AI/ML DATA ANAYLITCS AND DATA COLLECTION IN 5G/6G NETWORK

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ROHDE&SCHWARZ
Make ideas real

AGENDA

- AI/ML in Wireless Communication
- AI/ML in 5G Core Network
- AI/ML in 5G Air Interface
- Outlook for AI/ML in 6G Network

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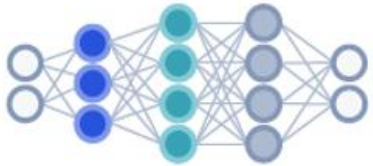
WHY AI/ML FOR WIRELESS COMMUNICATION?

AI/ML models complex relationships between parameters of a system and finds patterns in data

input



output

Wireless communication needs to take complex decision based on Parameters & Events

AI/ML can help wireless technologies to find patterns, predictions , classification on wireless parameters

WHICH USECASES FOR AIML FOR WIRELESS?

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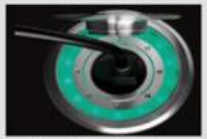
Smart Metering

By 2023 this installed base will double to reach 1.34 billion meters
ABI Research

Electric Cars



Approximately 20 major cities worldwide have announced plans to ban fuel-cars by 2030 or sooner Deloitte, 2019

Smart City Sensors

Predictive sensor monitoring to prevent disasters

Financial

Predictive modelling, market & investment analysis, anomaly detection

Retail and Services

Customer behaviour analysis and consumption adoption, promotions

Sports and Entertainment

Maximize over the top experiences

Utility Providers

More efficient power generation and resource management

Manufacturing

Automated low latency for robotic manufacturing plants

Healthcare

Application prioritization, abnormality detection, monitoring

Traffic and Trade Management

Complex traffic management and optimisation

Education

Student analysis, modelling of courses, uptake and performance

Tourism and Restaurants

Mobility prediction analysis , promotion and offers, planning

IMPORTANCE OF DATA COLLECTION

- Data is the new truth !
    - AI/ML Model Training need large amount of Data
    - AI/ML Data Collection is the key
    - AI/ML Data Collection needs domain and usecase specific knowledge

- Data can be :
    - Real field data (Confidentiality, Accessability, Labelling)
    - Synthetic generated

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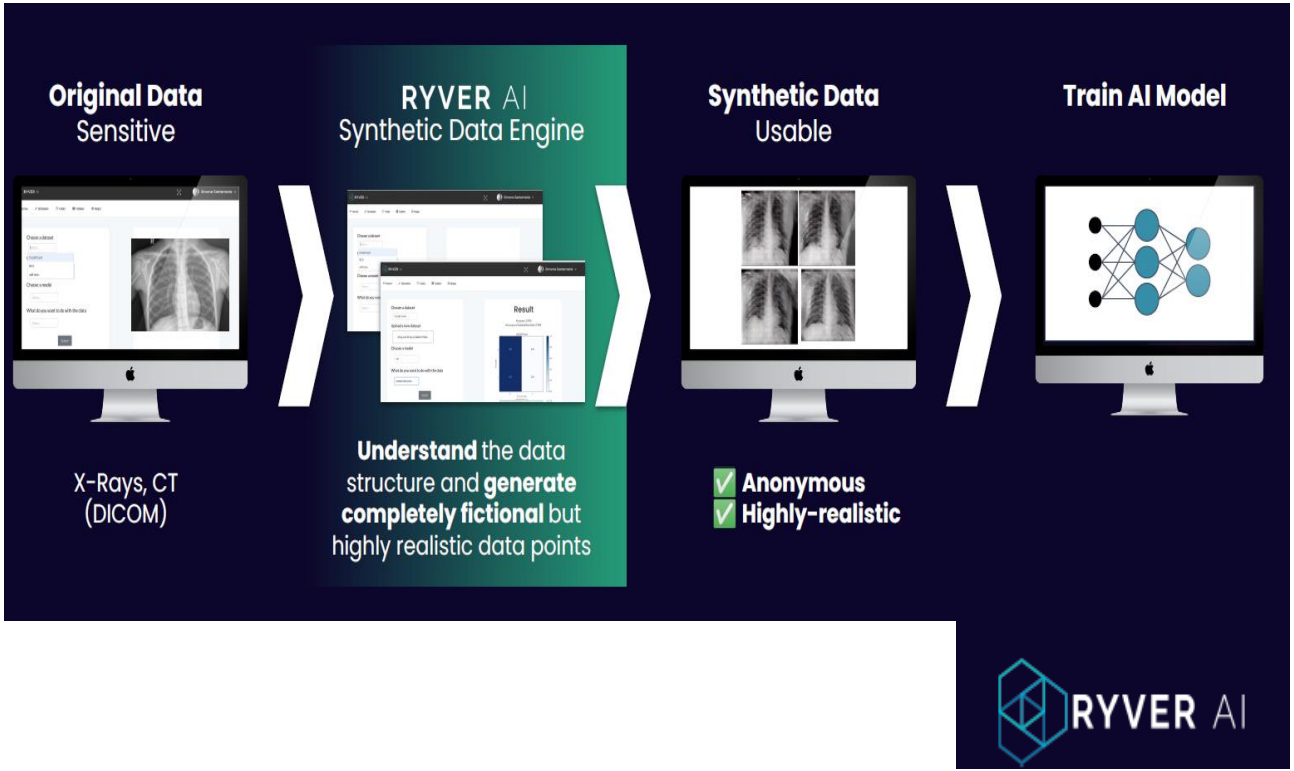
EXAMPLE OF CREATION OF SYNTHETIC DATA



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EXAMPLE OF CREATION OF SYNTHETIC DATA

The **self-driving car** de-pends on so-called self-learning algorithms, which require **large amounts of "training data".**

Without this data, the ambitious goal of producing fully autonomous vehicles will remain out of reach.

The production of this training data or "ground truth da-ta" requires **vast amounts of manual labour in data annotation**, per-formed by crowdworkers across the globe.

Table 1: Relevant providers of training data in 2018

Company	Platform	Origin (est.)	Alexa rank	Crowd size	Funding
Amazon	MTurk	USA (2005)	5,800	500,000	–
Appen	Appen	AUS (1998)	21,000	1,000,000	(public: APX)
Figure Eight	(various)	USA (2007)	30,000	(5,000,000)	$58 Million
clickworker	clickworker	GER (2005)	35,000	1,200,000	$13.7 Million
Mighty AI	Spare5	USA (2014)	37,000	500,000	$27.3 Million
Hive (.ai)	Hive Work	USA (2013)	49,000	300,000	$18 Million
Playment	Playment	IND (2015)	168,000	300,000	$2.3 Million
Scale (.ai)	Remotasks	USA (2016)	187,000	–	$4.6 Million
CloudFactory	(BPO)	UK (2011)	(334,000)	(3,000)	$13 Million
Crowd Guru	Crowd Guru	GER (2008)	416,000	52,000	–
Samasource	(BPO)	USA (2008)	(815,000)	(7,000)	$1.5 Million
Alegion	(various)	USA (2011)	855,000	–	$4.1 Million
understand.ai	(BPO)	GER (2016)	(3.300,000)	–	$2.8 Million

Hans Böckler Stiftung

WORKING PAPER FORSCHUNGSFÖRDERUNG

Number 155, August 2019

Crowdsourced Production of AI Training Data

How Human Workers Teach Self-Driving Cars How to See

Florian Alexander Schmidt

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AI/ML in 5G Core Network

Core Network (5GC)

Radio Access (gNB)

Air Interface (NR)

Device

Network Resource Management
Prediction of traffic volume
Automation
adaptation to triggers events
Monetisation
Prediction of customer & service adoptions

Radio Load Balancing & Coverage
Predictions based on UE/MDT measur.
Mobility Optimization
Inter-node information for Self Organizing Network
Network Energy Saving

Air interface performance
e.g., improved throughput, robustness, accuracy or reliability, etc.
Reduced complexity/overhead.
e.g. number of parameters

Network Data Analytics Functions (NWDAF)

SON/MDT Enhancements for AI/ML

Air Interface Enhancements for AI/ML

Release 15/16

Release 17

Release 18/19

NWDAF IN 5G CORE NETWORK

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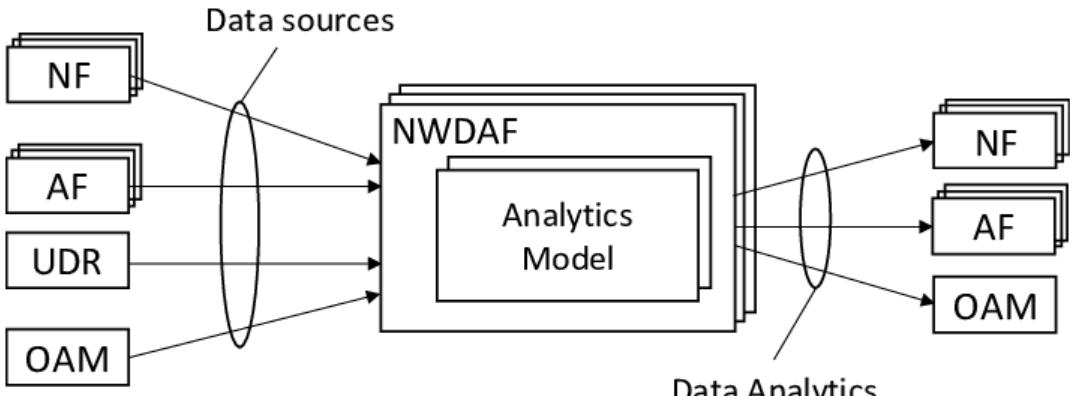

AF: Application Function
NF: Network Function
NWDAF: Network Data Analytics Function
OAM: Operation and Management
UDR: Unified Data Repository

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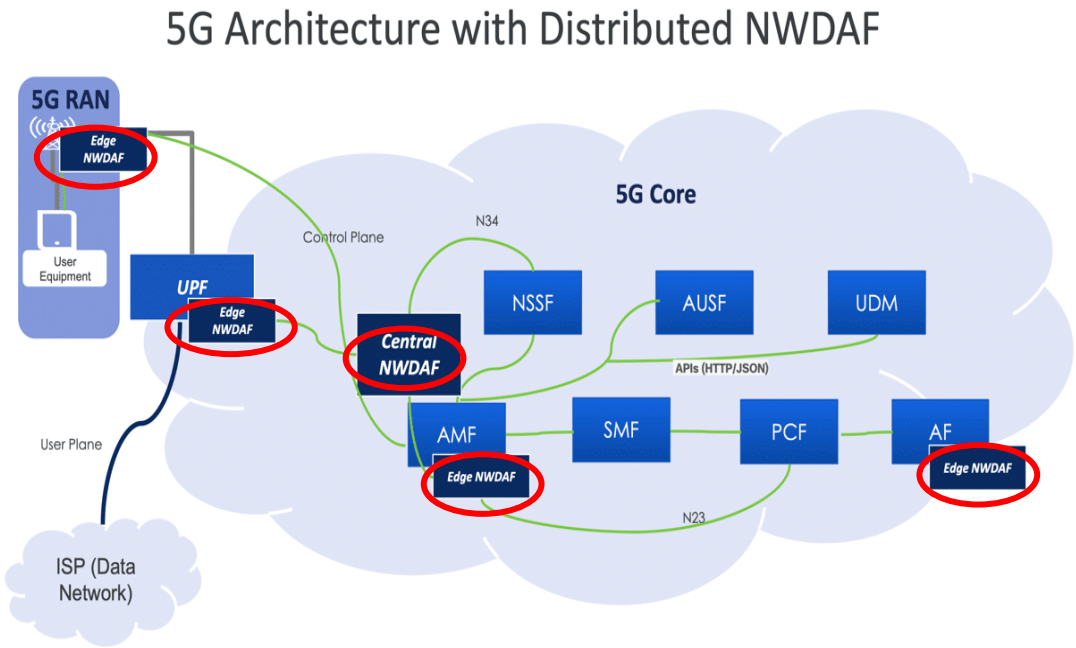
NWDAF IN 5G CORE NETWORK



NWDAF IN 5G CORE NETWORK

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	Report	Function delivered
1	NF Load	Load analytics information & predictions for NFs
2	User Data Congestion	Congestion information - Current & Predicted for a specific location
3	Abnormal Behavior	Abnormal behavior/Anomaly detection for a group/specific UE
4	UE Mobility	Mobility related information and prediction for a group/specific UE
5	Network Performance	Network Load Performance computation and future Load prediction
6	Slice Load	Load level Computation and Prediction of a Network Slice instance
7	Observed Service Experience	Service Experience Computation & Prediction for an Application/UE group
8	QoS Sustainability	QoS change statistics for an Analytics target period in the past or future by area
9	Expected Behavior	Expected behavior prediction for a group/specific UE
10	UE Communication	Communication pattern prediction for a specific UE

AI/ML FOR UE MOBILITY

The Access and Mobility Management Function (AMF) defines Registration Areas for UEs, and UEs send location updates (signaling messages) to the AMF when they leave the Registration Areas.

Consider a suburban tram following the same route through Barcelona every day.

Without NWDAF, the Registration Area (shaded red) is very small, and there will be many registration updates as the tram travels along its route.

With NWDAF, the Registration Area (shaded red) is much larger, and there will not be any registration updates as the tram travels along its route.

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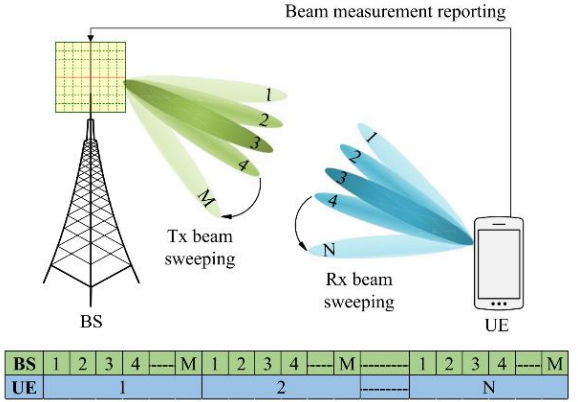
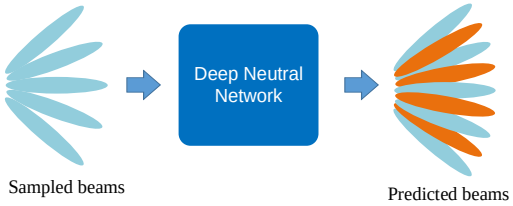
USECASE : BEAM MANAGEMENT

- **Why ML for beam management?**
  - **Conventional:** Exhaustive beam sweep
    - As propagation losses increase with 5G / 6G:
      - Larger number of narrower beams
      - More signalling overhead
      - Larger latency

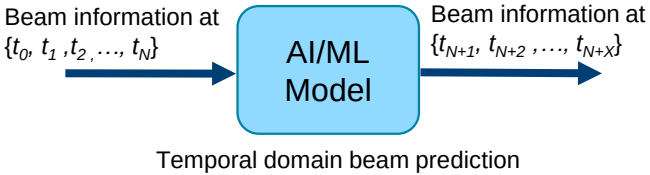


USECASE : BEAM MANAGEMENT

- **Spatial Beam Prediction:**
  - Infer from a subset of beams
  - Selection based on **highest RSRP**
  - With prediction → Less measurements required



- **Temporal Beam Prediction**:
  - Allows lower beam measurement frequency
  - Infer future RSRP or best beam index



AI/ML DATA COLLECTION FOR BEAM MANAGEMENT

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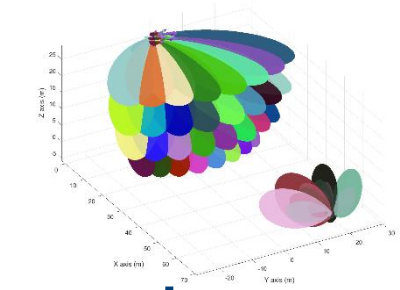

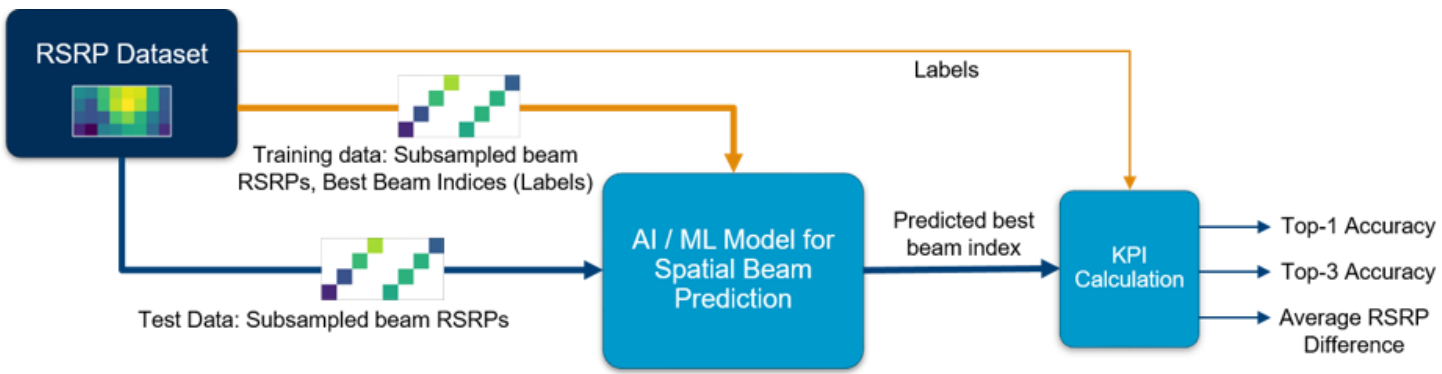

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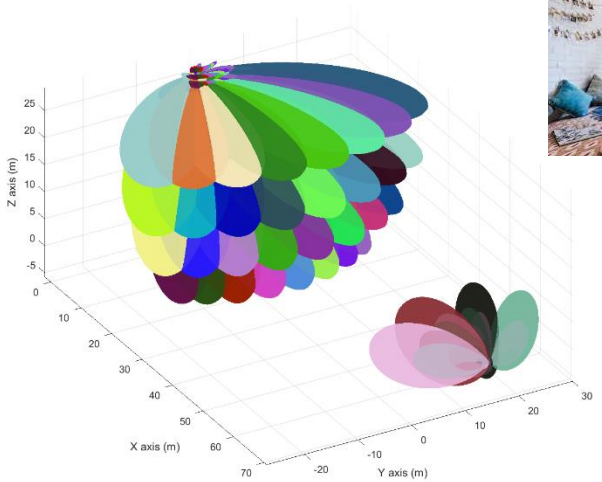

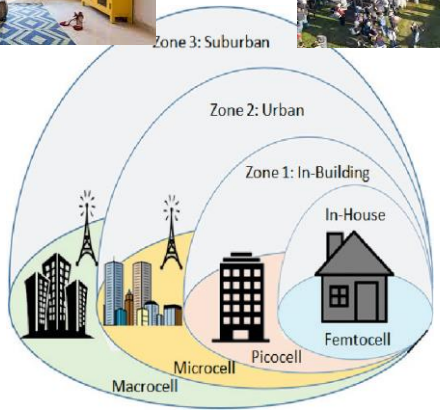

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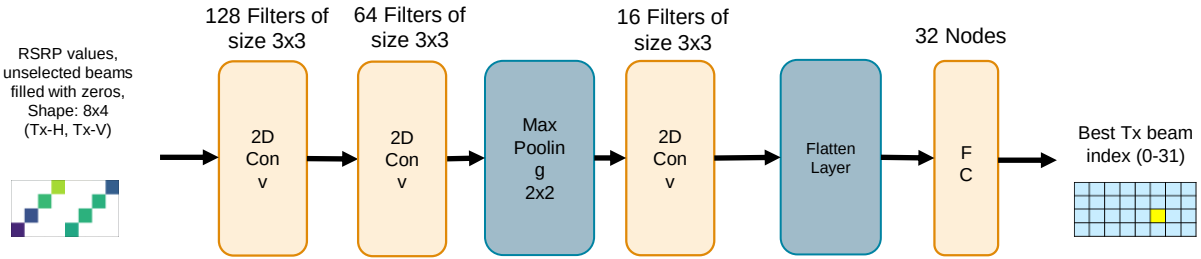

Training	Test	Top-1 Accuracy	Top-3 Accuracy	Average RSRP Difference (dB)
UMa 0% indoor	UMa 0% indoor	74.7 %	93.2 %	1.08
	UMa 80% indoor	47.9 %	74.8 %	2.54
UMa 80% indoor	UMa 0% indoor	69.4 %	92.4 %	1.25
	UMa 80% indoor	**48.6 %**	**76.3 %**	**2.24**
Mixed: UMa 0% indoor + UMa 80% indoor	UMa 0% indoor	73.0 %	93.0 %	1.09
	UMa 80% indoor	48.7 %	76.1 %	2.34

Mixed data set can get most information

- AI/ML in Wireless Communication
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- AI/ML in 5G Base Station
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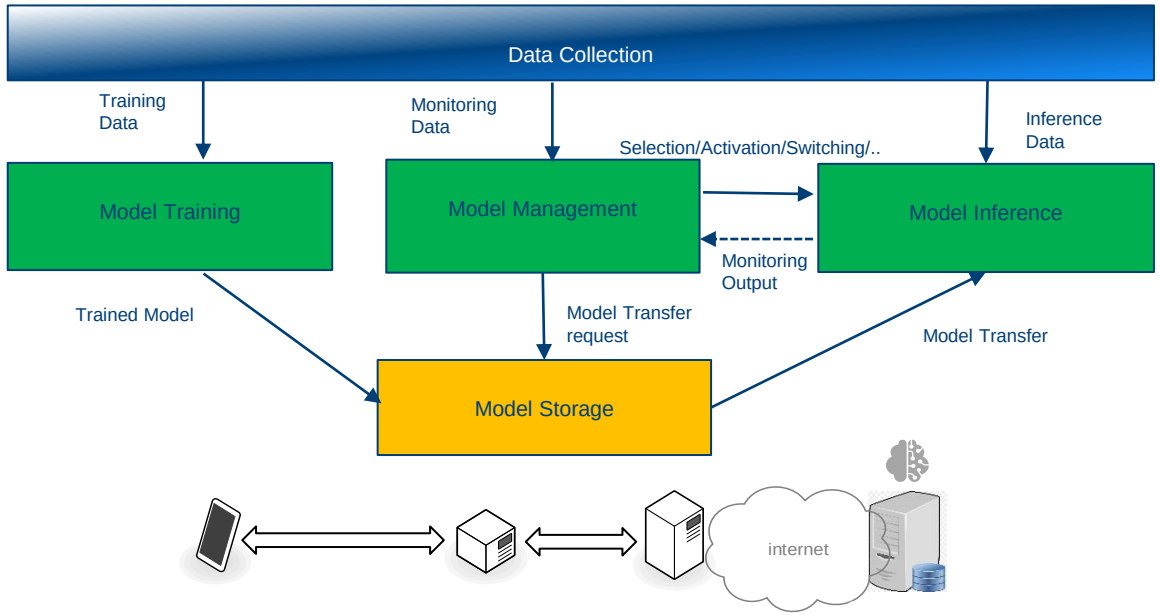
AI/ML MODEL LIFECYCLE

Model Life Cycle include aspects of AI/ML model like model training, model deployment, model inference, model monitoring, model updating.

Include definition of Components needed i.e. Data Collection, Model Storage



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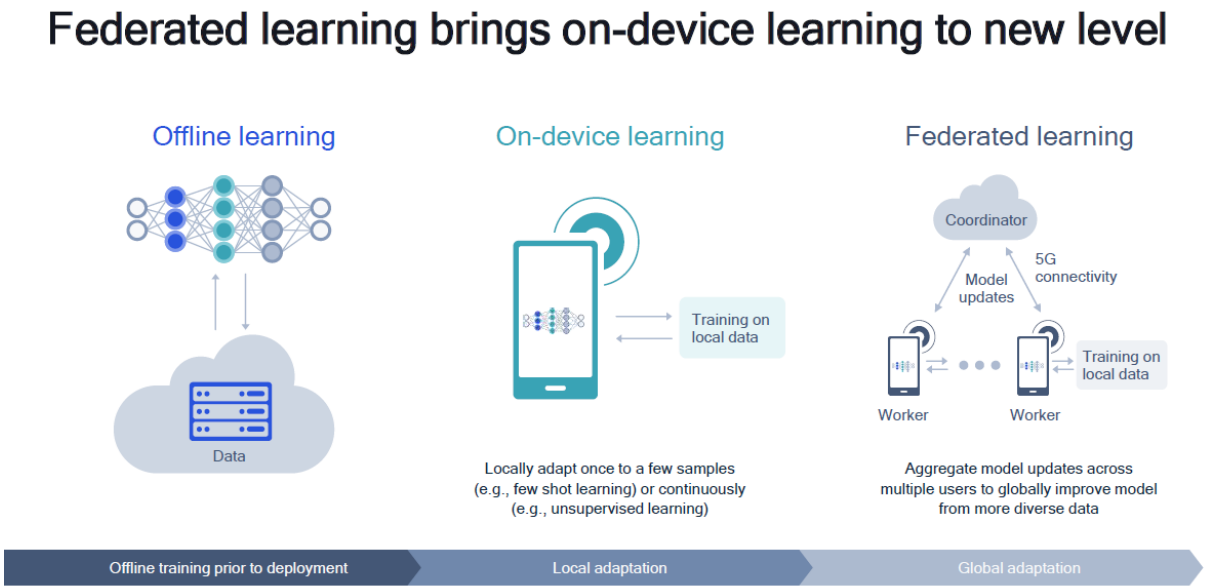
DO WE NEED TO SHARE AI/ML DATA ?



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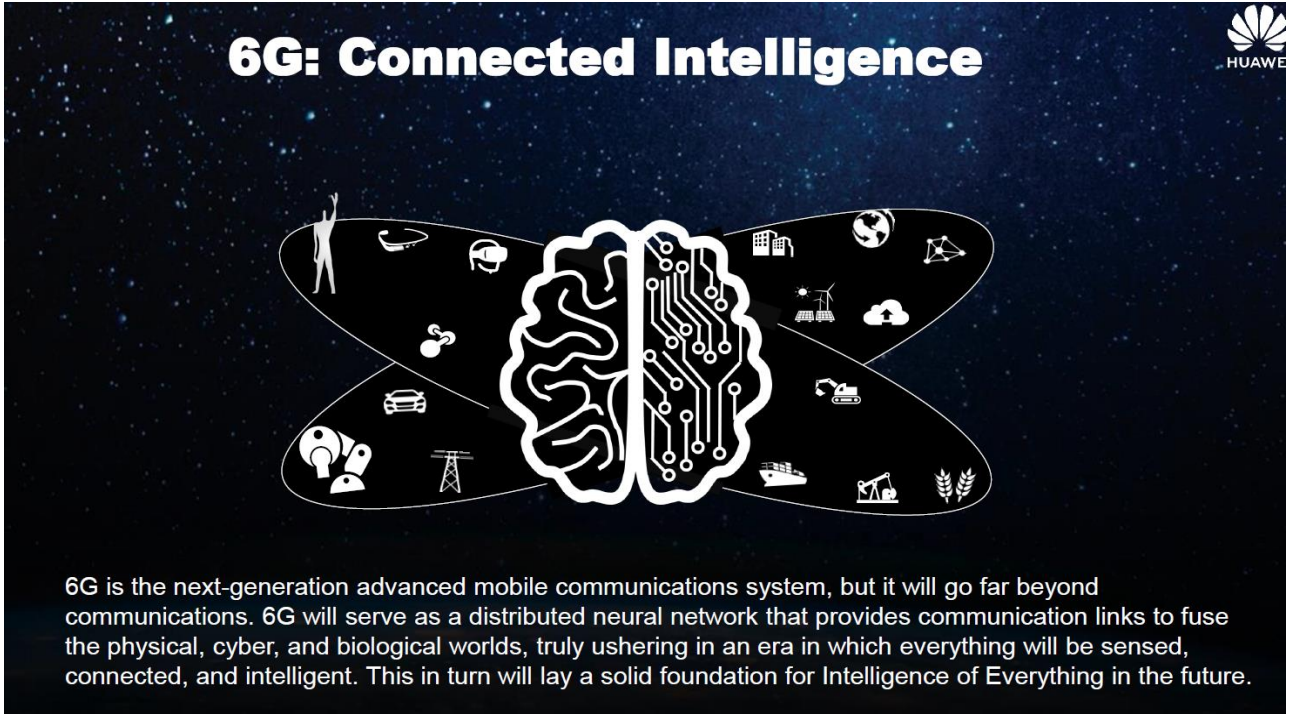
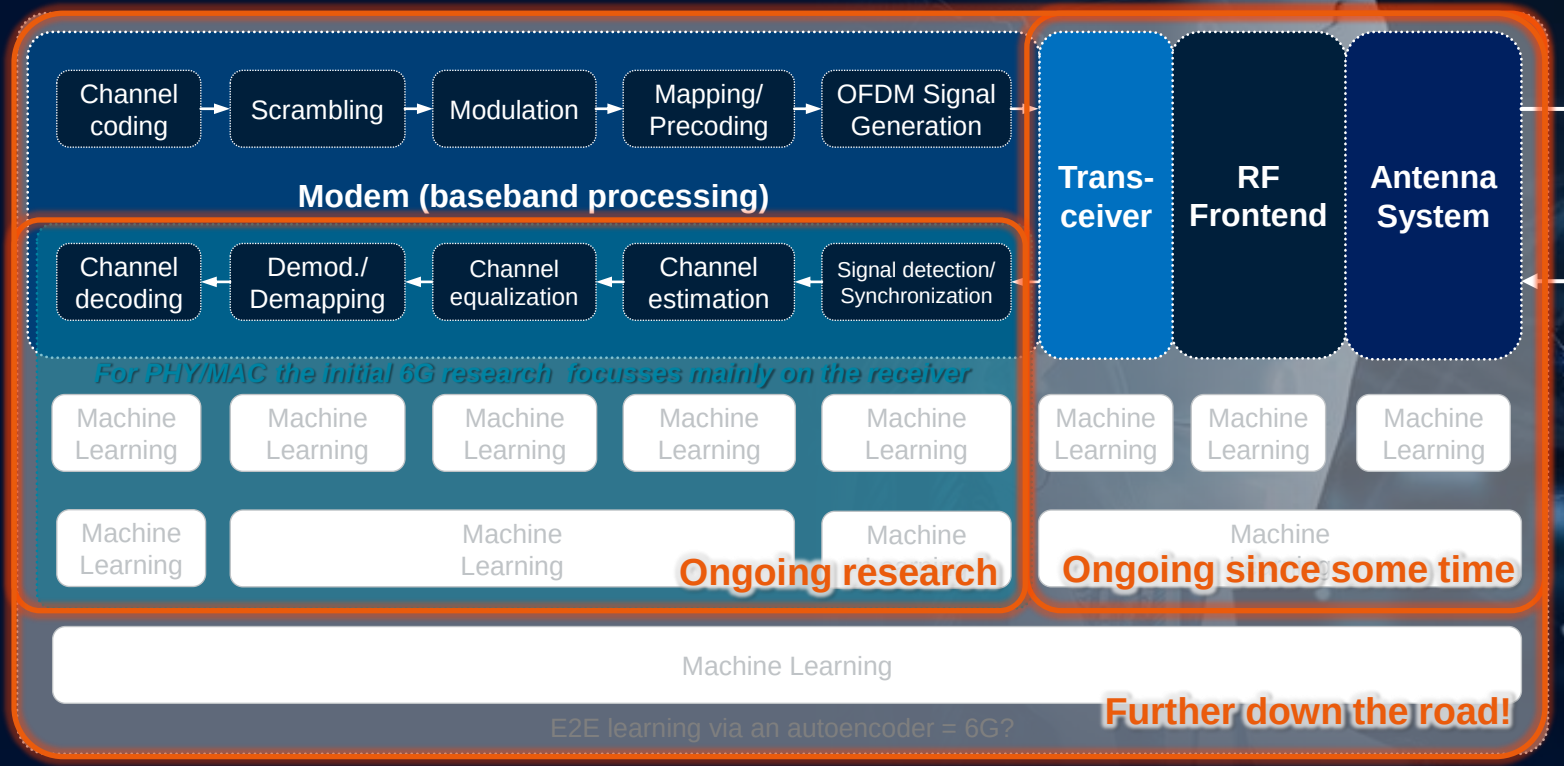


WHAT POTENTIALLY COMES NEXT?
AI-NATIVE AIR INTERFACE FOR 6G?



ML applied to individual processing blocks

ML replaces multiple processing blocks

ML used to jointly optimize TX, RX and baseband processing;

ML designs part of 6G PHY/MAC itself

Q&A