Knowledge Management for Autonomous Network

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1. Background-Introduction of knowledge management

➢ **General definition of knowledge management**:
  • the process of identifying, capturing, storing, sharing, and utilizing knowledge and information within an organization or community.
➢ **Knowledge management in autonomous network:**
  • significantly differs from traditional knowledge management processes.
  • the goal is to achieve automatic acquisition, generation, application, and updating of knowledge to realize automation and intelligent management and operation in network.
  • the requirements for knowledge management in AN have changed.
➢ **The advantages of managing knowledge in autonomous network:**
  • Improve accuracy and reliability: By continuously learning from its experiences and past performance, an autonomous network can identify and correct errors and improve its overall accuracy and reliability.
  • Increase efficiency: An autonomous network can use its knowledge to automate and optimize its functions, leading to increased efficiency and reduced costs.
  • Adapt to changing conditions: An autonomous network can use its knowledge to adapt to changing conditions and requirements, ensuring that it can continue to function effectively even as the environment changes.
  • Enhance security: Effective knowledge management can enable an autonomous network to detect and respond to security threats, leading to increased protection against cyberattacks and other threats.

1. Background- Gap analysis

SDO	WI	Introduction
TMF	IG1130F "SDN/NFV impacts on TAM Knowledge Management"	provided detailed analysis of KM application and suggestions for improvement of the current application. It's pointed out that the current scope in this project is limited to Knowledge Management application residing in the Enterprise domain.
	TMF IG1190E "AIOps Knowledge Management "	introduced the new challenges and opportunities that need to be addressed in AIOps and finally recommended the principles in the process of the knowledge management process for AI.
ETSI	GS ENI 005v311 "System Architecture"	defined knowledge management functional block as part of the ENI system architecture, and introduced knowledge processing, repositories, function of knowledge management functional block, operation of knowledge management FB from a conceptual level.
	GR ENI 015 "Processing and Management of Intent Policy"	described the construction procedure of knowledge graph and how to use knowledge graph to manage Intent.
	GR ENI 031 "Construction and application of fault maintenance network knowledge graphs."	described use cases and a construction method of fault maintenance knowledge graphs.
ITU	ITU-T SG2/Q6 M.fkmtom "Framework of knowledge management for telecom operation and management"	classify knowledge in telecom operation and management and also proposed a framework of knowledge management for telecom operation and management, including knowledge pre-processing, knowledge construction, knowledge storage, knowledge management service and knowledge service.

* SDOs are realizing the importance of knowledge management. However, there is no knowledge management specific to autonomous network.

1. Background- Motivation

It is necessary to further clarify the definition of knowledge, classification of knowledge, the source of knowledge, requirements of knowledge management in autonomous network, knowledge management architecture and functionality, and procedure of knowledge management.
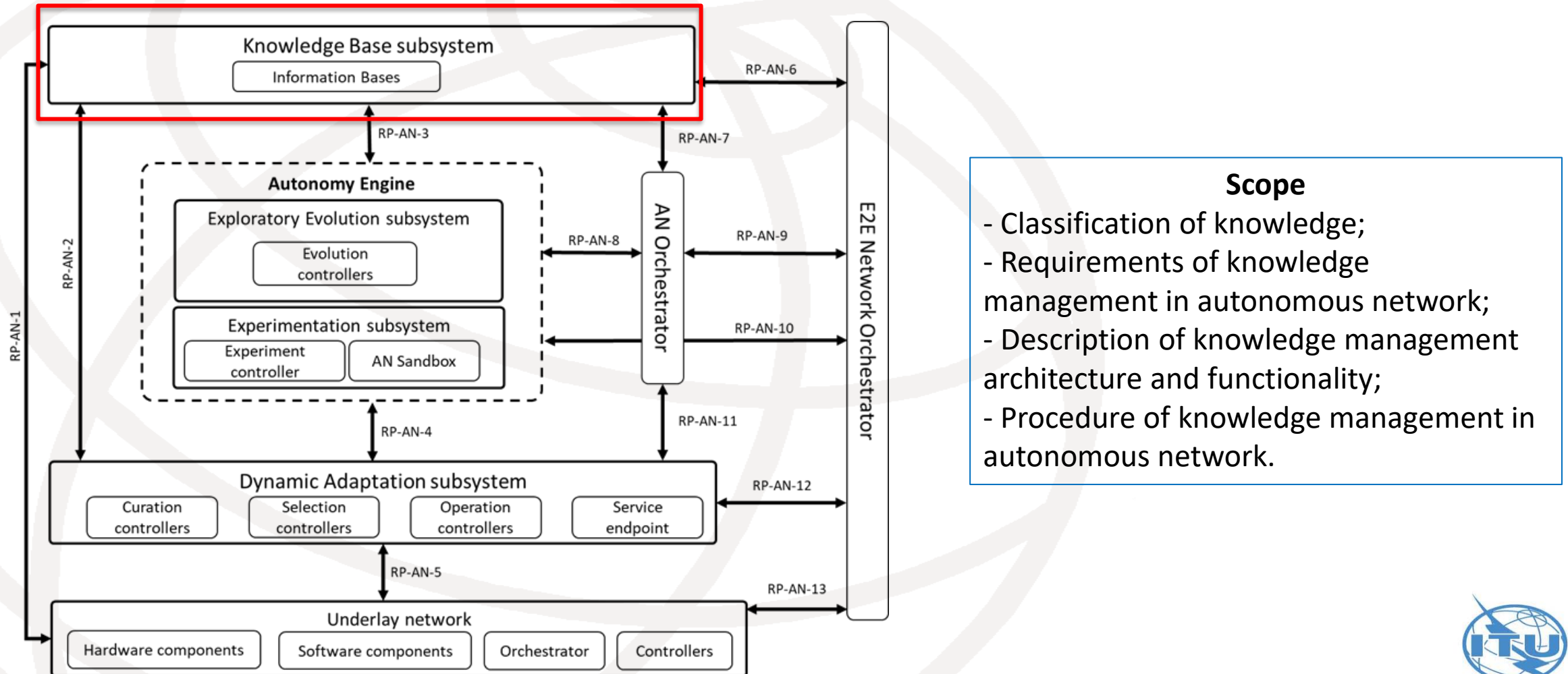
Scope
- Classification of knowledge;
- Requirements of knowledge management in autonomous network;
- Description of knowledge management architecture and functionality;
- Procedure of knowledge management in autonomous network.

Figure The position of knowledge management in AN architecture

2. Introduction of KM Project -Classification of knowledge

Based on knowledge processing level

- ➢ **Raw data**: The original, unprocessed data that is collected or obtained from various sources.
- ➢ **Cleaned data**: Cleaned data is the result of data pre-processing, which involves techniques such as data cleaning, data normalization, and handling missing values. In this stage, errors, duplicates, and irrelevant information are removed to improve the quality and reliability of the data.
- ➢ **Applied knowledge**: Applied knowledge is the result of applying cleaned data to derive insights and make informed decisions.

Based on application scenarios

- ➢ **Network Planning Scenario**
- • Network requirement analysis
- • Network topology design
- ➢ **Network Construction Scenario**
- • Device configuration
- • Service deployment
- ➢ **Network Optimization Scenario**
- • Network performance optimization
- ➢ **Network Operation and Maintenance Scenario**
- • Fault troubleshooting
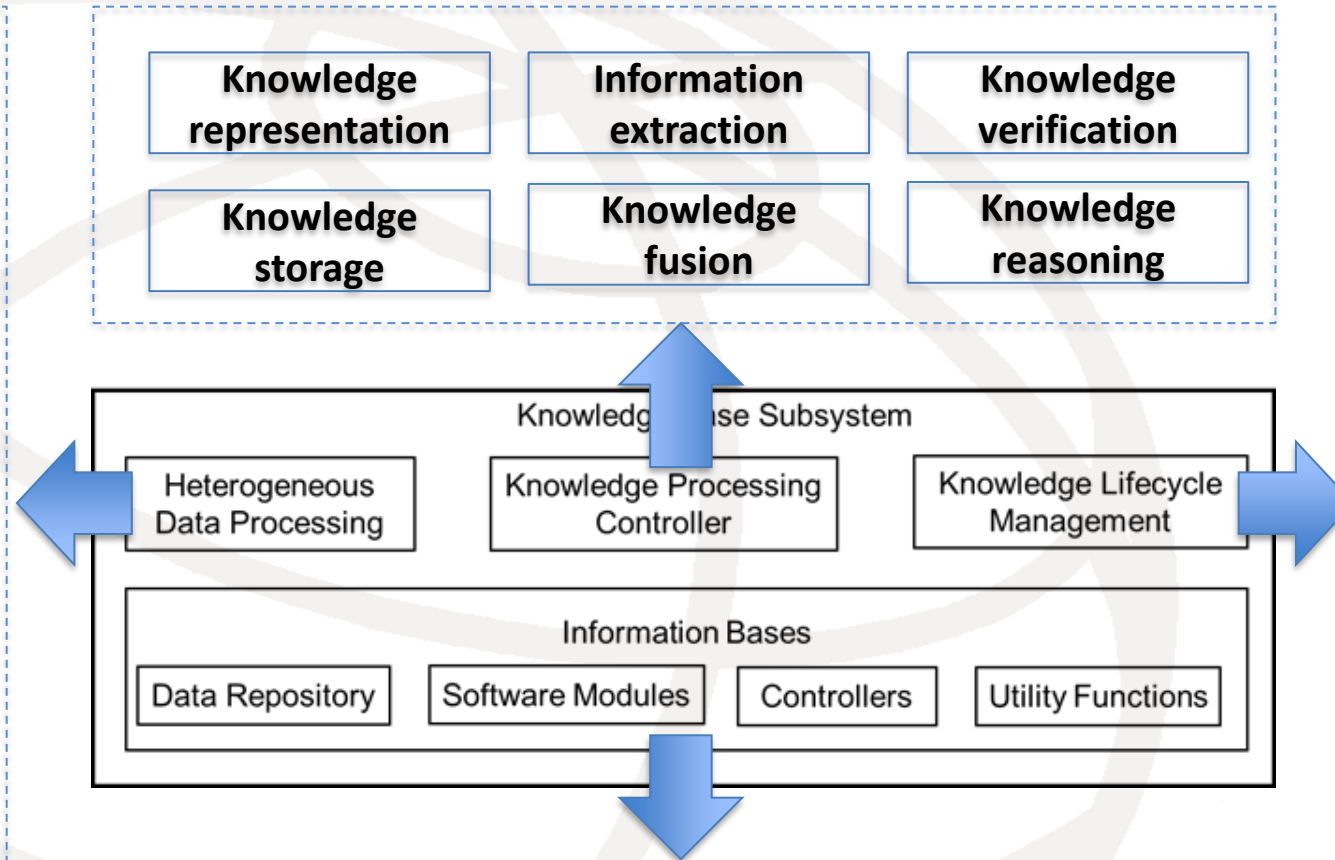- • Performance monitoring

Based on source of knowledge

- ➢ **Internal knowledge** includes knowledge obtained or derived from other subsystems or components in autonomous network [ITU-T Y.AN-Arch-fw].
- ➢ **External knowledge** includes externally obtained network topology, operation and maintenance manuals, expert experience, etc.

2. Introduction of KM Project -Requirement
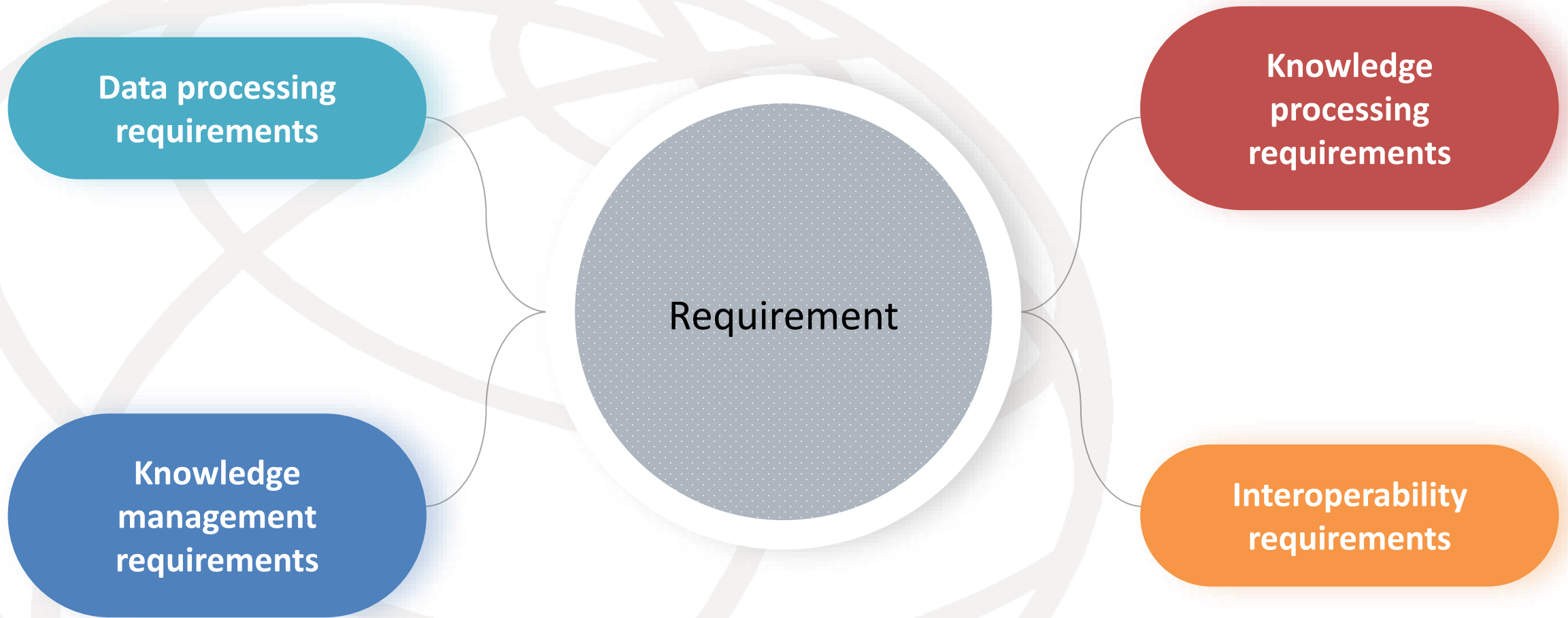
2. Introduction of KM Project -Knowledge management architecture and functionality

➤ The multi-source and heterogeneous data cannot be directly used for subsequent analysis, reasoning, and decision-making.

➤ The data processing functionality pre-processes the data collected by the autonomous network (Data cleansing, data filtering, etc.) and converts to a unified format, and sends the processed available data to the knowledge processing agent.

Knowledge representation	Information extraction	Knowledge verification
Knowledge storage	Knowledge fusion	Knowledge reasoning

Knowledge Base Subsystem

Heterogeneous Data Processing	Knowledge Processing Controller	Knowledge Lifecycle Management

Information Bases

Data Repository	Software Modules	Controllers	Utility Functions

➤ This document will define the different states of the knowledge lifecycle and how to transform from one state to another. Knowledge lifecycle states may include: creation, activation, deactivation, termination, etc.

Information base stores the collected data, knowledge, data models, ontologies, etc. for autonomous network to query and use, and in turn, new information and knowledge generated by other subsystems and components will update the information base.

# 3. Implementation-Knowledge graph technology base

The knowledge graph technology base provides following capabilities:

➢ Intelligent pipeline knowledge graph construction:
  - provides rich knowledge extraction algorithms and AI annotation algorithms
  - users can quickly configure each step of the knowledge graph pipeline to improve the efficiency of knowledge graph construction
➢ Knowledge update and management:
  - update and maintain the established knowledge graph through the knowledge graph technology base
  - support the management and sharing of the established knowledge graph
➢ Multi-domain knowledge integration:
  - Heterogeneous data integration and disambiguation of knowledge from different data sources under a unified specification to achieve multi-domain knowledge integration.
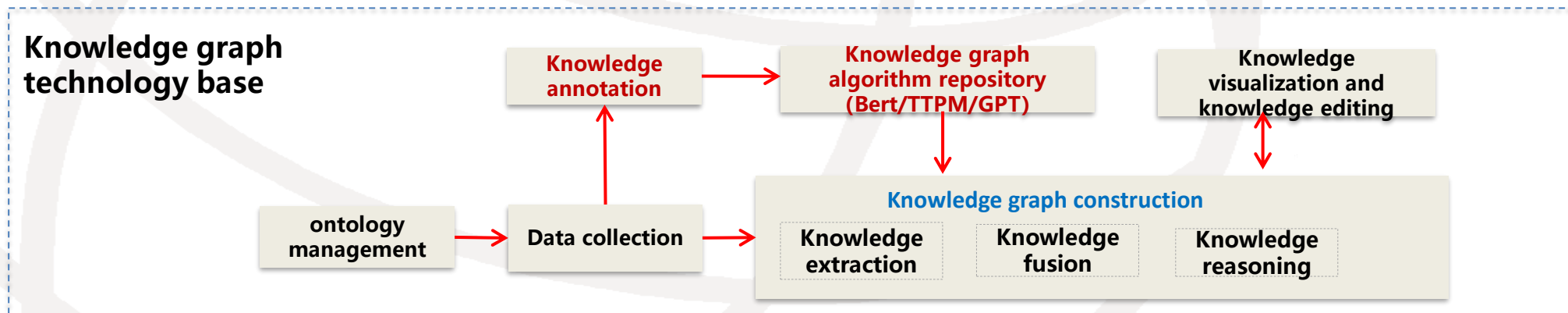
3. Implementation-Knowledge management application

- **Root Cause Positioning for IP new metropolitan area network (MAN)** : Based on historical alarm data, device topology data, and expert experience, create a new MAN alarm knowledge graph to achieve IP alarm root cause positioning.

- **5GR intelligent recommendation**: Create a wireless network knowledge graph, to find the root cause according to poor quality communities/inefficient site work orders, and intelligently recommend solutions.

- **IPRAN alarm root cause positioning**: Based on the IPRAN knowledge graph to find the root cause positioning of fault network devices and links in IPRAN.

- **OTN alarm processing knowledge graph**: Based on OTN alarm work order data, create a OTN alarm processing knowledge graph and recommend solutions for OTN alarm work orders
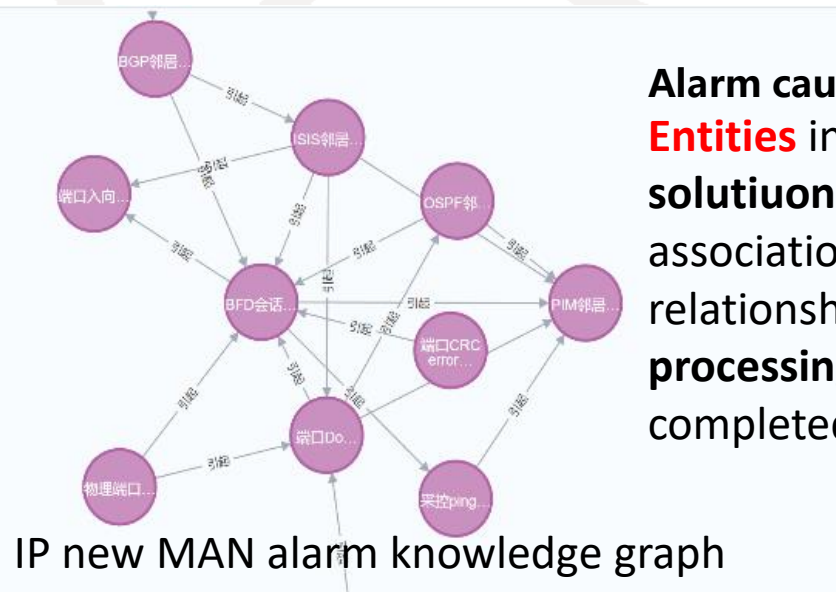
IP new MAN alarm knowledge graph
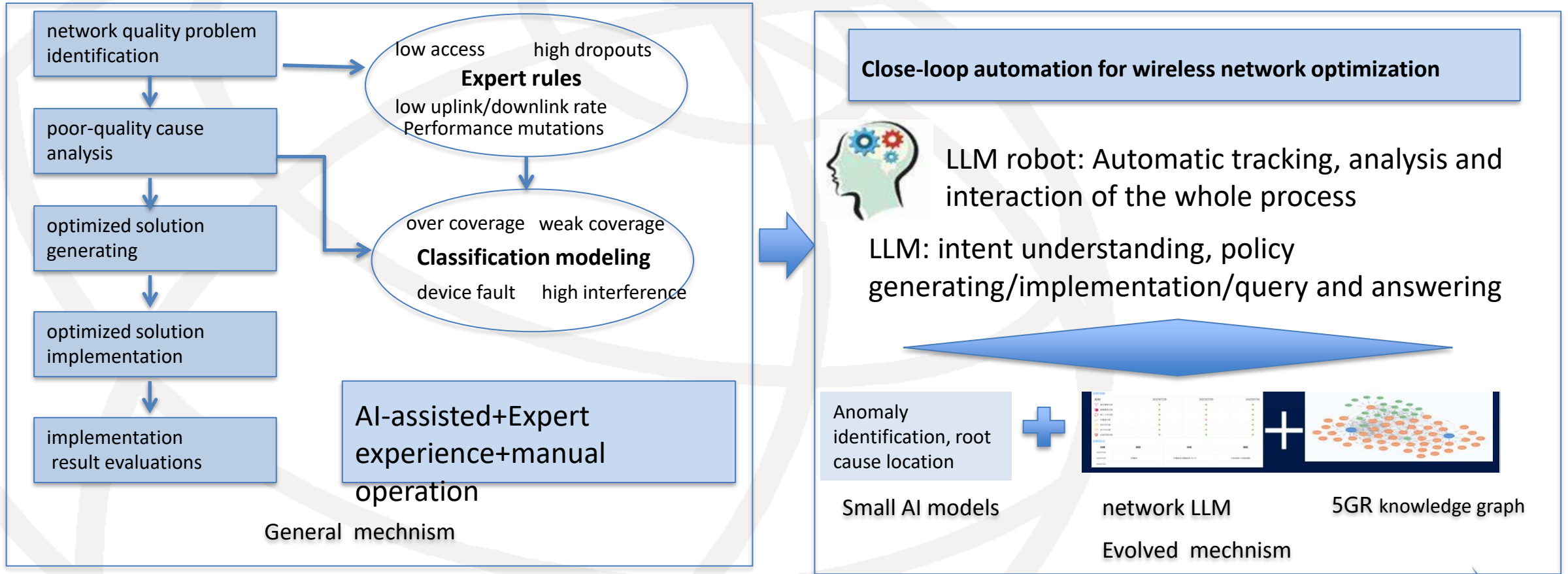
Alarm cause analysis:
Entities include **alert types, processing solutiuons**, and **relationships** include associations between **alert types**, relationship between **alarm types and processing solutiuons**, and can be completed by importing expert rule

Alarm propagation path: Based on the knowledge graph technology and graph search algorithm, an **explainable root cause propagation path** is generated to achieve second-level alarm root cause positioning.

3. knowledge graph and Large language model integration

For network management optimization, by adopting knowledge graph integrated with Large language model, generates high-precision poor-quality root causes and optimization solutions.
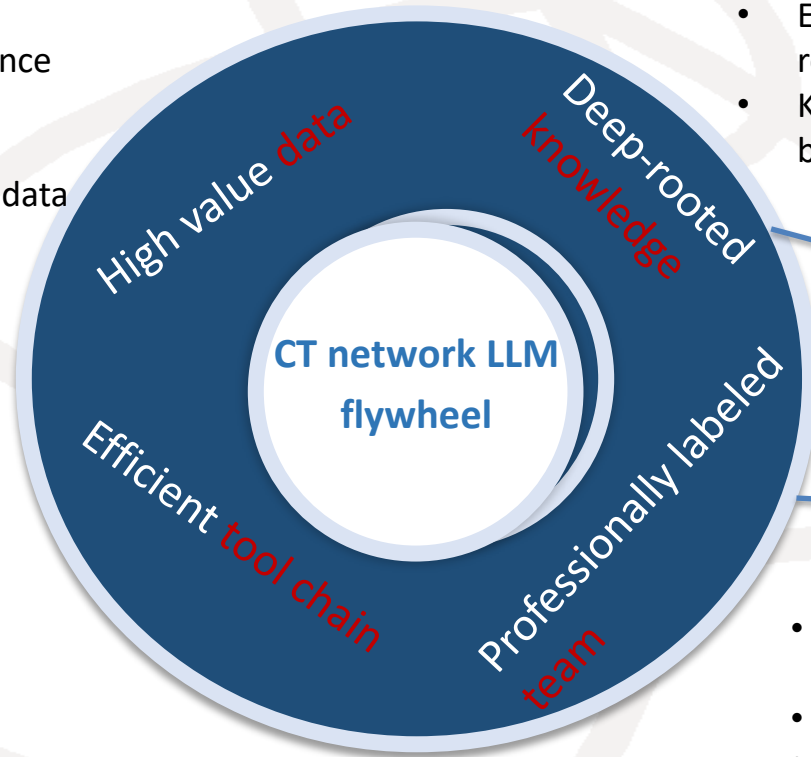
network quality problem identification

poor-quality cause analysis

optimized solution generating

optimized solution implementation

implementation result evaluations

low access   high dropouts
Expert rules
low uplink/downlink rate
Performance mutations

over coverage   weak coverage
Classification modeling
device fault   high interference

AI-assisted+Expert experience+manual operation

General mechnism

Close-loop automation for wireless network optimization

LLM robot: Automatic tracking, analysis and interaction of the whole process

LLM: intent understanding, policy generating/implementation/query and answering

Anomaly identification, root cause location

Small AI models

network LLM

5GR knowledge graph

Evolved mechnism

Knowledge graph+LLM driven: Human-machine interaction, automatic, intelligent

3. Data flywheel fully revitalizes the value of knowledge

- Cloud network work order
- Alarm logs
- Expert experience knowledge
- Typical operation and maintenance cases
- Structured network data
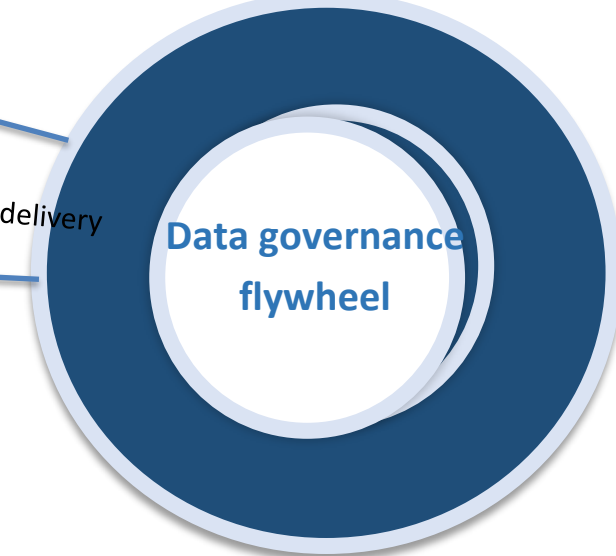- Unstructured service operation data

- Data cleaning and quality assessment tools
- Information extraction and data enhancement tools
- Data annotation tools, safety detection tools
- Knowledge processing tools, corpus quality testing tools

- Network operation plan and rules, expert experience
- Enterprise professional cases, reports, standards
- Knowledge graph + Knowledge base dual base

Network digital twin data analysis
Multi-domain knowledge assets

High value data

Deep-rooted knowledge

CT network LLM flywheel

Efficient tool chain

Professionally labeled team

LLM feed data governance

Efficient generation and continuous delivery of high-value model training corpus

Data governance flywheel

- Operation and maintenance personnel
- Data analyst
- AI engineer

Thanks

AN FG contacts

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