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RESEARCH FORUM®

Artificial Intelligence in the Wireless Arena:

A White Paper by the WWRF AI Working Group

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Outline

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- Motivation
- AI for the Wireless World
- Challenges in Deploying AI in the Wireless Domain
- Conclusion and Future Directions

Motivation

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- Simple yet powerful tool for trying to solve current and future problems in wireless communication
- AI is transformative in every link of communications systems, including devices and network elements
- Crucial change:
  - As the techniques need to rely on data, the owners of the data become a key player
- Potentials, roadblocks and roll out issues are identified

AI for the Wireless World (1)

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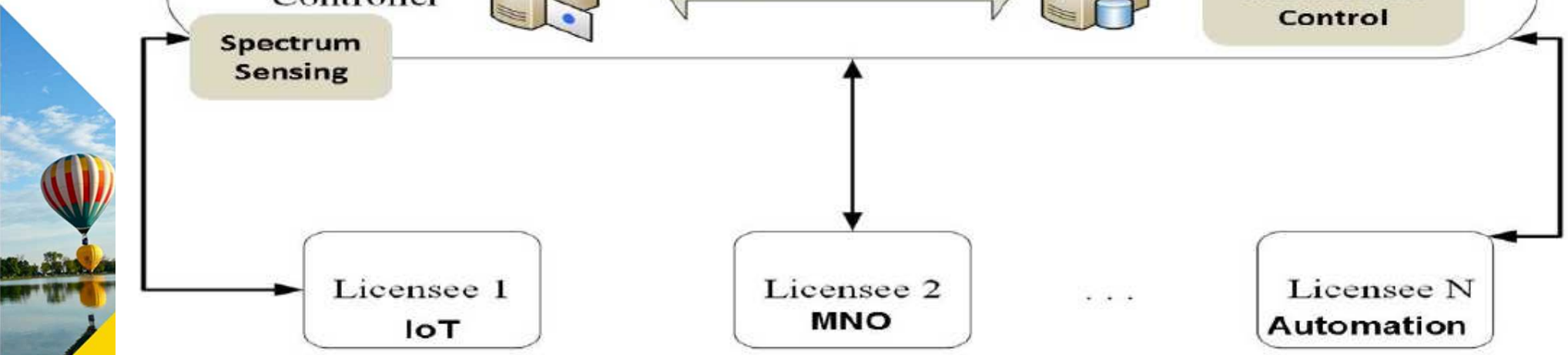
- History – started from image processing, NLP, military
- Intelligent Spectrum Management: static -> smarter
  - Provide predictable QoS to spectrum licensees via previous experiences
  - Improve efficiency, reduce interference, increase affordability



AI for the Wireless World (2)

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- Radio Air Interface
  - Efficient tuning of massive MIMO antenna systems
  - Data-assisted air interface design capable of learning the physical hardware imperfections
  - Beam assignment techniques based on reinforcement learning
- Radio Access
  - Older techniques are inefficient => move to number of retransmissions of the RACH to design scheduling algorithms, RL and Deep RL

AI for the Wireless World (3)

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- Radio resource management
  - Network slicing: Optimize slice management via Deep Learning regressions, mimicking a computationally demanding operation with neural networks vs. Reinforced Learning
- Network automation
  - Self-healing of the network management systems: anomaly detection and automating the changes to maintain the QoS
  - Respond to alarms and fault conditions automatically -> predicting and preventing -> Transform the way networks are operated
- User mobility
  - Predict UE patterns for pre-emptive QoS provisioning from automated factories to autonomous vehicles

Summary

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Wireless Topic	Threats	AI support
Spectrum management	✓ Guaranteeing a SLA to the spectrum incumbents in a dynamic environment.	✓ Spectrum assignment based on predictive QoS to incumbents.
Air interface	✓ Ultra-fast beam assignment in massive MIMO. ✓ Robustness to hardware impairments.	✓ Beam management via reinforcement learning. ✓ Data-based air interface design.
Radio access	✓ RACH decision and user scheduling in mIoT scenarios. Network slicing in RAN	✓ Deep reinforcement learning based on the number of successful and unsuccessful transmissions.
Radio resource management	✓ Network slicing optimization in heterogeneous networks.	✓ Mimicking computationally demanding optimization techniques via deep learning regression.
Network management	✓ Currently unpredictable network failures and outages.	✓ Data based QoE predictions in order to pre-emptively manage the network mal-functionings.
Users mobility	✓ Communications to autonomous vehicles with heterogeneous degree of mobility.	✓ Data based predictable mobility patterns.

Challenges of Deploying AI

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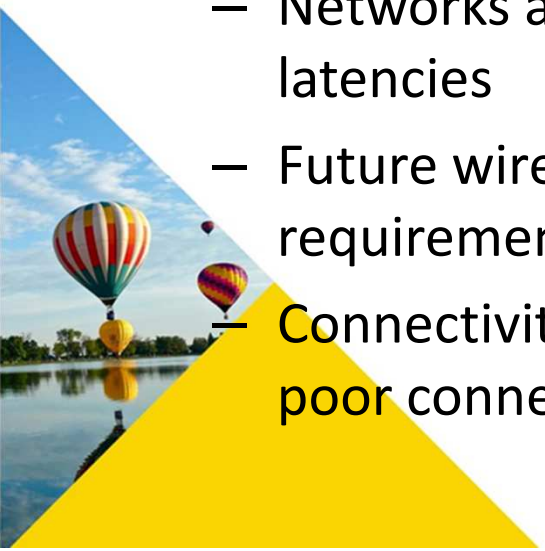
- AI expected to enable future networks with enormous complexity by DL and ANN
- AI requires a large amount of data and its processing interchange, and comes with privacy, security and cost concerns
- Centralized/cloud-based vs distributed AI or Mobile AI (aka Federated AI)
- Issues of cloud-based AI:
  - Networks are required to ensure strict end-to-end communication latencies
  - Future wireless networks will have privacy and security as key requirements
  - Connectivity should be ensured even in areas and/or times where only poor connection to the cloud exists



Distributed AI

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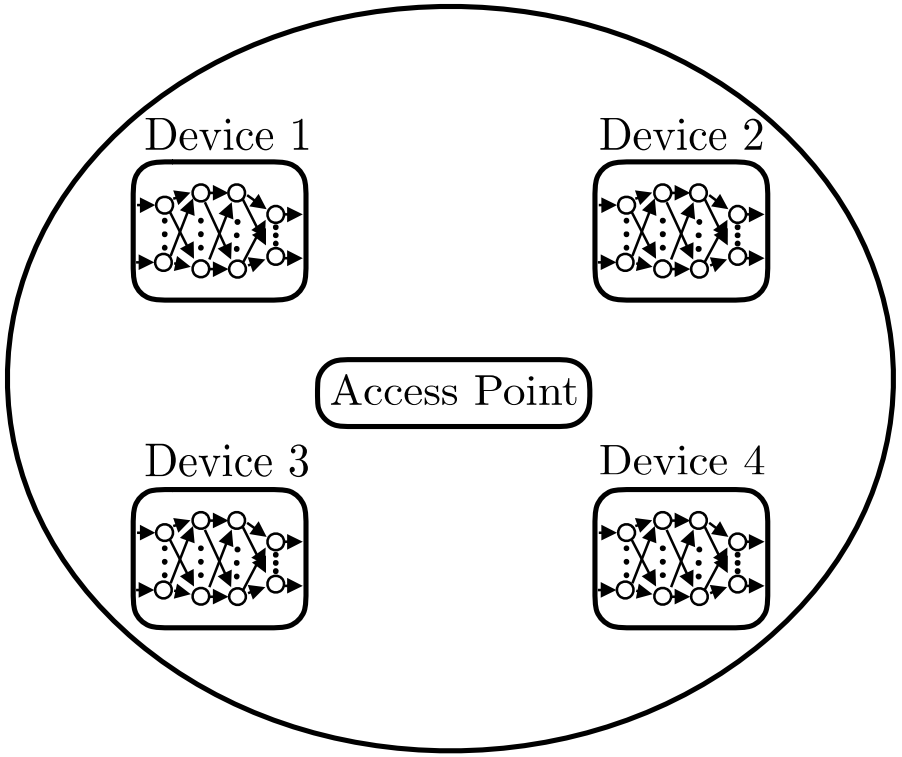

- Each network element is an independent decision maker
- However, difficult to manage the evolution of the network, leading to potential failures
- Make all devices connected to an AP self-configuring through their own ANN

Federated AI

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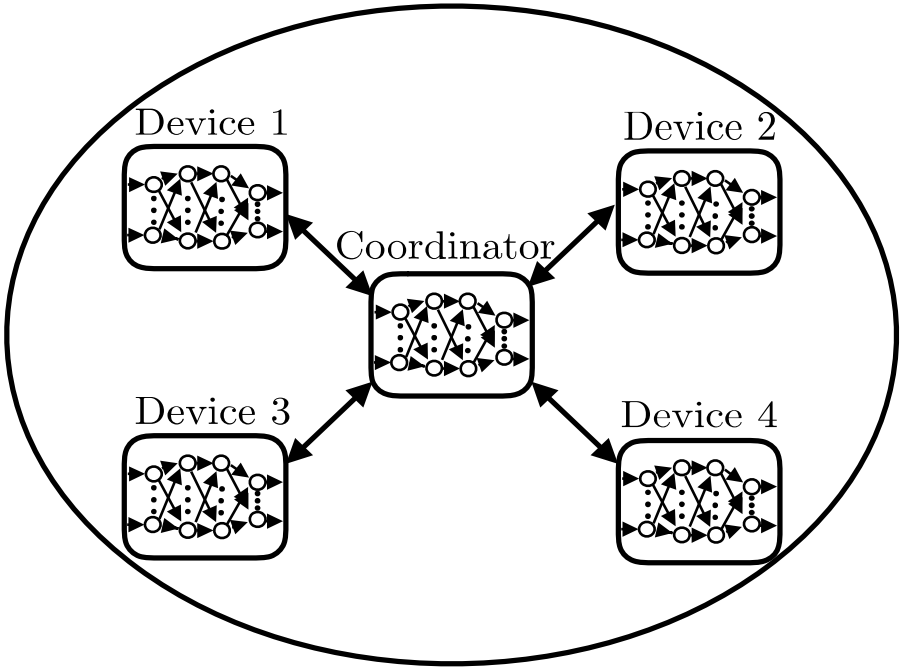

- Balance between purely distributed AI and cloud-based AI
- Distribute data and computation to all the nodes but with coordination
- All agents perform learning and a coordinator orchestrates it (called federated learning)

Challenges in Rolling Out AI

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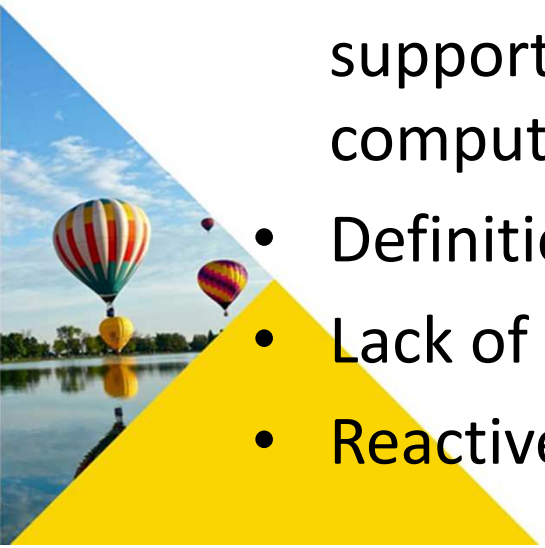
- Need to adapt the network operations processes
- Training overhead in learning based AI solutions
- AI perceived as a threat for employment by telecom operators
- AI may act as a black box and may generate liability issues between parties if no explainable mechanisms in place to explain what happened and why
- Power consumption of existing AI hardware is too high to support either large-scale rollout or distributed edge computing for IoT
- Definitions and technologies not yet matured
- Lack of KPIs and standards
- Reactive => Predictive => Pro-active



Ethics

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- *"AI Ethics Guidelines for Trustworthy AI – April 2019"* EU Report. Also, a report from French CNIL bring out the same concerns and guidelines.
  - Key requirements for a trustworthy AI:
    - Technical Robustness and Safety
    - Privacy and Data Governance
    - Transparency
    - Traceability
    - Accountability

Thank you!

- Questions and inquiries?

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