**ITU AI/ML 5G Challenge – Applying AI/ML in 5G networks. A Primer**

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# 1 Executive Summary

Artificial Intelligence (AI) will be the dominant technology of the future and will impact every corner of society. In particular, AI / ML (machine learning) will shape how communication networks, a lifeline of our society, will be run. Many companies in the information and communication business are exploring how to make best use of AI/ML. ITU has been at the forefront of this endeavour exploring how to best apply AI/ML in future networks including 5G networks.

The time is therefore right to bring together the technical community and stakeholders to brainstorm, innovate and solve relevant problems in 5G using AI/ML. Building on its standards work, ITU is conducting a global ITU ML5G Challenge on the theme “How to apply ITU’s ML architecture in 5G networks”.

* Participants will be able to solve real world problems, based on standardized technologies developed for ML in 5G networks. Teams will be required to enable, create, train and deploy ML models (such that participants will acquire hands-on experience in AI/ML in areas relevant to 5G).
* Participation is open to ITU Member States, Sector Members, Associates and Academic Institutions and to any individual from a country that is a member of ITU. There are two categories: “student” and “professional”.
* The incentives for sponsors, partners, and participants include:
* Accelerated problem solving of AI/ML problem statements in 5G
* Generating solutions through crowdsourcing of AI/ML problem statements for data and/or problem owners
* Talent development in the field of AI/ML in 5G
* Networking with experts in the field of AI/ML in 5G
* The challenge consists of three rounds:
* 1st round: Regional Round, conducted in regions/countries. The best projects in each region will advance to the second round.
* 2nd round: Global Round. The best projects of the Global Round compete for the winning prize at a Global Conference – to be conducted in the host country of the main sponsor.
* 3rd round: This round consists of demos and presentations at the Final Conference mentioned above. Winners of the 3rd round will be chosen from the best teams of the Global Round.

NOTE- Observers: In addition to the winners of 2nd round, selected teams from 1st and 2nd round may be invited to the global conference as observers by the discretion of the judgment panel.

* The challenge will span over a nine months period in 2020:
* Call for interest: February – April 2020
* 1st round = Regional Round: May – July 2020
* 2nd round = Global Round: August – October 2020
* 3rd round = Final Conference: November or December 2020
* ITU has developed a range of standards-based Machine Learning mechanisms in 5G. Participants of the ITU ML5G Challenge are encouraged to base their work on those standards. Use cases (“problem statements”) can be taken from the relevant ITU specification, but participants can also tackle new use cases relevant to AI/ML in 5G.
* We encourage participants to submit open source implementations. However, solutions based on proprietary implementations are also accepted.
* The challenge will have four technical tracks:
1. Network-track,
2. Enablers-track,
3. Verticals-track,
4. Social-good-track,
* Four type of data will be used:
	1. Real data (secured)
	2. Open data
	3. Synthetic data
	4. No data
* Data privacy: Different security levels (role-based access) to access training and testing data will be applied to accommodate privacy issues: a secure-track would make sure isolated, segregated sandboxes and best-practices are in place for secure data handling.
* A unique feature of this challenge is that mentoring will be offered to students who participate in the challenge.

# 2 Motivation

Demand by network operators to master the application of ML in networks is strong. Neither today’s nor the up-and-coming 5G networks are designed to make best use of ML. However, every company in the networking business is investigating the introduction of ML in order to optimize network operations, increase energy efficiency and curtail the costs of operating a network. ML will enhance network management and orchestration and make predictions to optimize network operations and maintenance. This optimization is becoming increasingly challenging and important as networks gain in complexity to support the coexistence of a diverse range of services. Network operators aim to fuel ML models with data collected from multiple technologies and at different levels of the network. They are calling for deployment mechanisms able to future-proof their investments in ML. They also need interfaces to transfer data and trained ML models across ML functionalities at multiple levels of the network.

# 3 Participation

Participation is open to ITU Member States, Sector Members, Associates and Academic Institutions and to any individual from a country that is a member of ITU.

Participants: These are individuals and companies that participate in the ITU ML5G Challenge, providing solutions to problem sets of the challenge.

There are two categories of participants: student and professional.

## 3.1 Students

Students need to be registered as students at a university when they sign up for the ITU ML5G Challenge.

Students can form teams comprising of 1-4 members. Experts will mentor students on problems, providing guidance and good practices for participation in this Challenge.

## 3.2 Professionals

Anyone else is considered a “professional”. A professional works usually in a company and has the necessary skills to complete the problem sets they choose to tackle in the Challenge.

# 4 Problem statements and Technical Tracks

Participants will be able to solve real world problems (including those with social relevance), based on standardized technologies developed for ML in 5G networks. Teams will be required to enable, create, train and/or deploy ML models (such that participants will acquire hands on experience in AI/ML) in areas relevant to 5G. Problem statements will be taking either from ITU’s specification on use cases or can be decided by the participant(s) themselves. Problem statements will be organized into four technical tracks: Network-track, Enablers-track, Verticals-track and Social-good-track.

## 4.1 Problem statements

The ITU specification [“Machine learning in future networks including IMT-2020: use cases” (Supplement 55 to ITU-T Y.3170 series)](https://www.itu.int/rec/T-REC-Y.Sup55-201910-I/en) classified thirty use cases into five categories as below. For each use case, the requirements are further classified into those for data collection, data storage and processing, and application of ML output. The section headings are copied from the ITU specification:

* 6.1 Network slice and other network service related use cases: This category of use cases is related to the creation or management of network slices (e.g., resource management for network slices). Similarly, the use cases related to the creation or management of network services have also been classified into this category.
	+ 6.1.1 Cognitive heterogeneous networks and ML-based SON
	+ 6.1.2 Radio resource management for network slicing (RRM-NS)
	+ 6.1.3 End-to-end network operation automation – Service design
	+ 6.1.4 End-to-end network operation automation – Network resource adaptation
	+ 6.1.5 End-to-end network operation automation – Logical network design and deployment
	+ 6.1.6 End-to-end network operation automation – Fault detection and recovery
	+ 6.1.7 Application-specific network slicing through in-network machine learning
	+ 6.1.8 Smart traffic mirror – an ML-assisted network service
	+ 6.1.9 ML-based end-to-end network slicing for 5G
	+ 6.1.10 ML-based utility maximization of sliced backhauls
	+ 6.1.11 Energy efficient trusted multi-tenancy in IMT-2020 cross-haul
	+ 6.1.12 Network slice SLA assurance based on ML
	+ 6.1.14 Automated testing of services
* 6.2 User plane-related use cases: This category of use cases is related to the user plane of the network. The use cases which belong to this category may use the user plane in different manners, for example as a source of data or sink for configurations (e.g., traffic classification).
	+ 6.2.1 Traffic classification
	+ 6.2.2 Long-term traffic forecasting
	+ 6.2.3 Emergency services based on ML
* 6.3 Application-related use cases: This category of use cases is related to the applications running on the network, e.g., using application data for machine learning in the network.
	+ 6.3.1 AN-assisted transmission control protocol window optimization
	+ 6.3.2 Retention and storage intelligence function
	+ 6.3.3 Data-driven architecture for ML at the edge
* 6.4 Signalling or management related use cases
	+ 6.4.1 ML-based mobility pattern prediction
	+ 6.4.2 Load balance and cell splitting/merging
	+ 6.4.3 ML-based QoE optimization
	+ 6.4.4 ML-based network management for Industry 4.0
	+ 6.4.5 ML-based correlations between transport KPIs and radio KPIs
	+ 6.4.6 ML-based end-to-end network management
	+ 6.4.7 ML-aided channel modelling and channel prediction
	+ 6.4.8 ML-based link adaptation optimization
* 6.5 Security related use cases: This category of use cases is related to the security aspects of the network.
	+ 6.5.1 Combating use of counterfeit ICT devices – ML-assisted network service
	+ 6.5.2 ML-based identification of illegal exchanges using SIM boxes

For the network-track (see below), the use cases mentioned in the Supplement 55 can be used as a reference or the participants can pick their own problem statement.

In addition, ITU has also published an architecture framework document for machine learning in future networks including IMT-2020 [ITU-T Y.3172]. There are also ITU FG ML5G specifications on data handling framework, intelligence level and ML marketplaces (see clause 8.1 for a detailed list). Any of these could be used as input for the enablers-track or the participants can pick their own problem statement.

Appendix B contains the template for a problem statement and an example.

## 4.2 Network-track

This track is designed considering the use cases of AI/ML in IMT-2020 networks.

In this track therefore, participants will build, train and deploy ML models for use cases in the network. Problem statements and data sets will be geared towards the challenges of distributed ML Pipeline as described in ITU Y.3172, e.g. optimization techniques, distribution mechanisms, federated learning mechanisms etc.

The Network-track will make sure that the use cases involving AI/ML in 5G networks are covered.

NOTE- The problem statements in this track may mostly use real data (see clause 5.1) depending on the nature of the problem statement.

## 4.3 Enablers-track

ML models alone are not sufficient to integrate intelligence in future networks. Training, evaluation, deployment, inference, and application of ML output in the network requires enabling technologies and tools in the network. An end-to-end solution may therefore comprise of an ML model, a set of APIs, data, metadata and other resources to realize the full capabilities of the models in a network.

In this track, participants will design and implement toolsets that can help in an end-to end implementation of ML model deployment in a real network. These toolsets consist of APIs, metadata, and other software such as Adlik, Acumos, ONAP, O-RAN OSC.

The Enablers-track will make sure that the end-to-end 5G solutions are covered and not just the ML models.

NOTE- The problem statements in this track may mostly use no data (see clause 5.1) depending on the nature of the problem statement.

## 4.4 Verticals-track

In this track, participants will apply ML/AI in 5G networks to other verticals such as manufacturing, education, health, public safety, transportation/automotive, finance, government, retail, agriculture, energy, smart cities, and media and entertainment. This track allows the combination of verticals and 5G to exploit the green-field opportunities for AI/ML applications. The key drivers of implementing 5G within these industries are the potential revenue growth opportunities for mobile operators and new business models.

## 4.5 Social-good-track

One of the flagship events of ITU in collaboration with other UN bodies is The AI for Good Global Summit. It aims to bring forward AI research topics that help achieve the Sustainable Development Goals (SDGs). This is done in order to find practical applications of AI and support strategies to improve the quality and sustainability of life on our planet.

In this track, participants/teams will identify and solve problems whose solutions are aimed to provide socially relevant applications (“AI for Good”) in 5G using AI/ML. Some examples of the solutions are advancing education, healthcare and wellbeing, social and economic equality, space research, and smart and safe mobility. Selected teams will be invited to participate in the AI for Good Summit in May 2020.

# 5 Data

## 5.1 Types of data

Four different types of datasets will be offered: real data, open data, synthetic data, and no data.

* **Real data:** This is anonymized network data from operators. The problem sets derived from this data can span across all four tracks but are more likely to play a role in the Network and the Verticals track. Network data is sensitive and cannot be shared on an open platform and requires a high level of security. However, this type of dataset is important for inference using ML in 5G networks. Different security levels to access training and testing data would be offered to accommodate privacy issues: tracks that run with real data would make sure isolated, segregated sandboxes (see ITU-T Y.3172) and best-practices are in place for secure data handling (“secure-track”). Access to this data may be restricted on role-basis and need-basis. Secure data-handling techniques (see ITU-T Y.3174) would be put in place for the “secure-track”. The secure-track will allow the design and implementation of ML models using data from operators by experts from network operators, ML researchers, and data scientists (with multi-disciplinary researchers from academia).
* **Open data**: This is data that is open and freely available on the Internet related to network operations. This type of data can span across multiple tracks.
* **Synthetic Data**: This data is from simulations. This will be used to solve problems from different tracks depending upon application.
* **No data**: In some instances, there will be no data requirement to solve problem sets in that particular track. An example is the enablers track in which development of toolsets to support/enable an end-to-end implementation of AI in 5G networks does not require any data.

## 5.2 Data sets

* **Real data:** ITU is discussing with various partners to make this available.
* **Open data**: A compiled list of open data sets will be made available.
* **Synthetic Data**: Some of the academic partners have come forward with simulation platforms with specific data.

## 5.3 Data provider

Data provider may be from academia, industry organizations, Standards Development Organizations, companies, and organizations that identify and/or provide data which could be used for solving specific problem statement. The data may be open (available to anyone) or private (available to select set of participants who satisfy the conditions set forth by the data provider).

## 5.4 Data privacy policy

Use case descriptions (according to Supplement 55 to ITU-T Y.3170-series “Machine learning in future networks including IMT-2020: use cases”) will be scrutinised according to policies and regulations. Data may be pre-processed and provided only using pre-published APIs, and may be secured using login/token. Data handling APIs (according to ITU-T Y.3174) will be provided based on the use case and filtered based on organization policies. Data anonymization may be applied according to policies and regulations. A non-disclosure agreement (NDA) may be included in the terms of participation. Challenge may be local, where applicable, according to policies and regulations, but the results of the Challenge, without including local user data, may be presented in the form of a competition paper. API access to data shall be monitored and licensed based on agreement. Some test data set may be private and will not be disclosed.

# 6 Mapping of Tracks to Data and Participation

The table below maps the data types to the technical tracks.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Technical Track** | **Real Data****(“secure track”)** | **Open Data** | **Synthetic Data** | **No Data** |
| Network | ✓ | ✓ | ✓ |  |
| Verticals | ✓ | ✓ | ✓ |  |
| Enablers |  |  |  | ✓ |
| Social good | ✓ | ✓ | ✓ | ✓ |

Table 1: Mapping of tracks to types of data

Students can participate in any of the four technical tracks and for any types of data. However, to participate in the track with real data (“secure track”), they can only participate if the problem/data owners have vetted the students to work on the specific problems.

Mentoring will be offered to students.

# 7 Regional Round, Global Round, Global Conference and Timelines

## 7.1 Overview

The ITU ML5G Challenge will consist of three rounds:

* 1st round: Regional Round, conducted in regions/countries. The best projects in each region will advance to the second round.
* 2nd round: Global Round. The best projects of the second round will be invited to a Global Conference – to be conducted in the host country of the sponsor – to determine the final winners.
* 3rd round: Final Conference. The final winners will be chosen only among the best teams of the Global Round.

NOTE- Observers: In addition to the winners of 2nd round, selected teams from 1st and 2nd round may be invited to the final conference as observers by the discretion of the judgment panel.

The challenge will span over a nine months period in 2020:

* Call for interest: February – April 2020
* 1st round = Regional Round: May – July 2020
* 2nd round = Global Round: August – October 2020
* 3rd round = Final Conference: November/December 2020



The timeline of the ITU ML5G Challenge is outlined below:

* February 2020: securing sponsorship
* February 2020: publicise the Challenge
* March – April: participants to sign up and determine the projects they will be working on; determine the composition of the Challenge Management Board and the Judging Panel
* May 1, 2020: Regional Round starts
* July 24: Final submission for Regional Round
* July 31: Announce regional winners
* August: Global Round to start
* November: Final submission for Global Round
* November/December: Final Conference, announcing the winners of the ITU AI/ML in 5G Challenge

We define a “Collaborator” as an organization (such as a network operator, vendor, or platform provider, companies, universities, etc) that will provide problem statements, datasets, platform to run the Challenge, sponsorship, computing resources, experts etc. to run the Challenge. A Collaborator can be a regional entity or a global organization. In case the Collaborator is a regional entity, it can work with the regional partner (see section below). If the Collaborator is a global body, then it can work with ITU for channelizing its membership towards various Regional Rounds and the Global Round.

## 7.2 1st Round: Regional Round

The participants will register to the regional challenge, choose problems depending on their interests, and provide solutions based on criteria set by the regional partner. The best teams or participants from the regions/local challenge will compete in the Global Round of the challenge.

We define a “Regional Partner”as an umbrella body (in some cases an organization - such as a Regulator, a Standards Development Organization, industry bodies, etc.) which coordinates and runs the Regional Round.

* The Regional Partner will arrange sponsorship, resources and coordinate with local entities on problem statements, datasets, and how to run the challenge within the ITU timeline.
* The Regional Partner will setup a local management committee with local entities such as operators, vendors, companies and universities in the country.
* Regional Partners may bring existing challenges run by various entities in the region into the fold of the ITU ML5G Challenge while keeping in mind the focus of AI/ML in 5G.
* Regional Partners may use local languages and practices for the Regional Rounds. Language of communication with the Challenge Management Board, for the Global Round and the conference must be English.
* Regional Partners may design the website for Regional Round in their local language and other promotional material in coordination with the Challenge Management Board (see below).
* The Regional Partner will host the data sets securely (within the region, in compliance with local laws and regulations for data handling and privacy) in coordination with local Collaborators.

NOTE- regional partners may tune the tracks according to local requirements and sensitivities.

NOTE- it is possible for one entity to assume different roles simultaneously (unless there is a conflict of interest).

## 7.3 2nd Round: Global Round

The best participants of the Regional Round (= 1st Round) advance to the Global Round (= 2nd Round). The participants can either continue working on the problems that they have worked on in the Regional Round, taking into account the comments of the Judging Panel, or they can pick a new problem statement/use case.

## 7.4 3rd Round: Final Conference

To mark the conclusion of the ITU AI/ML in 5G Challenge, a Global Conference will be organized in the country of the main sponsor. The best teams of the Global Round will compete for the winning prizes at the Final Conference

NOTE- Observers: In addition to the winners of 2nd round, selected teams from 1st and 2nd round may be invited to the final conference as observers by the discretion of the judgment panel.

Hosting the Final Conference will provide an opportunity for the main sponsor to engage with the best minds in AI/ML in this domain.

The aim of the Final Conference is many-fold:

* **Climax:** the Final Conference will mark the end of the nine-month period of preparation and competition by the participants. The best proposals from Regional Rounds will advance to the Global Round, from where conference entries may be chosen, making sure that the conference will be attended by the crème de la crème.
* **Spotlight**: Demonstration and presentations from participating teams who have passed through the regional challenges.
* **Edu-fun:** Lectures, presentations and tutorials from ITU/UN experts and partner organizations covering all aspects of technology. It will bring together teams, mentors, sponsors, and partners to share knowledge and experience during the competition.
* **On-track:** Multi-track sessions to cover various domains e.g. verticals, networks, ML methods.
* **Hack:** Hackathon sessions may be collocated with the Final Conference and boost the innovation level of the host ecosystem.
* **Work:** Workshops specifically for students to collaboratively solve problems.
* **Fit:** Fitting together the winning ideas and follow-ups will make sure that the impact to the host is long-lasting.

# 8 Standards, open source and IPR

## 8.1 Standards

ITU has developed a range of standards-based Machine Learning mechanisms in 5G. The goal is to provide a full toolkit to build Machine Learning into networks. Participants of the ITU AI/ML in 5G Challenge are encouraged to base their work on those standards which can be found in the appendix- clause 15.

## 8.2 Open Source

We encourage participants that there solutions are open source implementations, based on (ITU) standards. Open source implementations will enable industry stakeholders and Member States to access the outcomes of this competition and collaborate with teams in their domains.

However, solutions based on proprietary implementations are also accepted.

## 8.3 IPR

The IPR (intellectual property rights) are determined by the submitter. The declarations by the submitter would be stored by ITU and would be available online.

# 9 Judging the submissions

## 9.1 Common output format

The challenge participants may produce the following as output:

* Demo video (short, can be uploaded to the challenge website)
* Demonstration explaining the concept and solution using AI/ML in 5G.
* Brief paper explaining the problem and solution, with a section explaining the relationship to standards e.g. ITU-T Y.3172, Y.3173, Y.3174, Q.5001 and partner resources.

## 9.2 Additional output for open source code

In the case that the output will be shared as open source, the following deliverables from participants will be proposed, in addition to those in clause 9.1:

* Final version of the code;
* Reproducibility: we recommend participants to create a docker image which contains all dependencies and environments required for the algorithm to run;
* ReadMe file which contains description of the algorithm;
* Minimum system configuration required to run the algorithm;
* Details of any Data used to train the model (metadata);
* Another key value-add would be alignment of open source with standards – application of standard based ML mechanisms in 5G would be encouraged in open source as part of this challenge. Wherever applicable, outcomes of the global challenge will be encouraged to be shared in open forum as an open source project.
* Test cases and results which proves the benefits of the solution.

## 9.3 Additional output for proprietary code

In case the output is proprietary (not open source), the following deliverables from participants will be proposed, in addition to those in clause 9.1:

* Reproducibility: we recommend participants to create a docker image which contains all dependencies and environments required for the algorithm to run;
* ReadMe file which contains description of the algorithm;
* Minimum system configuration required to run the algorithm;
* Details of any Data used to train the model (metadata);
* Test cases and results which proves the benefits of the solution.

## 9.4 Evaluation Criteria

Final criteria for selecting winners from each round and in the conference will be published by the “Challenge Management Board” (see below).

Following provides a list of draft criteria:

* Novelty & originality
* Status and maturity of technical implementation, reproducibility.
* Viability & Impact on Market (practicality of the solution and significance of its impact)
* Interoperability and mapping to global standard documents (including ITU).
* Performance (evaluation based on performance measures such as accuracy, speed, scalability and quality).
* Quality of demonstration, documentation and presentation.

## 9.5 Prizes

The top three teams selected by the challenge judging committee will be recognized and certificates of appreciation shall be presented as below:

* 1st prize winning team: "Global champion of  ITU  AI/ML5G Challenge"
* 2nd prize winning team: "Second runner-up of ITU AI/ML challenge in 5G"
* 3rd prize winning team: "Third runner-up of ITU AI/ML challenge in 5G"

 Networking with top telecom companies will be provided to these teams during the event. Additional prizes and letters of appreciation may be awarded on a per-topic basis at the discretion of the judges during the event.

## 9.6 Judges Panel

The judges panel is a collection of individuals from across the world who may evaluate, on an on-going basis, the progress and merit of the solutions proposed by the participants to the problem statements. The team of judges monitor and passively evaluate the merit during the Regional Round, the Global Round and the Final Conference. They arrive at and provide a score for each participant at the end of each round. Individuals in the judges panel will be selected by the Challenge Management Board.

10 Administration of the ITU ML5G Challenge

The ITU Secretariat will provide administrative support for the ITU ML5G Challenge, in collaboration with Regional Partners, Collaborators, participants and the “Challenge Management Board”.

The “Challenge Management Board” comprises individuals from academia, industry organizations, SDOs, companies, and organizations that help on technical aspects of the ITU ML5G Challenge including problem statements, tracks, data sets, partners, logo guidelines etc. The Challenge Management Board is active in the Regional Round, the Global Round and the Final Conference.

ITU secretariat will publish a draft IP policy and the Challenge Management Board will review it and suggest any changes, considering the Regional Round, Global Round and the Final Conference in coordination with the regional partners and the host.

In addition, there will be a “Judging Panel” comprising of experts who will judge the solutions of the Regional Round, the Global Round and the Final Conference. The “Judging Panel” will be set up by the Challenge Management Board in coordination with the regional partners where applicable.

NOTE- In case of synchronization between the Regional and the Global Round, for problem statement and/or data, Challenge Management Board will discuss and decide it e.g. mapping of regional problem statements or tracks to the Global Round.

NOTE- The coordination for Global Round will be done by the Challenge Management Board in alignment with Regional Partners. For example, a uniform selection criteria may be defined for the Global Round which is agnostic and unbiased towards specific details of the problem or data sets.

NOTE- The Challenge Management Board may discuss and decide the use of data sets for the Global Round.

11 Resources

The following resources will be available for the participants of the ITU ML5G Challenge:

* Mentors: experts who mentor the students in order to enhance their skills and understanding of applicant of AI/ML in 5G.

Note:- "Mentors" may be individuals who help the participants in the "students track" as well as the sponsor-nominated students and professionals. This may involve providing technical clarifications, assisting with solution approaches, toolsets etc. The mentors are active in the Regional Round, the Global Round and the Final Conference.

* Links to software: Adlik, ONAP, O-RAN OSC Resources, Acumos (based on partner support).
* Cloud Credits (based on partner support).
* Tool sets and APIs from partners (setup by sponsors.)
* ITU ML5G Challenge website
* Datasets:
	+ hosted on contest platforms : provided by sponsors, partners and collaborators.
	+ open datasets from e.g. Kaggle, AIcrowd, OpenML, …
	+ Simulated datasets from collaborators.

NOTE- please see [ML5G-I-222] available from <https://extranet.itu.int/sites/itu-t/focusgroups/ML5G/SitePages/Home.aspx> for a compilation of resources.

# 12 Sponsorship

The sponsorship types and amounts for the ITU AI/ML in 5G Challenge can be found in the sponsorship package. The package can be provided upon request. However, in terms of sponsorship for the Regional Rounds, the Regional Partner is required to provide sponsorship of the local round. This can be done in coordination with ITU and/or with Collaborators from that region.

# 13 Benefits

## 13.1 Benefits for partners and collaborators

Partner organizations, e.g. network operators in specific regions, may enable data and conduct regional stages of the global challenge. The ITU Global Challenge offers the partners the following (see sponsorship package for details):

* It provides a logical, global target for the regional challenge. This association may result in sustained interest in the regional stage due to branding, publicity and continuity to the global stage.
* Collaborative feedback from the global challenge for partners: learnings from the global and regional stages may be looped back into the partner organizations for further advancements in technology.
* Publish the results in the “ITU Journal: *ICT Discoveries*” (subject to acceptance).

## 13.2 Benefits for participants

* Shape the future: Opportunity to define, provide inputs and shape the technologies related to AI/ML and 5G networks.
* Create your network: Network with ITU experts and peers.
* Be practical: Platform to gain hands-on experience related to AI/ML and concepts related to future networks.
* Be known: gain global recognition in the form of prizes, appreciation and publications of the results in ITU journal (subject to acceptance).
* Implement your dreams: receive support for implementing their use cases and technology ideas using software and access to platforms, e.g. cloud credits and licenses.
* Be Social: Solutions targeted to solving socially relevant issues may be selected for presentation and demonstration in AI for Good Global Summit 2020.

## 13.3 Special Benefits for certain sponsor categories

* Focussed on-site and remote mentoring for host-nominated participants (for Supersponsor: two weeks mentoring sessions on site twice in 2020, conducted by experts; for Platinum sponsor: one week mentoring session on site in 2020, conducted by experts).
* Mentoring throughout the Challenge, e.g. setting up an ML Sandbox (Platinum, Gold++)
* Mentoring for post-processing and publishing the results in publications and standards contributions (Platinum).
* Workshop presentation slots (different number of days for Platinum, Gold++, Gold, Silver)
* Co-branding of the ITU Global Challenge and publicity.
* Channeling curated output to the host organization in the form of skills, presentations, standards, open-source, and academic and industry partnerships.
* Some of the committee and panel positions for the global challenge shall be reserved for host experts.
* Co-branding of the challenge and publicity for specific category (based on the domain e.g. Automotive may be sponsored by a player in that industry).
* Funnelling of innovative approaches to specific problems of interest in their areas or domains.

# 14 Contact

AI5GChallenge@itu.int

# 15 Appendix A: ITU standards on Machine Learning for 5G

* [ITU-T Y.Sup55] ITU-T Supplement “ITU-T Y.3170-series - *Machine learning in future networks including IMT-2020: use cases”*: For each use case description, along with the benefits of the use case, the most relevant possible requirements related to the use case are provided.
* [ITU-T Y.3172] ITU-T Recommendation “*Architectural framework for machine learning in future networks including IMT-2020*”: The standard offers a common vocabulary and nomenclature for Machine Learning functionalities and their relationships with networks, providing for ‘Machine Learning Overlays’ to underlying technology-specific networks such as 5G networks. It describes a ‘loosely coupled’ integration of Machine Learning and 5G functionalities, minimizing their interdependencies to account for their parallel evolution. The language developed in ITU-T Y.3172 gives network operators complete power over the extension of Machine Learning to new use cases, the deployment and management of Machine Learning in the network, and the correlation of data from sources at multiple levels of the network.

The components of the architectural framework include ‘Machine Learning Pipelines’ – sets of logical nodes combined to form a Machine Learning application – as well as a Machine Learning Function Orchestrator’ to manage and orchestrate the nodes of these pipelines.

‘Machine Learning Sandboxes’ are another key component of the framework, offering isolated environments hosting separate Machine learning pipelines to train, test and evaluate Machine Learning applications before deploying them in a live network.

* [ITU-T Y.3173] ITU-T Recommendation “Framework for evaluating intelligence levels of future networks including IMT-2020”: this standard supports the assessment of intelligence levels across different parts of the network and develops a standard way for different parties to look at the intelligence level of the network, helping operators to evaluate vendors and regulatory authorities to evaluate the network.
* [ITU-T Y.3174] ITU-T Recommendation “Framework for data handling to enable machine learning in future networks including IMT-2020”: The requirements for data collection and processing mechanisms in various usage scenarios for ML in 5G are identified along with the requirements for applying ML output in the machine learning underlay network. Based on this, a generic framework for data handling and examples of its realization on specific underlying networks are described.
* [ITU-T ML5G-I-216] “Requirements, architecture and design for machine learning function orchestrator” (work in progress): This standard specifies the design of the ‘Machine Learning Function Orchestrator’.
* [ITU-T Y.ML-IMT2020-MP] ITU-T draft Recommendation “ML marketplace integration in future networks including IMT-2020”: this standard will be supporting the interoperability of Machine Learning marketplaces, marketplaces hosting repositories of Machine Learning models.

# 16 Appendix B: Problem Statement Sample

The template below is the sample to be used when developing problem statements.

NOTE- please see [ML5G-I-222] available from <https://extranet.itu.int/sites/itu-t/focusgroups/ML5G/SitePages/Home.aspx> for a compilation of problem statements.

|  |  |
| --- | --- |
| ID-number | ITU-ML5G-PS-TEMPLATE |
| Title | Do not modify this particular table, this serves as a template, use the one below. |
| Description | NOTE 3- include a brief overview followed by a description about the problem, its importance to IMT-2020 networks and ITU, highlight any specific research or industry problem under consideration. |
| Challenge Track | NOTE 4- include a brief note on why it belongs in this track |
| Evaluation criteria | NOTE 5- this should include the expected submission format e.g. video, comma separated value (CSV) file, etc.NOTE 6- this should include any currently available benchmarks. e.g. accuracy. |
| Data source | NOTE 7- e.g. description of private data which may be available only under certain conditions to certain participants, pointers to open data, pointers to simulated data. |
| Resources | NOTE 8- e.g. simulators, APIs, lab setups, tools, algorithms, add a link in clause 2. |
| Any controls or restrictions | NOTE 9- e.g. this problem statement is open only to students or academia, data is under export control, employees of XYZ corporation cannot participate in this problem statement, any other rules applicable for this problem, specific IPR conditions, etc. |
| Specification/Paper reference | NOTE 10- e.g. arxiv link, ITU-T link to specifications, etc. |
| Contact | NOTE 11- email id or social media contact of the person who can answer questions about this problem statement. |

For example:

|  |  |
| --- | --- |
| ID-number | ITU-ML5G-PS-001 |
| Title | 5G+AI+AR |
| Description | **Background**: Remote collaboration has been an important tool to fight the recent COVID-19 outbreak. Effectiveness of such tools could be augmented using the support of AR/VR over IMT-2020 networks. Similar applications of AR/VR over IMT-2020 are emerging in sports, medicine, public welfare, socializing, and entertainment. eMBB specifications of 5G NR can address the needs of rich media needs of AR/VR. Device ecosystem is maturing with examples like Google Glass and Microsoft HoloLens. Infrastructure support with edge computing is already standardised. However certain specific areas needs to be further addressed using AI/ML.**Problems**: <<This requires further work>> Mobile AR/VR applications require low-latency to overcome motion sickness and alignment problems of head movements. Predictive content management and rendering could be a studied under this challenge. Mobility when combined with coverage or interference can lead to connectivity problems for AR/VR applications, which are especially sensitive even to short interruptions. Line of sight requirements when using certain frequency bands can add to this problem. An environment based inference on mobility (indoor and outdoor) could benefit AR/VR experience by end-users as well as adaptive options for application developers.<<TBD: add more>> |
| Challenge Track | Vertical-track (invite participant to make solutions for 5G, AI and AR application in vertical industries) |
| Evaluation criteria | Solution, criteria hasn’t been determined |
| Data source | Training data from existing AR/VR testbeds over IMT-2020 networks, with feedback on connection, quality, responsiveness to head movements, and time-aligned network data. |
| Resources | AR IDE (we are negotiating with partner), SDK which can plugin intelligent agents, simulators like [Unity]. |
| Any controls or restrictions | This problem statement is open to all participants. |
| Specification/Paper reference | [1] ` "Very Long Term Field of View Prediction for 360-degree Video Streaming", Chenge Li, Weixi Zhang, Yong Liu, and Yao Wang, 2019 IEEE Conference on Multimedia Information Processing and Retrieval.[2] "A Two-Tier System for On-Demand Streaming of 360 Degree Video Over Dynamic Networks", Liyang Sun, Fanyi Duanmu, Yong Liu, Yao Wang, Hang Shi, Yinghua Ye, and David Dai, IEEE Journal on Emerging and Selected Topics in Circuits and Systems (March 2019 )[3] “Multi-path Multi-tier 360-degree Video Streaming in 5G Networks”, Liyang Sun, Fanyi Duanmu, Yong Liu, Yao Wang, Hang Shi, Yinghua Ye, and David Dai, in the Proceedings of ACM Multimedia Systems 2018 Conference (MMSys 2018),[4] “Prioritized Buffer Control in Two-tier 360 Video Streaming”, Fanyi Duanmu, Eymen Kurdoglu, S. Amir Hosseini, Yong Liu and Yao Wang, in the Proceedings of ACM SIGCOMM Workshop on Virtual Reality and Augmented Reality Network, August 2017; |
| Contact | China Unicom |

# 17 Appendix B: List of Resources

[1] Data set: Raymobtime is a collection of ray-tracing datasets for wireless communications. <https://www.lasse.ufpa.br/raymobtime/>, aldebaro@ufpa.br

[2] ML marketplace: It is an open source network AI platform developed by China Unicom Network Technology Research Institute, which integrates AI model development, model sharing. <https://github.com/cube-ai/cubeai>, liutf24@chinaunicom.cn

[3] Toolkit: an end-to-end optimizing framework for deep learning models. <https://github.com/Adlik/Adlik>, yuan.liya@zte.com.cn

[4] Challenge platform: a data challenge platform which lists several challenges and competitions. <https://knowledgepit.ml/>

[5] Data sets: An open AI research and innovation platform for networks and digital infrastructures for industries, SMEs and academia to share a broad range of telecom data and AI models. <https://se-caid.org/>

[6] Challenge: past competition, led by AIIA in China <https://cloud.tencent.com/developer/contest/AIIA-Unicom> <http://aiiaorg.cn/AIDC/2019AIDC/index.html> <https://mp.weixin.qq.com/s?__biz=MzU0MTEwNjg1OA==&mid=2247487451&idx=1&sn=cb4370e9fa9d7f827dc632c79fe41d2d&chksm=fb2fb81ecc583108221592c69fdea3eb226da933859514dbd9fb8c15288c6fcb392c65399ddc&mpshare=1&scene=1&srcid=&sharer_sharetime=1575542631509&sharer_shareid=75fb4d5f665341fa1dafcbc554417e75&key=67a2c7aa29623c33d72ba777f7853d102e6f4db8ac8b23733613e267ce0dae54ca817de36bde651b3cf32c3a0daf055c432e46c3b8f43b088f60edcdef801a54201eea05d0de9051201391ee19fd326f&ascene=1&uin=MjEzNjY3NDQ5Mw%3D%3D&devicetype=Windows+7&version=62070141&lang=en&exportkey=AoB%2BIuWyreUPRCOzxdLg0q0%3D&pass_ticket=fCmC%2FiTFfXlmGxvOLq%2BdVPRElGBj59sZO2eVMyeABxg07Ve7tOfmRWTtKc1rmCRV>

[7] Challenge: past competition, includes data sets, including the largest Chinese public domain reading comprehension dataset, DuReader <https://www.kesci.com/home/competition/5ad56e667238515d80b53704>

[8] Data and challenge: a research project for an open source data exchange software platform, <https://www.iudx.org.in/>

[9] Past challenge, Datathon to develop innovative solutions based on India Urban Data Exchange (IUDX), <https://cps.iisc.ac.in/pudx/>

[10] Data: a large dataset of 30+ kinds of data (mobile, weather, energy, etc. from Telcom Italia big data challenge. <http://theodi.fbk.eu/openbigdata/>

[11] Data: The Mobile phone activity dataset is a part of the Telecom Italia Big Data Challenge 2014. <https://www.kaggle.com/ijfezika/mobile-phone-activity-exploratory-analysis>

[12] Data: Mobile Data Challenge (MDC) Dataset, restricted to non-profit organizations, <https://www.idiap.ch/dataset/mdc> (you need to make a request to get a copy)

[13] Data: MIRAGE-2019 is a human-generated dataset for mobile traffic analysis with associated ground-truth, <http://traffic.comics.unina.it/mirage/>

[14] Data: An air quality dataset that could be useful for verticals <https://www.microsoft.com/en-us/research/project/urban-air/>

[15] Data: UCR STAR is built to serve the geospatial community and facilitate the finding of public geospatial datasets to use in research and development. <http://star.cs.ucr.edu/>

[16] Data: NYU Metropolitan Mobile Bandwidth Trace, a.k.a. NYU-METS, is a LTE mobile bandwidth dataset that were measured in New York City metropolitian area; <https://github.com/NYU-METS/Main>

[17] Data: Challenge and dataset from comes from Omnet++ network simulator, contains several topologies and thousands of labeled routings, traffic matrices with the corresponding per-flow performance (delay, jitter and losses). <https://bnn.upc.edu/challenge2020>

[18] Data: data sets for Unveiling the potential of GNN for network modeling and optimization in SDN. This data set can be divided in two components: (i) the data sets used to train the delay/jitter RoutNet models and (ii) the delay/jitter RouteNet models already trained <https://github.com/knowledgedefinednetworking/Unveiling-the-potential-of-GNN-for-network-modeling-and-optimization-in-SDN/tree/master/datasets>

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