Data-driven Autonomous Optimization of 5G Networks

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Industrial Policy and Competition Driving 5G

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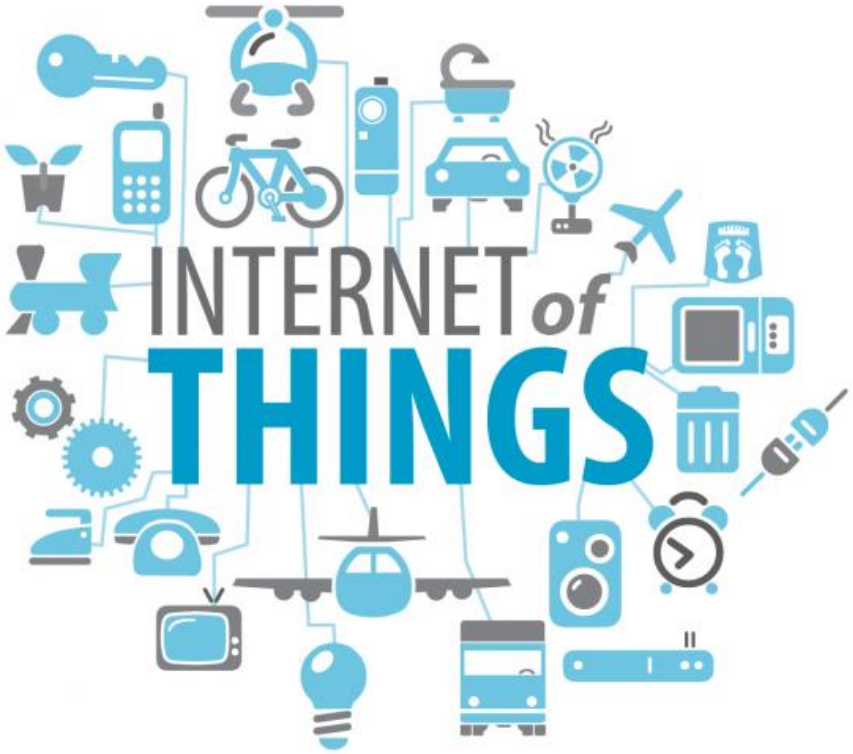
Contents

- ✓ IoT brings massive data to 5G
- ✓ Measurement optimization
- ✓ Performance optimization
- ✓ Service optimization
- ✓ Experience optimization

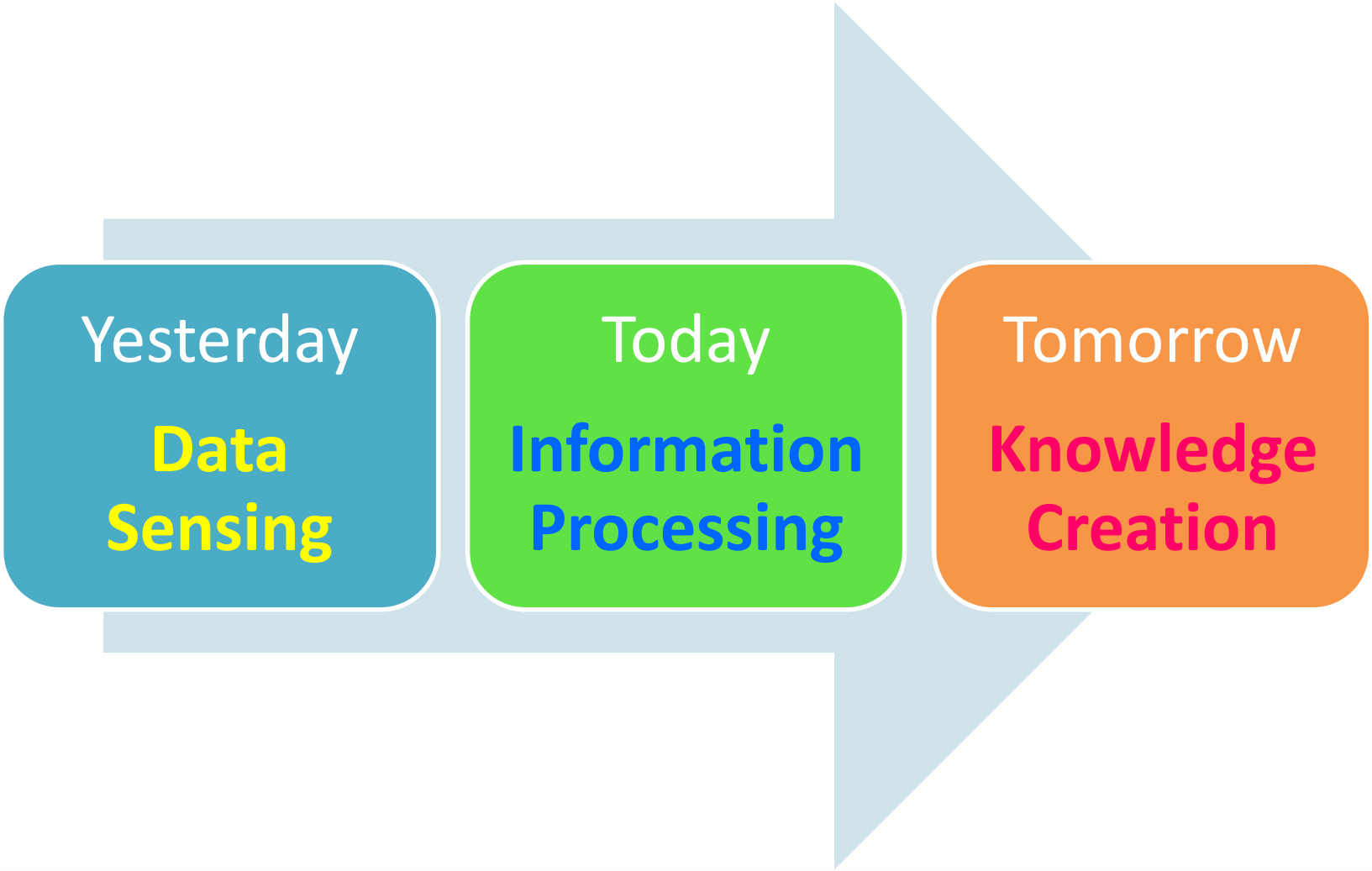
People-Centric Network ➔ IoT Network

4 billion connected people

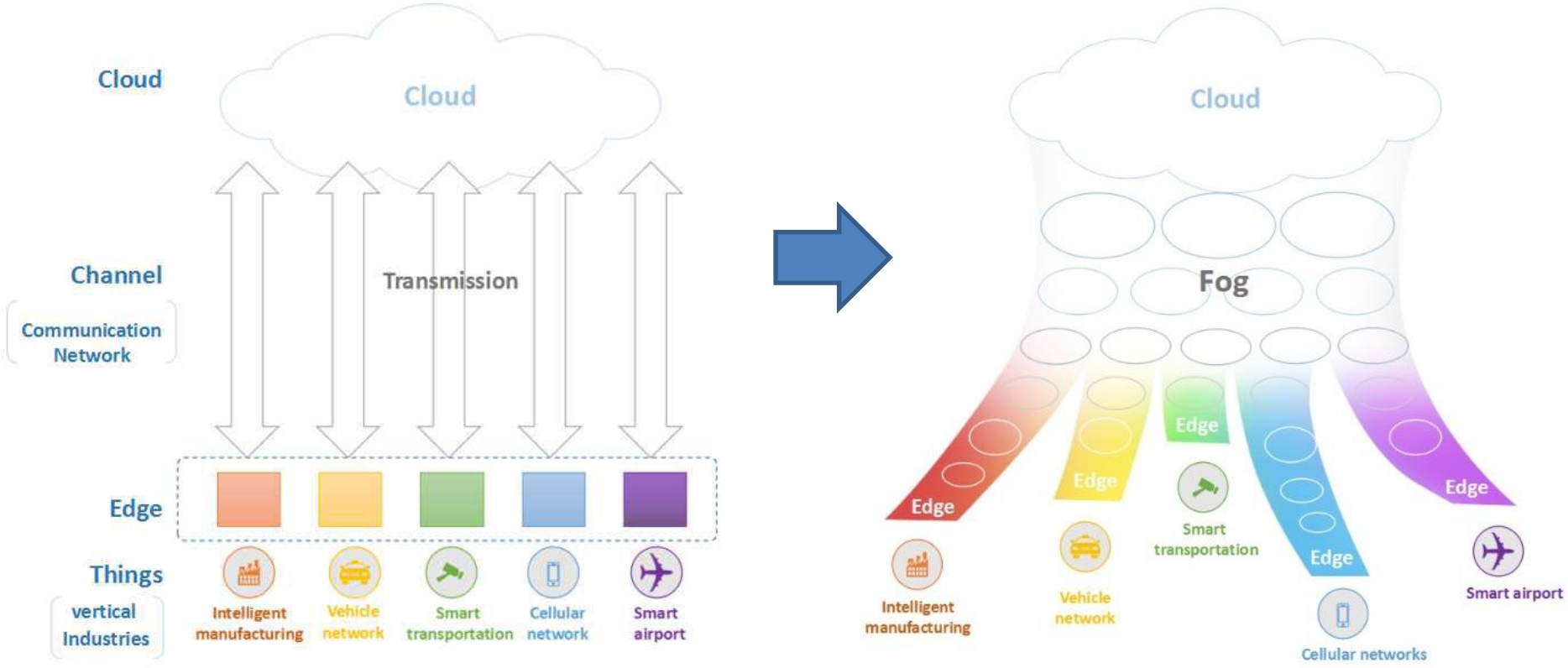
Ovum Forecasts (IoT World, May 2019)
IoT devices will grow to 21.5bn by 2023, while revenue will nearly double to $860bn.



More and More Intelligent Services



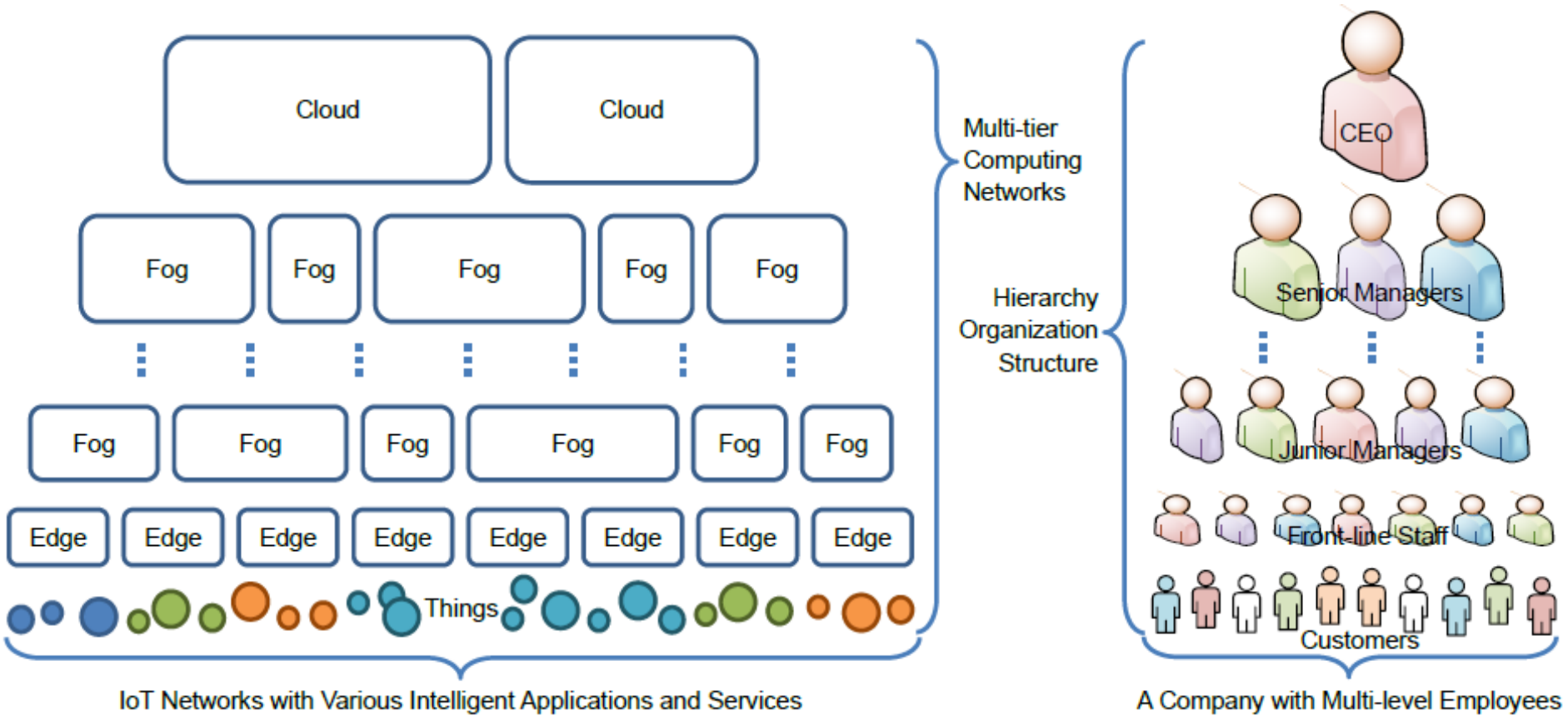
Multi-tier Computing Networks



FA²ST: Fog as a Service Technology, IEEE Communications Magazine, Oct. 2018.

Multi-tier Computing Networks for Intelligent IoT, Nature Electronics, Jan. 2019.

Cloud, Fog, Edge and Things



Measurement Optimization: Network Diagnosis

Every month

- 10,000KM+ road testing
- 12K+ base stations for 2G/3G/4G networks
- 100M records for customers in Shanghai

Past: People

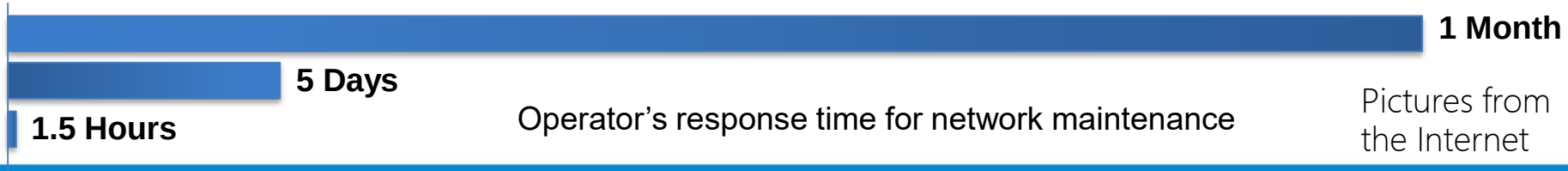
Past: 250 Man Days

Now: Cloud

Now: 48 hours

Edge+Fog+Cloud

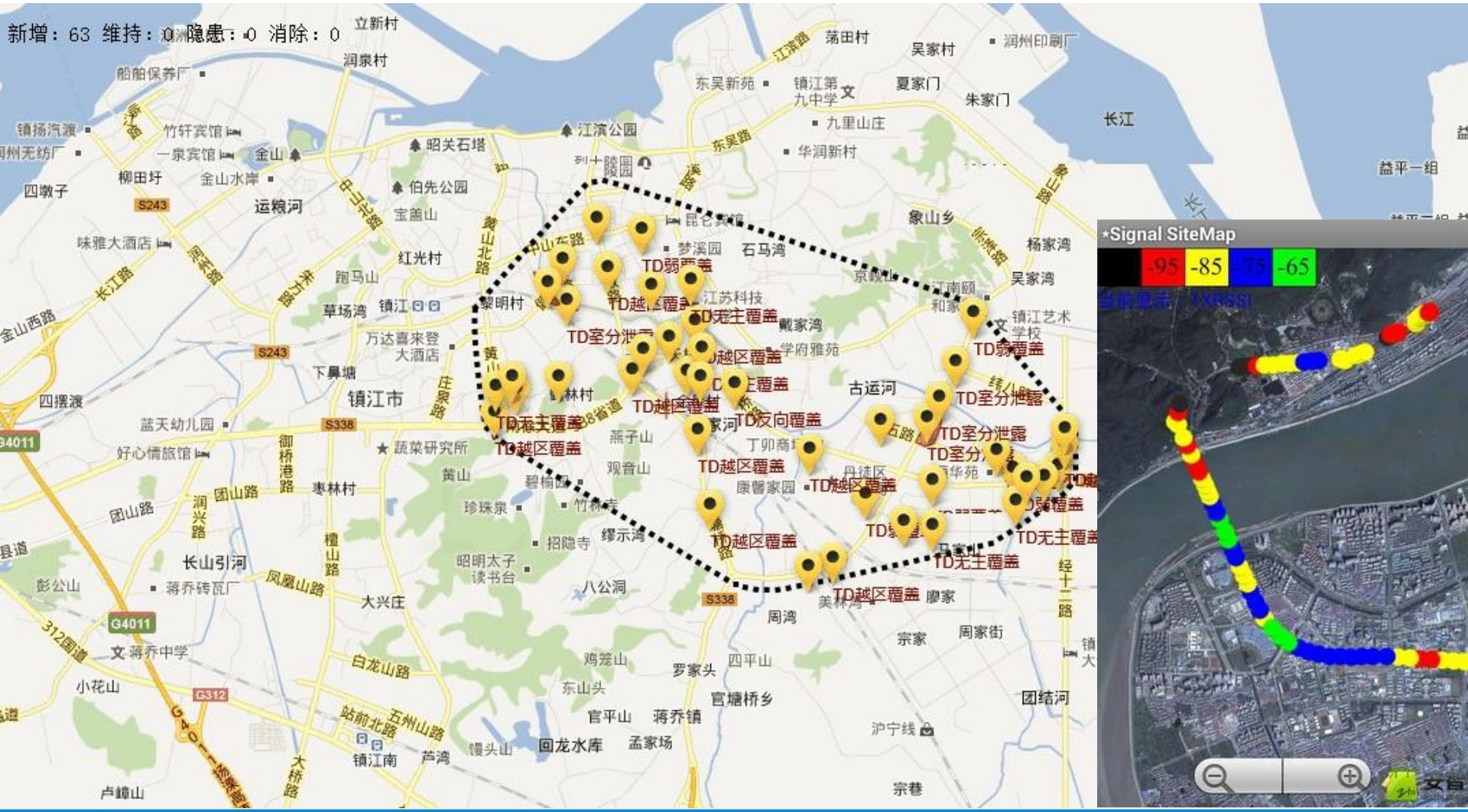
Soon: 0.5 hours



Operator's response time for network maintenance

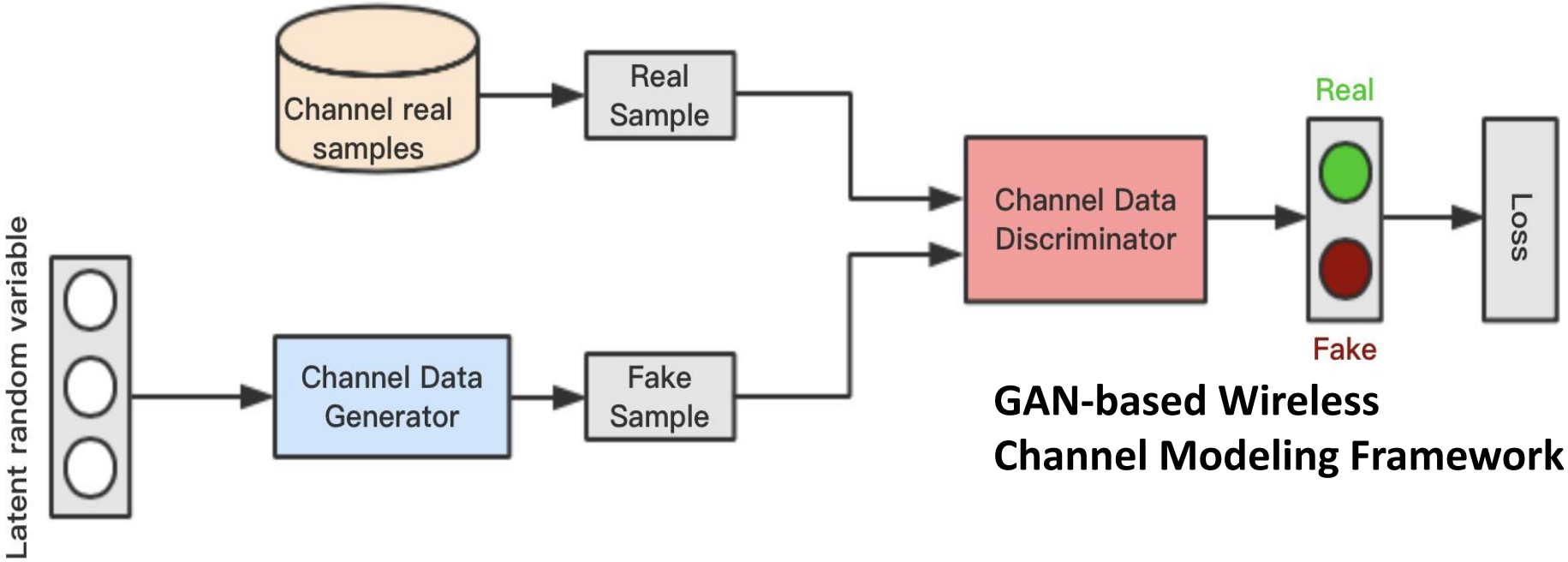
Pictures from the Internet

Measurement Optimization: Network Diagnosis



Measurement Optimization: Channel Modeling

- Machine Learning techniques are very effective in approximating arbitrary functions and hidden features.
- Fog/edge computing technologies support regional/local environments with very relevant measurement data, system parameters, and network resources.



GAN-based Wireless Channel Modeling Framework

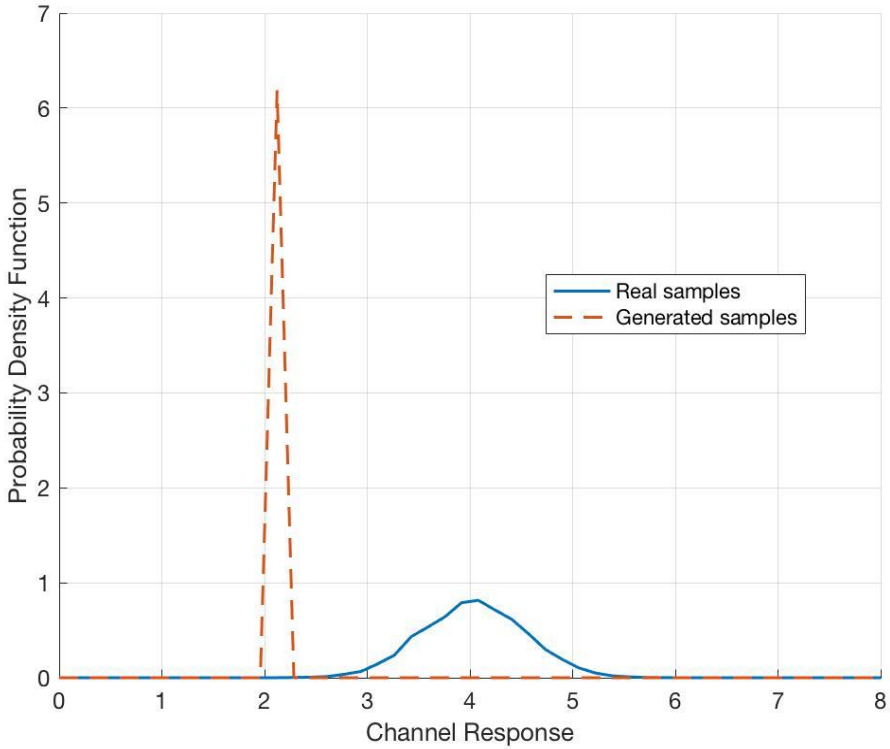
Minimize the need for domain-specific knowledge and technical expertise in wireless communications and signal propagation.

Measurement Optimization: Channel Modeling

- Example: AWGN Channel
- Mean: 4, Standard Deviation: 0.5

	Channel data generator	Channel data discriminator
Learning rate	0.001	0.010
Learning rate decay	1.0×10^{-5}	1.0×10^{-4}
Activation function	ReLU	ReLU
Minibatch size	32	32
Number of hidden layers	2	3
Neuron number of each hidden layer	50	100

Key Parameters

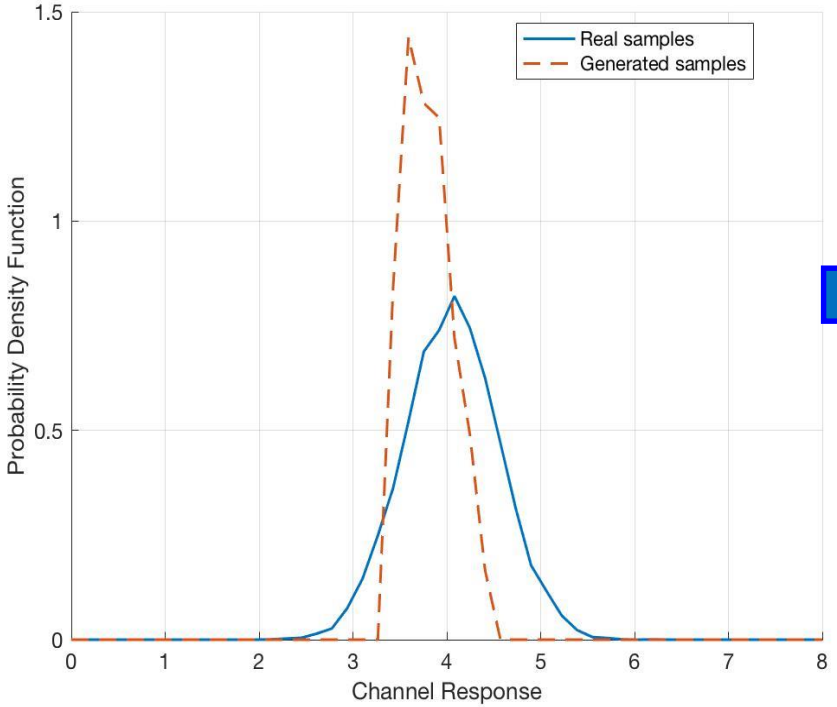


Beginning of the Training Process

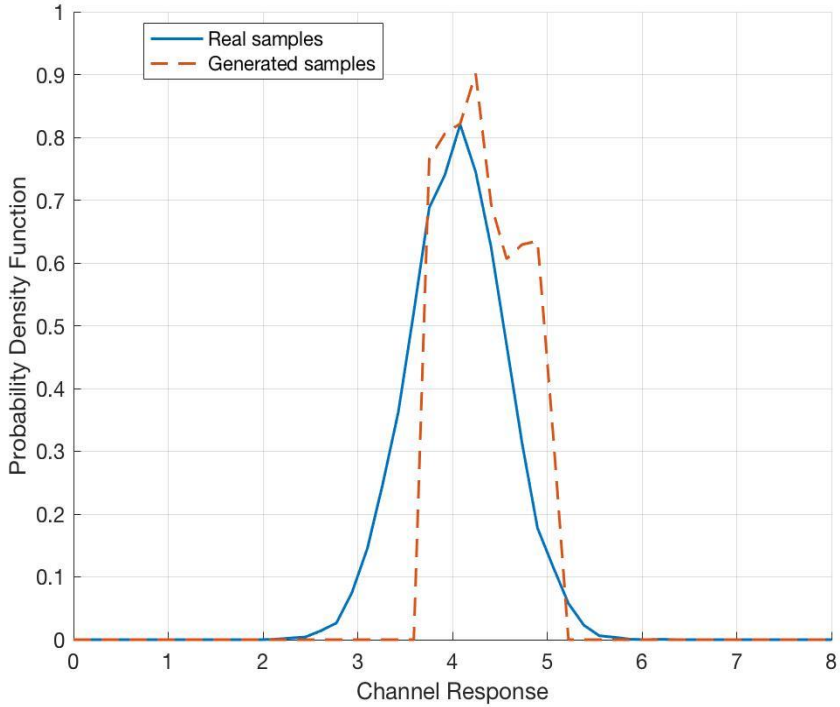
Generative Adversarial Network-based Wireless Channel Modelling, IEEE Communications Magazine, Mar. 2019.

Measurement Optimization: Channel Modeling

- Example: AWGN Channel
- Mean: 4, Standard Deviation: 0.5



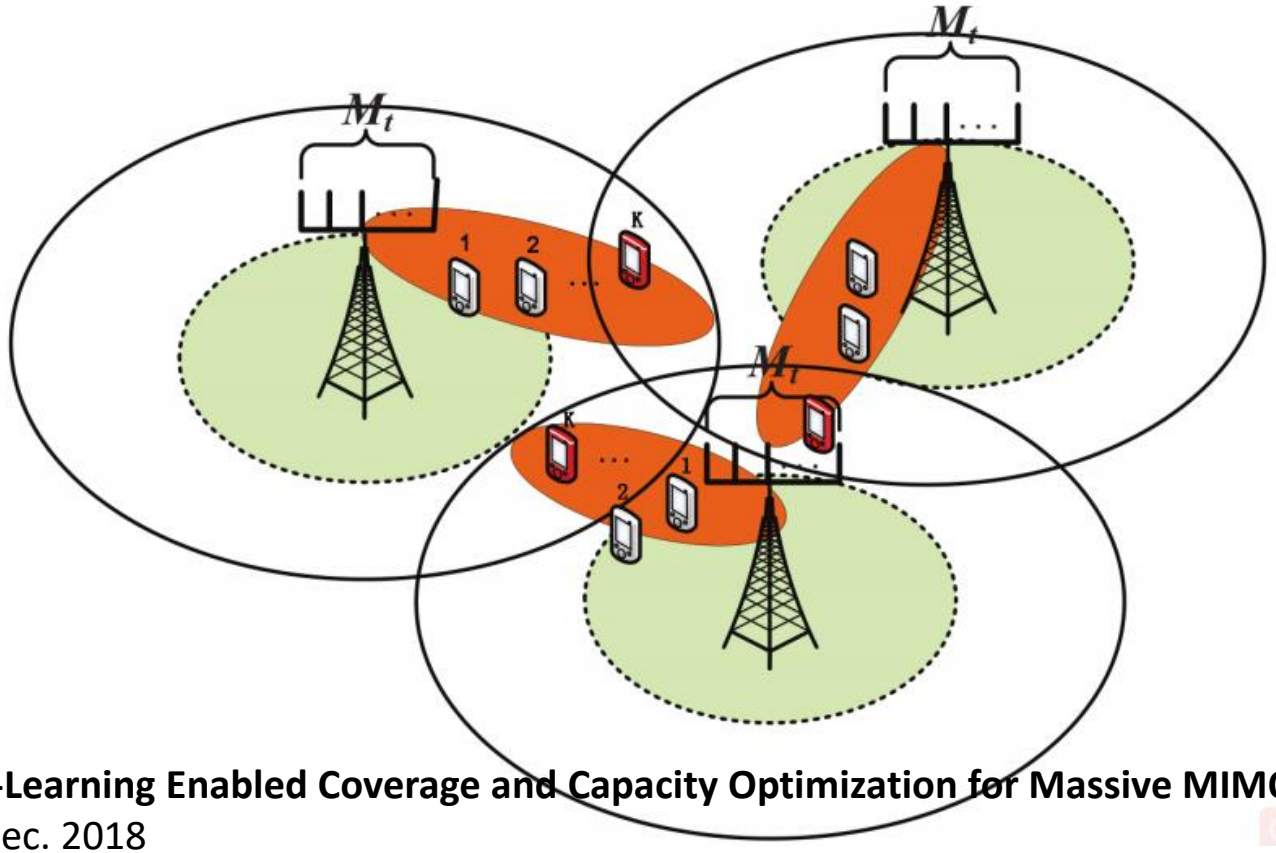
Without Minibatch Discrimination



With Minibatch Discrimination

Performance Optimization: Coverage and Capacity

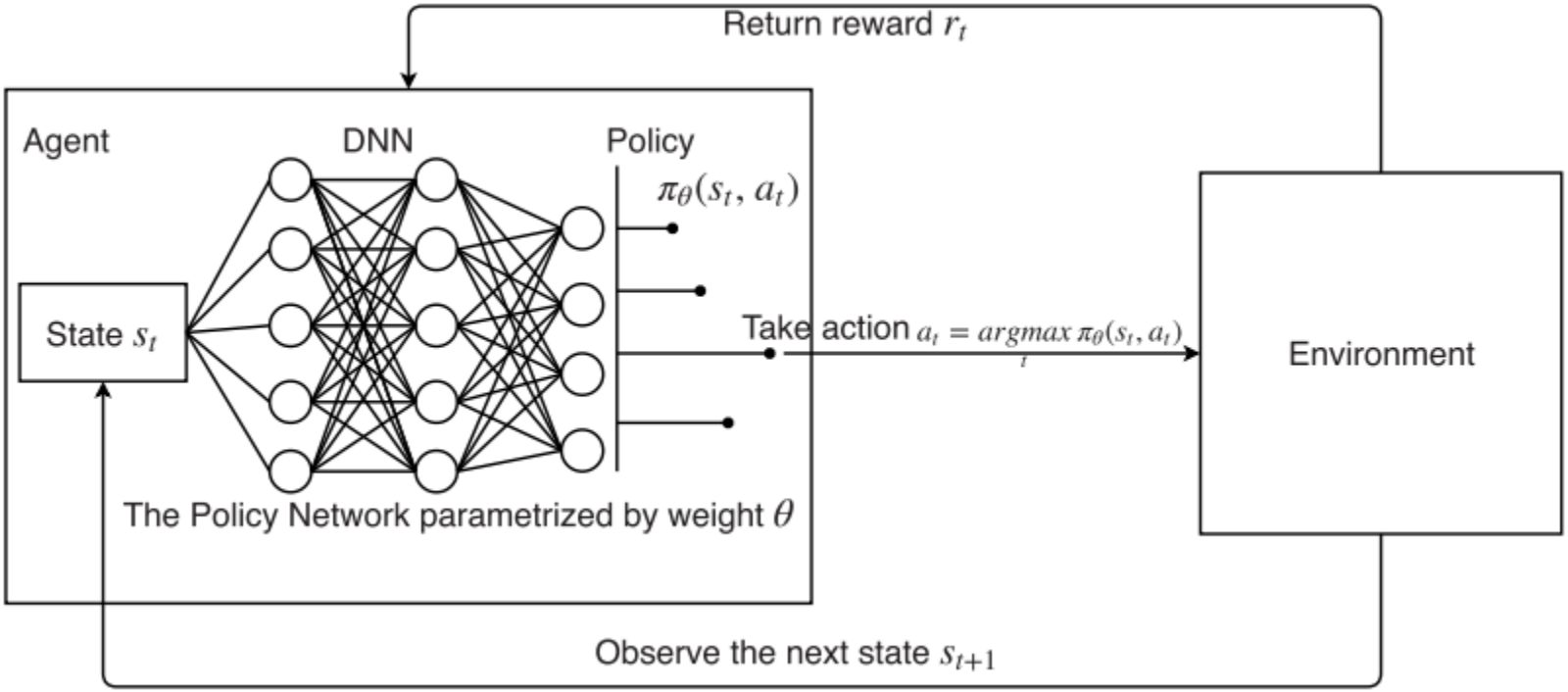
- Tradeoff between system capacity and service coverage is very complex in massive MIMO wireless systems, thus the Coverage and Capacity Optimization (CCO) problem is hard to solve.



DECCO: Deep-Learning Enabled Coverage and Capacity Optimization for Massive MIMO Systems, IEEE Access, Dec. 2018

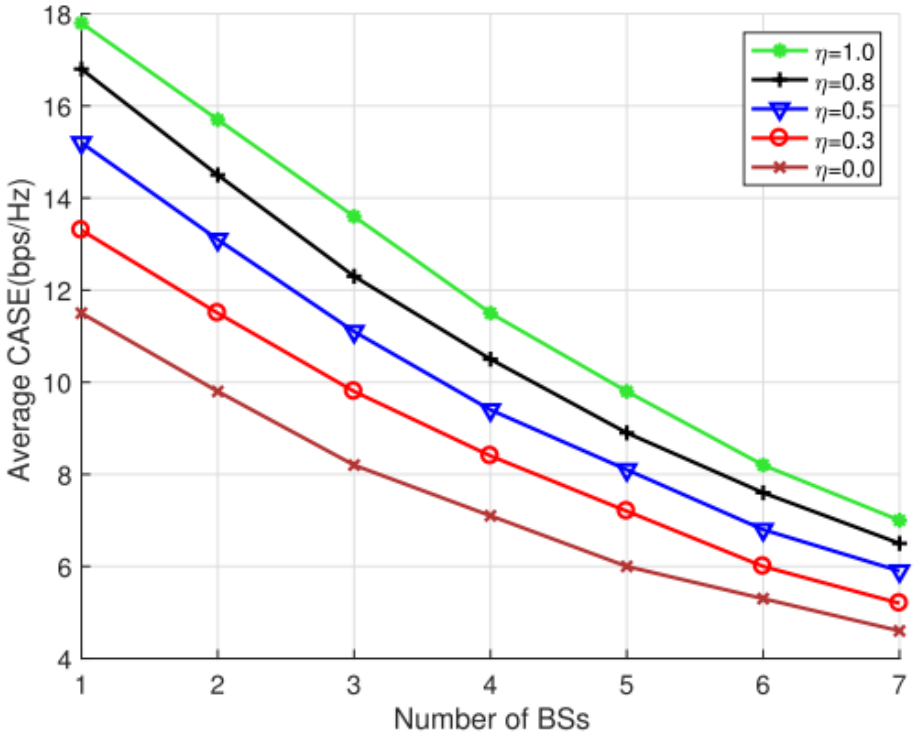
Performance Optimization: Coverage and Capacity

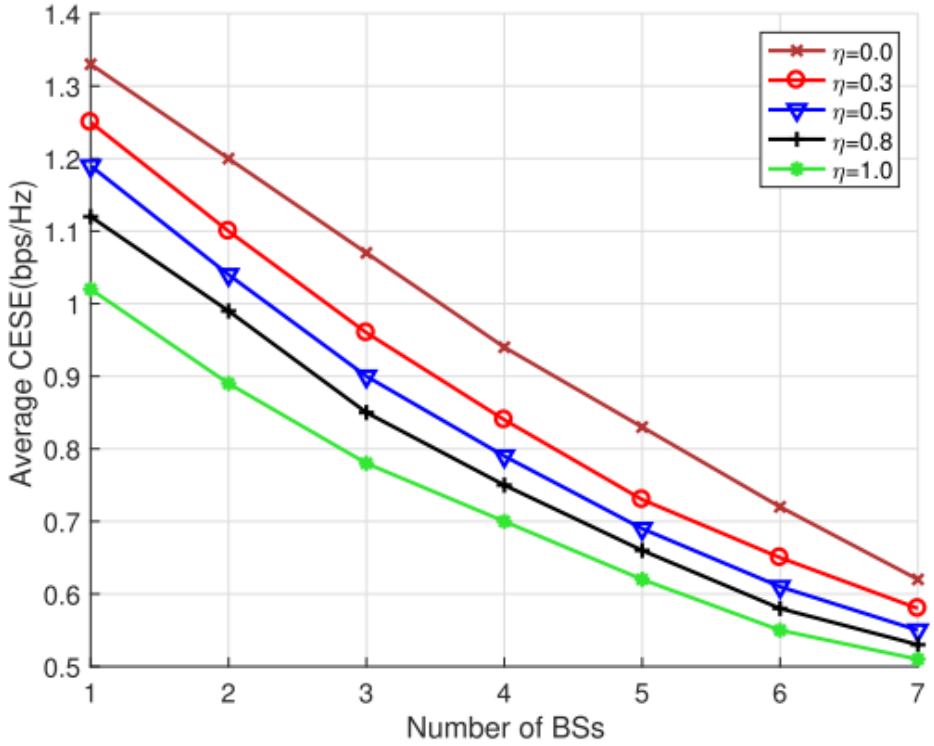
- ✓ Reinforcement learning is a model-free method to solve a Markov Decision Process (MDP).
- ✓ Deep Neural Networks (DNN) do not need human-crafted features and are used as the function approximators.



Performance Optimization: Coverage and Capacity

- DECCO algorithm performance under different weight factors.
- More BSs, more inter-cell interference, worse CASE and CESE.

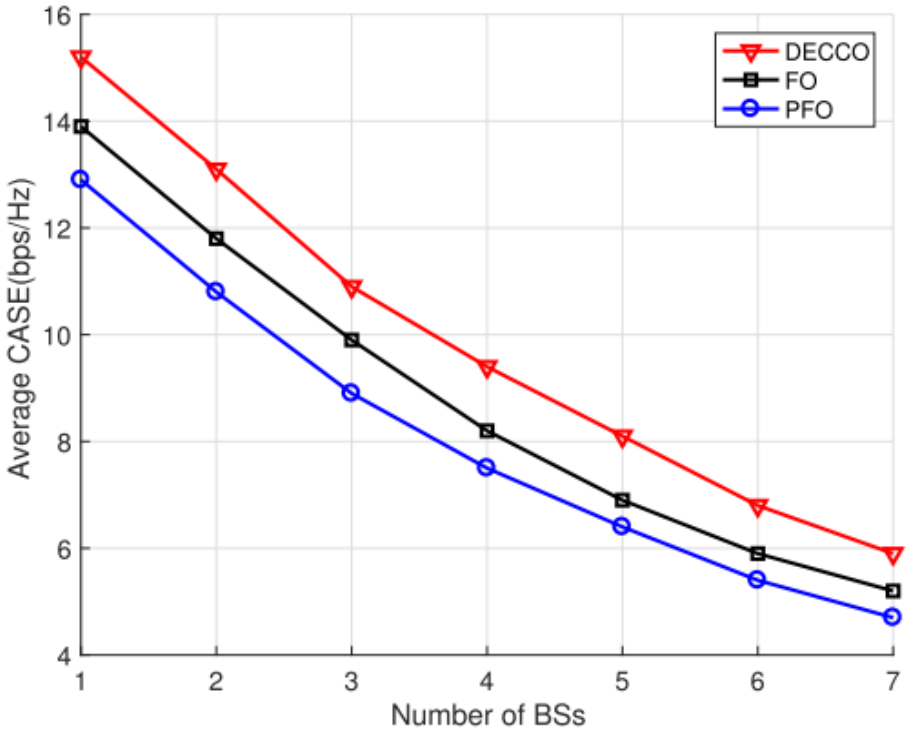


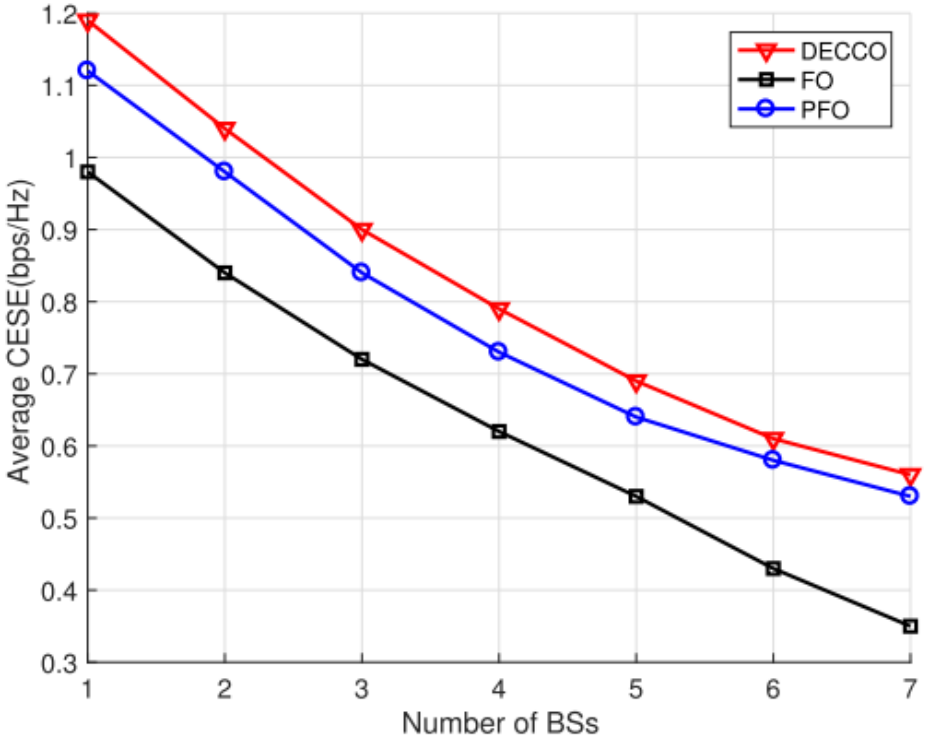


Cell Average Spectrum Efficiency (CASE) and
Cell Edge Spectrum Efficiency (CESE) per BS

Performance Optimization: Coverage and Capacity

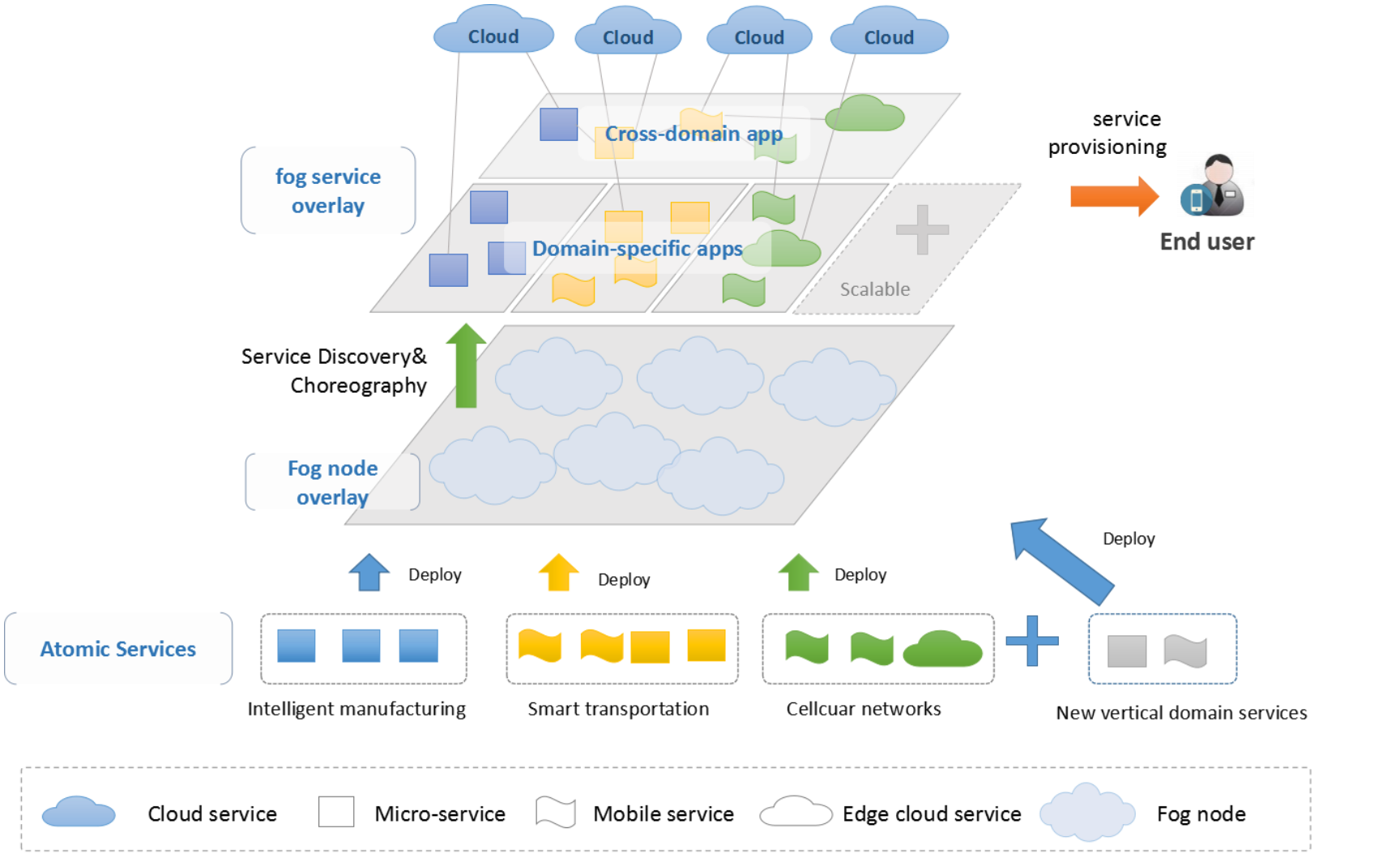
- DECCO outperforms Fixed Optimization (FO) and Proportional Fair Optimization (PFO) algorithms in both CASE and CESE.



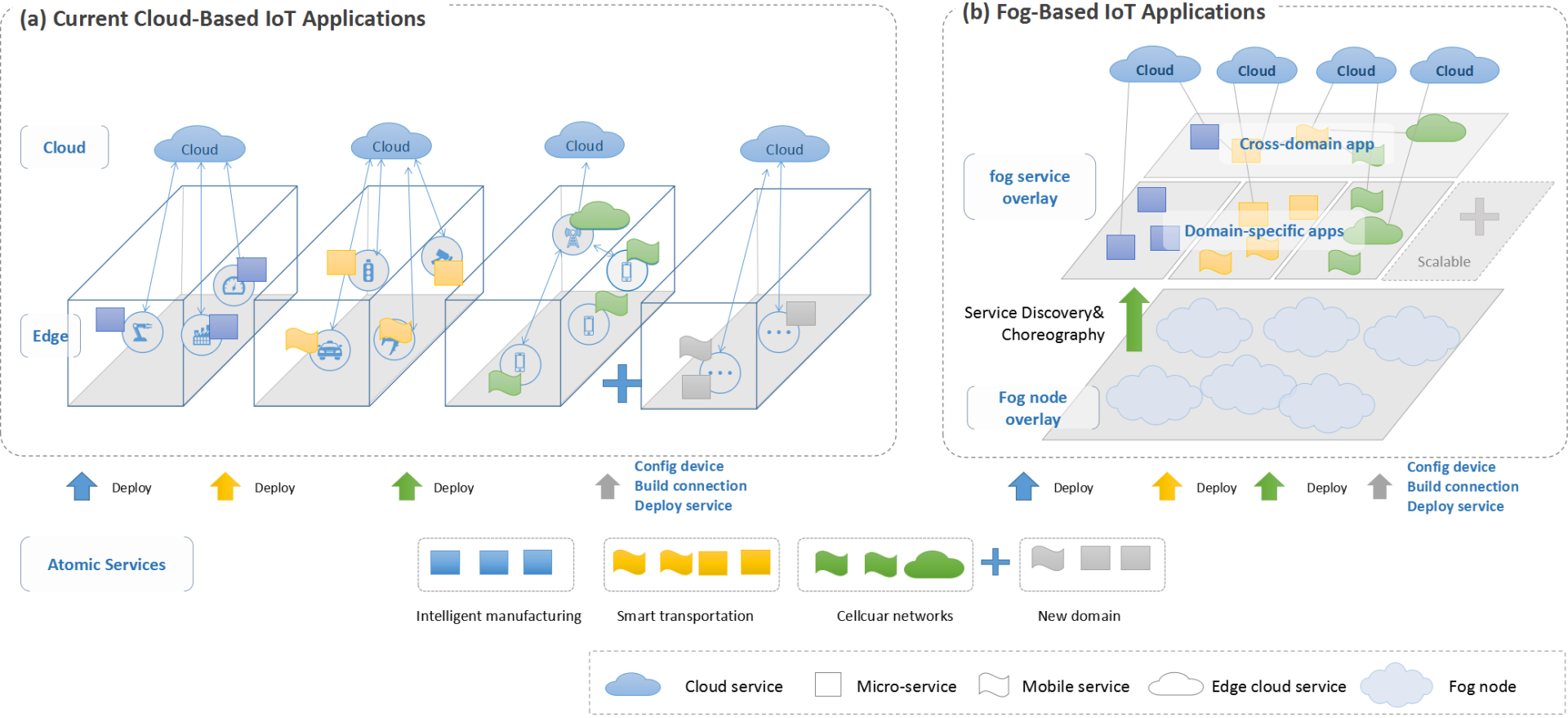


Cell Average Spectrum Efficiency (CASE) and
Cell Edge Spectrum Efficiency (CESE) per BS

Service Optimization: Autonomous Service Provision

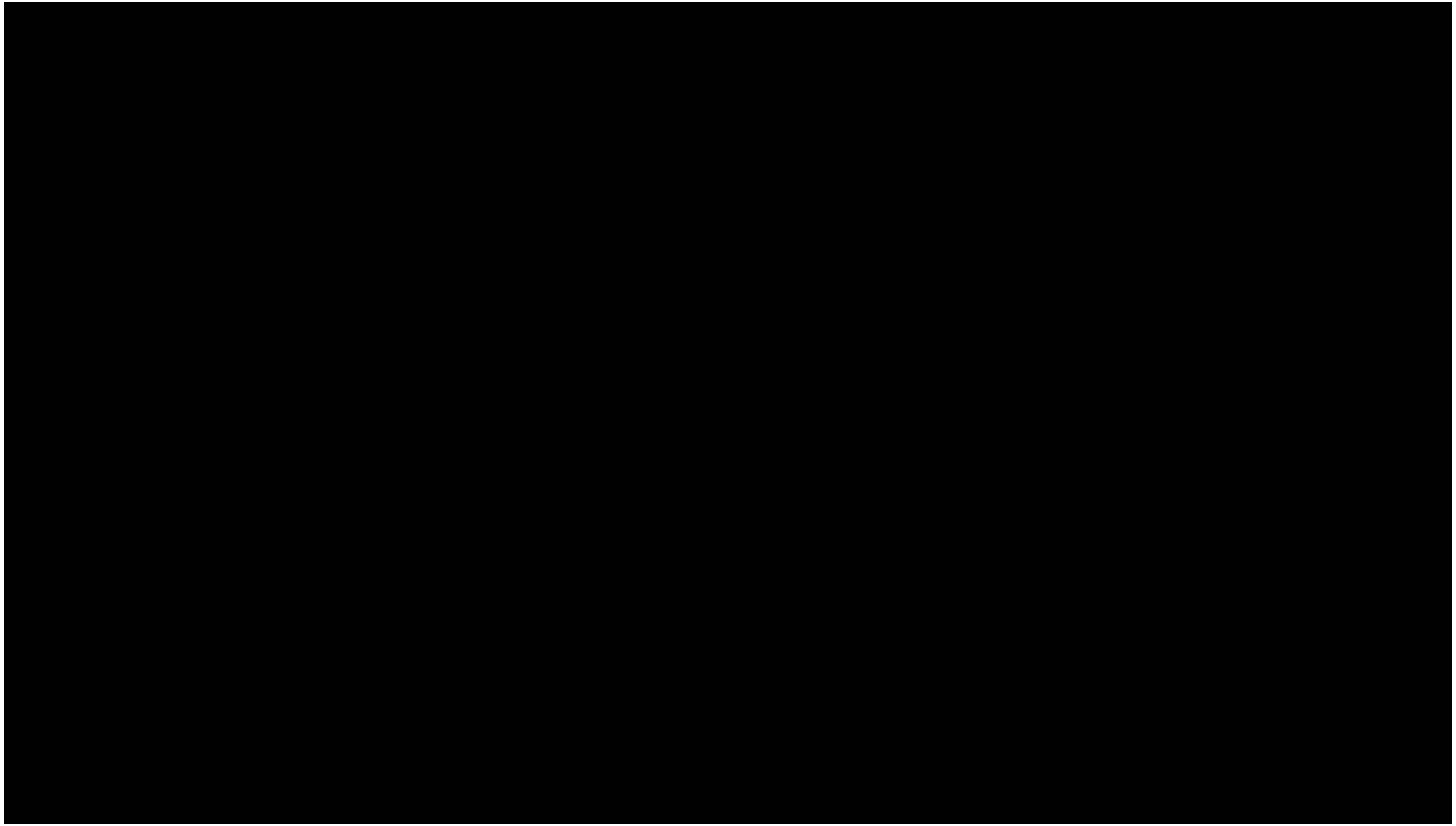


Service Optimization: Autonomous Service Provision



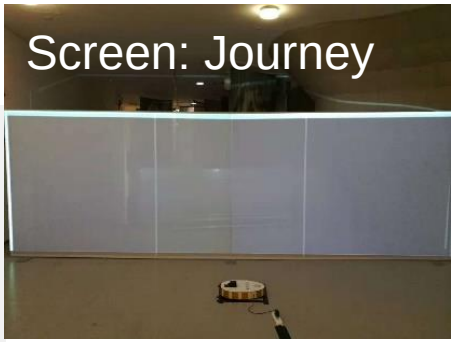
FA²ST: Fog as a Service Technology, IEEE Communications Magazine, Oct. 2018.

Service Optimization: Robot Rescue

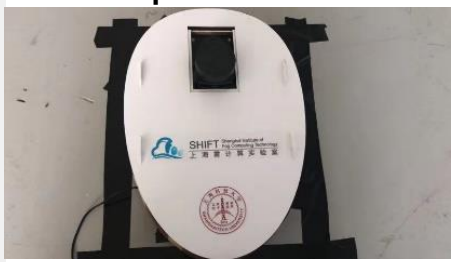


Experience Optimization: Interactive Art

ShanghaiTech
创意与艺术学院



Sensor: Position and Speed



Projector: Interactive Experience


More Data,
Better Service
Thank you!
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