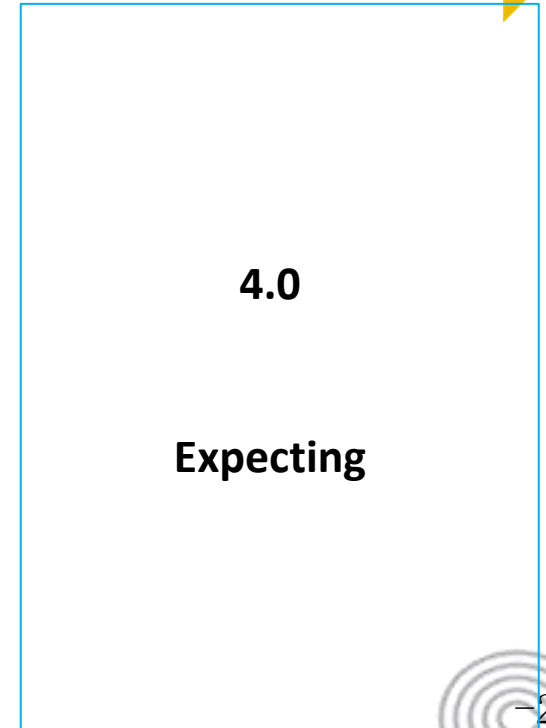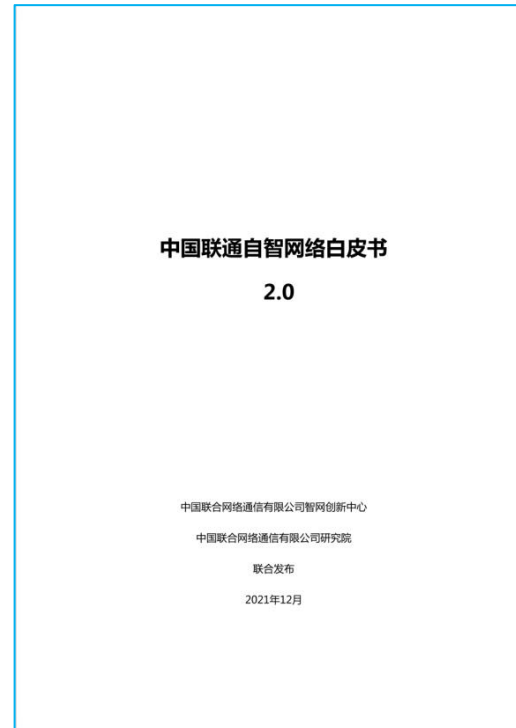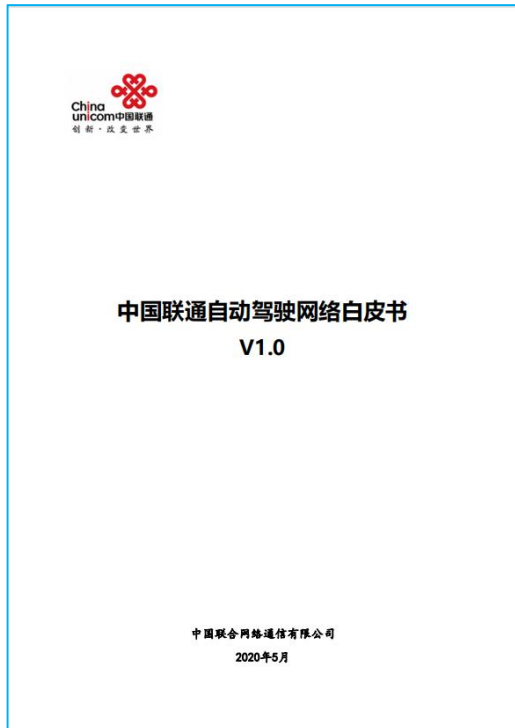
□ **Scenarios of AN reach L4 (advanced intelligence) by 2025**



**1个目标**

**2025年达到自智网络L4**
中国联通自智网络目标

**3个要素**

目标架构
方向牵引

三位一体
方法体系

运营实践
落实措施

**X个技术**

人工智能　数字孪生　知识图谱　联邦算力　网络演算　智能决策
图神经网络　增量学习　网络大模型　分布式算力协同　……

**Overall idea "1+3+X"**

➢ **1 goal**: L4 by 2025

➢ **3 elements**: Target architecture; Methodology; Operational practices

➢ **X techniques**: AI, digital twin, GNN, ...

## Plans

➢ **L2 by 2022**: Reach of L2 (primary intelligence) in key areas by the end of 2022.
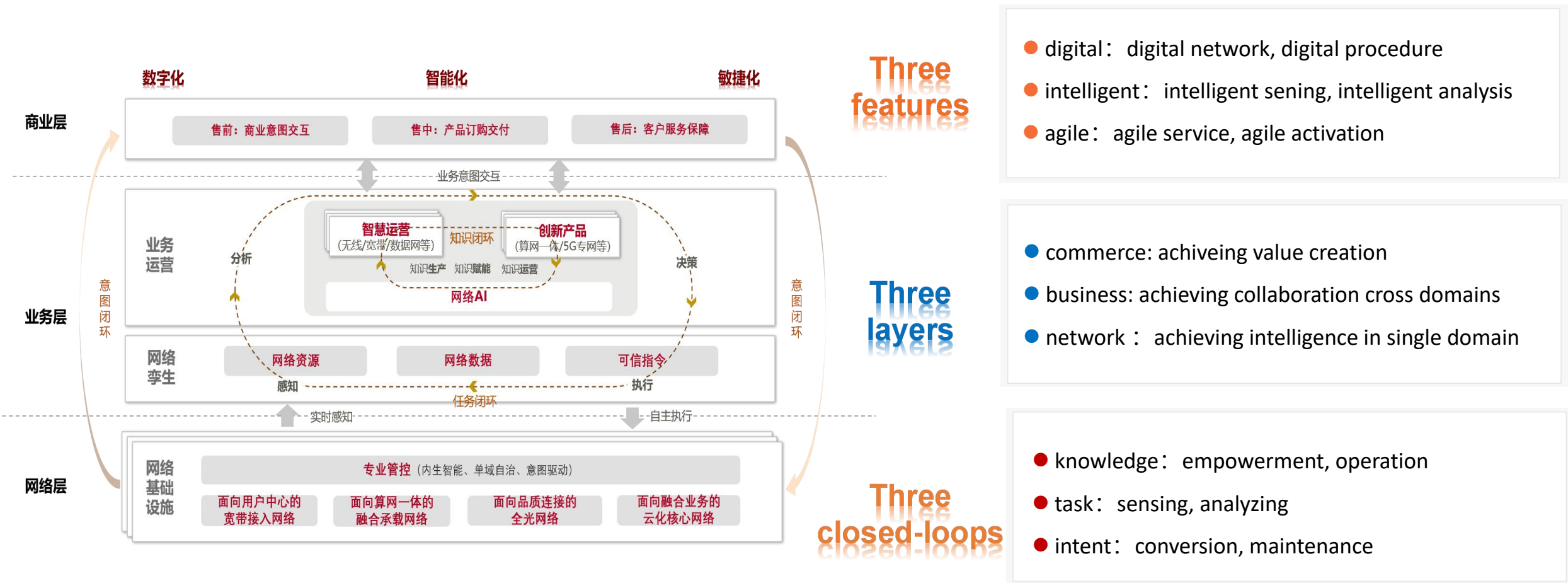
➢ **L3 by 2024**: Reach of L3 (intermediate intelligence) in many areas with business visibility and intelligent decision-making capabilities by exploration of technologies such as active sensing and inteligent simulations.

➢ **L4 by 2025**: Reach of L4 (advanced intelligence) with a closed loop driven by business and customer intents by application of technologies such as AI and digital twin.

# Target archecture of AN

□ **Develop three features and achieve three closed-loops around three layers, driving the evolution of China Unicom's AN**



- digital：digital network, digital procedure
- intelligent：intelligent sening, intelligent analysis
- agile：agile service, agile activation

- commerce: achiveing value creation
- business: achieving collaboration cross domains
- network：achieving intelligence in single domain

- knowledge：empowerment, operation
- task：sensing, analyzing
- intent：conversion, maintenance

□ This system is a comprehensive intelligent service system for China Unicom network operation and maintenance scenarios.

□ The system combines AI and AR capabilities to provide intelligent assistance for China Unicom's front-line worker in network operation and maintenance.

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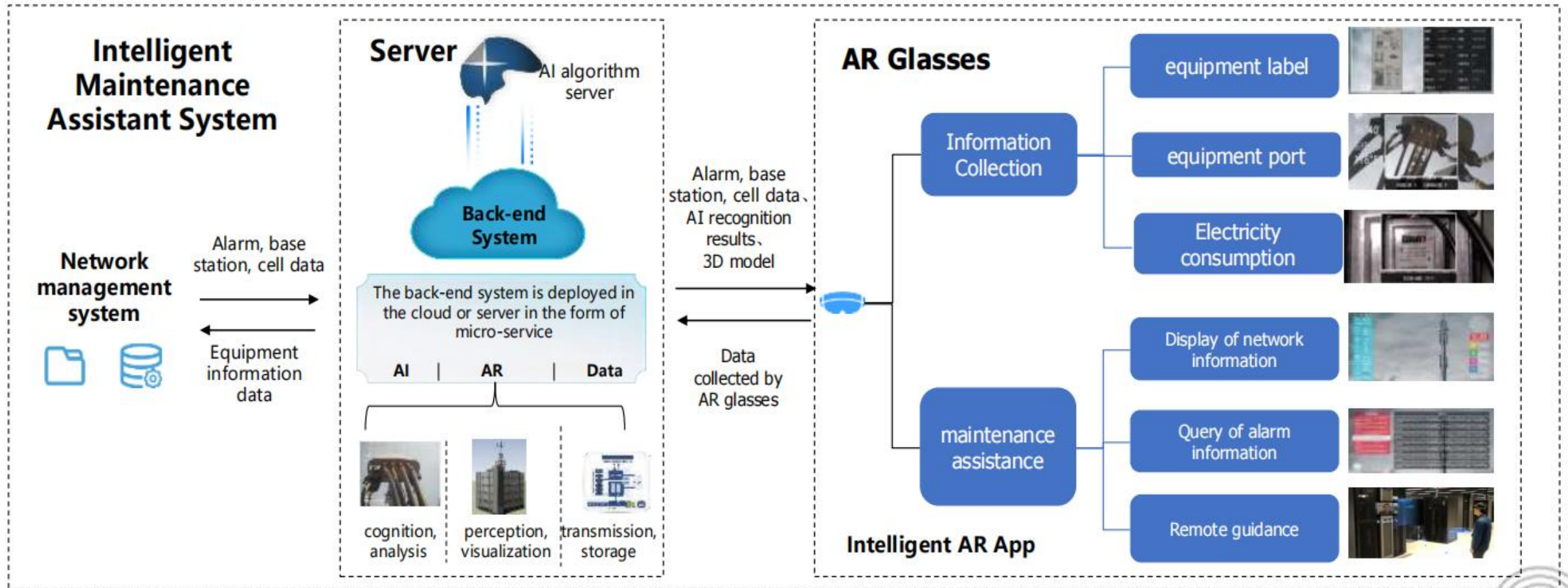
☐ **Actor interaction for intelligent maintenancece.**

3rd party developer

Intelligent maintenance assistance system

Backend

Intelligent AR App (Glasses)

Automated collection of data

Automated analysis using AI/ML

Query regarding maintenance [data/alarms]

Automated rendering of service assistance

Create novel apps using SDK

Evolution of analysis

Evolution of data collection

Create reports for humans
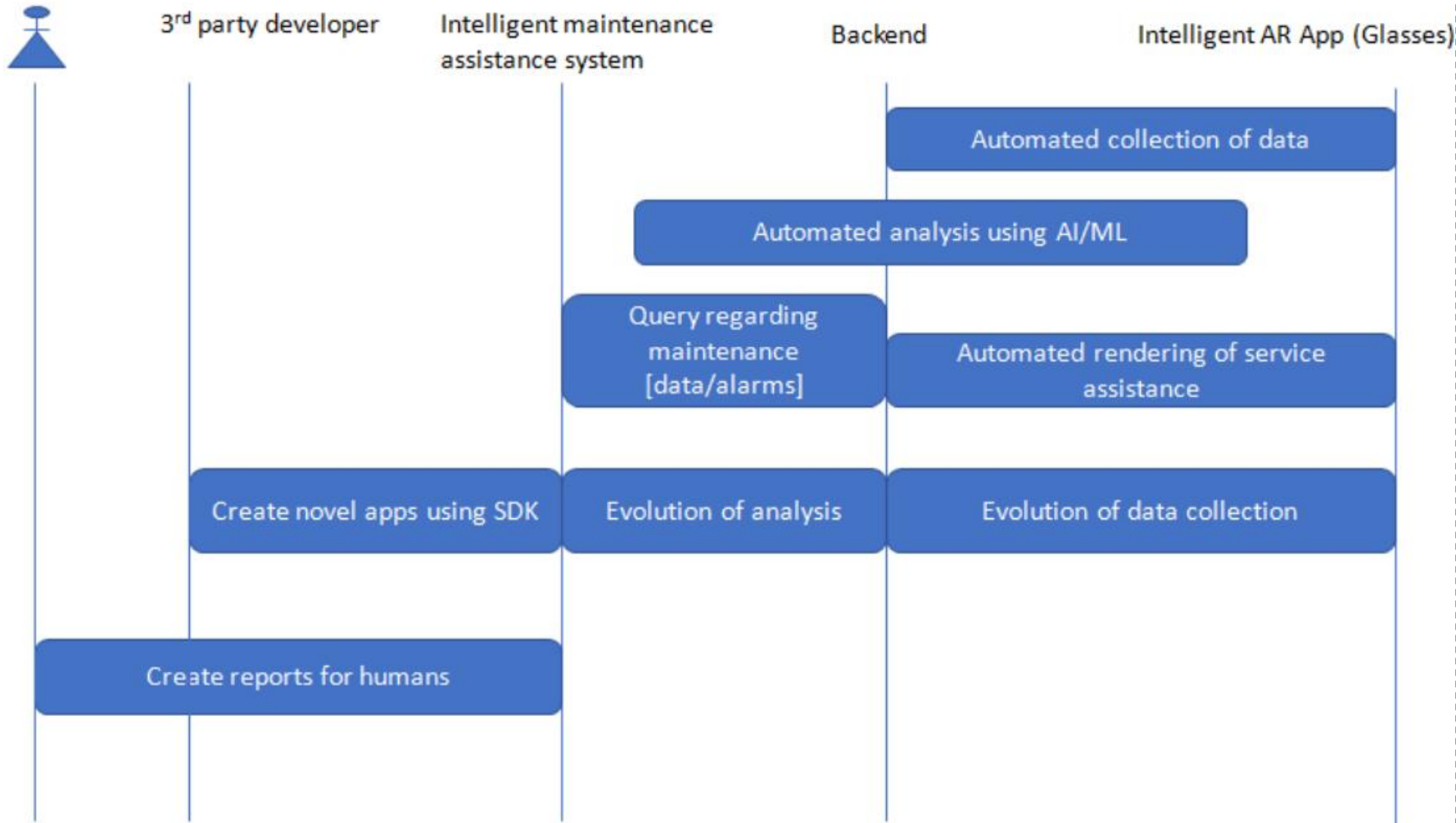
The steps in this use case are as below:

1. Using AR glasses (and other external sensors), collect data about the environment.

2. AI based cognition analysis, perception visualization and other analysis algorithms are applied on the collected data to create a virtual model of planning and design to real environment to assist network designers.

3. This model is then used in conjunction with real data for maintenance and optimization by intelligence maintenance assistance system.

☐ **Lession learnt: AI+AR is applied to AN**

**Critical requirements**

- AN-UC029-REQ-001: It is critical that autonomous networks (AN) enable collection of environment data related to network operation and maintenance using automated techniques such as augmented reality (AR) glasses.

- AN-UC029-REQ-002: It is critical that autonomous networks (AN) enable analysis of environment data related to network operation and maintenance using cloud and AI techniques.

- AN-UC029-REQ-003: It is critical that autonomous networks (AN) provide intelligent assistance, rendered using automated techniques such as AR, for network operation and maintenance.

- AN-UC029-REQ-004: It is critical that autonomous networks (AN) update the data collection mechanisms and data analysis mechanisms along with the result rendering mechanisms based on the analysis by AI/ML on the collected data from AR and the evolution of the underlay networks.

- AN-UC029-REQ-005: It is critical that autonomous networks (AN) provide periodic and/or asynchronous updates to humans about the operation of the intelligent assistant system.

# Agenda

1 **Overview of AN use cases**

2 **Specific use cases of AN**

3 **AN of China Unicom**

4 **Summary**

# Summary

□ **Document (FGAN-I-157), outcome of FG-AN meetings, is a collection of use cases.**

□ **Four use cases are presented comprehensively in aspects of purpose, description, flow, and relation to AN subsystems.**

□ **Current status and advance of AN of China Unicom from withe papers.**
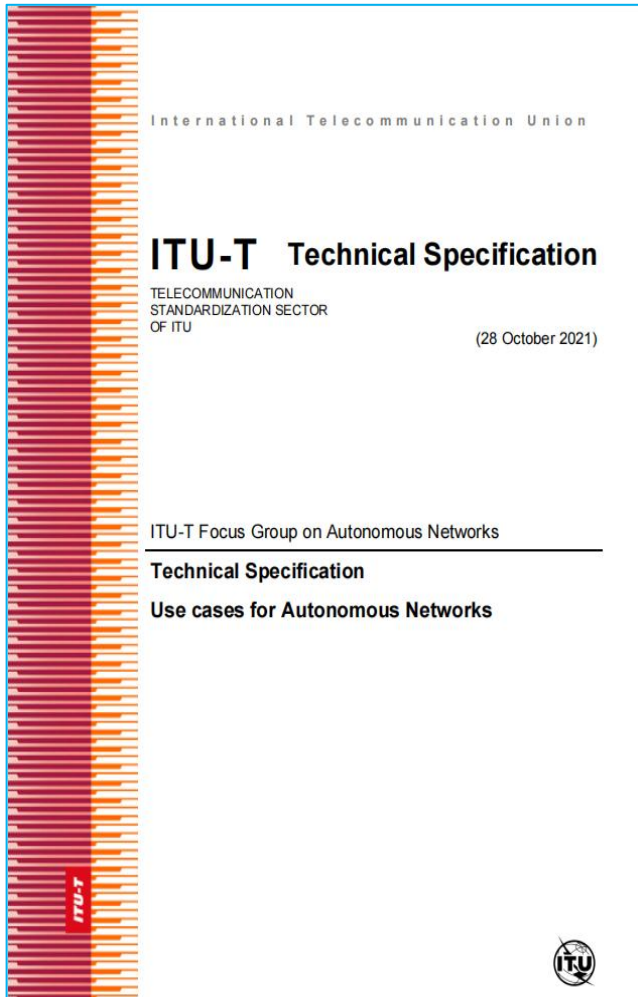
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TELECOMMUNICATION
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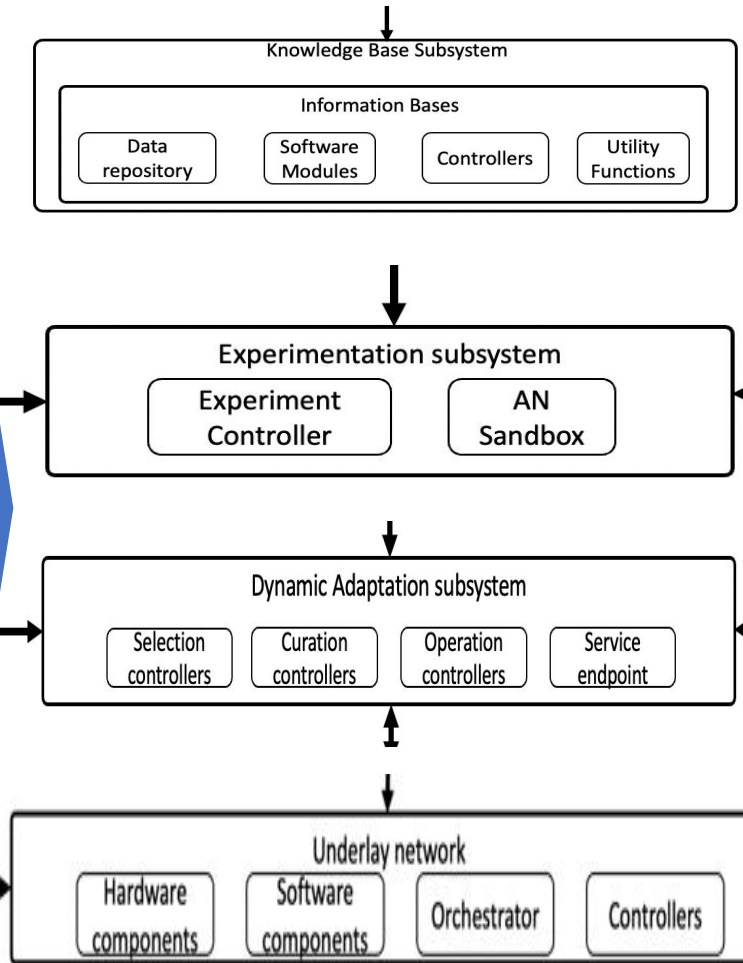
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Use of knowledge in autonomous network

**FG-AN-usecase-027**
Experimentation as a service

**FG-AN-usecase-031**
OpenCN

**FG-AN-usecase-029**
Intelligent Maintenance Assistance System

THANK YOU!