情報通信研究機構
National Institute of Information and Communications Technology

Artificial Intelligence Framework for Network Management

P. Martinez-Julia (NICT), S. Homma (NTT), Diego Lopez (Telefónica)

draft-pedro-nmrg-ai-framework-00

Pedro Martinez-Julia
Network Architecture Laboratory, Network Research Institute
National Institute of Information and Communications Technology (NICT)
pedro@nict.go.jp

IETF 112

Network Management Research Group

8 November 2021

Overview

- Automating network management (NM) with artificial intelligence (AI) enables computer and network systems (CNS) and its infrastructures to **grow in complexity**.
- Several mechanisms must **interoperate** to **achieve the full exploitation of AI**:
  - Machine learning (statistic) classification and regression, logic and semantic reasoning, neuro-symbolic deduction, planning, etc.
- An **AI framework** must be defined to ensure seamless connection among all components participating in NM:
  - An **ontology** must be researched and maintained.
  - The **operation of all AI functions** must be defined.
  - A **method for assessing the correct handling** of ontological elements and AI functions must be defined.

Background (I)

- **Virtual Computer and Network Systems**:
  - Have high degree of flexibility and reliability.
- **SDN and NFV**:
  - (Conceptually) centralized control and function (software) reuse.
- **Management and Control**:
  - Increased complexity of both underlying and overlying systems.
  - Must perform the dynamic adaptation of virtual resources to the specific needs of their operation environments.

Background (II)

- **AI ≠ ML**:
  - AI has a broader spectrum of methods, some of them are already exploited in the network for a long time.
  - **Perception**, **reasoning**, and **planning** must be exploited for NM.

- **Intelligence ≠ Intelligent**:
  - Intelligence emphasizes data gathering and management:
    - Which can be processed by systematic methods or intelligent methods…
  - Intelligent emphasizes the reasoning and understanding of data to actually “posses” the intelligence.

AINEMA: AI Framework for NM

- **AINEMA** is a generic, scalable, deployable and trustworthy AI framework for NM:
  - Use: design, deploy, instantiate, scale and validate AI solutions for network OAM.
  - The framework will particularly target E2E NM.

- **Key components**:
  - **The data framework**:
    - Responsible for acquiring, modeling, storing, and distributing data, both historical, collected off-line, and real-time, on-line, from different parts of a network in a unified and efficient manner.
    - Provides the internal communication layer to the AI framework and serves as the communication path between the AI framework and network orchestration entities.
  - **The AI modules**:
    - Contain the AI functions that individually or collectively accomplish local, E2E or global intelligent tasks for network OAM.
  - **The AI hub**:
    - Receives data, knowledge, and localized decisions from AI modules and outputs desired actions as recommendations to network management entities. The AI hub is also in charge of the life cycle management of the AI modules.

AINEMA Operation Overview

1) A **data collection sub-process** retrieves the performance measurements from the managed computer and network system (MCNS).

2) A **reasoning sub-process** receives (from 2) collected data and additional context information, and finds out the rules that are governing the situation of the MCNS.

3) A **solving sub-process** gets (from 2) the situation and rules to build a dynamic knowledge graph (KB) that represents the current situation (CS) of the MCNS:
   - The KB follows a particular ontology for representing the MCNS and its situation, the rules, actions, and performance measurements.
   - The dynamic KB is transformed to find an acceptable situation (AS). The actions required will be applied for the MCNS to reach the AS.

4) A **planning sub-process** receives (from 3) the solution graph and makes a linear plan of actions to execute in order to enforce the required changes to the MCNS:
   - The actions are the building blocks of the plan. Each block will be defined with a precondition, invariant, and post-condition.
   - A planning algorithm should be used to obtain such plan of actions by linking the building blocks in a way acceptable for the network.

Application Concepts to Research (I)

- **Support for the Closed Loop**:
  - Data plane elements must provide feedback that is comprehensible by the AI framework to implement a closed control loop for the MCNS.
- **Network Intelligence**:
  - Data analytics must extend the AI methods to incorporate target-centric automated intelligence methods that, for example, are able to hypothesize about the situation of the MCNS and collect evidences to support or reject the hypothesis.
- **External Event Detectors**:
  - The behavior of the MCNS depends on its users, whose behavior depends, in turn, on factors that rely generally outside the MCNS.
  - External detectors provide a huge source of intelligence data that can be exploited as evidence to demonstrate or invalidate the hypotheses about the behavior of the MCNS.

Application Concepts to Research (II)

- **Anticipation of Network Requirements**:
  - Instead of exploiting AI for just predicting network requirements, AI must be used to anticipate situations that are sure to happen in the future and make preventive corrections to avoid them. This quality will be exploited in the form of network digital twins.

- **Support for Intelligent Reasoning**:
  - External event information must cross the administrative domain of the network to which it is relevant. This means that there must be interfaces and security policies that regulate how information is exchanged.
  - Enough meta-data must be associated to performance measurements to clearly identify all aspects of the effects
  - The management ontology must be extended by all concepts from the boundaries of the MN and its context.

Gaps and Standardization Issues

- **Common interfaces**:
  - Methods from different providers/vendors must be able to coexist and work together, either directly or by means of a translator. They must, however, use the same concepts, albeit using different naming, so they actually share a common ontology.
- **Component assessment, quality assurance**:
  - Information retrieval must be assessed for quality so that the outputs from AI reasoning, and thus management solutions, can be reliable.
- **Synchronized concepts and ontologies**:
  - Ontological concepts must be consistent so that the types and qualities of information that is retrieved from a system or object are as expected.
- **Limited information dissemination**:
  - The protocols used to communicate (or disseminate, or publish) the information must respond to the constraints of their target usage.

Thanks for Your Attention

Questions?

– EOF –