SCLA | Sustainable Cities Latin America

Arequipa
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Edge Computing: The new frontier for extensible smart city systems

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The Digital Era…

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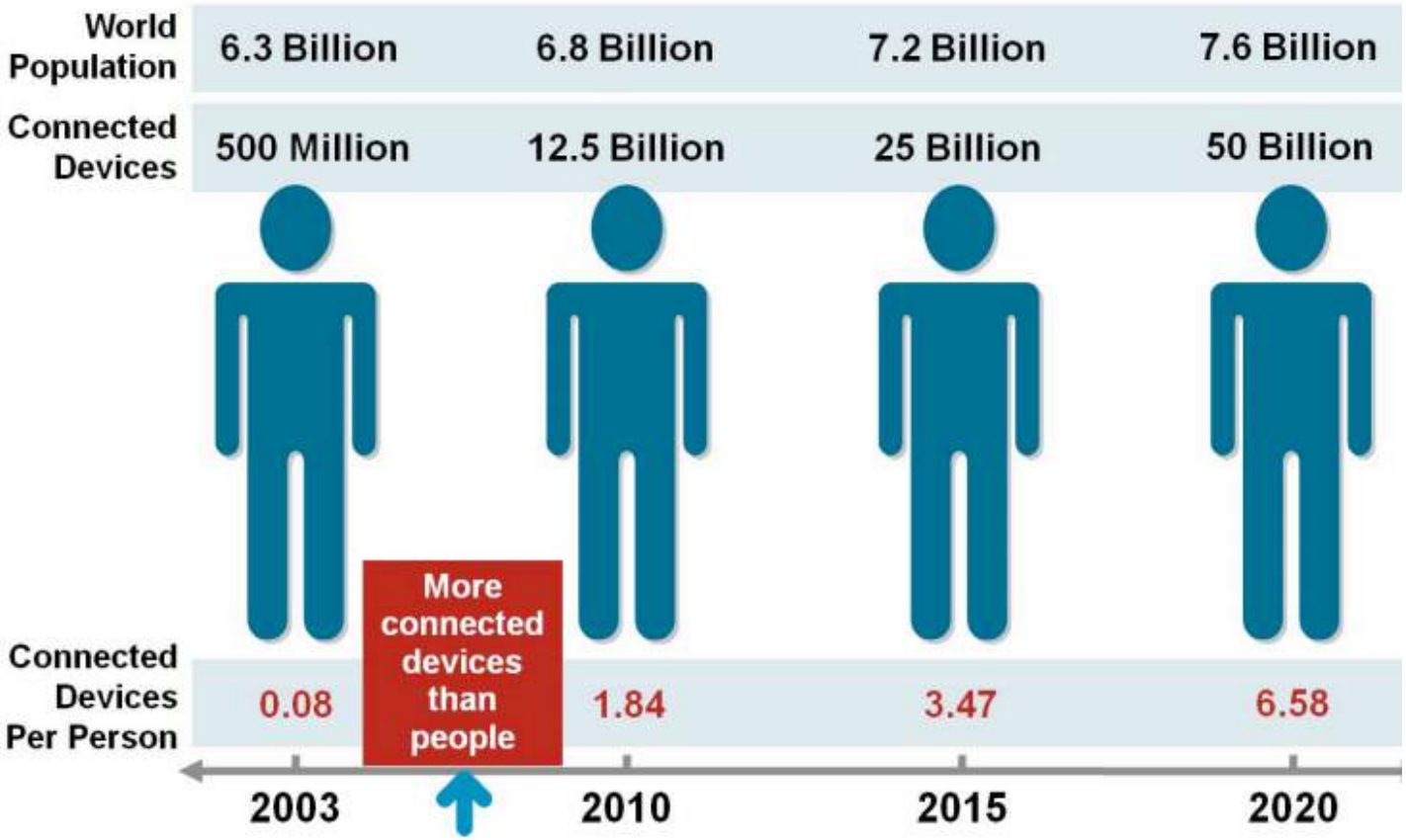
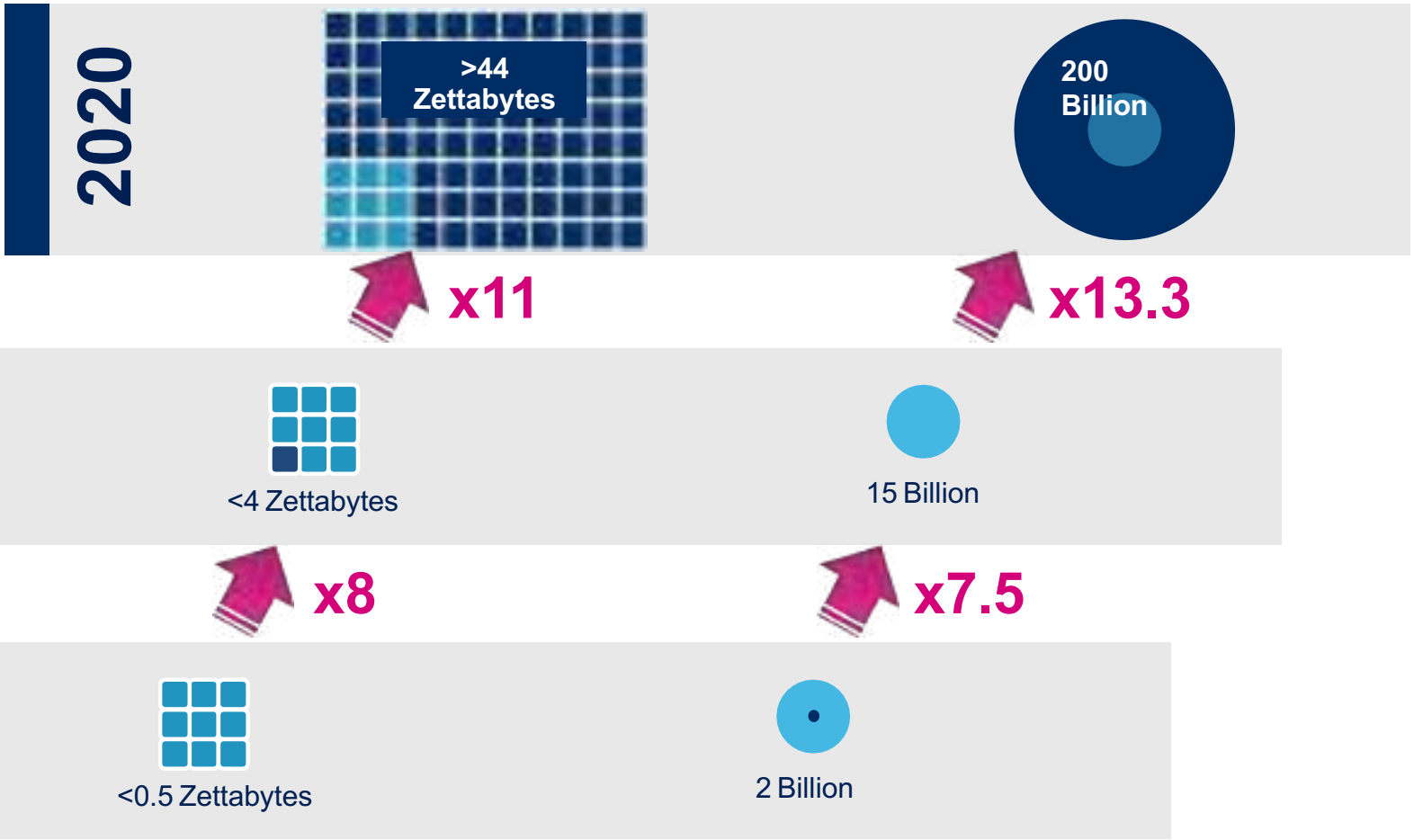
Historical Limits Overcome: Connectivity



Source: Cisco IBSG, April 2011

Digital Revolution



A Zettabyte = 10^{12} Gigabytes

Smart Devices Revolution

Smart Environments

Smart Transportation

Smart Public Safety

Smart Home

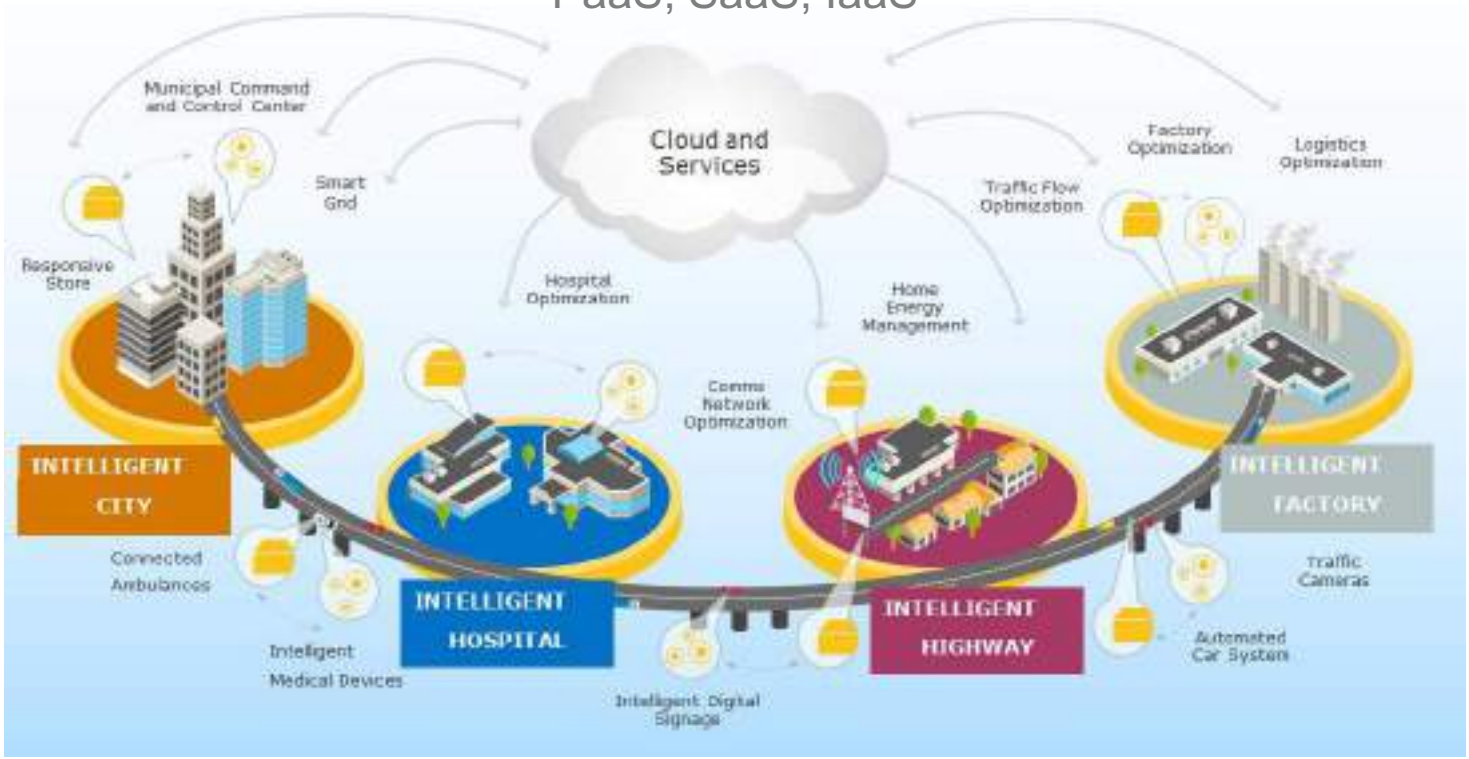
Smart Health

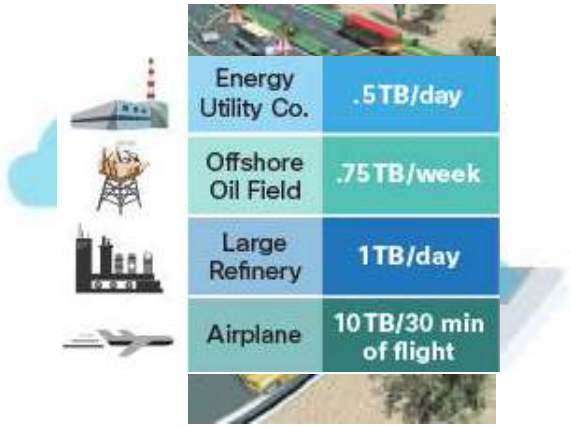
Industry 4.0

Smart Grids

Cloud Computing

PaaS, SaaS, IaaS





Assumption of enough bandwidth available for data gathering

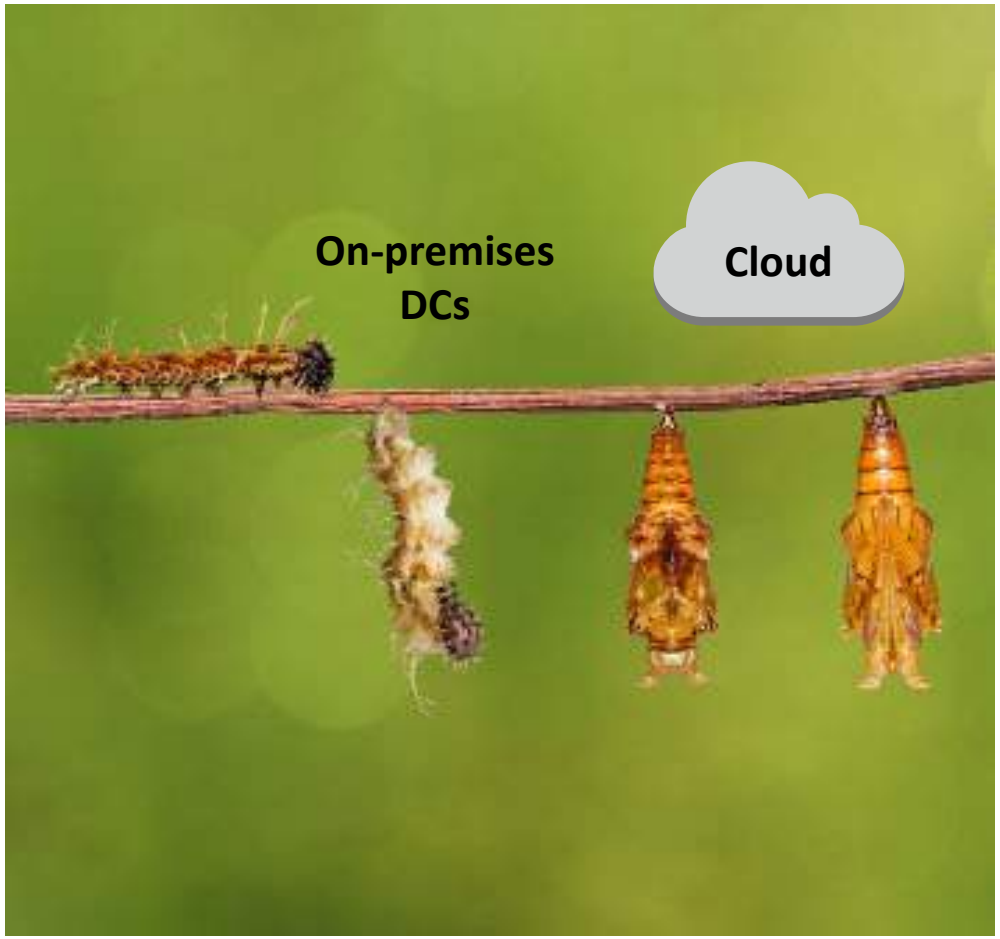
Technology evolution always ahead!

2018 - nearly 90% of enterprise-generated data was processed in centralized DC or cloud

2022 - 25% of data-processing will be centralized, remaining 75% occurring somewhere on the network edge.

Relying on centralized cloud platforms to deliver services and analyze data creates a series of logistical problems

"Current cloud model was not designed for variety and velocity of data generation from IoT at really large-scale" Cisco, 2015.



Edge Computing

What is it?

Computing workloads migration from cloud data centers to 'edge' locations nearer (one hop) source of the data being processed.

* https://www.grandviewresearch.com/press-release/global-edge-computing-market
** Smarter With Gartner - Rob van der Meulen October 3, 2018. https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/

Edge Computing

Why?

Unprecedented high performance as opposed to a centralized cloud infra, promising near real-time insights and flexible localized actions.

* https://www.grandviewresearch.com/press-release/global-edge-computing-market
** Smarter With Gartner - Rob van der Meulen October 3, 2018. https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/

Edge Computing

Is it profitable?

70% of Households Subscribe to at Least One Streaming Service

The Global Autonomous Vehicle Market Will Grow to **$556.67** Billion by 2026

The IoT Healthcare Market Will Grow to **$534.3** Billion by 2025

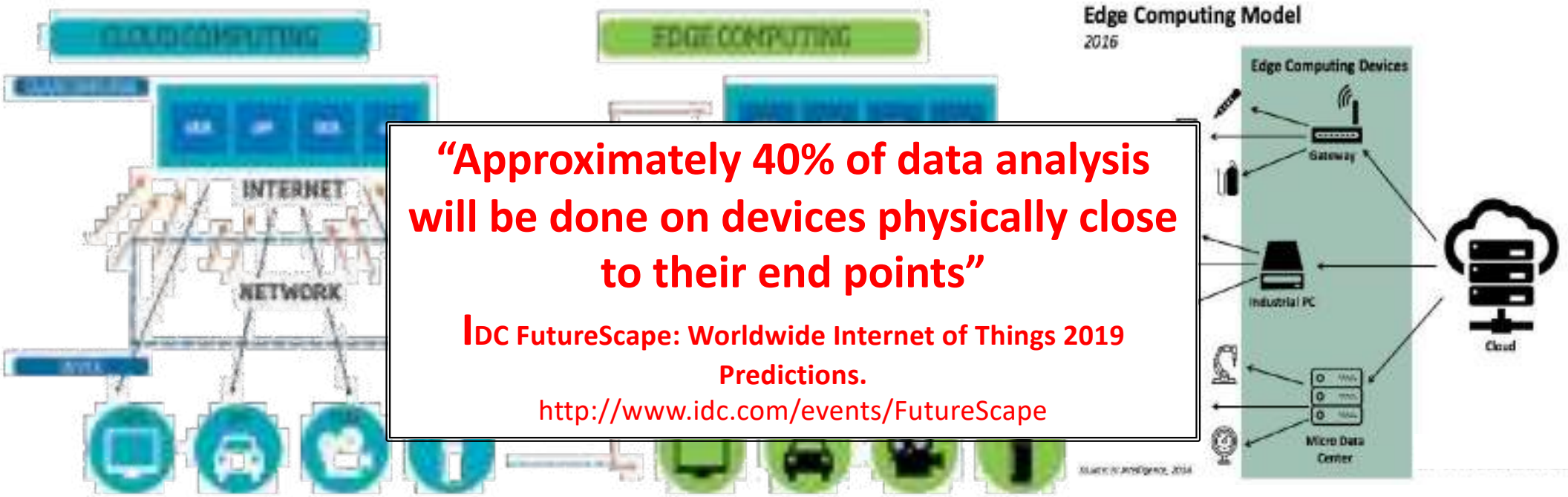
By 2022, There Will Be **65.9 Million** AR/VR Headsets in the Market

Investments in Smart City Tech Will Reach **$135** Billion by 2021

Global Edge Computing Market will value **$28.84** Billion By 2025*

* https://www.grandviewresearch.com/press-release/global-edge-computing-market
** Smarter With Gartner - Rob van der Meulen October 3, 2018. https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders/

The "Next" Frontier
The Cloud Where Things Are



"Approximately 40% of data analysis will be done on devices physically close to their end points"

IDC FutureScape: Worldwide Internet of Things 2019 Predictions.

http://www.idc.com/events/FutureScape

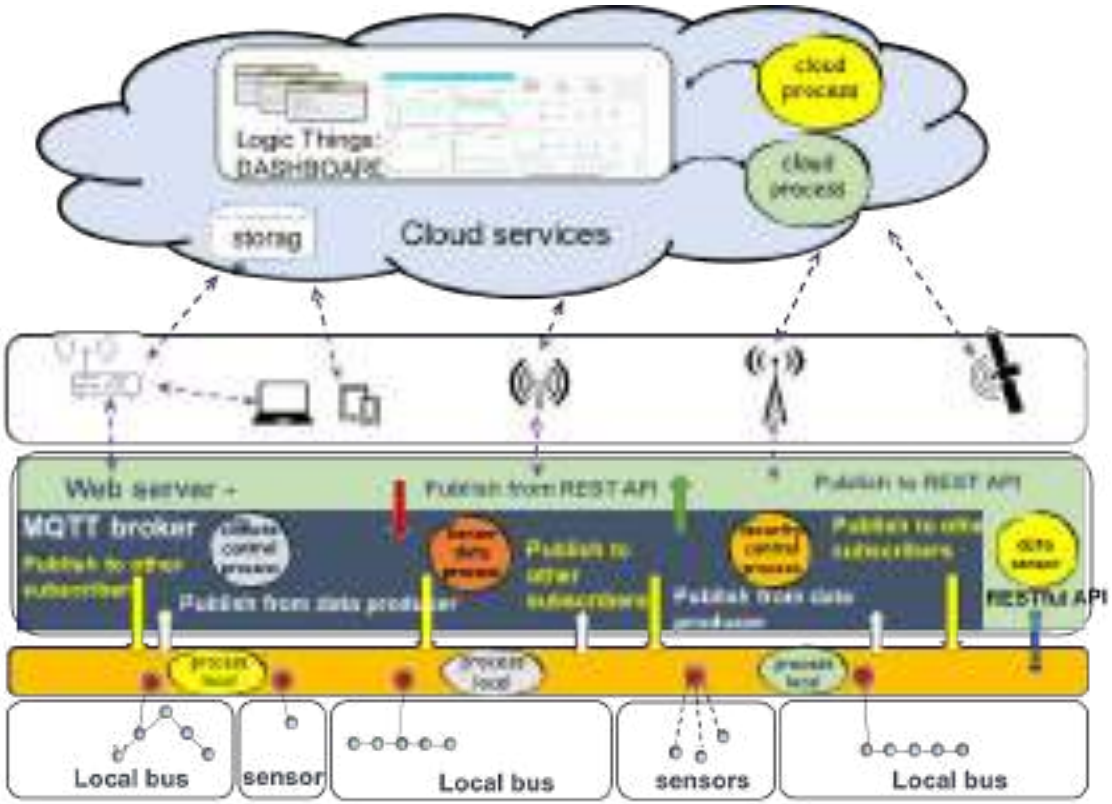
Edge Computing: Conceptual Architecture

Cloud

Comm.

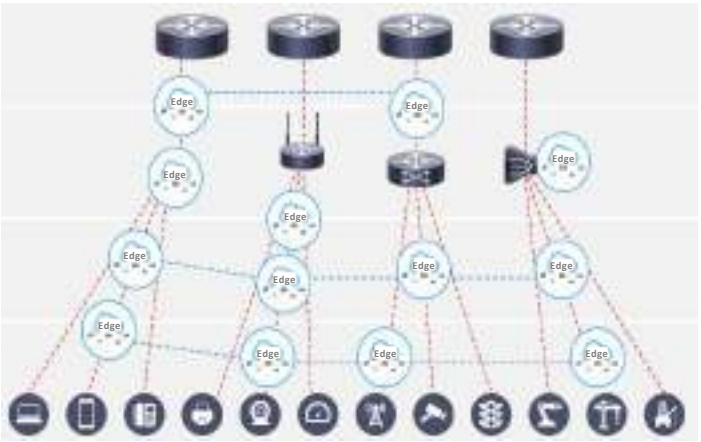
Edge

Extreme Edge



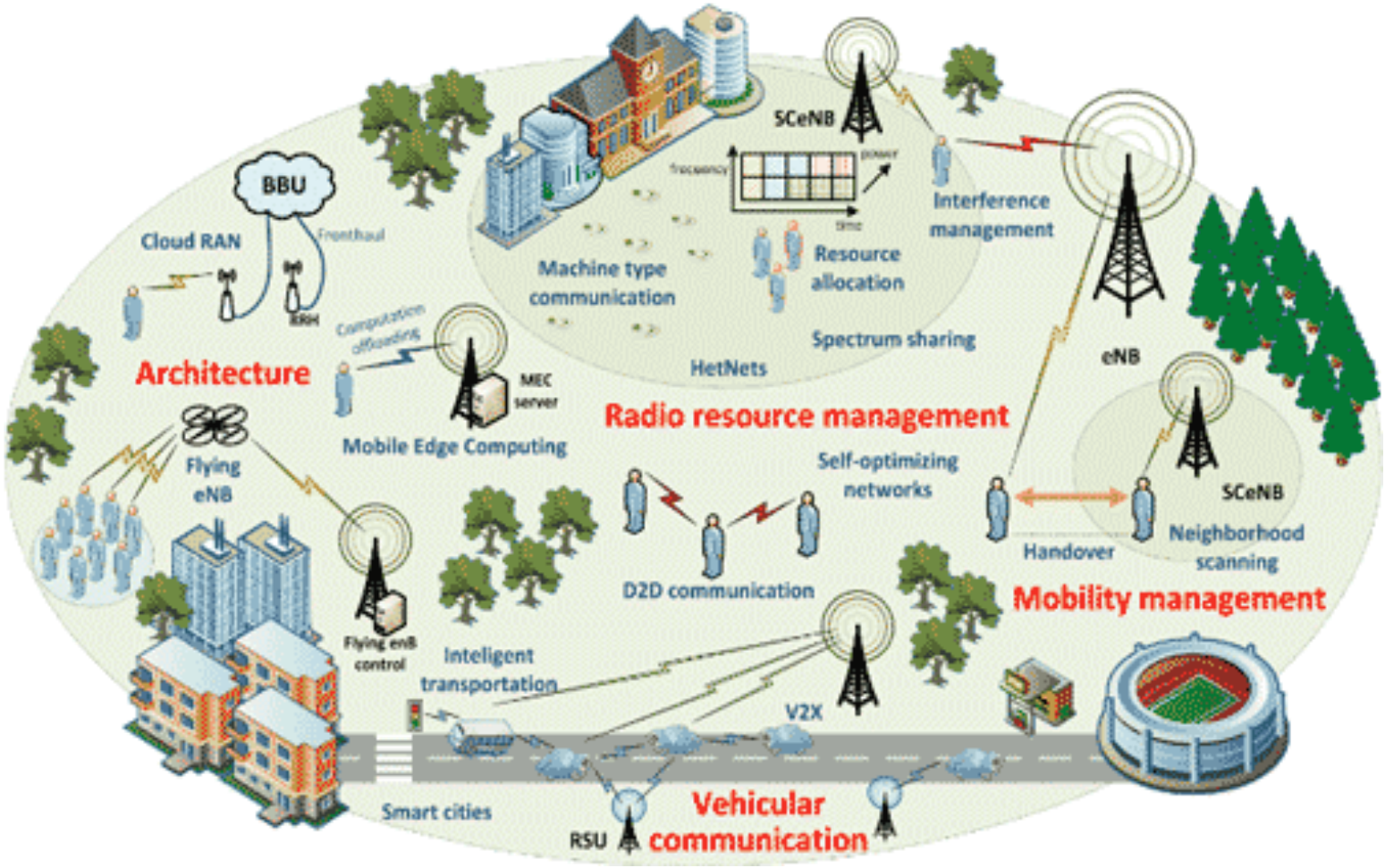
Edge Computing	Immediate first hop from things (e.g., Aps, BSs, or gateways) to provide computing
Fog Computing	Hierarchical service provisioning anywhere from cloud to things
Mist Computing	Computation is done at extreme edge (on IoT devices them-selves)

Ashkan Yousefpour *et all* "All one needs to know about fog computing and related edge computing paradigms: A complete survey," Journal of Systems Architecture, 2019. Doi: 10.1016/j.sysarc.2019.02.009.

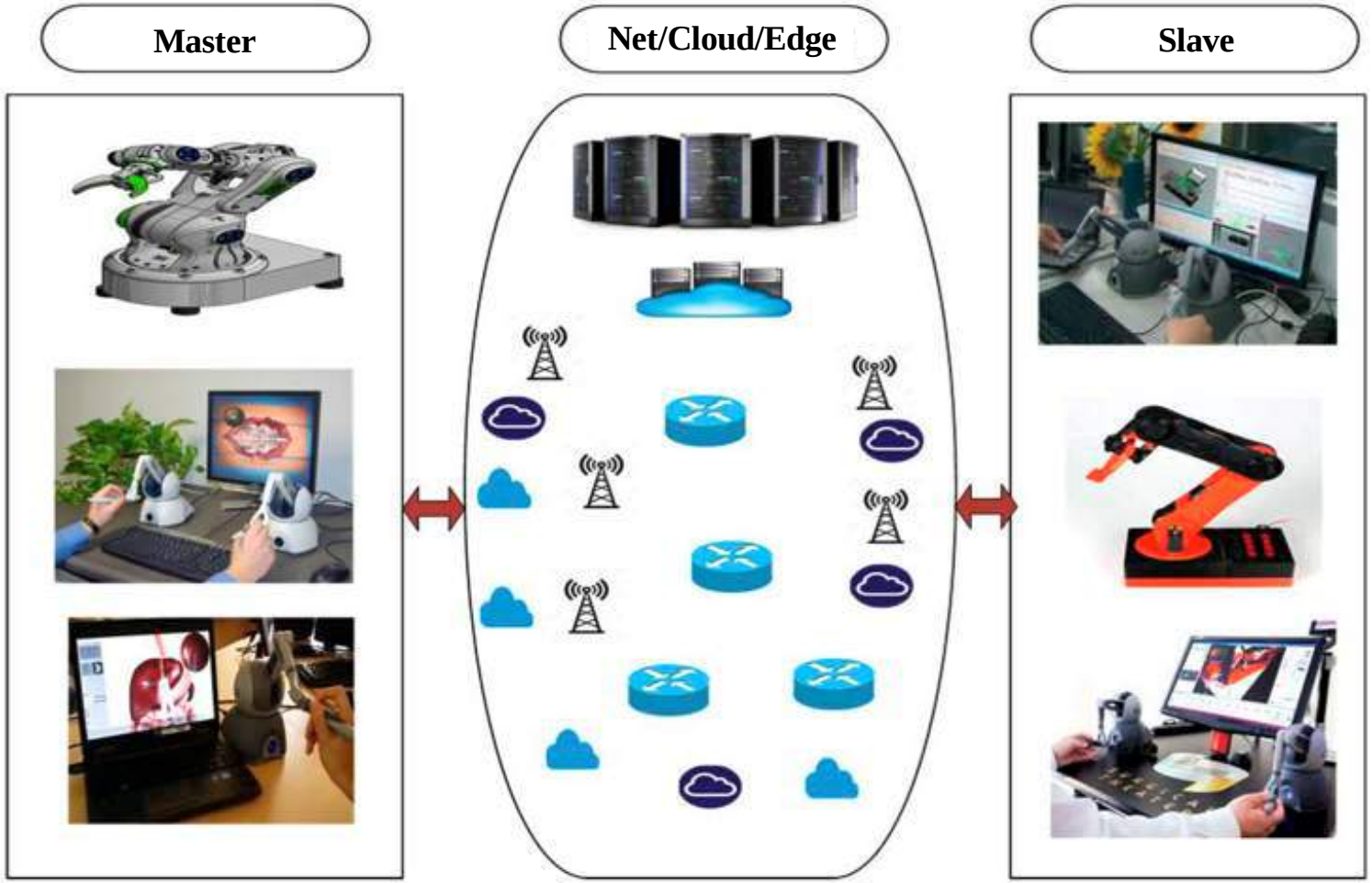


Edge Computing Supported Smart City Applications

Mobile Edge Computing

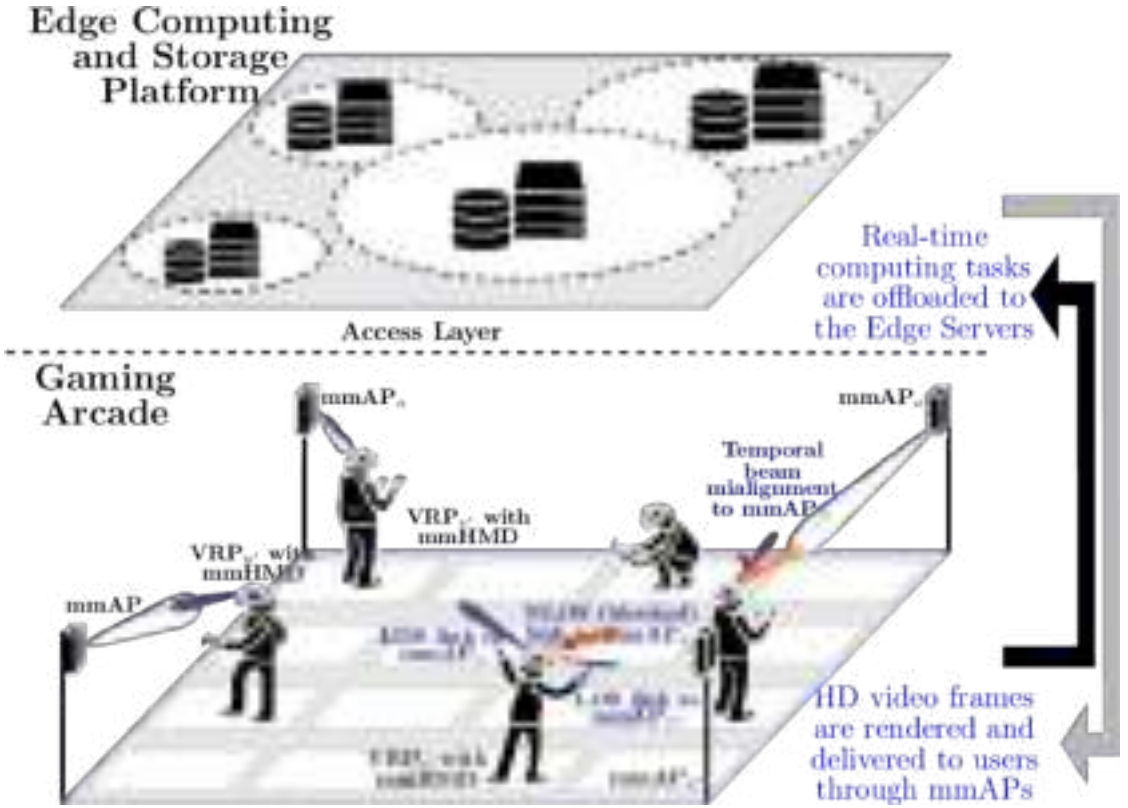


Verticals: Tactile Internet



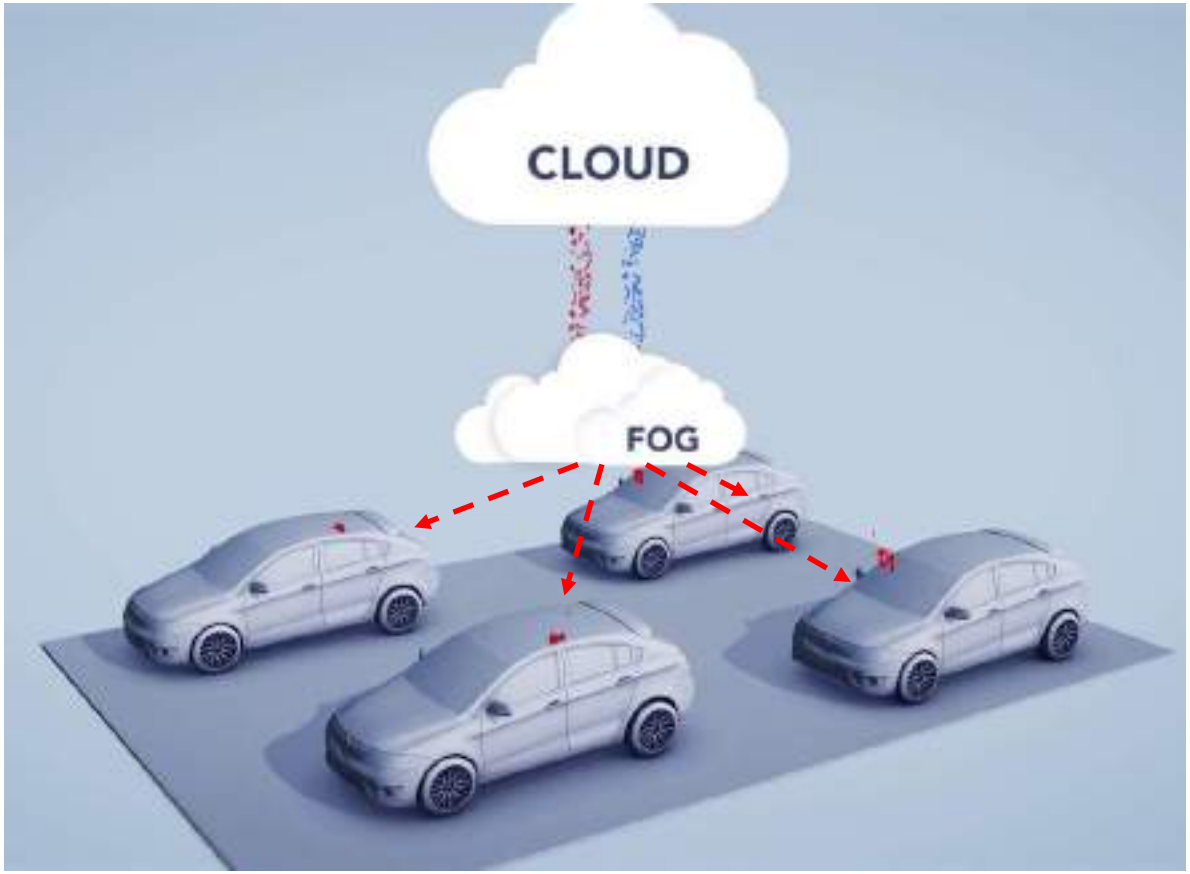
J. Sens. Actuator Netw. 2018, 7(1), 1. Doi: 10.3390/jsan7010001

Verticals: Mobile/Cloud Gaming and Immersive Video



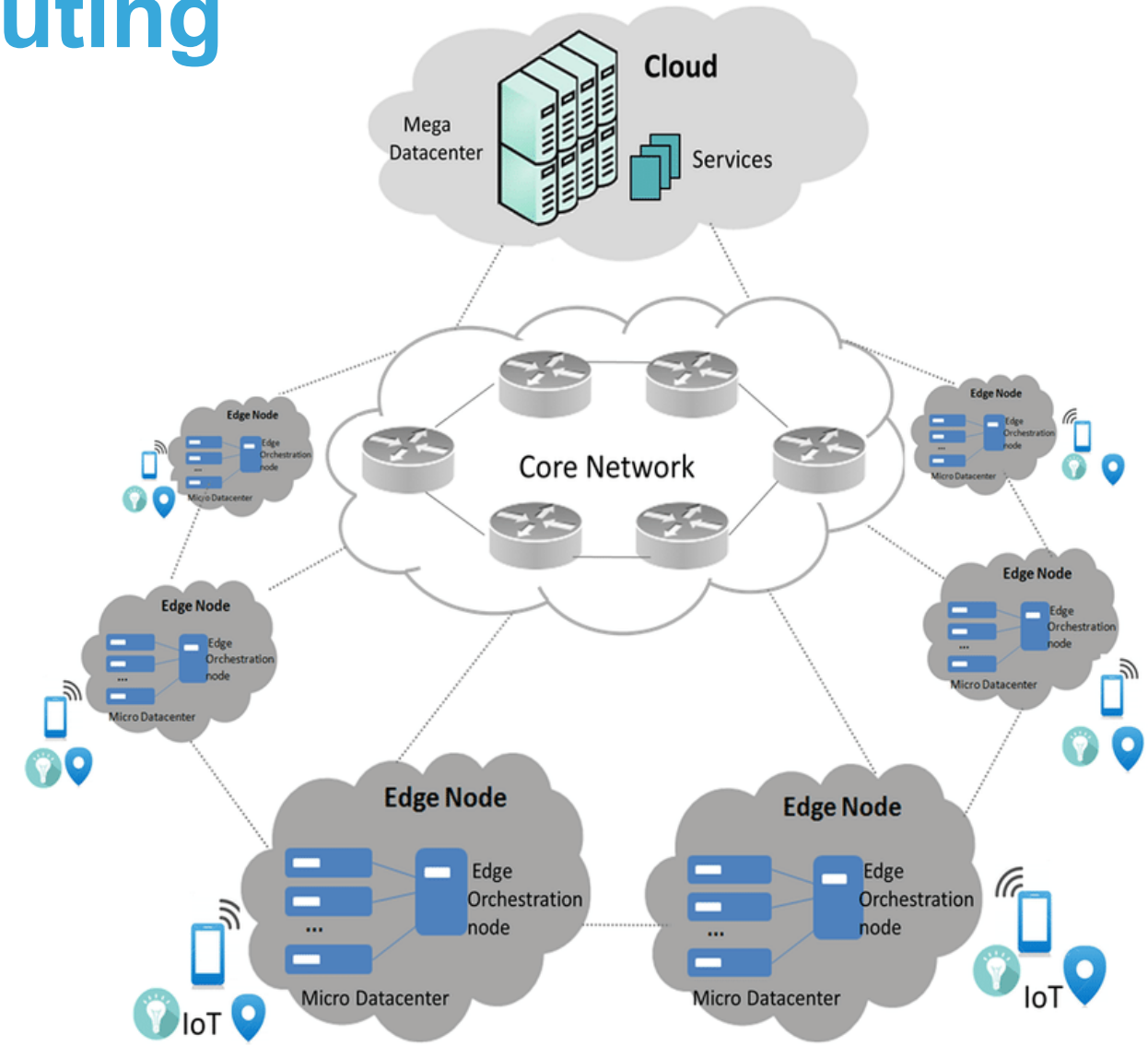
IEEE Network 32(2) 2018. Doi: 10.1109/MNET.2018.1700268

Verticals: Autonomous Vehicles



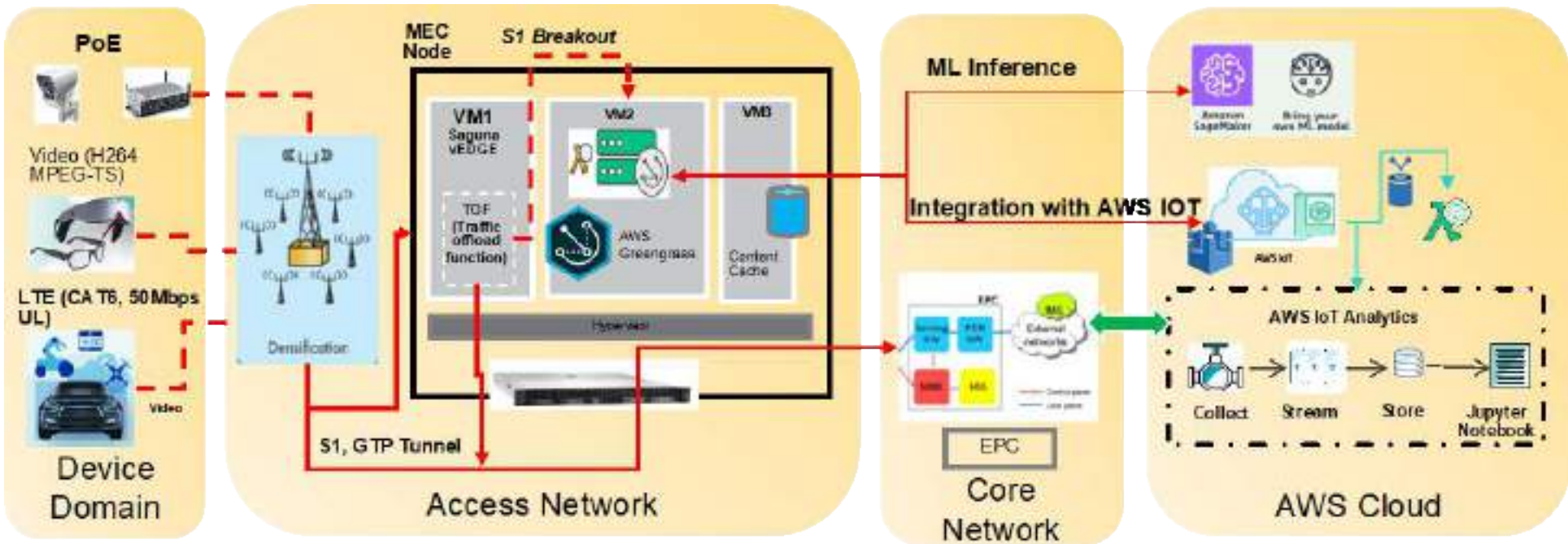
Edge computing platform

- Virtualization substrate
- APIs for global access
- Management and orchestration (MANO)
- Global measurement

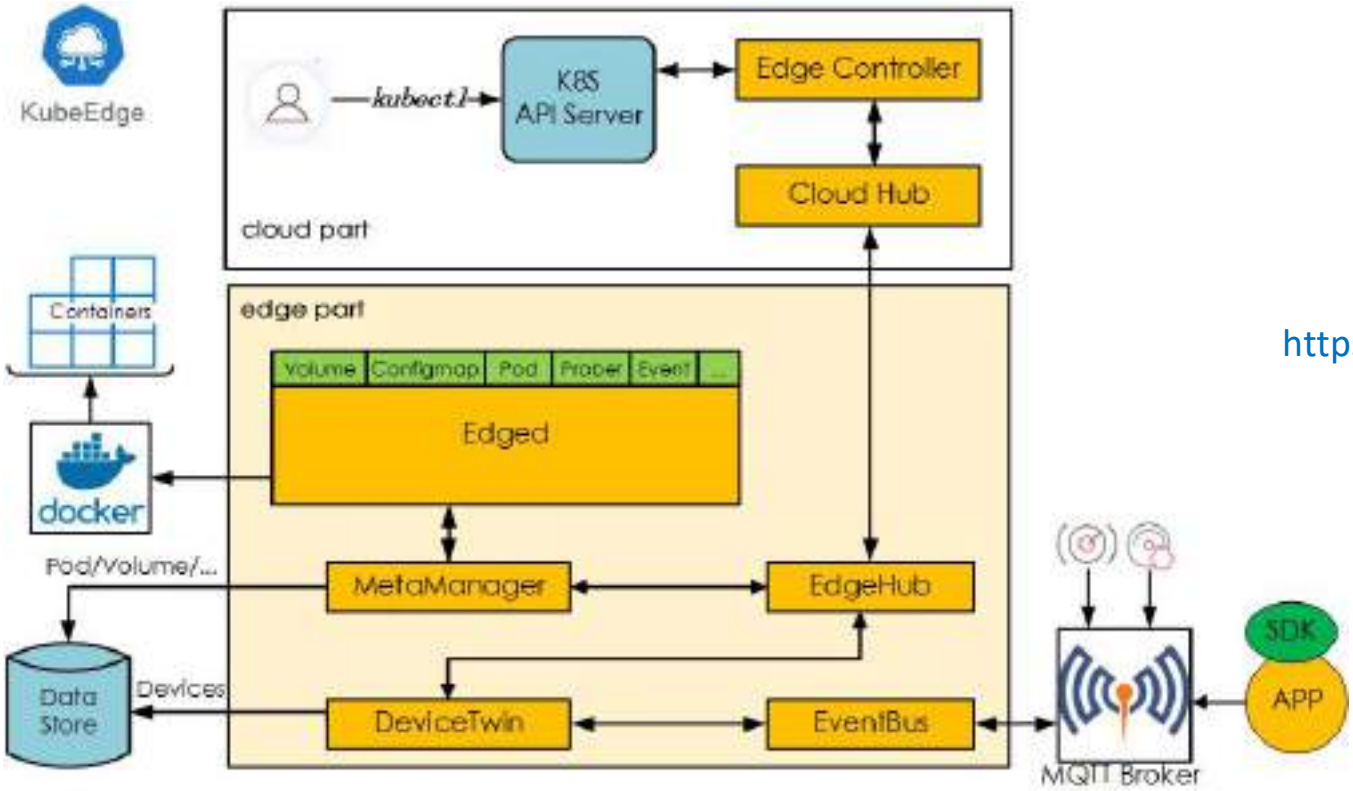


Edge Computing Enabling Technologies

Amazon Web Services



Edge Computing Enabling Technologies

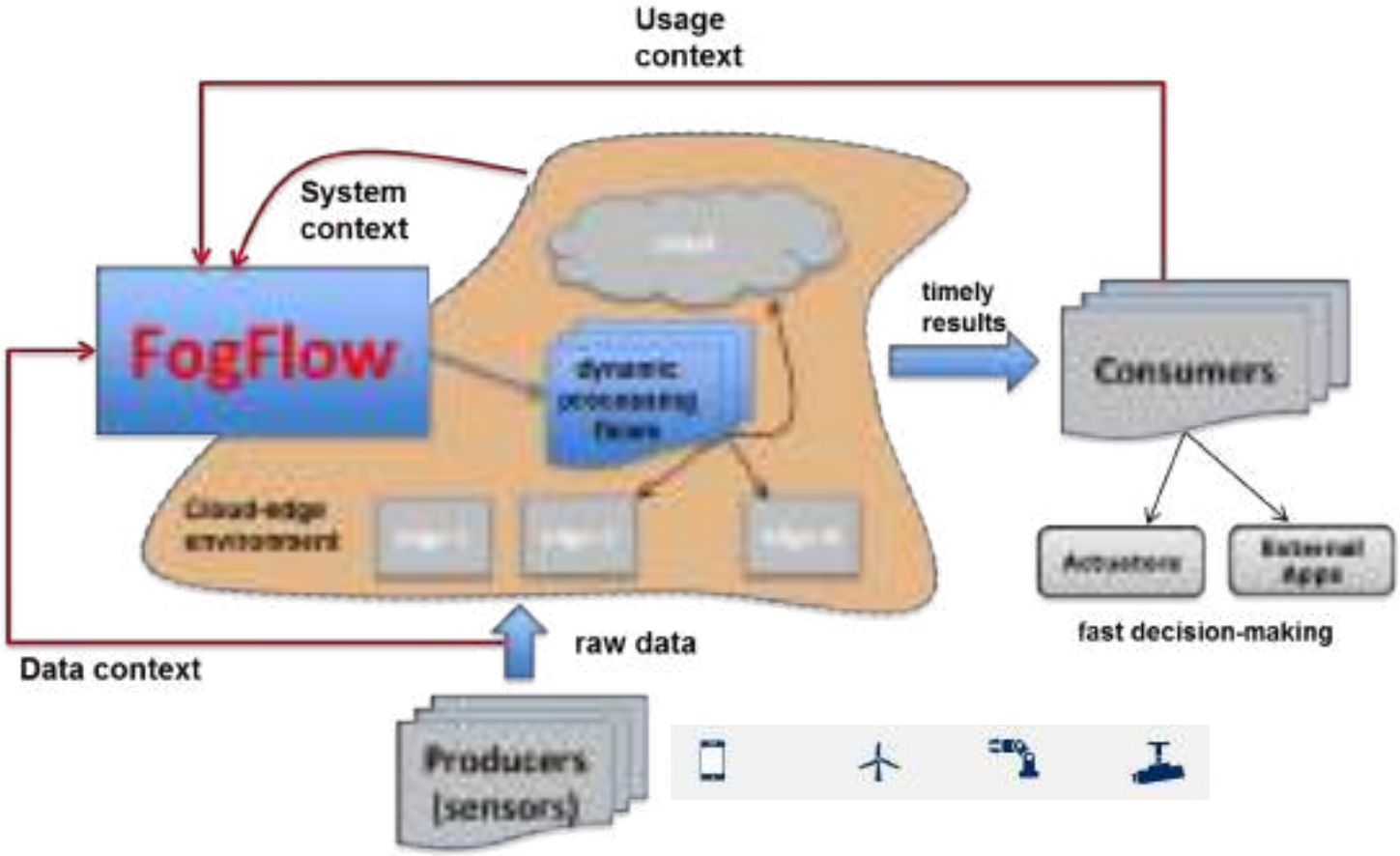


KubeEdge

Kubernetes Native Edge Computing Platform to orchestrate both Edge and Cloud components open sourced!

https://github.com/kubeedge/kubeedge

Edge Computing Enabling Technologies



FIWARE

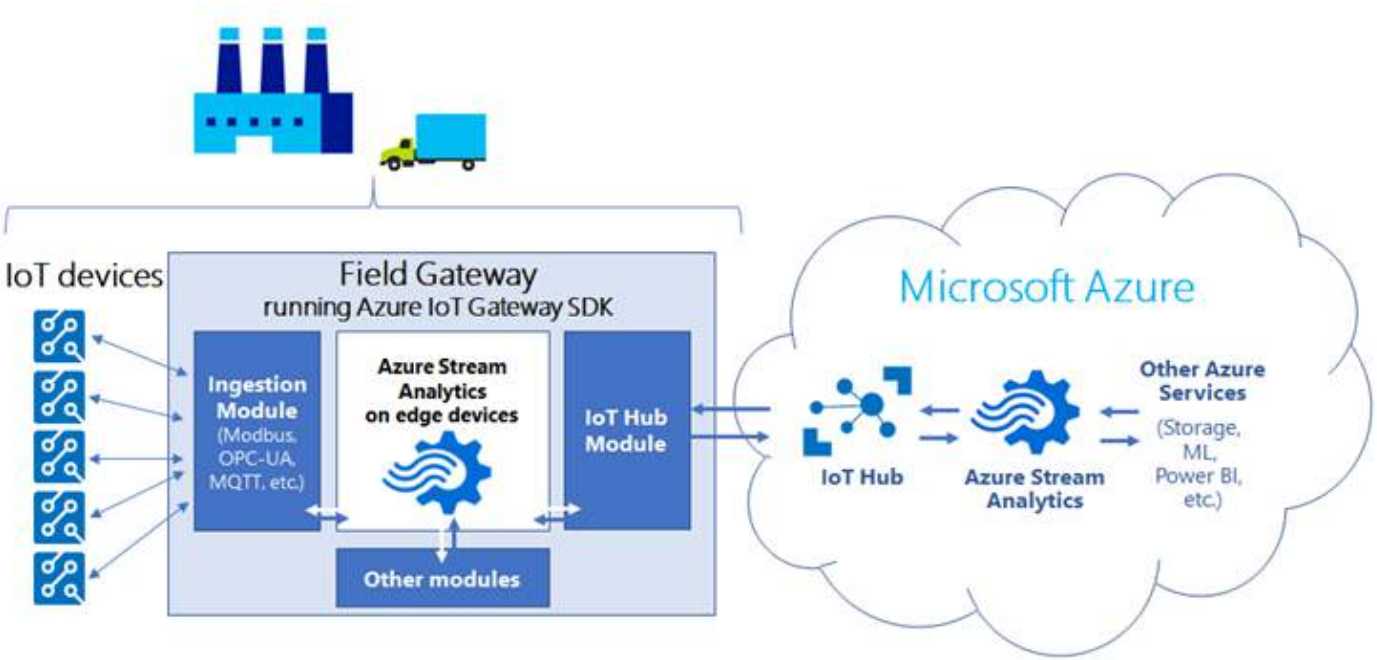
FogFlow

Programming Cloud-Edges

FIWARE-based IoT edge computing framework to automatically orchestrates dynamic data processing flows over cloud and edges

https://github.com/smartfog/fogflow

Edge Computing Enabling Technologies

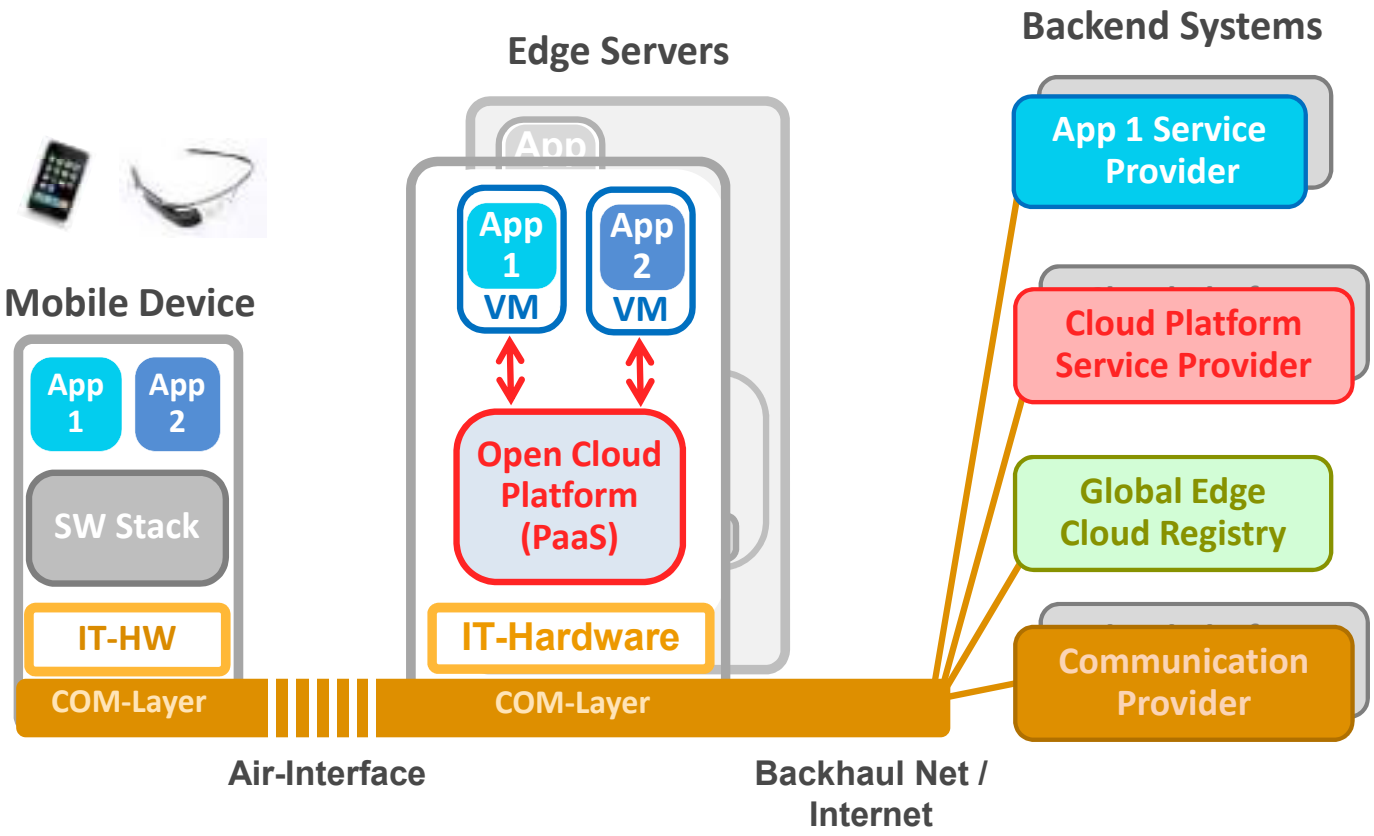


Azure

Enables cloud/edge as a single interworking environment from the application services to AI to security and management.

http://azure.microsoft.com

Edge Computing Enabling Technologies



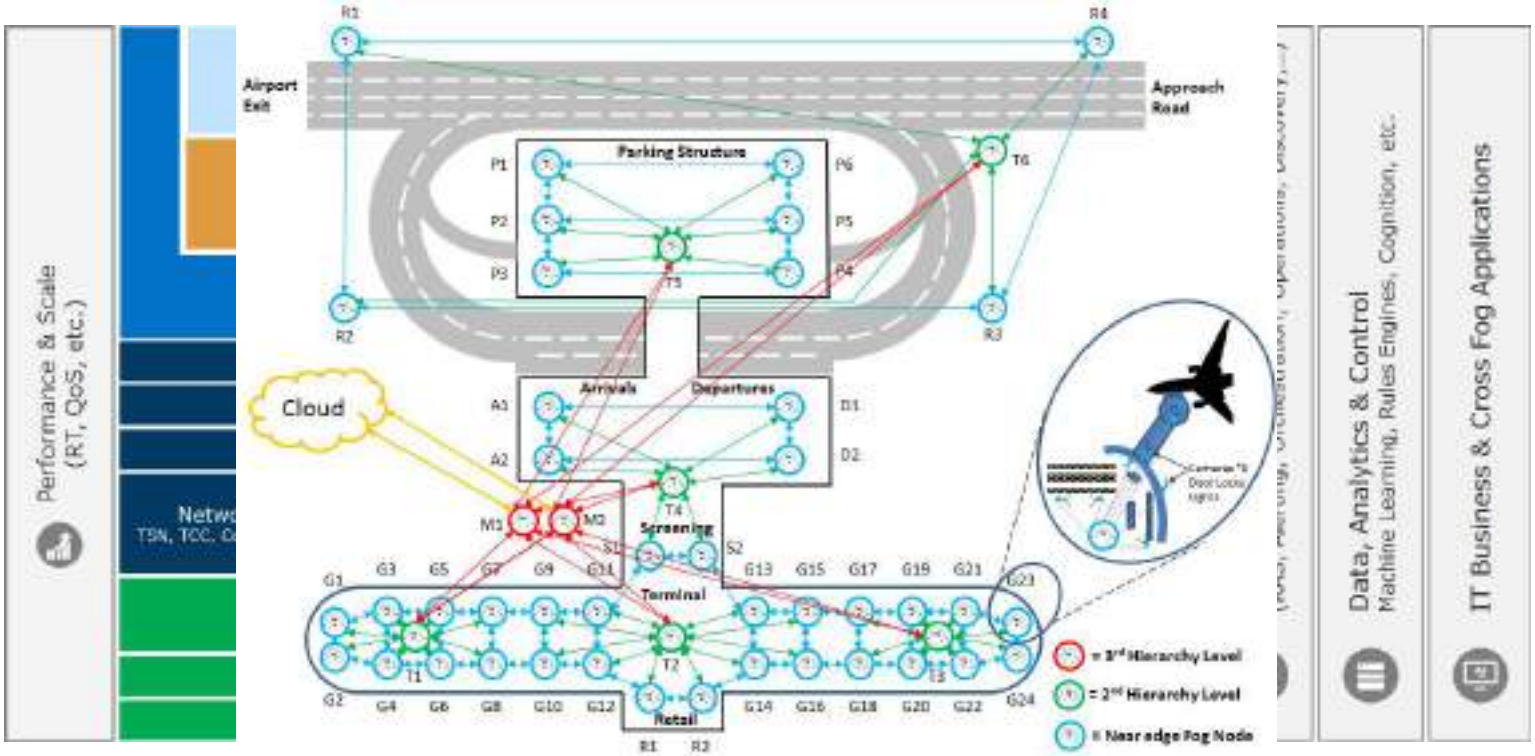
openEDGEcomputing

A general framework for edge computing

http://openedgecomputing.org

Example of Edge Computing Enabling Technologies

Usecase Reference Architecture: Smart Video Surveillance



https://www.openfogconsortium.org/

Ongoing Challenges

- Standardization, benchmarking and market
- Frameworks, protocols and languages
- Libraries and lightweight enablers
- Partitioning and offloading
- Management and Orchestration (MANO)
- Service placement, chaining, and discovering
- Security and privacy
- Etc.

Edge Computing Opportunities

- AI to powerfully drive new business models
- Microservices to facilitate edge development
- Increase IoT generation density
- Add new flavors and verticals
- Industry and academy collaboration
- New secure approaches (federations, etc.)

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Thanks, questions?

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