IEEE Future NETWORKS

Enabling 5G and Beyond

International Network Generations Roadmap (INGR) Virtual Workshop

AI/ML Working Group

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IEEE

10-year Vision

- Provide fully automated and assured end-to-end network and service life cycle management
- Support a myriad of IoT services (e.g., healthcare, transportation, smart energy, smart cities, smart industry, sustainable agriculture, financial services, gaming/entertainment) offered by service providers and verticals
- Deliver reliable connectivity, low latency, and high bandwidth services driven by AI/ML analytics

Scope

- Consider application of AI/ML to all layers of network stack – Physical to Application Layer
- Explore cross-layer optimization using AI/ML
- Identify and address range of options from monitoring, to learning to actuation, while considering aspects of performance, security and reliability that run through all layers
- We believe AI/ML will impact and interact with almost all the other Future Network Working Groups

Today's Landscape

- Current consensus is that AI/ML has a great potential for networking applications
- The networking field itself provides rich and challenging problems for the AI/ML community, with application of algorithms ranging from passive supervised learning to active reinforcement learning
- However, concerns related to model interpretability, trust, data privacy, algorithm adversarial attacks have slowed AI/ML adoption in the networking area

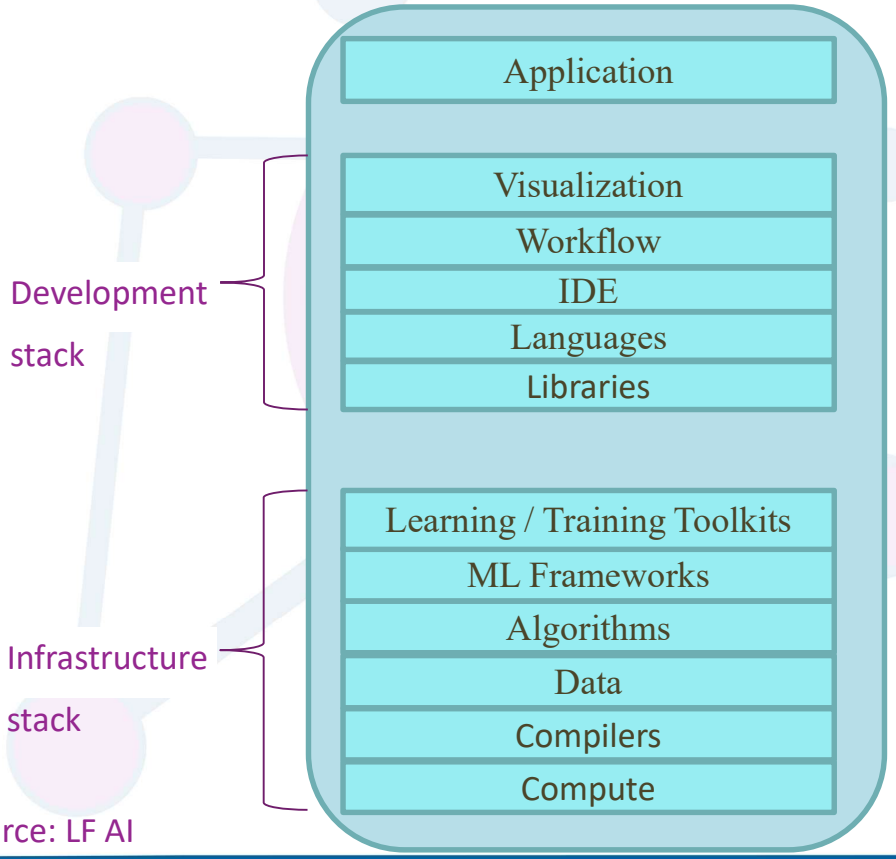
Top Needs for 10-year Vision

- Need for data availability and standard use cases for testing and experimentation, as is the case in other fields such as image processing and natural language applications
- Need approaches that integrate networking domain knowledge with AI/ML algorithmic solutions for scalability and reliability
- Need for algorithms with high sample efficiency to deal with limited data sets and requirements for fast control loops
- We need to close gap for interpretability and trust
- Vulnerability and susceptibility to adversarial attacks
- Role of standardization

Progress Update Since June Meeting

- Have been hosting bi-weekly working group (WGs) meeting
  - Every other Thursdsay 6:00 P.M. ET
  - EAP, Security WGs have presented
- Conducted a survey of AI/ML stacks in Open Source
- Identified Emerging Solutions
- Developed architecture for 5G AI/ML E2E Operations
- New Members were reviewed and accepted
  - On-going process of integration
- Draft version of AI/ML White Paper has been posted for review
  - Working in progress version being updated regularly
- Hosted IEEE AI/ML Workshop at IEEE 5G World Forum 2020
  - https://ieee-wf-5g.org/ai-ml-track/

AI/ML Stacks in Open Source



Source: LF AI

Development Stack Technologies

- **Libraries:** NumPy, OpenCV, OpenNMT
- **Languages:** Python, AIML, LISP, Haskell, R, Pyro
- **IDE:** PyCharm, VS Code, MATLAB, Jupyter
- **Workflows:** Acumos AI, Jupyter, Anaconda, ONNX, Marquez, Milvus, NNStreamer, Sparklyr
- **Visualization:** MATLAB, Seaborn, Facets, Tableau, Jupyter, Marquez
- **Full stack solutions:** Driverless AI

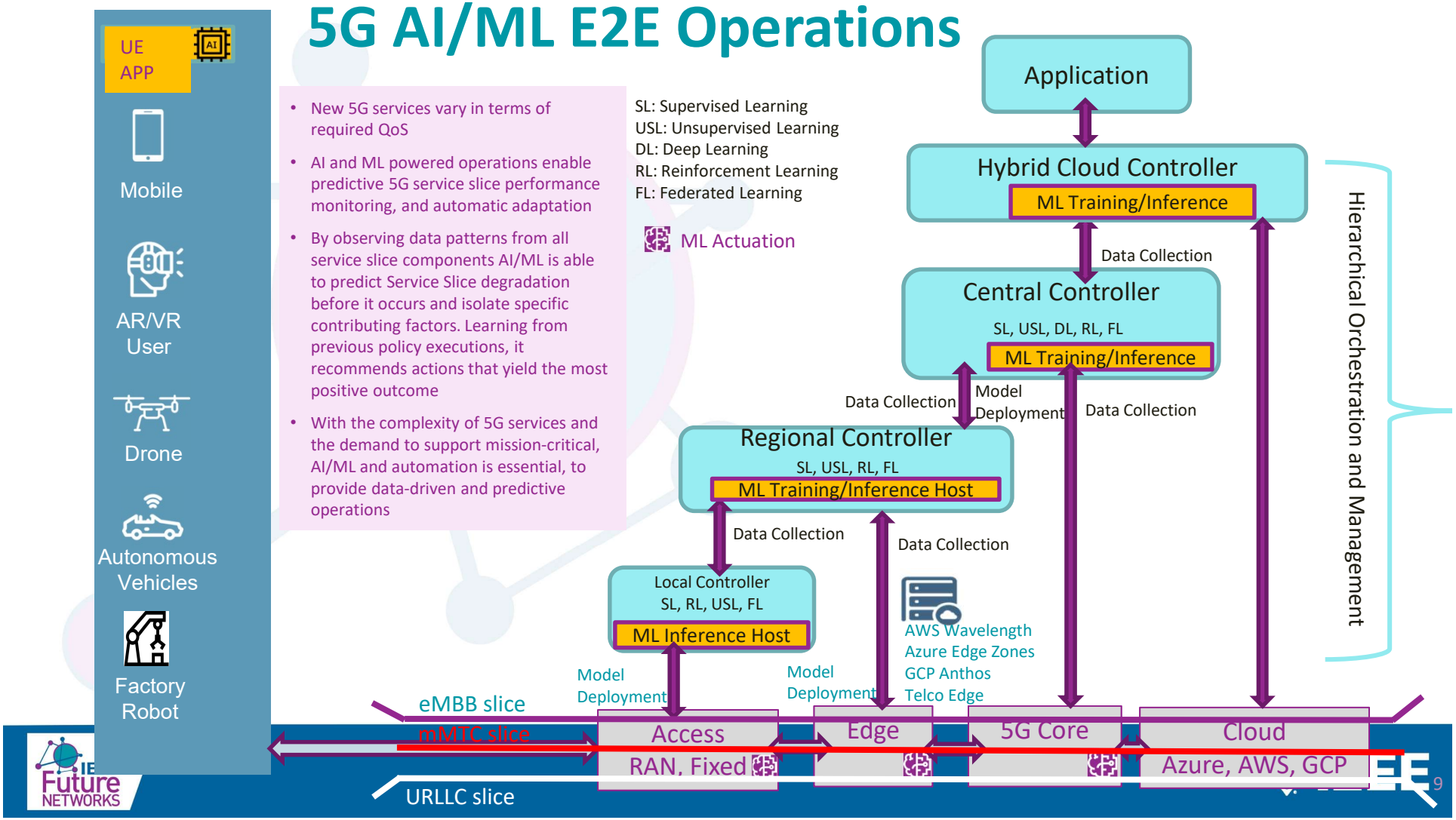
Infrastructure Stack Technologies

- **Compute:** VM, Containers, GPUs
- **Compilers:** NNVM, TVM
- **Data:** SQL, NoSQL, Spark, Tableau
- **Algorithms:** Supervised, Unsupervised, Reinforced
- **ML Frameworks:** CNTK, Tensorflow, MXNET, Caffe2, Scikit-learn, Keras, PyTorch
- **Learning / Training Toolkits:** Horovod, Ludwig, Adlik, Elastic Deep Learning, ForestFlow
- **Full stack solutions:** Angel ML

Emerging Solutions

- Transfer Learning, Multitask Learning, Meta Learning
  - Small data
  - Improved sample efficiency
- Federated Machine Learning
  - Distributed Data
  - Private Data
- Auto-ML
- Robust Learning to Adversarial Attacks
- Energy-Efficient Machine Learning
- Quantum Machine Learning
- Time-Aware Machine Intelligence

5G AI/ML E2E Operations



Next Steps

- Meet with other WGs, discuss challenges and solutions to meet needs
- Foster active participation from group members and add new members
- Continue to host periodic Working Groups Meetings
- Continue to work on the AI/ML white paper
- Organize future AI/ML Workshops, Conferences
- AI/ML Webinars and Podcasts
- Explore Academia and Standards Engagement
- Promote sharing of data and baseline cases for testing and improvements

Get involved!

Working Group Members

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If you would like to join the working group please send mail to:
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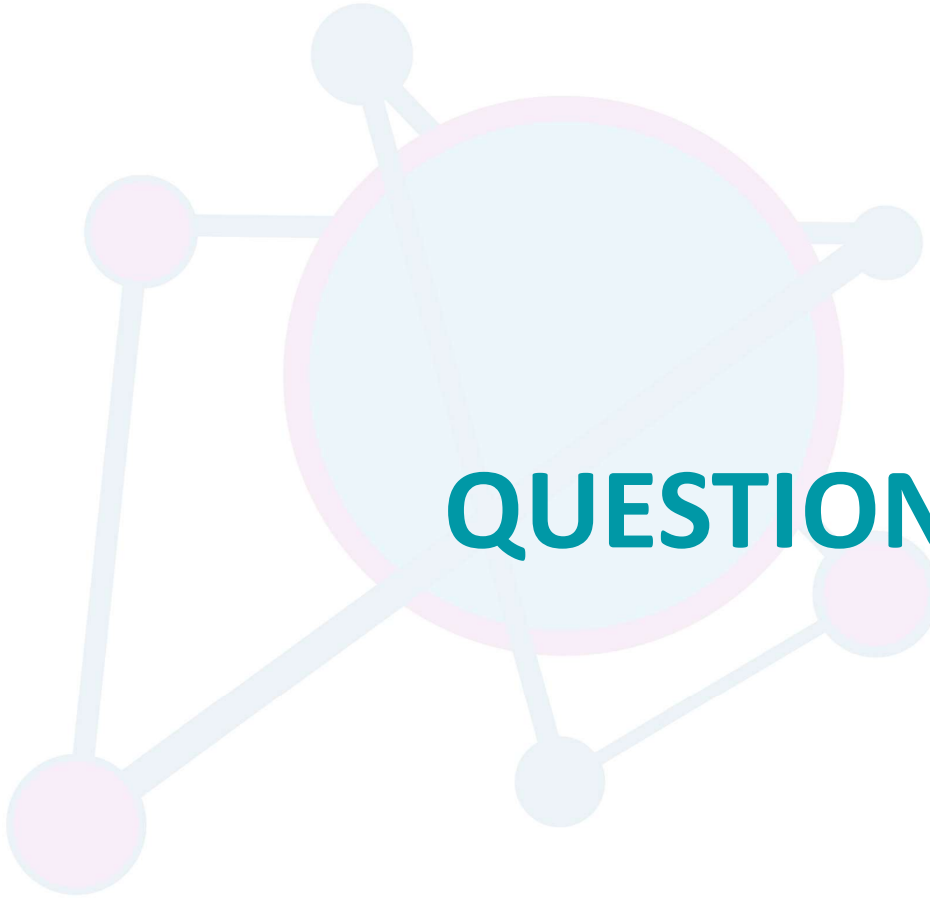
We look forward to active contributions from existing and new members, in particular, on the white paper



QUESTIONS?