

# AI and 6G: Opportunities and Challenges

EuCNC & 6G Summit 2023, 6G workshop series by Hexa-X & Hexa-X-II



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Aalborg University



Speaker 5  
**Ather Gattami**  
Bitynamics

# Hexa-X AI Panel

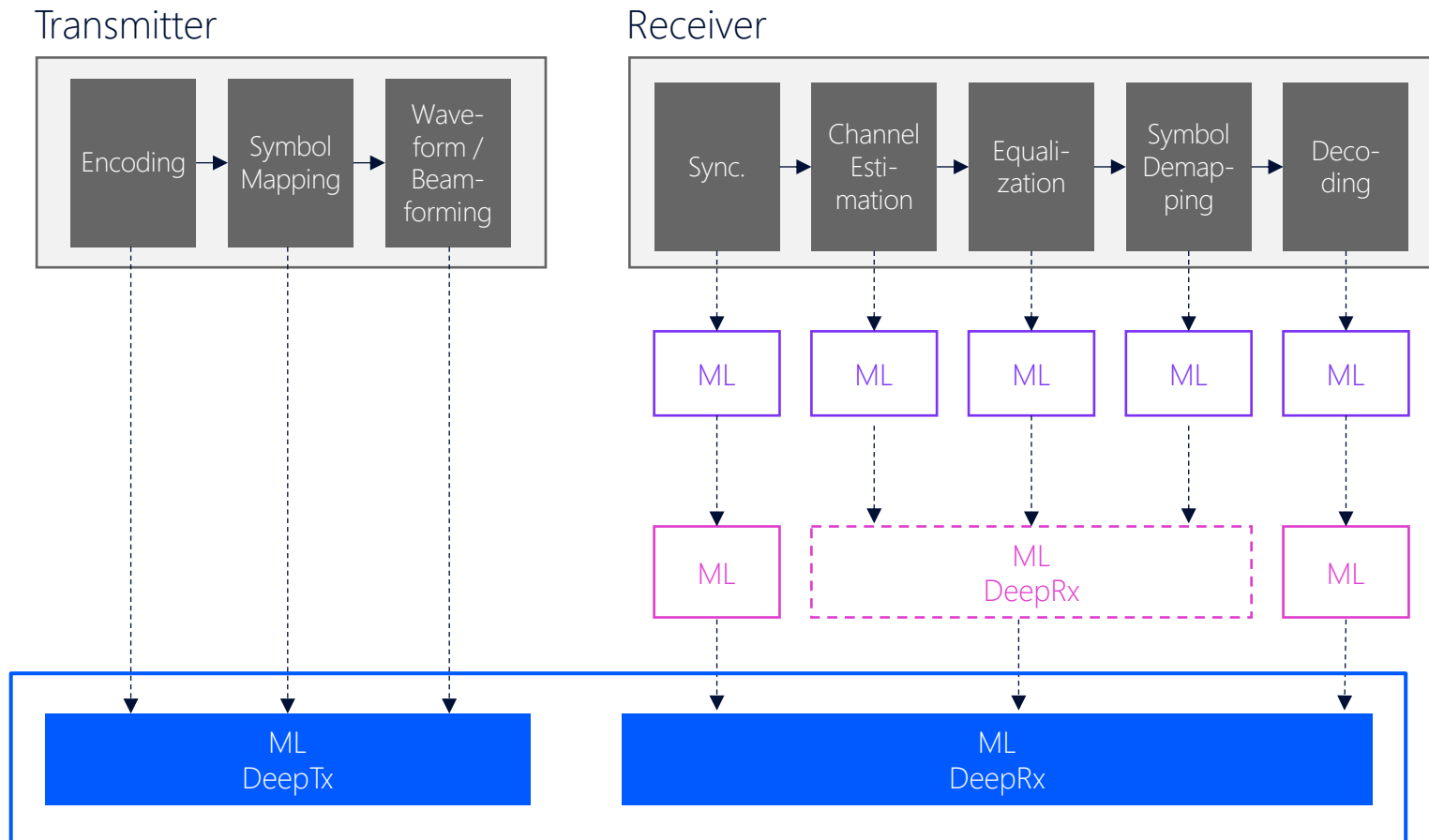
Dani Korpi  
June 2023

The Nokia Bell Labs logo is displayed in white text within a dark teal circular area. The text is arranged in three lines: "NOKIA" on the top line, "BELL" on the middle line, and "LABS" on the bottom line. The font is a clean, sans-serif typeface.

NOKIA  
BELL  
LABS

# AI-native air interface

## The roadmap to learning radios



5G

The classical architecture

5G-Advanced phase 1

ML replaces/enhances individual processing blocks

5G-Advanced phase 2

ML replaces multiple processing blocks

6G

ML designs part of the PHY itself

NOKIA  
BELL  
LABS



# AI and 6G: Opportunities and Challenges

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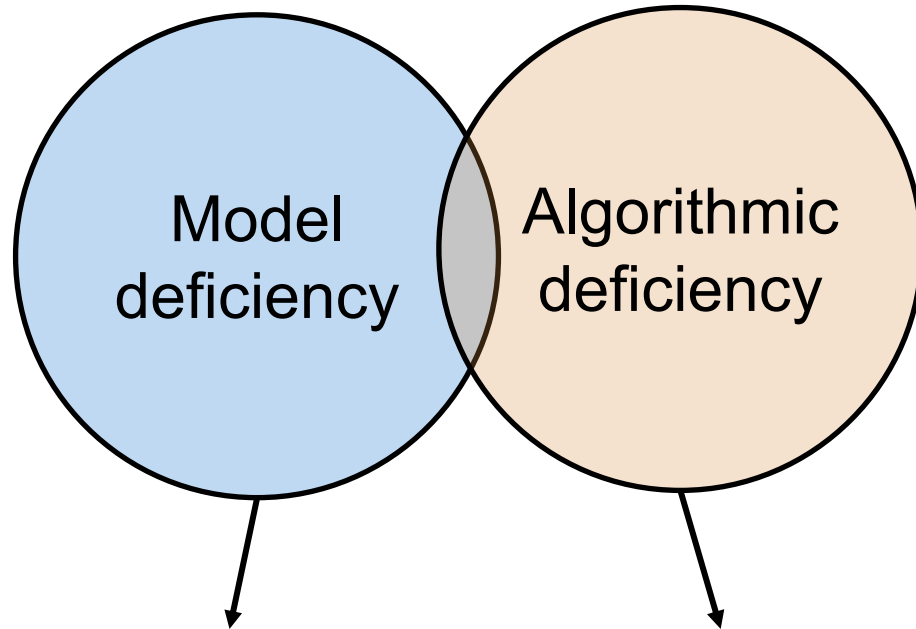
Emil Björnson

Professor of Wireless Communication

Fellow of IEEE, Digital Futures, and Wallenberg Academy

KTH Royal Institute of Technology, Stockholm, Sweden

# AI: One Tool in the Toolbox



- User behavior
- Application pattern
- Codecs (Semantics)
- Fine-tune general algorithms with trainable parameters

**Don't expect too much!**  
Many small refinements







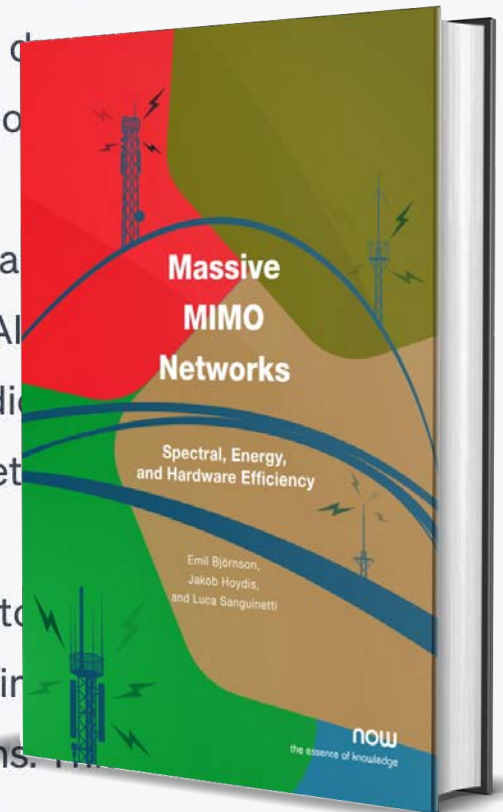
How can AI be used to make 6G networks better?



AI can play a significant role in improving 6G networks in several ways. Here are some potential applications of AI in enhancing 6G networks:



1. **Intelligent Resource Allocation:** AI algorithms can optimize the allocation of network resources such as bandwidth, power, and computing capacity in real-time. This dynamic resource allocation can enhance network efficiency and ensure optimal utilization of available network resources, leading to improved network performance.
2. **Network Management and Optimization:** AI can be employed to monitor and manage network infrastructure, including base stations, antennas, and network nodes. AI-powered network management systems can identify network bottlenecks, predict network congestion, and proactively optimize network parameters to deliver better performance and quality of service.
3. **Intelligent Beamforming:** Beamforming techniques are crucial for 6G networks to achieve higher data rates and improve coverage. AI algorithms can optimize beamforming by analyzing real-time data on user locations, signal quality, and network conditions. This enables dynamic and adaptive beamforming to focus signals precisely where they are needed, increasing network capacity and improving overall performance.



# Some Challenges and Opportunities

Technical debt and dependencies

Unstable extrapolation to unseen cases

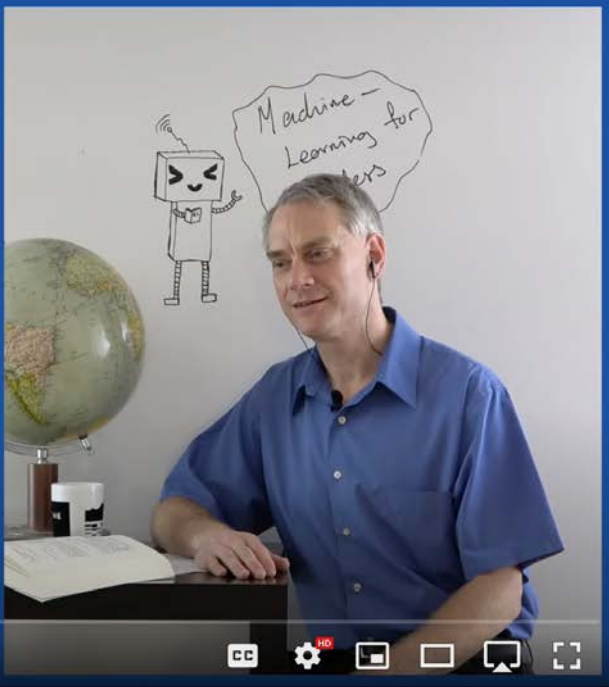
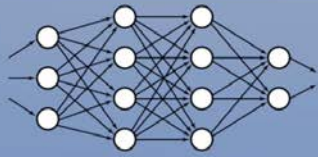
Data collection over networks

Hardware acceleration

Detection of irregularities

Inter-vendor O-RAN optimization



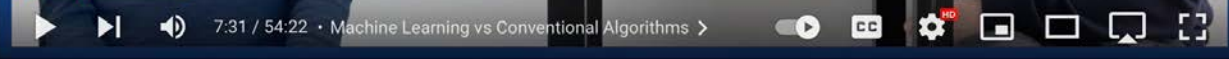


Ep 7. Machine Learning for Wireless [Wireless Future Podcast]

[Youtube.com/wirelessfuture](https://www.youtube.com/wirelessfuture)



Wireless for  
Machine Learning



Ep 15. Wireless for Machine Learning (with Carlo Fischione) [Wireless Future Podcast]

Hexa-X

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# AI and 6G: Opportunities and challenges

Nandana Rajatheva

06.06.2023

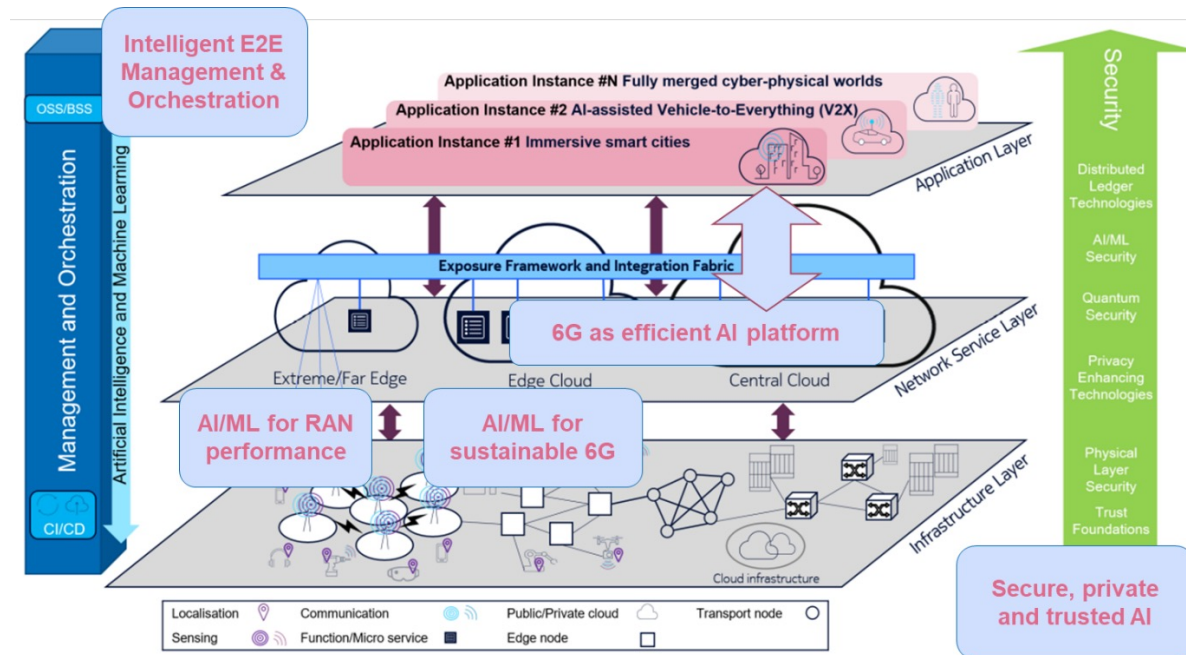
[hexa-x.eu](http://hexa-x.eu)





# AI and 6G: Learning to Communicate & Communicating to Learn

- **Learning to Communicate:** AI-driven solutions for 6G systems to enhance network performance with extreme flexibility and low complexity
  - Air interface design including radio transceivers and PA non-linearity reduction
  - Physical layer and channel estimation
  - Distributed-MIMO - beamforming optimisation and radio resource management
- Challenges:
  - Need for novel KPIs, KVIs, and metrics to properly assess the performance
  - Need for novel network architectures including the integration of computing and storage capabilities into communication networks, to be jointly optimized and orchestrated with wireless resources



- **Communicating to Learn:** 6G networks as an efficient AI platform
  - Workload management including AI-as-a-Service (AlaaS), energy efficiency targets, load balancing in federated learning, and joint orchestration of radio and computing resources
  - Trustworthy and distributed AI - resilience to adversarial attacks, and (federated) explainable AI

# Thank you!

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HEXA-X.EU



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# on machine learning and 6G

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**AALBORG UNIVERSITY**  
DENMARK

**AI and 6G: Opportunities and Challenges**  
@ EuCNC, June 6, 2023

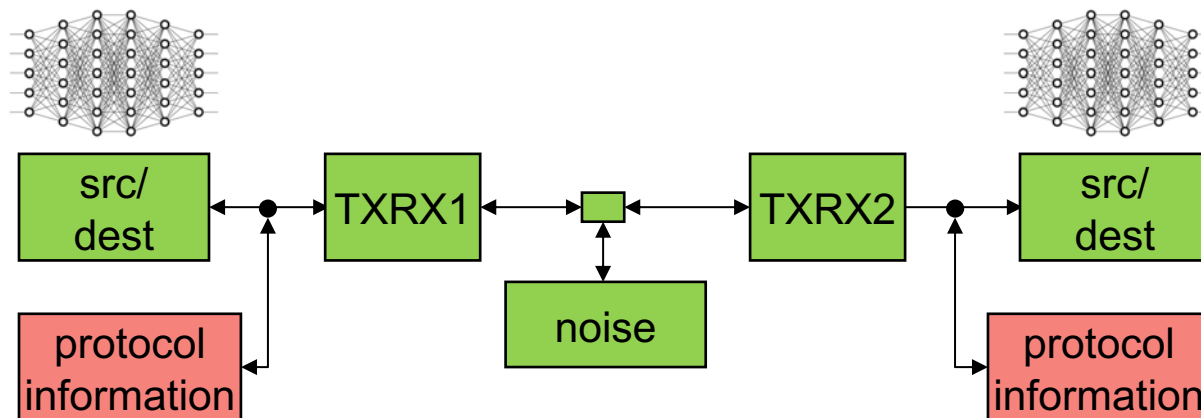
# there principal roles

- facilitate data processing, compression, and communication
- verify and calibrate performance guarantees
- learning-based solutions to difficult algorithmic problems



# data processing, compression, and communication

- continuously growing intelligence in the nodes
- what can be predicted,  
does not need to be communicated
- growing intelligence changes the technical problem  
to a **semantic** communication problem



[\*] P. Popovski, O. Simeone, F. Boccardi, D. Gündüz, and O. Sahin, "Semantic-Effectiveness Filtering and Control for Post-5G Wireless Connectivity", Journal of the Indian Institute of Science, invited paper, 2020.

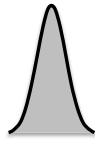
[\*\*] Q. Lan, D. Wen, Z. Zhang, Q. Zeng, X. Chen, P. Popovski, and K. Huang, "What is Semantic Communication? A View on Conveying Meaning in the Era of Machine Intelligence", Journal of Communications and Information Networks (JCIN), invited paper, accepted, 2021.

# verify and calibrate performance guarantees

uncertainty in wireless

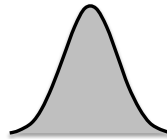
inherent randomness of wireless

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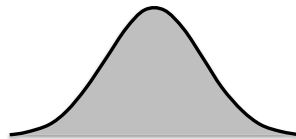


ignorance about channel statistics

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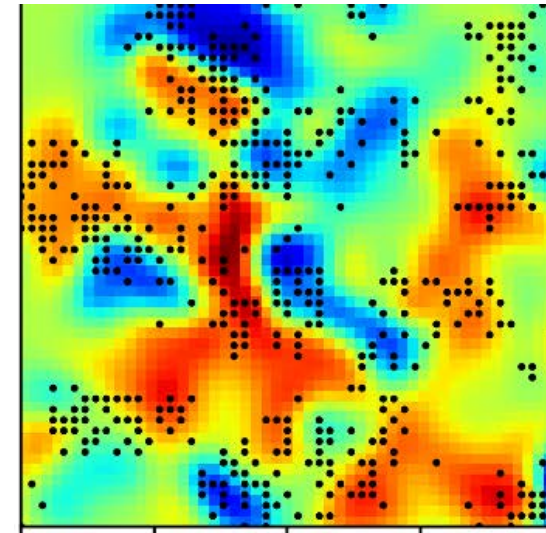


changes of the channel statistics



ML is must-have for **ultra-reliability**

- model selection
- learning
- performance evaluation



T. Kallehauge, A. E. Kalør, P. Ramirez-Espinosa, M. Guillaud, and P. Popovski, "Delivering Ultra-Reliable Low-Latency Communications via Statistical Radio Maps," in IEEE Wireless Communications Magazine, accepted, 2022.

# learning for algorithmic problems

ML can be through to problems that would otherwise need very complex hand-crafted algorithms

examples

- joint source-channel coding
- radio resource allocation for heterogeneous traffic

need for explainable AI

