Joint ITU-ETSI Workshop on "Machine Learning in communication networks"
(Sophia Antipolis, France, 16 March 2020)

Achievements on AI/ML within ITU-T SG13, with focus on Q20/13 activities

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ITU-T SG13 Questions’ involvement in AI/ML studies – 1/3/2020

WP	Title	Questions
1	IMT-2020 Networks & Systems	Q.6: Quality of service (QoS) aspects including IMT-2020 networks **Currently involved in AI/ML studies from QoS perspective (achievements and ongoing work items: Y.3175 “Architecture of machine learning based QoS assurance for the IMT-2020 network” – [consented on 13 March 2020])**
		Q.20: IMT-2020: Network requirements and functional architecture **Currently involved in AI/ML studies from use cases, requirements, network capabilities and architecture perspective (achievements and ongoing work items: see next slides)**
		Q.21: Software-defined networking, network slicing and orchestration **Currently involved in AI/ML studies from Q21 studies perspective (achievements and ongoing work items: Y.IMT2020-mAI “Traffic typization IMT-2020 management based on an artificial intelligent approach”, Y.IMT2020-NSAA-reqts “Requirements for network slicing with AI-assisted analysis in IMT-2020 networks”)**
		Q.22: Upcoming network technologies for IMT-2020 and future networks **No specific studies related to AI/ML at this time**
		Q.23: Fixed-mobile convergence including IMT-2020 **No specific studies related to AI/ML at this time**
2	Cloud Computing & Big Data	Q.7: Big data driven networking (bDDN) and deep packet inspection (DPI) **Currently involved in AI/ML studies from big data and deep packet inspection perspective (achievements and ongoing work items: Y.bDDN-MLMec “Mechanisms of machine learning for big data driven networking”, Y.MecTA-ML “Mechanism of traffic awareness for application-descriptor-agnostic traffic based on machine learning”, Y.MLN-Fr “Framework for man-like networking”)**
		Q.17: Requirements, ecosystem, and general capabilities for cloud computing and big data **Currently involved in AI/ML studies from XaaS and Big data perspective (achievements and ongoing work items: Y.Sup.aisr ”Artificial Intelligence Standard Roadmap”, Y.MLaaS-reqts “Cloud computing - Functional requirements for machine learning as a service”)**
		Q.18: Functional architecture for cloud computing and big data **No specific studies related to AI/ML at this time**
		Q.19: End-to-end cloud computing management and security **No specific studies related to AI/ML at this time**
3	Network Evolution &Trust	Q.1: Innovative services scenarios, deployment models and migration issues based on future networks **No specific studies related to AI/ML at this time**
		Q.2: Next-generation network (NGN) evolution with innovative technologies including software-defined networking (SDN) and network function virtualization (NFV) **No specific studies related to AI/ML at this time**
		Q.5: Applying networks of future and innovation in developing countries **No specific studies related to AI/ML at this time**
		Q.16: Knowledge-centric trustworthy networking and services **No specific studies related to AI/ML at this time**

AI/ML studies in Question 20/13
"IMT-2020: Network requirements and functional architecture"

Motivation

… This end-to-end flexibility will bring challenges to the architecture and functional design of IMT-2020 considering the diversity of service requirements. Challenges come in large part from the incorporation of network softwarization into every component. Well known techniques such as NFV and SDN will together allow unprecedented flexibility in the IMT-2020 systems. Such flexibility will enable many new capabilities including network slicing.

Considering also the complexity implied by such flexibility, the application of artificial intelligence including machine learning technologies will be also very beneficial for IMT-2020 systems in terms of network operations and application support capabilities.

This question focuses on the study of the requirements, capabilities, architecture and key technologies to realize IMT-2020 networks. And the ecosystem from business models and use cases should be promoted to build and realize the better cooperation with users. Open source projects should also be utilized and guide to meet the requirements of IMT-2020 networks.

Question

Study items to be considered include, but are not limited to:

…

What key technologies related to IMT-2020 are required to realize IMT-2020 networks?

How to incorporate network intelligence into IMT-2020?

Tasks

Tasks include, but are not limited to:

…

Development of Recommendations and other relevant documents on overall requirements and functional architecture of IMT-2020 incorporating technologies including network softwarization, network slicing, orchestration, capability exposure, artificial intelligence including machine learning, etc.

Q20/13 achievements: Supplement 55 to Y.3170 series

"Machine learning in future networks including IMT-2020: use cases"

- Analysis of use cases for machine learning in future networks including IMT-2020, presented in a unified format.

Originally contributed as output of FG-ML5G

Use case categories

- Network slice and other network service related use cases (14)
- User plane-related use cases (3)
- Application-related use cases (3)
- Signalling or management related use cases (8)
- Security related use cases (2)

Each use case is illustrated with the basic set of possible related requirements

- Critical requirements
- Expected requirements
- Added value requirements

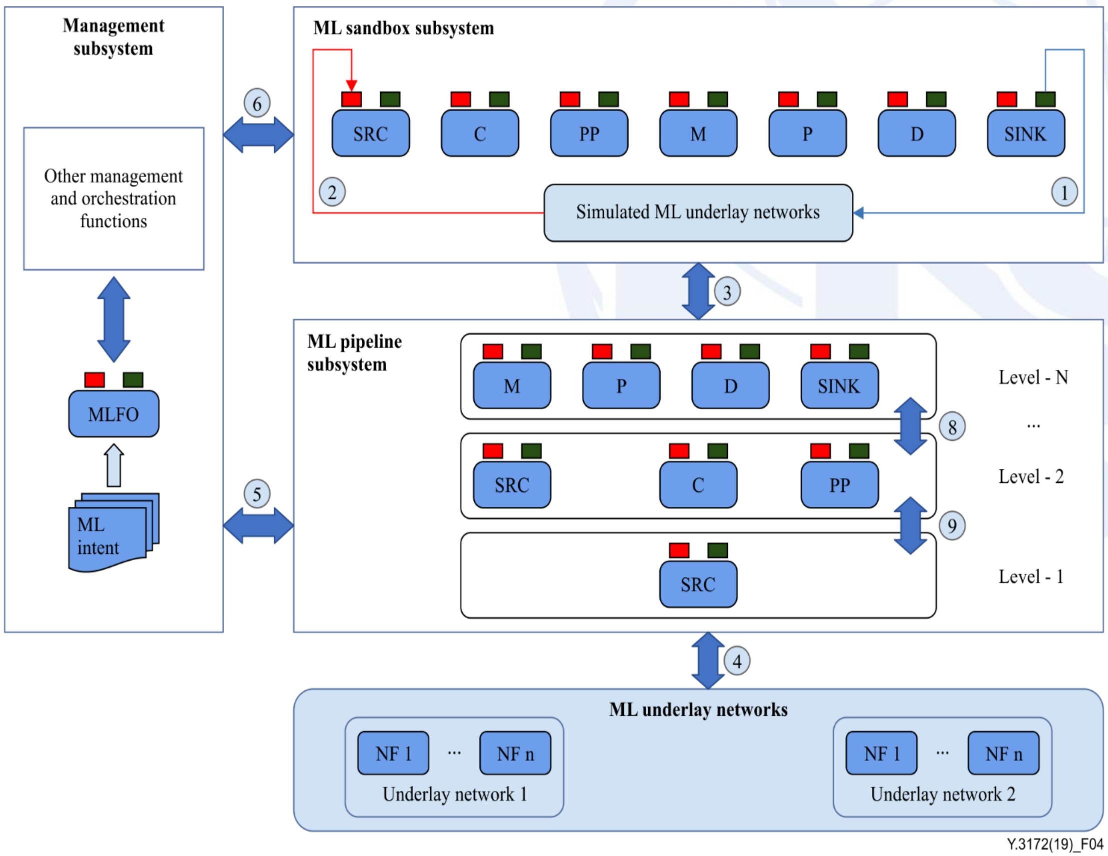
Requirements have been organized according to data collection, data storage and processing, application of ML output.

Q20/13 achievements: Y.3172 (foundational document)

"Architectural framework for ML in future networks incl. IMT-2020"

- A set of architectural requirements and specific architectural components (incl. ML pipeline, ML management and orchestration functionalities, ML sandbox) to satisfy requirements
- The integration of such components into the network
- Guidelines for applying framework in different technology-specific underlying networks

Originally contributed as output of FG-ML5G



High-level architecture

ML pipeline: **set of logical nodes**, each with specific functionalities, that **can be combined to form a ML application in telecommunication network**. It may be deployed on **simulated or live ML underlay networks.**

ML function orchestrator (MLFO): logical node with functionalities that **manage and orchestrate the nodes of ML pipelines based on ML Intent and/or dynamic network conditions**

ML sandbox: **isolated domain** which allows the **hosting of separate ML pipelines to train, test and evaluate them before deploying in live network.** It can use data from simulated ML underlay networks and/or live networks.

Q20/13 achievements: Y.3173

"Framework for evaluating intelligence level of future networks incl. IMT-2020"

Framework for evaluating the intelligence of future networks, including:

- Method and architecture view for evaluating the intelligence levels of future networks
- Informative: relationship between the framework and work in other standards or industry bodies (ETSI ISG ENI, SAE, GSMA, TM Forum), and application of the method on representative use cases

Originally contributed as output of FG-ML5G

Motivation:

AI is promising technology to cope with increasing complexity and improve network performance.

As networks become more and more intelligent, it is important to adopt a standard method for evaluating network intelligence levels.

Values of a standard method for evaluating network intelligence levels:

- evaluation basis for measuring the intelligence levels of a network and of its components
- help industry to reach unified understanding of network intelligence concepts
- reference for industry supervisors to formulate network strategies and development planning
- decision support to network industry for planning network technology features & products' roadmaps

Network intelligence level		Dimensions				
		Action Implementation	Data Collection	Analysis	Decision	Demand Mapping
L0	Manual network operation	Human	Human	Human	Human	Human
L1	Assisted network operation	Human & System	Human & System	Human	Human	Human
L2	Preliminary intelligence	System	Human & System	Human & System	Human	Human
L3	Intermediate intelligence	System	System	Human & System	Human & System	Human
L4	Advanced intelligence	System	System	System	System	Human & System
L5	Full intelligence	System	System	System	System	System

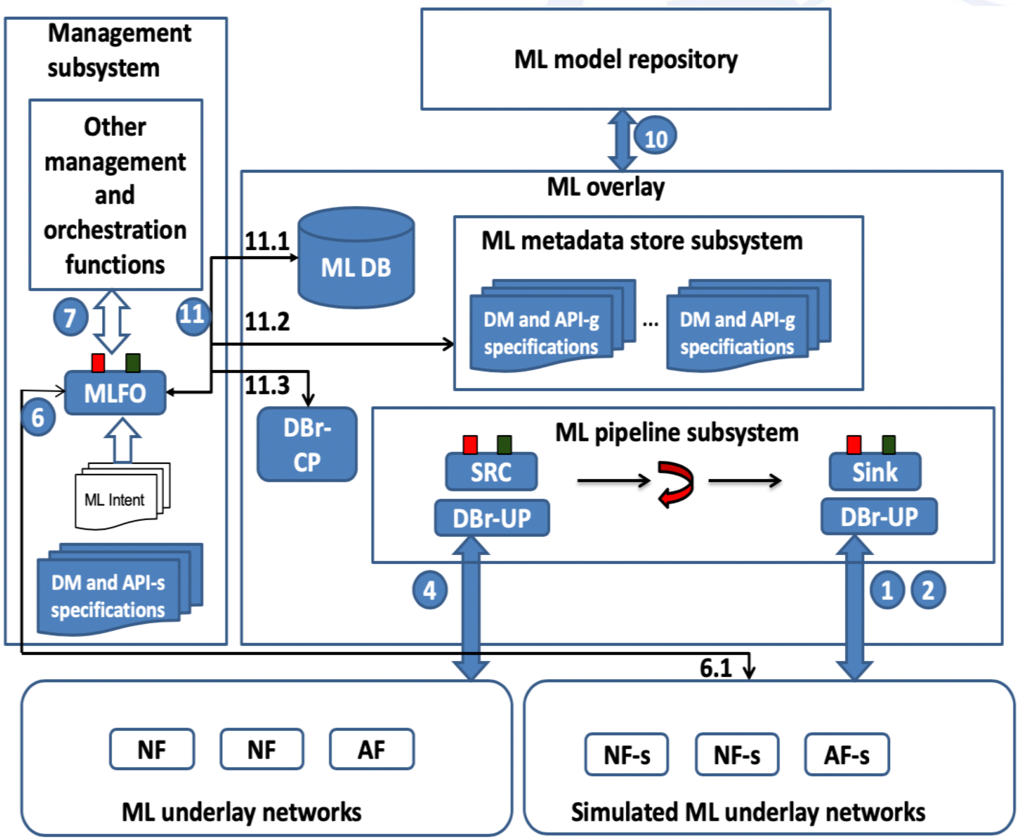
The overall network intelligence level is determined by selecting the minimum per-dimension network intelligence level across all dimensions

Q20/13 achievements: Y.3174

“Framework for data handling to enable machine learning in future networks including IMT-2020”

- Requirements for data collection and processing mechanisms in various usage scenarios for ML
- Requirements for applying ML output in the ML underlay network
- Framework for data handling and examples of its realization on specific underlying networks

Originally contributed as output of FG-ML5G



High-level architecture of the data handling framework

Challenges addressed by this study:

- diversity in network data sources makes challenging to implement Y.3172 framework
- increased flexibility and agility with richer configuration options make challenging to enable the use of ML mechanisms
- evolving sources of data together with a multiplicity of applicable network configuration parameters and policies make challenging to adapt to the changes while preserving the quality of data needed for ML applications

Reused high-level architectural components defined in [ITU-T Y. 3172] **plus some newly defined data architectural components**

The integration of the high level architectural components to a ML underlay network by interfacing with NFs, along with the placement of the ML functionalities, forms the data handling framework

Ongoing Q20/13 work items

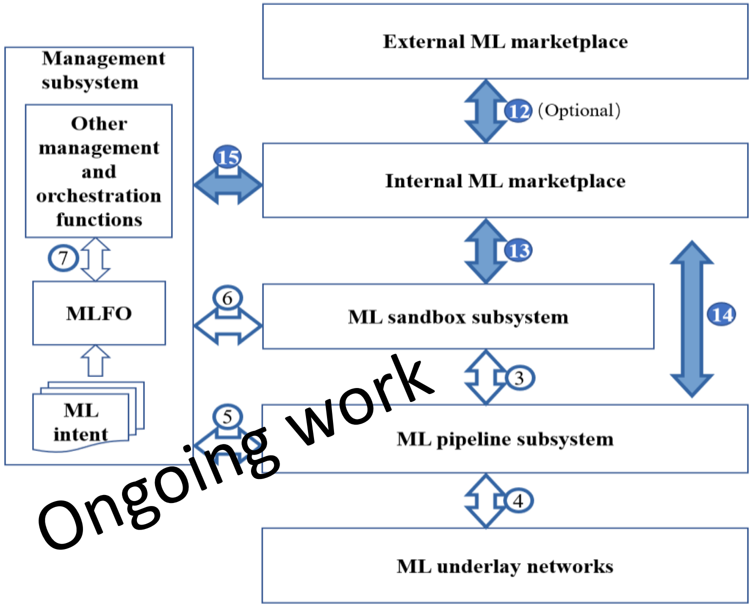
Document	Title	Editors	Priority	Target date
ITU-T Y.ML-IMT2020-NA-RAFR /AAP	**Architecture framework for AI-based network automation of resource adaptation and failure recovery for future networks including IMT-2020**	Ved P. Kafle (kafle@nict.go.jp), Tatsuji Miyamoto (tt-miyamoto@kddi.com), Taro Ogawa (taro.ogawa.tg@hitachi.com), Takayuki Kuroda (t-kuroda@ax.jp.nec.com)	High	**Q2-2020**
ITU-T Y.ML-IMT2020-serv-prov /AAP	**Architecture framework of AI-based user-oriented network service provisioning for future networks including IMT-2020**	Ved P. Kafle (kafle@nict.go.jp), Taro Ogawa (taro.ogawa.tg@hitachi.com), Takayuki Kuroda (t-kuroda@ax.jp.nec.com), Tatsuji Miyamoto (tt-miyamoto@kddi.com)	High	**Q2-2020**
ITU-T Y.ML-IMT2020-MP /AAP	**Machine learning marketplace integration in future networks including IMT-2020**	Tengfei Liu(liutf24@chinaunicom.cn), Qi Sun(sunqiyjy@chinamobile.com), Yongsheng Liu(liuys170@chinaunicom.cn), Liya Yuan(yuan.liya@zte.com.cn)	High	**Q2-2020**
ITU-T Y. IMT2020-AIICDN-arch /AAP	**AI integrated cross-domain network architecture for future networks including IMT-2020**	Qin Li(liqinyjy@chinamobile.com), Yushuang Hu(huyushuang@chinamobile.com), Liya Yuan(yuan.liya@zte.com.cn), Aipeng Guo(guoap7@chinaunicom.cn)	High	**Q4-2021**

More on the ongoing Q20/13 work items 1/4

"Machine learning marketplace integration in future networks incl. IMT-2020"

- Requirements for integration of ML marketplace in networks, derived from use cases.
- Based on these requirements, architecture for the integration of ML marketplace

Originally contributed as output of FG-ML5G



Architecture for ML marketplace integration in network

A network operator may use a **ML marketplace deployed internally and/or externally to the network operator's admin domains (difference is only in deployment).** An internal marketplace for a network operator may act as external marketplace for another network operator.

Integration challenges-> needs for standardization

ML models may be hosted in varied types of ML marketplaces While designing the ML application, **network operators need interoperable mechanisms for identification of the ML marketplace** which may be used as source for ML models.

Evolution of ML models may happen independent of the technology evolution in future ML underlay networks. While choosing the ML models from the ML marketplace, **network operators need interoperable, automated mechanism to select the appropriate ML solutions.**

Network operators should be able to follow the innovation curve in the ML marketplace without sacrificing their network KPIs

Lack of standard mechanisms to exchange ML models and related metadata between the operators' network and the ML marketplace, limits the interoperability.

Composing complex ML models by chaining simpler ML models is an important need for network operators. But **selecting the appropriate ML models from disparate ML marketplaces, and chaining them, requires support for such mechanisms from ML marketplaces.**

Efficient use of testing methods requires sharing of information between ML marketplaces and network operators

Deployment of ML models in operator's network depends on the deployment environment used in the network: ML models hosted in ML marketplace need to be amenable to such deployment environment.

Use of ML Intent and MLFO to search and select the ML model from the ML marketplace, based on the needs of the ML application.

Rich, standard metadata used in the interface between the ML marketplace and the MLFO to search and select the ML model most suited for the requirements of the ML application.

Interface between ML sandbox/ML pipeline subsystem and ML marketplace used to push the ML model from the ML marketplace to the ML sandbox/ML pipeline subsystem

More on the ongoing Q20/13 work items 2/4

"Architecture framework for AI-based network automation of resource adaptation and failure recovery for future networks including IMT-2020"

- Architecture framework of AI-based network automation for resource adaptation, failure detection and recovery for the purpose of improving network efficiency and maintaining QoS These goals are pursued by continuously monitoring the network and promptly deciding about appropriate actions for resource adaptation and failure recovery with the help of AI incl. ML
- Related to two use cases described in Supplement 55 to Y.3170 series

Major technical objective: to utilize the available resources as optimally as possible while maintaining the QoS of the services provided to the customers despite changing network conditions or occurrences of failures

AI-based techniques are leveraged:

- to collect and analyse the network measurement data related with performance, resource utilization and workload; to infer their patterns or trends;
- to identify failures by root cause analysis; to prescribe suitable recovery mechanism; to predict the future demands of resources or possibility of failure in various network nodes.

Based on the prediction, appropriate actions of failure recovery and resource adaptation can be decided.

The scope of the Recommendation includes:

- AI-based network automation architecture framework for resource adaptation
- AI-based network automation architecture framework for failure detection and recovery
- Resource adaptation functions with AI incl. ML
- Failure detection and route cause analysis with AI incl. ML

More on the ongoing Q20/13 work items 3/4

"Architecture framework of AI-based user-oriented network service provisioning for future networks including IMT-2020"

- Architecture framework of user-oriented network service provisioning with AI-based generation of network requirements, configuration and provisioning workflow.
- It considers a network/user interaction where both sides are administered independently by utilizing AI including machine learning.
- Related to service provisioning automation use cases in Supplement 55 to Y.3170 series

Motivation and major technical objective:

Application services in the future networks including IMT-2020 will be configured and operated on converged infrastructures consisting of diversified ICT infrastructure such as clouds, edges, and various types of networks.
There should be no gap between each application-service developer's requirements (intents) and the ICT infrastructure capabilities (the specifications), which are traditionally aiming at mass optimization. Some sort of interfaces between the intents and the specifications will be vital for effective and agile cooperation between application services and ICT infrastructure services.
There are multiple stakeholders, and the interface specifications between the customers and the providers have been addressed and evolving continuously in many SDOs. AI-supported interaction between them is a totally new issue.

AI-based techniques are leveraged:

The interfaces are required to be configured and operated automatically or autonomously, considering the complexity caused by the diversity both in application services and ICT infrastructure services.
AI incl. ML techniques are helpful to bridge the gap.

More on the ongoing Q20/13 work items 4/4

"AI integrated cross-domain network architecture for future networks including IMT-2020"

- Design principles and architecture of AI (incl. ML) integrated cross-domain network for future networks including IMT-2020

Motivation and major technical objective:

The current network domains lack an architecture to coordinate and unify the intelligent analysis systems of the different domains.

It is needed to specify a cross-domain network architecture for a unified AI integrated cross-domain network.

Design principles of AI Integrated Cross-Domain Network are expected to include:

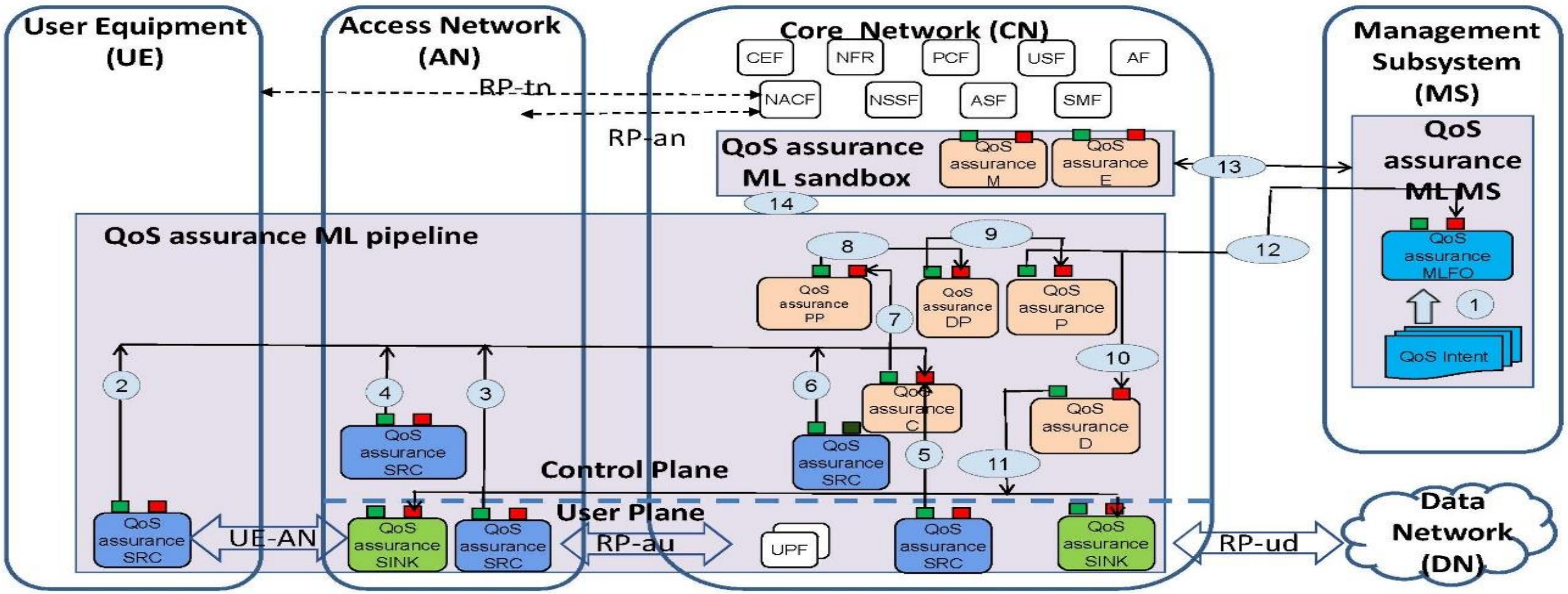
Unified framework, Distribution, Collaborative Design, Modularity and Reusability, Data sharing, On-demand intelligent provisioning, Scalability.

Other SG13 achievements on AI/ML

Q6/13 achievement: Y.3175 [consented on 13 March 2020]

"Functional architecture of machine learning based quality of service assurance for the IMT-2020 network"

- It applies the high level architecture defined in [ITU-T Y.3172] to fulfil the requirements for ML based QoS assurance for the IMT-2020 network



QoS assurance Service for egress
QoS assruance Service for ingress
SRC: QoS source of data
C: QoS data collector
PP: QoS data pre-processor
DP: QoS anomaly detection and prediction
SINK: QoS assruance target of ML output
P: QoS policy
D: QoS policy distributor
M: QoS assurance ML modelling
E: QoS assurance model evaluating

Architecture of ML based QoS assurance

Thank you very much for your attention

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