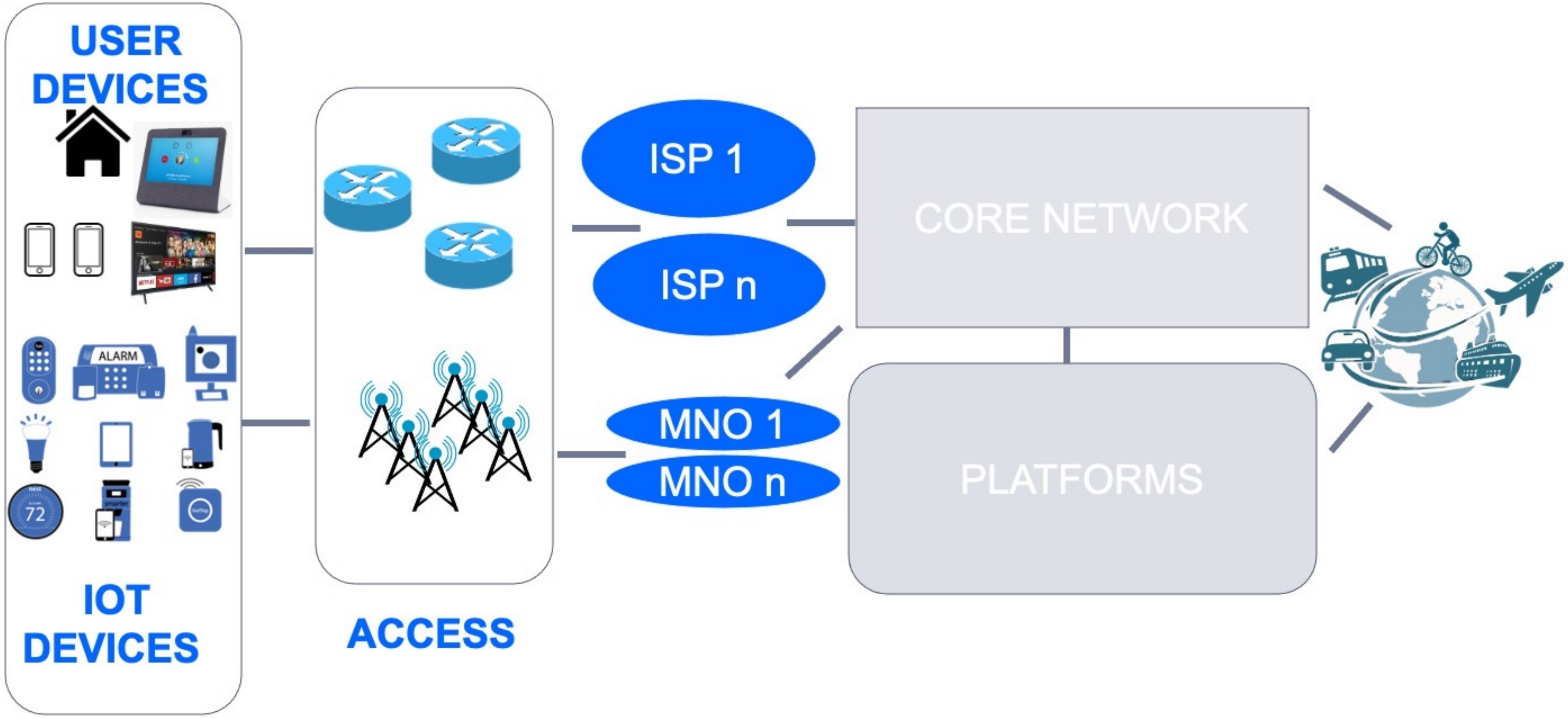
Telefónica

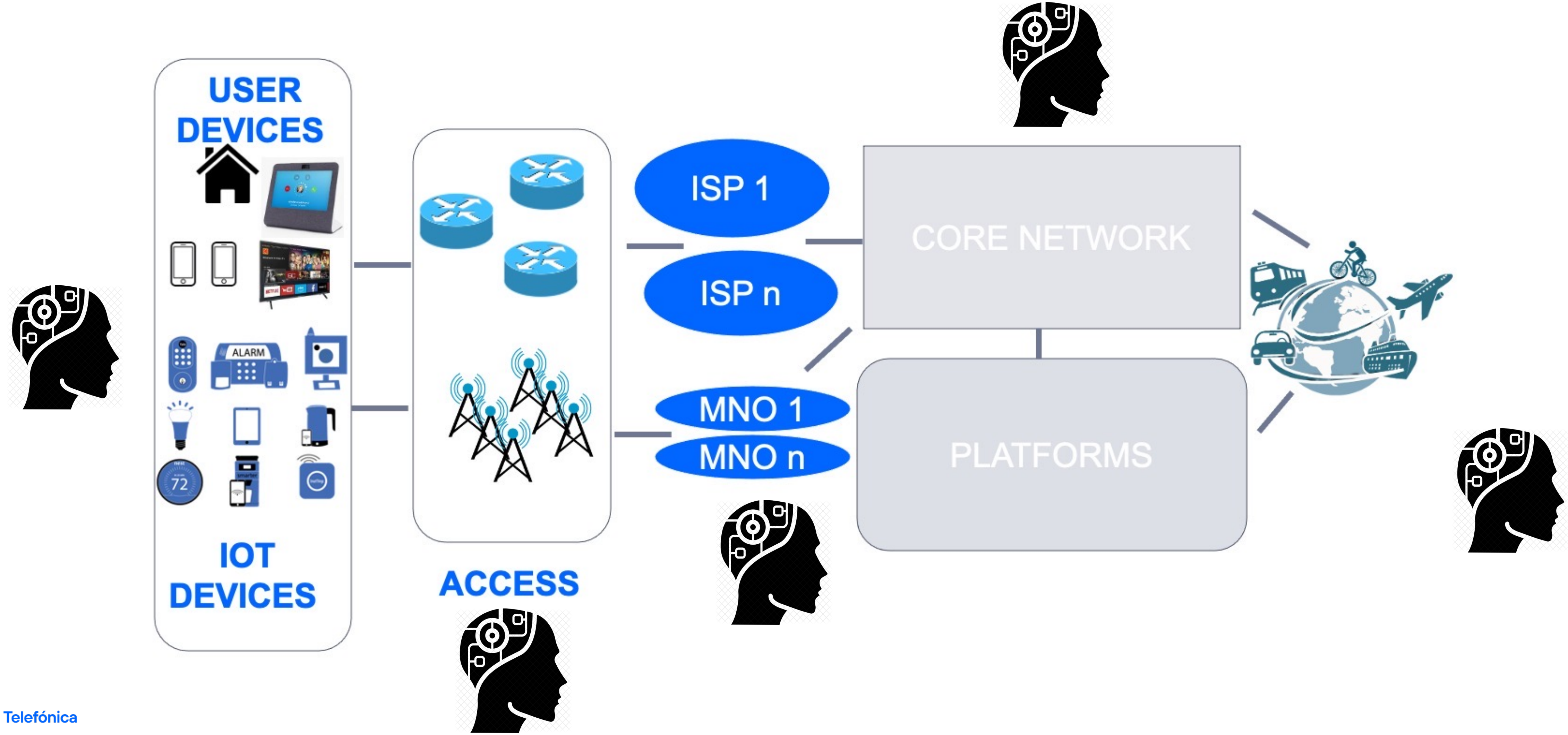
Artificial Intelligence and Decentralized Privacy Preserving Mechanisms for Telco Industry

Diego Perino
Telefonica Research

Telco "Networks" are complex!



Artificial Intelligence to the rescue ? !



USER DEVICES

IOT DEVICES

ACCESS

ISP 1

ISP n

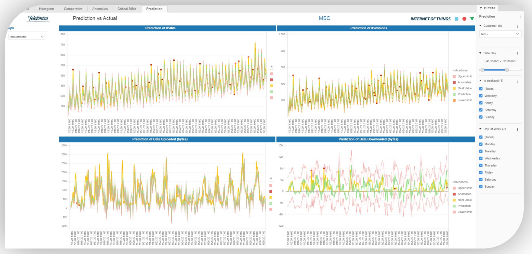
MNO 1

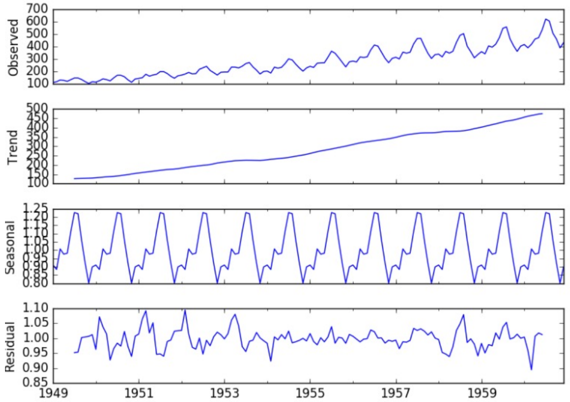
MNO n

CORE NETWORK

PLATFORMS

Intelligence for Networks…



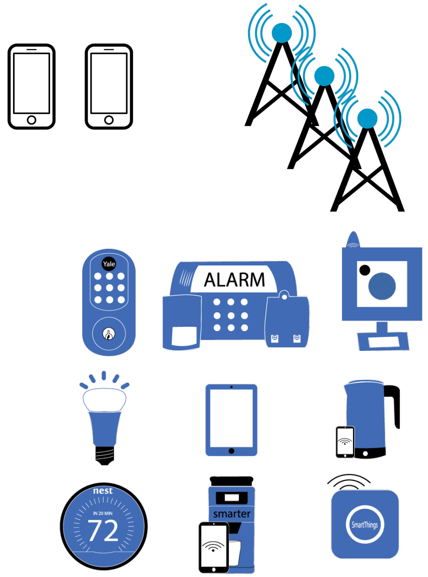


Platforms

- Cloud and Edge management
- IoT devices operations and added value services

Quality of Service/Experience

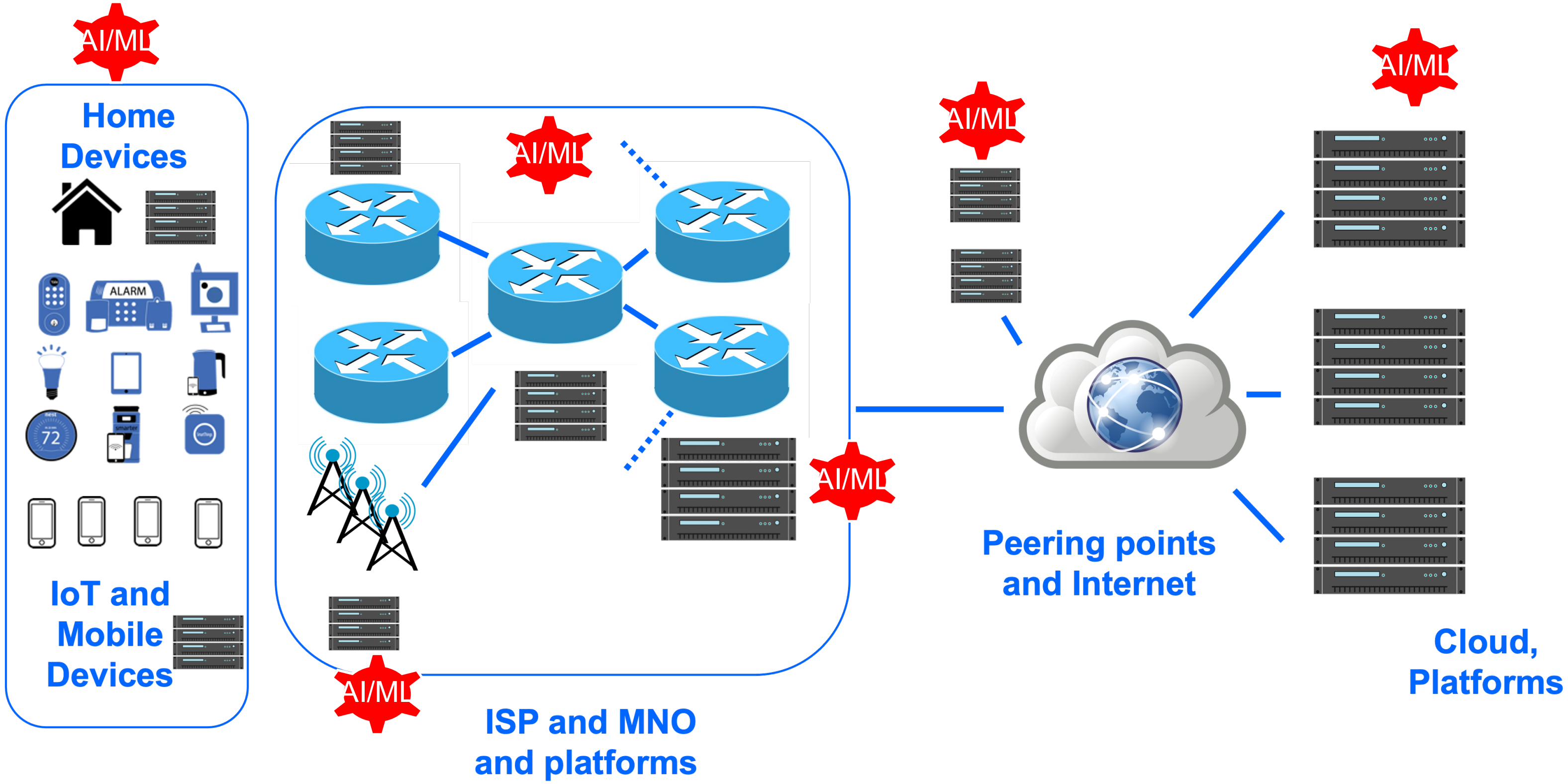
- Predict and Monitor Quality
- Detect Anomalies and React



Edge/Core networks

- Network Planning
- Network Operations
- Network Management

…networks for Intelligence



Networks for AI-based applications (e.g., XR)

- Provide processing capabilities everywhere

Networks as distributed Learning Infrastructure

- Distributed Learning, Federated Learning

Sustainable mobile broadband to unconnected people

Infrastructure with open-access technology and a revenue-sharing model

Thousands of small communities (2-3-4G)

MOUNTAIN 61%

COAST 14%

RAINFOREST 15%

Different power supply

SOLAR PANELS

POWER GRID

BATTERY

Heterogeneous third-party backhaul networks

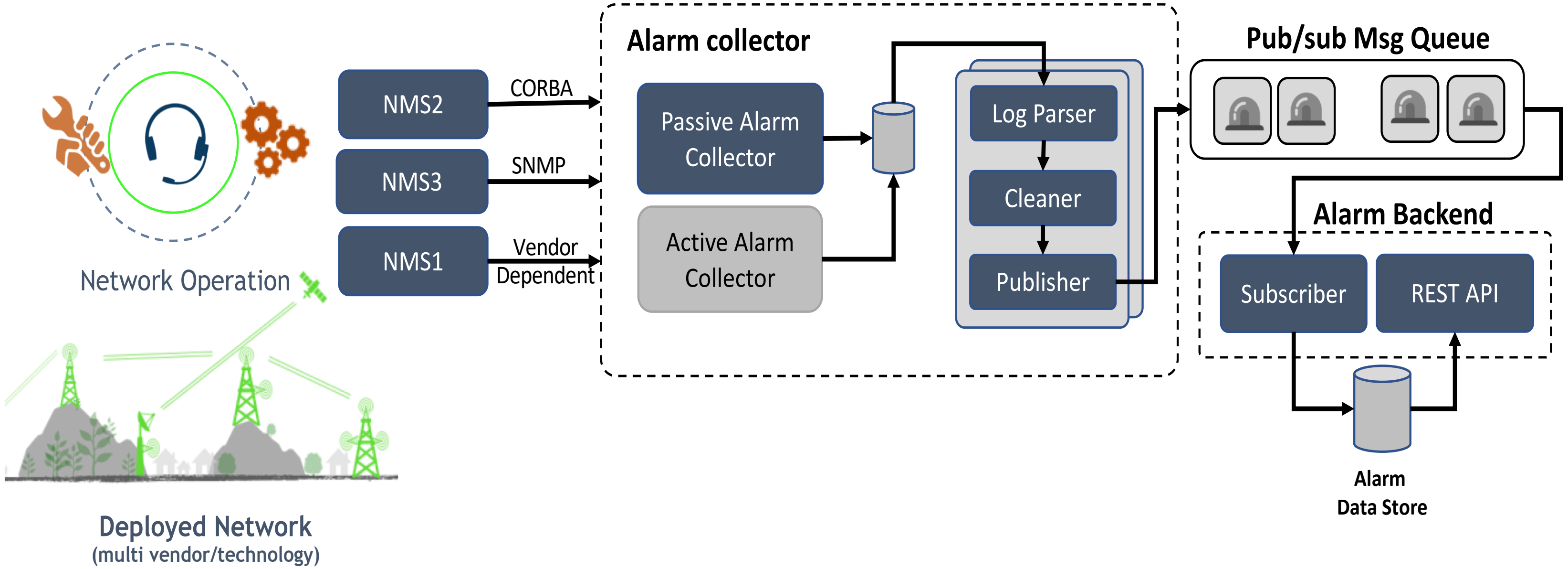
RADIO LINKS

SATELLITE

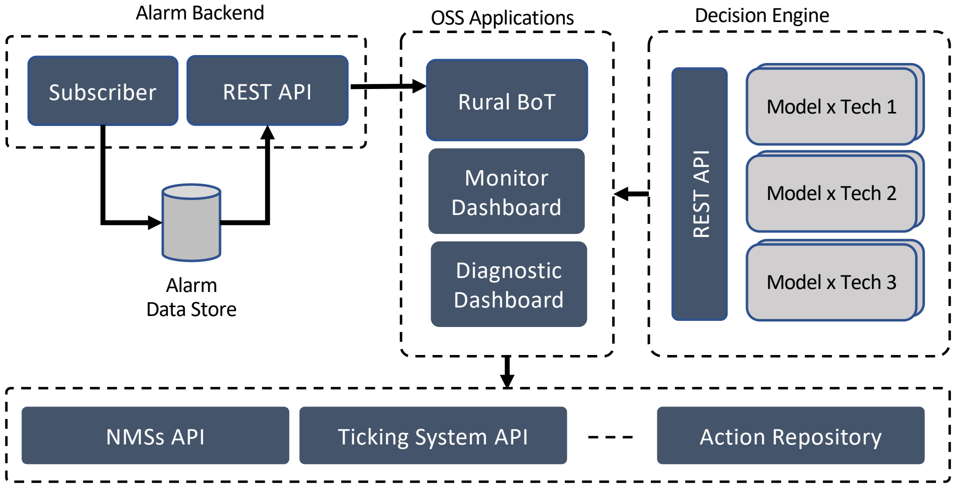
FIBER

Predefined route for operations (some site have no direct road access)

Micro-cell network operation

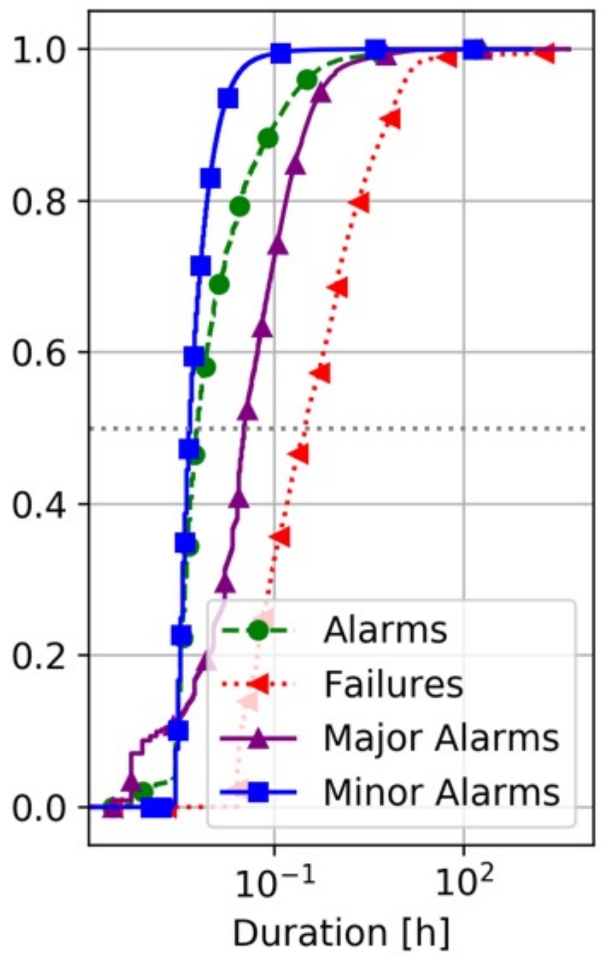


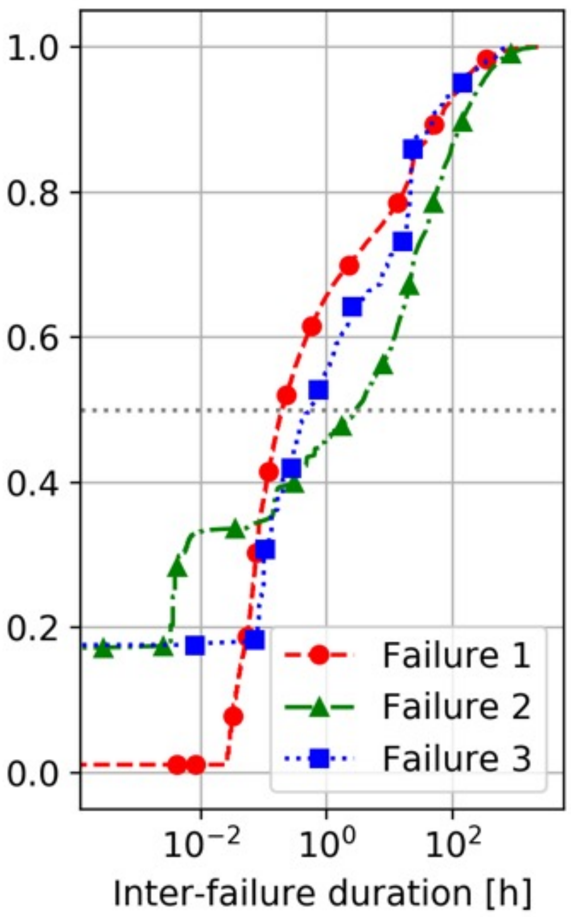
- Different KPIs for different vendors/radio technologies
- Alarms stored with active/cleared state



- Several apps for network management

Micro-cell network operation: 5 months data analysis

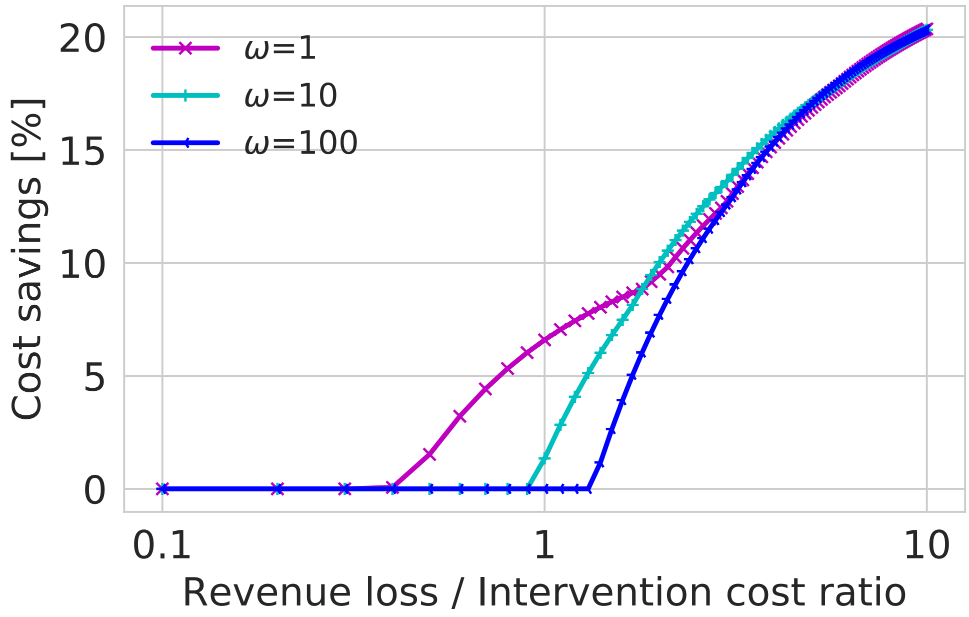


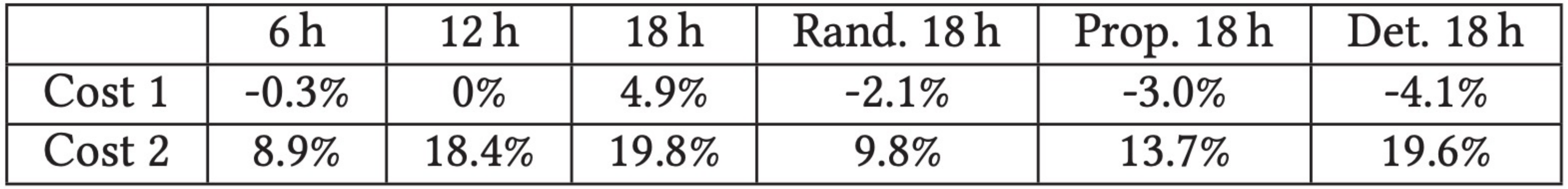


- Most failures are temporal: backhaul saturation or battery outages
- Control and predictive mechanism to avoid costly and unnecessary intervention
- It is critical to understand the nature of the failure

Conclusions and lessons learnt

- We need a good understanding of the status of the network, failures and field operation teams to contain costs
- Failures are mostly temporal and mainly caused by power outages or congestion issues
- Need of control and predictive mechanisms, and to understand the cause of the failure
- ML (and DL) and analytics can actually help to reduce costs (5-20% and design better rule-based systems)





	6 h	12 h	18 h	Rand. 18 h	Prop. 18 h	Det. 18 h
Cost 1	-0.3%	0%	4.9%	-2.1%	-3.0%	-4.1%
Cost 2	8.9%	18.4%	19.8%	9.8%	13.7%	19.6%

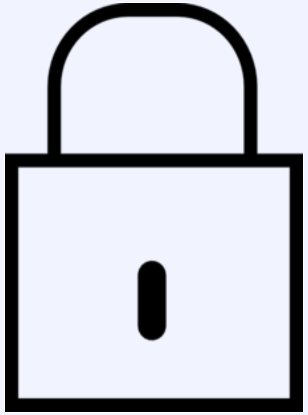
Diego Perino, Xiaoyuan Yang, Joan Serra, Andra Lutu, Ilias Leontiadis, Experience: Advanced Network Operations in (Un)-Connected Remote Communities, in proc. of ACM Annual International Conference on Mobile Computing and Networking (MOBICOM), September 2020

Challenges for current and future networks

- Global, holistic, end-to-end approach
- Usability and explainability
- Data/ground truth availability and quality
- Co-existence with traditional solutions
- Robustness
- Sustainability
- Accountability, Transparency and Fairness

…

How to get the benefits of AI while preserving user privacy and security?



Privacy Preserving Artificial Intelligence

Differential Privacy

Secured Multi-Party Computation

Fully Homomorphic Encryption

Federated Learning

Trusted Execution Environments

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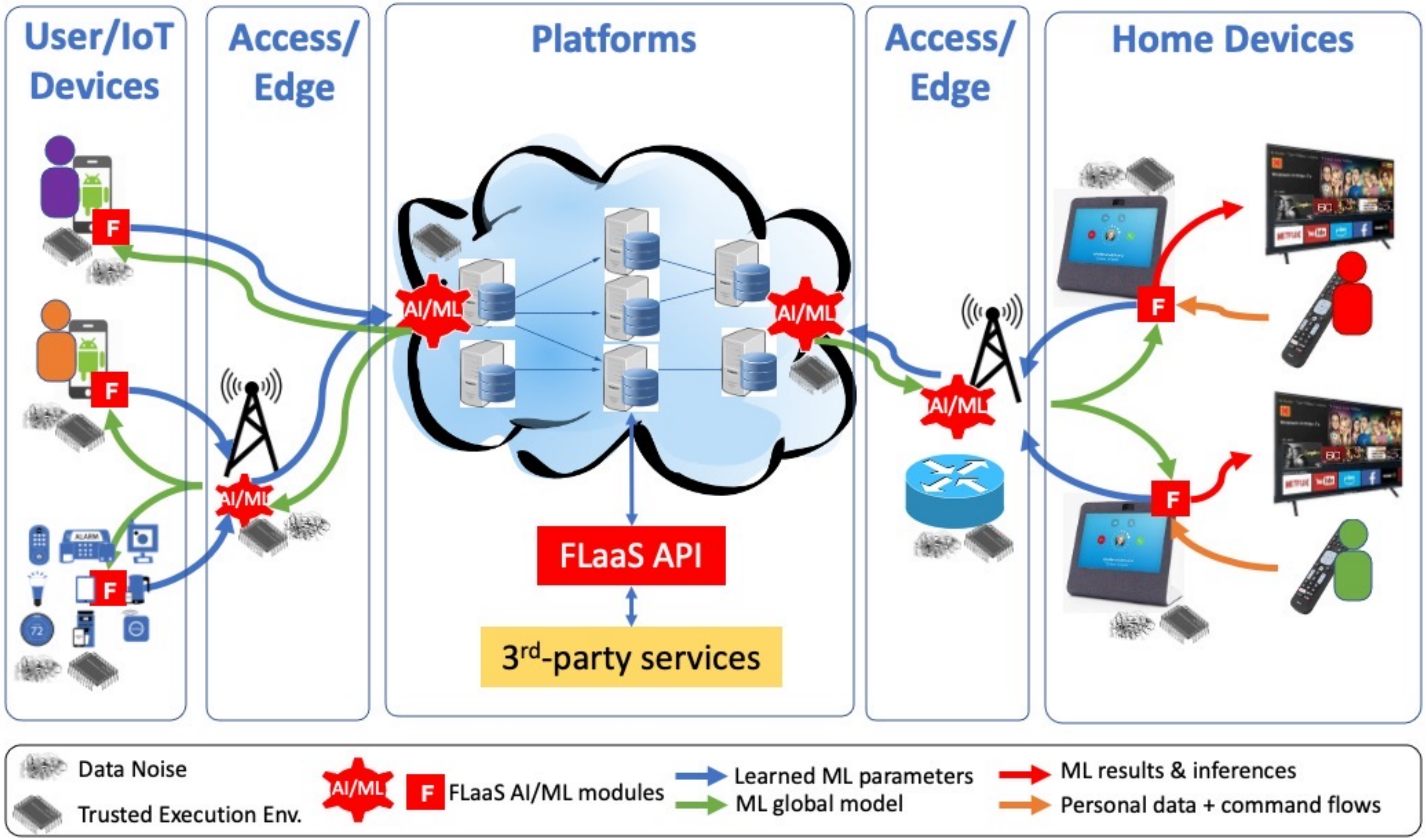
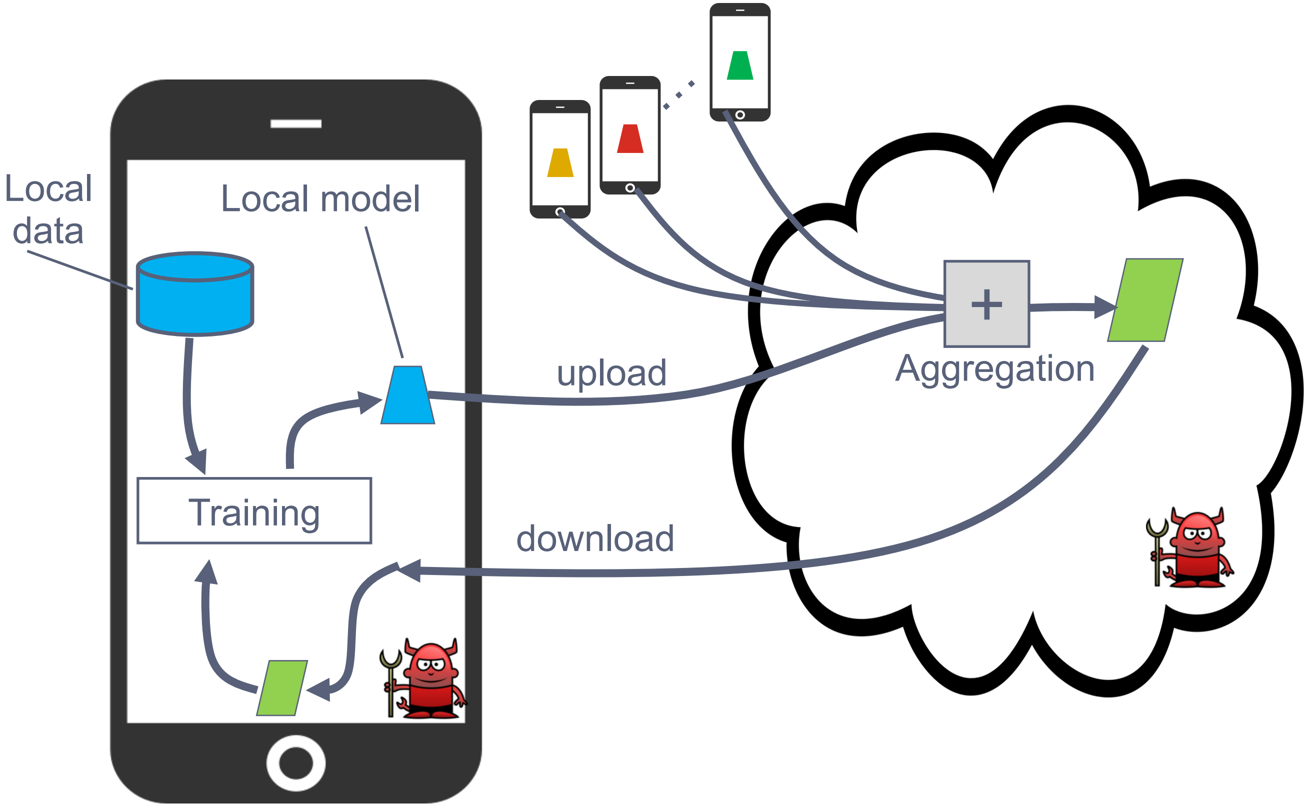
Example: Federated Learning as a Service (FLaaS)



Federated Learning may lead to privacy issues

-Models/gradients memorize datasets

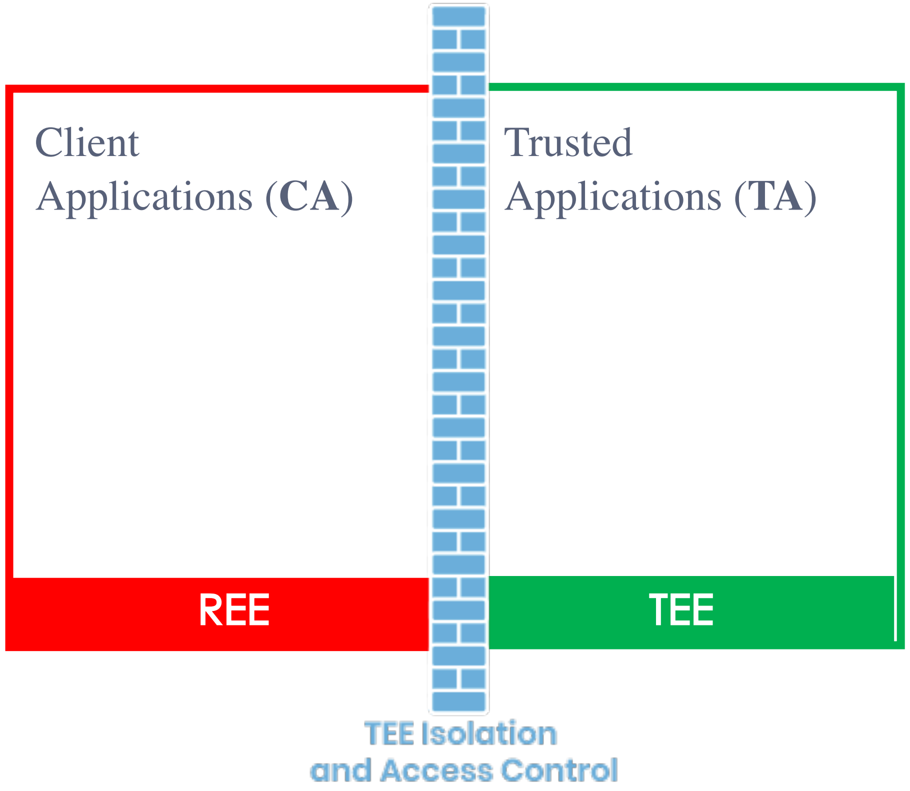
- Privacy-related attack
  - ○ Data reconstruction attack (DRA)
  - ○ Property inference attack (PIA)
  - ○ Membership inference attack (MIA)



Trusted Execution Environments

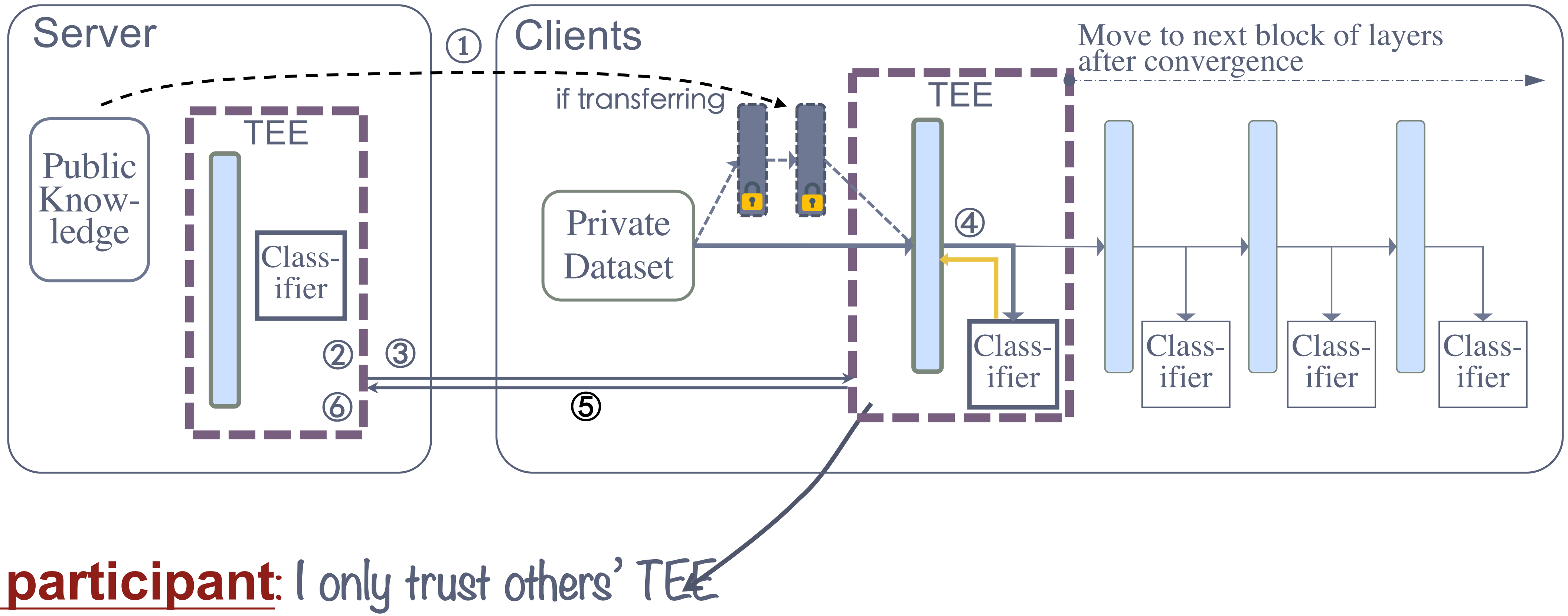
- DL with TEEs
  - Intel SGX ***vs*** Arm TrustZone
  - Inference ***vs*** Training
- Limited computational resources
  Secure memory
  - 128MB for Intel SGX
  - 16MiB for Arm TrustZone

Can we leverage TEEs for Federated Learning?



PPFL: Privacy-preserving Federated Learning with Trusted Execution Environments

Leveraging Greedy Layer-wise Learning



Any participant: I only trust others' TEE

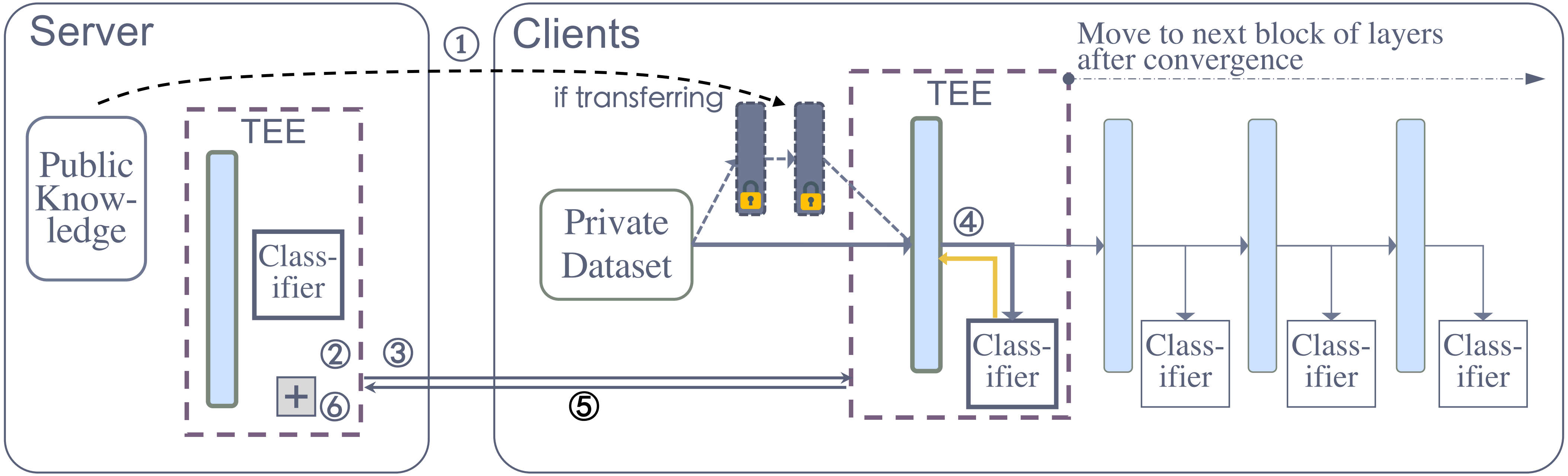
PPFL: Privacy-preserving Federated Learning with Trusted Execution Environments

Configuration

Device selection & secure channel
Transferring knowledge if any ①
Model initialization ②
model broadcasting ③

Reporting

Layer-wise local training ④
model reporting ⑤
Secure aggregation ⑥



Performance Evaluation and Summary

Privacy

- Protecting training layers to defend against privacy-related attacks

Model performance

- Comparable ML utility with even less communication cost

System cost

- ~15% CPU time, ~18% memory usage, ~21% energy consumption

Layer wise training

- Multi-layer block for heterogeneous environments

Code -> https://github.com/mofanv/PPFL

Fan (Vincent) Mo, Hamed Haddadi, Kleomenis Katevas, Eduard Marin, Diego Perino and Nicolas Kourtellis, PPFL: Privacy Preserving Federaded Learning with Trusted Executed environment, ACM Mobisys 2021 Best paper award
https://arxiv.org/pdf/2104.14380.pdf

Takeaways

- **AI can help networks for a better reliability, quality and security/privacy**
- **Networks can also help AI-based applications**
- **Challenges ahead but many promising solutions and directions**

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Diego Perino, Kleomenis Katevas, Andra Lutu, Eduard Marin, and Nicolas Kourtellis, Privacy-Preserving AI for Future Networks
https://dl.acm.org/doi/pdf/10.1145/3512343