



# OPEN EDGE COMPUTING INITIATIVE

- OVERVIEW BUSINESS, TECHNOLOGY AND TARGETS -

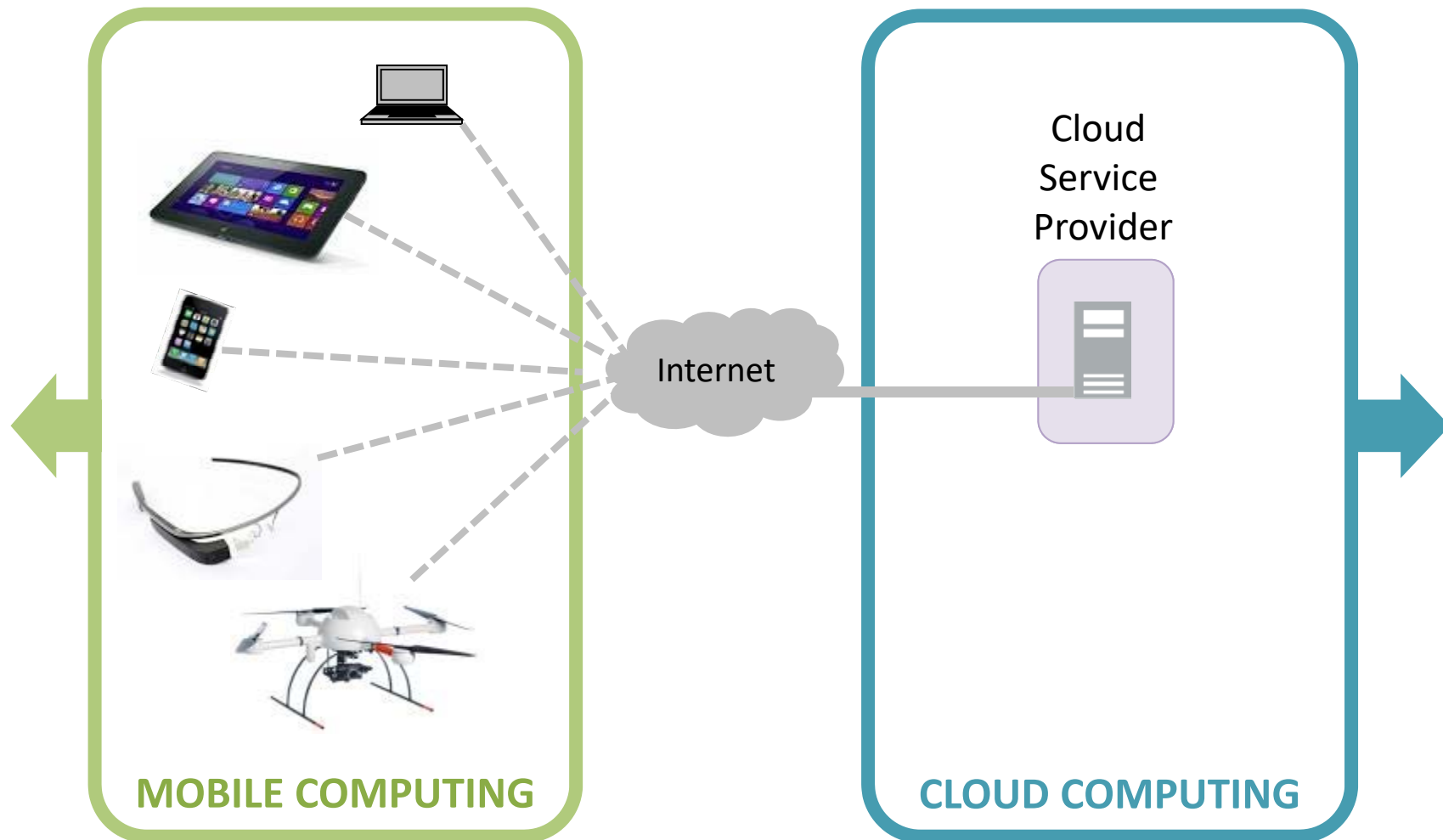
December 2019

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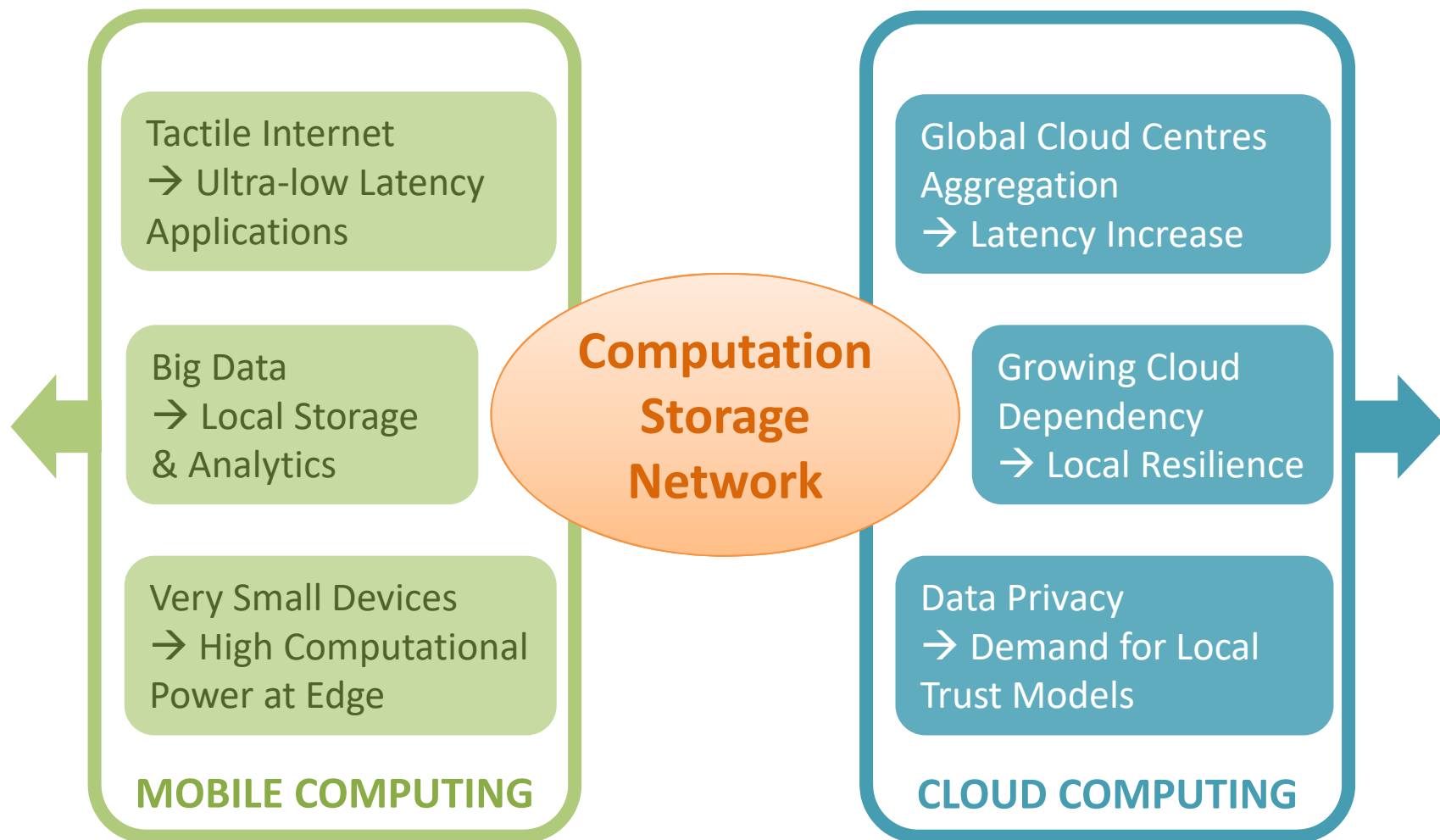
# INTRODUCTION TO OPEN EDGE COMPUTING

## Two Megatrends...



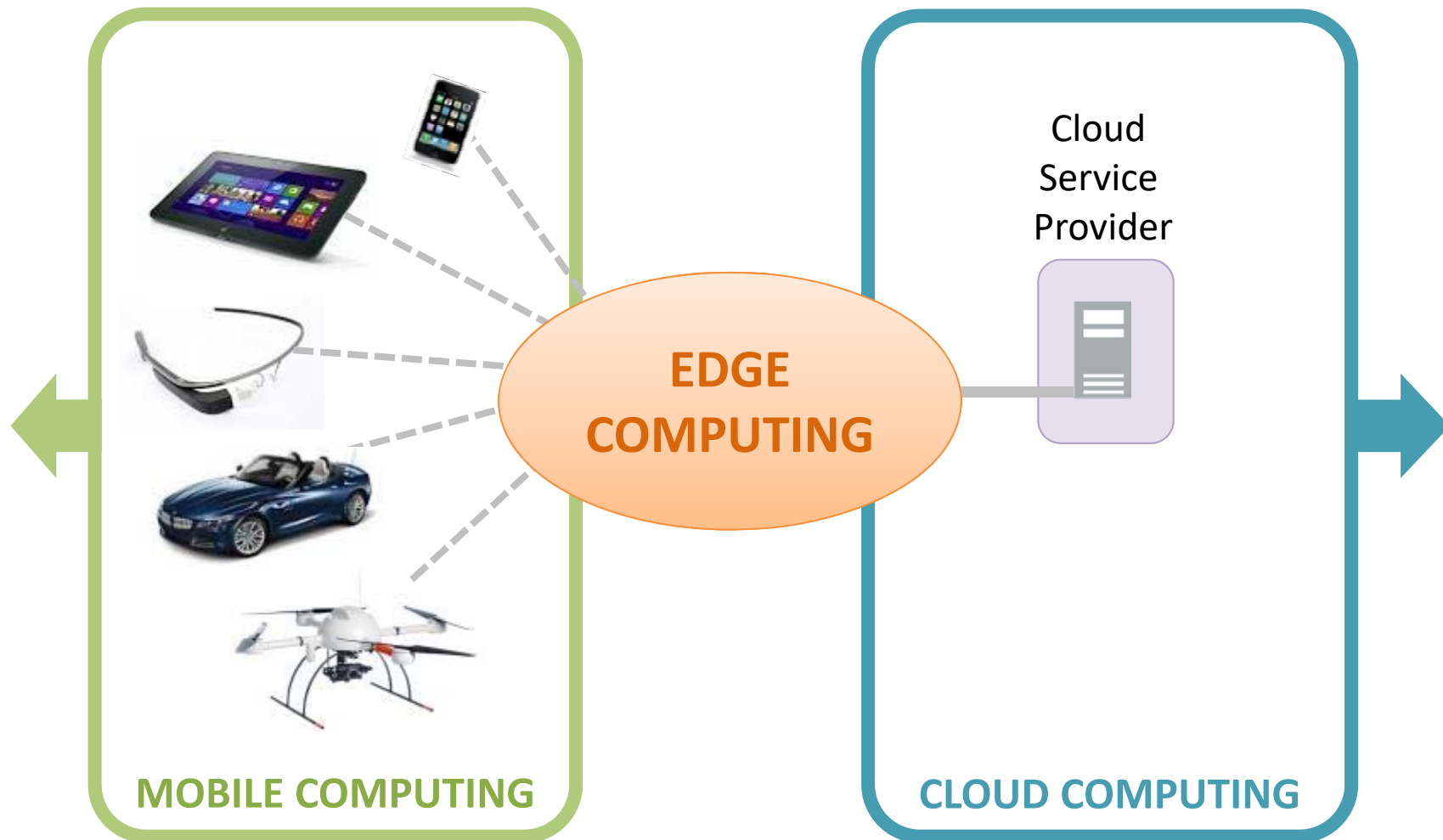
 ... are slowly drifting apart!

# Current Trends & Developments



➔ We need computational power, storage and network close to mobile devices and sensors

# We Need „Edge Computing“



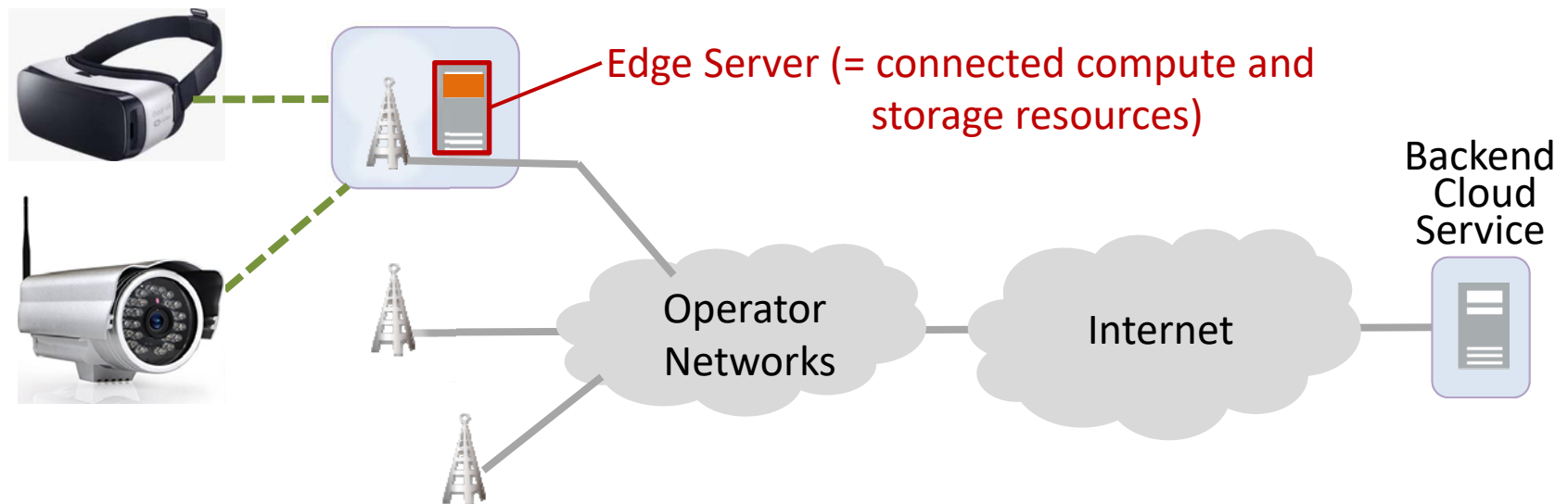
➔ Edge Computing: Little data centres and computing resources right next to the mobile device or sensor

# What is Edge Computing?

➔ Edge Computing: small data centres at the network edge that offer connected compute and storage resources right next to the user

## Example Use Cases:

- Virtual reality application connected with head mounted display
- Analyzing large volumes of data right at the edge (Edge Analytics)

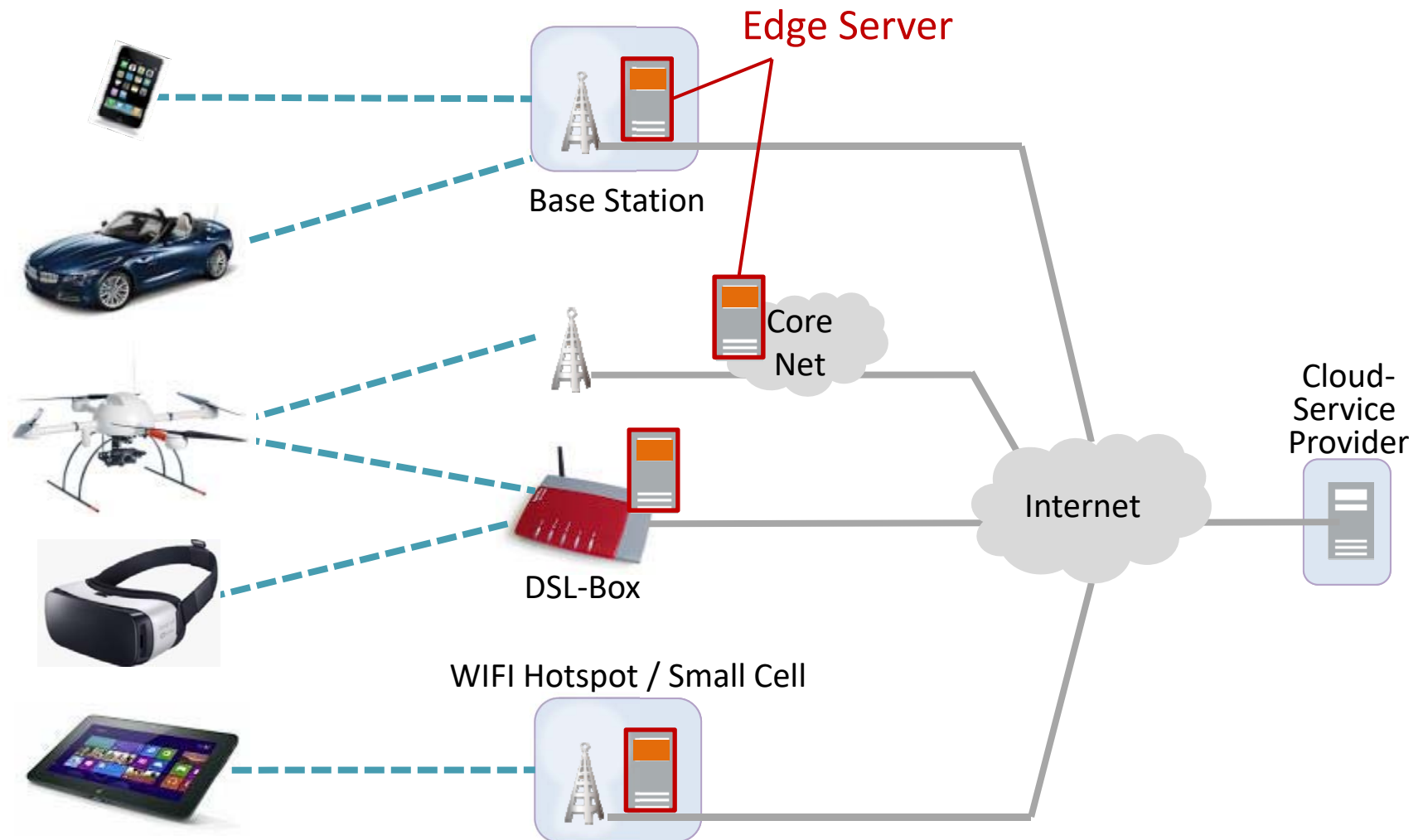


**Latency**



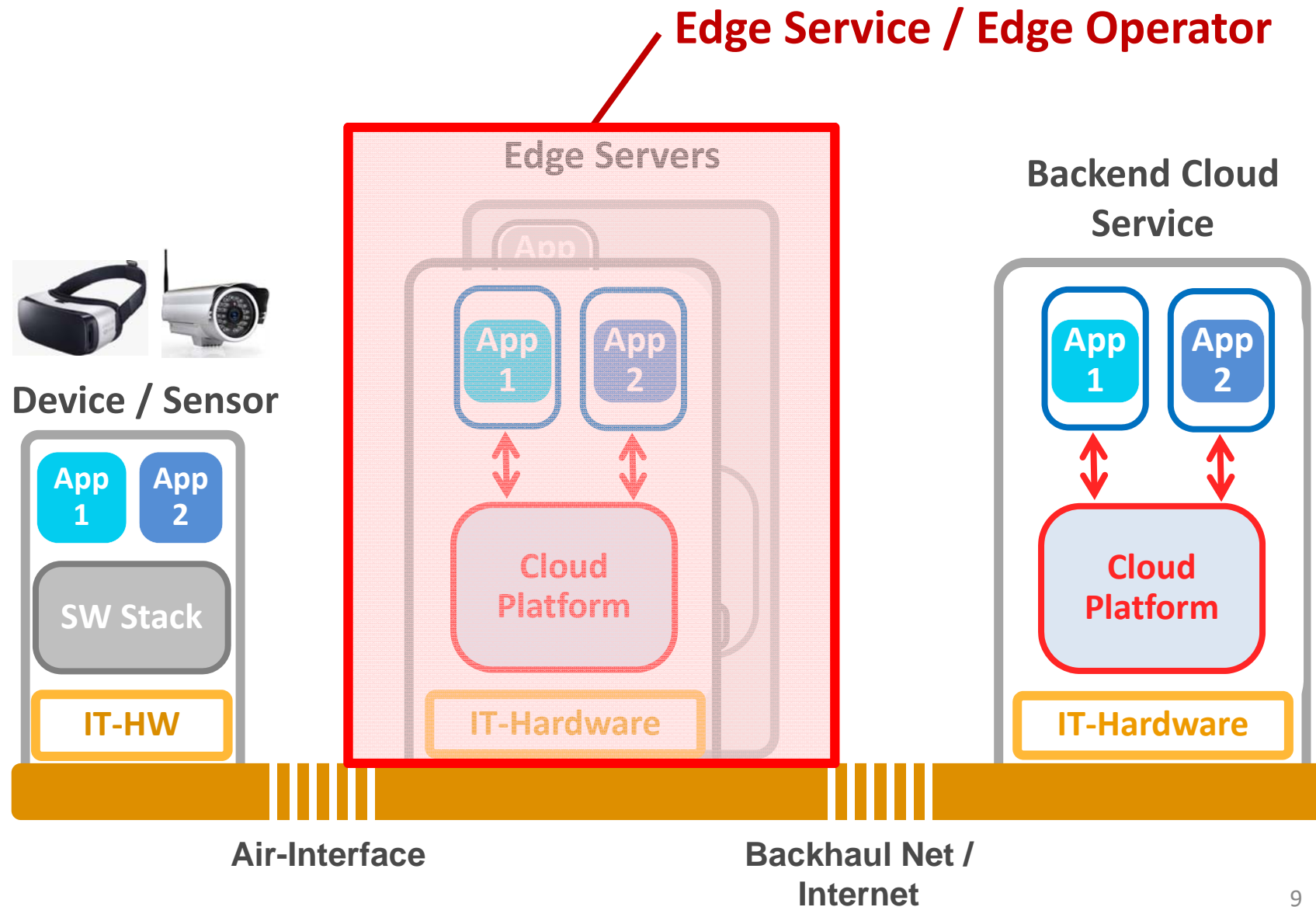
## Open Edge Computing Vision:

All network edge components offer edge resources through open and standardised mechanisms to any application, device or sensor to enable Edge Computing





# Edge Computing – Component Overview



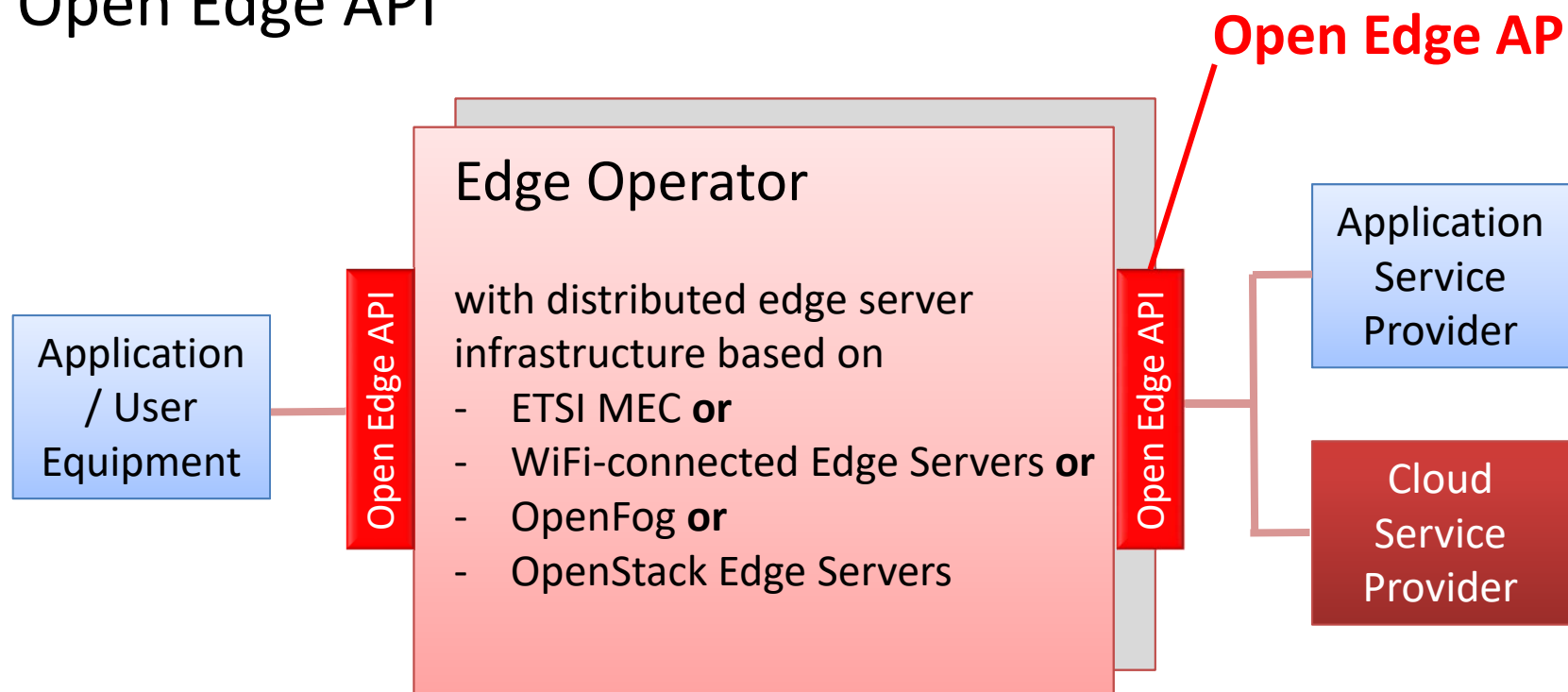
# Open Edge Computing – Fundamental Requirements



## Open Edge Services...

- ...have globally agreed access mechanisms available everywhere
- ...are independent of
  - the communication bearer and network provider
  - the underlying technology and technology provider
- ...are open to all application categories + technologies
- ...are supporting ALL relevant business scenarios

# Key Requirement for Success of Open Edge Computing: Open Edge API



**To establish the Open Edge API globally, we need a joint and coordinated action between...**

- ...Telecom Service Providers / Infrastructure Providers
- ...Cloud Service Providers / IT Technology Providers
- ...Application Service Providers / Industry Verticals

# **BUSINESS OPPORTUNITIES AND VALUE CHAIN**

# Many Edge-enabled Business Opportunities Emerge

## Example Areas

- Virtual / Mixed Reality
- Edge Analytics
- Virtual CPE
- New Automotive Services
- Enterprise Services (e.g. virtual desktop)
- Public Safety
- Mobile App Enhancements
- Industry 4.0
- Sensor Data Services
- Drone Support Services
- Health and Sports Services
- Online Gaming
- Enhanced Communication Services



 **Edge Computing is the next „big thing“ after Cloud Computing!**

# Will We Be Much Better Chefs in the Future?

Cooking with cognitive assistance in 2020:



Source: Prof. Satya, Carnegie Mellon University

see



read & hear

act

"Wait for the oil to heat up"



"Wait, the oil is not hot enough"



# Edge-enabled Services – Current Demonstrators



## Demonstration videos

- Table tennis Assistant  
[www.youtube.com/watch?v=lp32sowyUA](http://www.youtube.com/watch?v=lp32sowyUA)
- 2D Lego Assistant  
[youtu.be/uy17Hz5xvmY](http://youtu.be/uy17Hz5xvmY)
- Drawing Assistant  
[www.youtube.com/watch?v=nuQpPtVJC6o](http://www.youtube.com/watch?v=nuQpPtVJC6o)

## What's being shown

- Combines Google Glass with object recognition (of ball), motion prediction and real-time instructions to the user (where to hit the ball)
- Combines object recognition with giving instructions in real-time.
- Combines object recognition with corrective real-time feedback to the user.



Further edge demo applications based on the Open Cloud Reference Platform have been developed by Carnegie Mellon University:

[https://www.youtube.com/playlist?list=PLmrZVvFtthdP3fwHPy\\_4d61oDvQY\\_RBgS](https://www.youtube.com/playlist?list=PLmrZVvFtthdP3fwHPy_4d61oDvQY_RBgS)

# Business Value enabled through Edge Computing

## Business & Customer Value

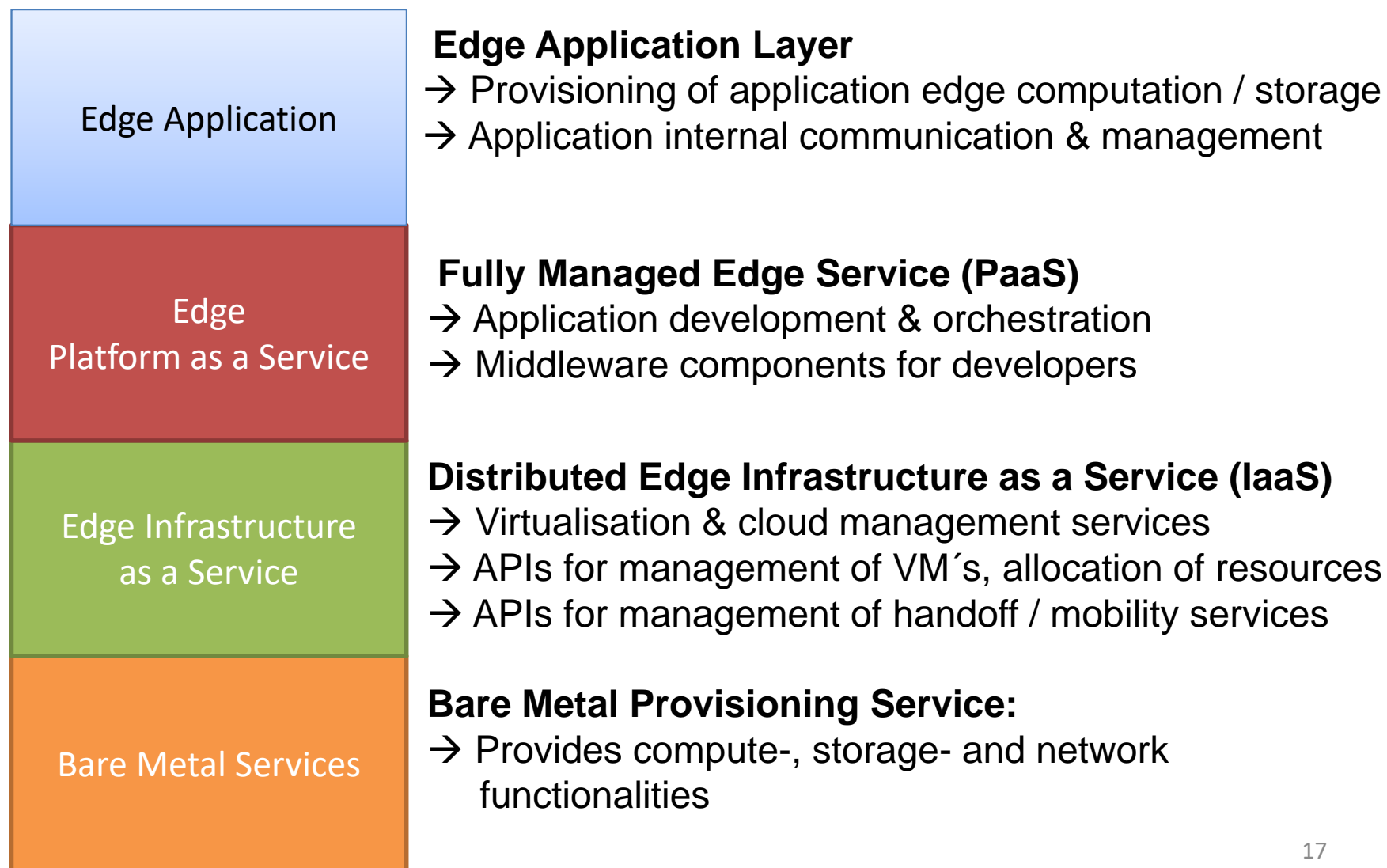
- Disruptive improvement in customer experience (e.g. Tactile Services)
- Expansion of device capabilities
- Offload of heavy computation from device to edge
- Enabler for new types of services via distributed computing (e.g. edge analytics for IoT)
- Keep personal data local
- Masking disruption of centralised cloud services
- Lower upload data volume to the Cloud (e.g. Edge Analytics)

## Prime factors

Latency:	↓
CPU Power:	↑
Storage:	↑
Battery lifetime:	↑
Server location:	↑
Privacy:	↑
Availability:	↑
Backhaul traffic:	↓



# Open Edge Computing Services – Overview Main Functionalities



# Business Scenarios & Service Offerings

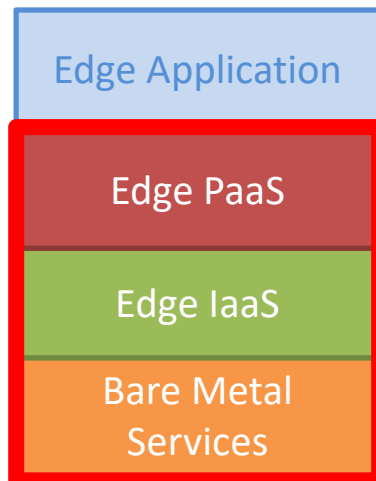
## Scenario A:

### Fully Managed Edge Service (PaaS)

→ All Edge Services are offered by the Edge Operator

#### Target Customers:

- Small / regional application providers
- Telecom operator internal optimisation services



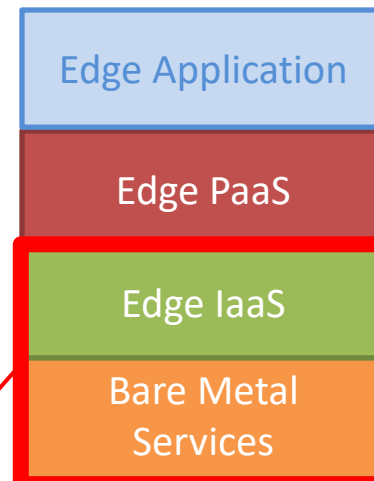
## Scenario B:

### Edge Infrastructure as a Services (IaaS)

→ Edge Services split between Edge Operator AND Cloud Service Provider

#### Target Customers:

- Global application providers
- Global Cloud Service Providers
- Large CDN providers



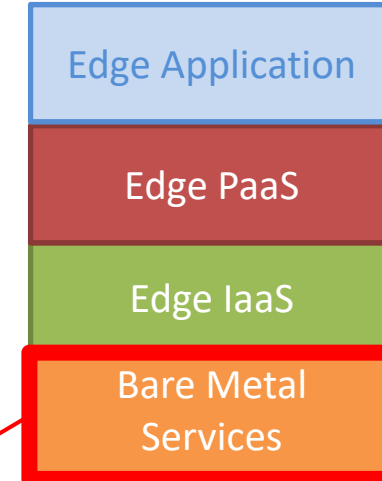
## Scenario C:

### Bare Metal Edge Services

→ Only bare metal infrastructure services offered by the Edge Operator

#### Target Customers:

- Global service providers (e.g. Google)



Edge Operator Services

# Edge Computing – Target Markets for Telecom Operators

## Edge-based B2C Services

- Virtual reality services
- Home service roboter

## B2B Distributed Edge Platform Services

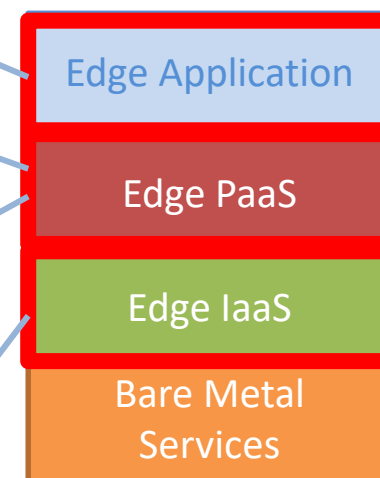
- Edge service for application providers
- Microservice hosting for cloud-based applications

## Enterprise Services / Vertical Solutions

- Drone control service solution
- Automated driving solution
- Robotics / manufacturing solution

## Distributed Infrastructure as a Service

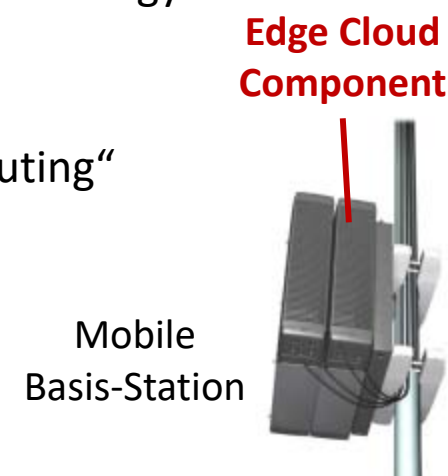
- Infrastructure services offered to cloud providers (AWS, MS Azure etc.)



# TECHNOLOGY OVERVIEW

## Edge Computing Technology - Current Situation & Gaps

- Carrier great edge server technology that is suited for edge computing is on the market since more than 4 years. This does include low-latency platforms, ETSI-MEC „compliant“ solutions as well as edge servers integrated in base stations.
- Many telecom operators have conducted trials with edge technology. Some operators have already launched edge services (main use case: edge caching services)
- ETSI Industry Specification Group „Multi Access Edge Computing“ ([www.etsi.org](http://www.etsi.org)) actively develops
  - Requirements for Edge Computing
  - Edge architecture focussing on mobile base-stations
  - Standard API's for telcom related edge applications
- Current Gaps:
  - There is a growing number of edge platforms launched in the market now: all of them provide different API's for edge application developers
  - To make Edge Computing a success it is important to convince edge application developers to provide edge native applications. They require ONE set of API's!



### General Target:

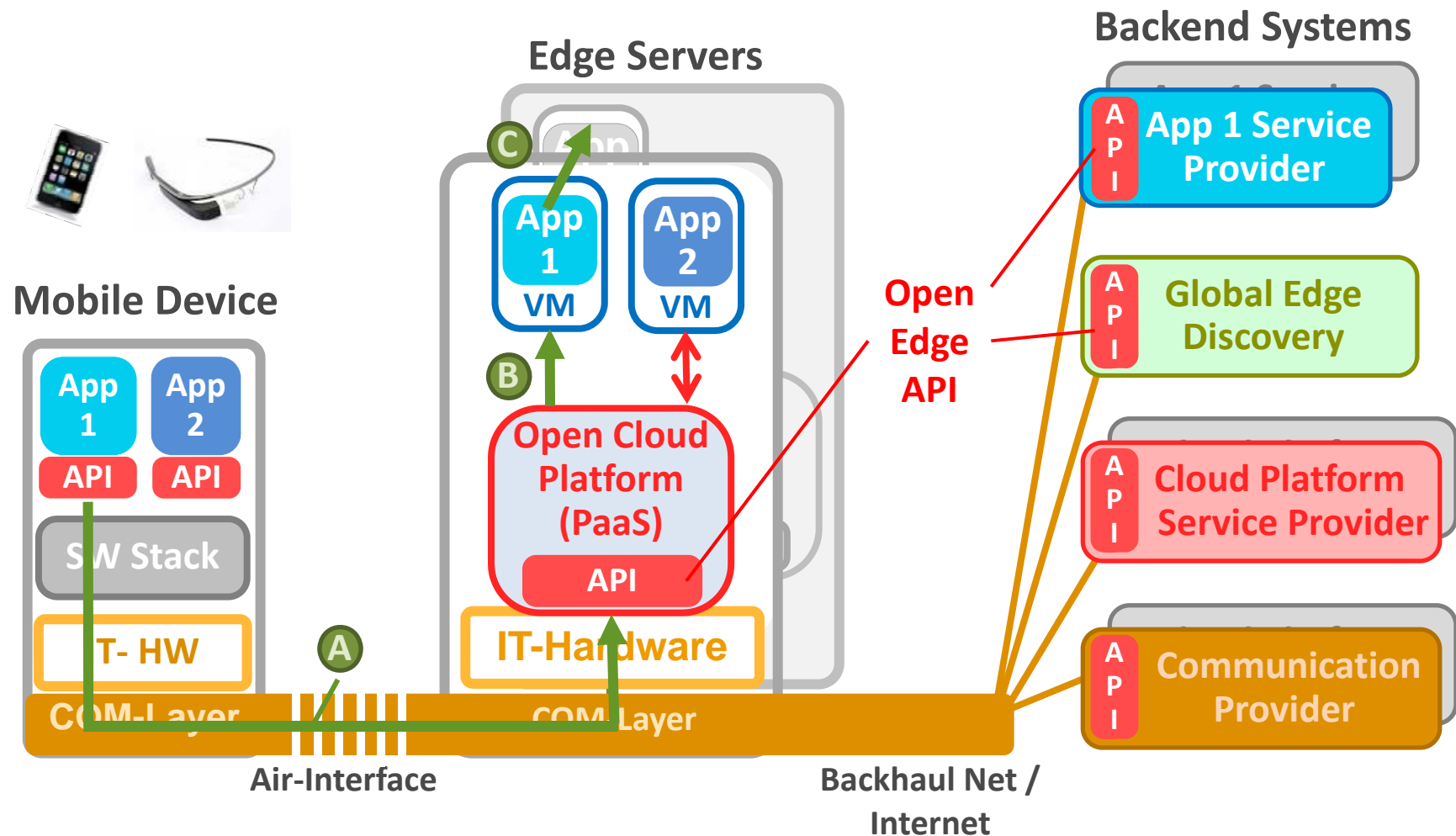
We have to provide an open API as well as a reference platform for Open Edge Computing and align it with the IT industry AND the telecoms industry 21

# Open Edge Computing Reference Platform

- We have implemented a first version of the Reference Platform for Open Edge Computing
  - The Reference Platform is an open source implementation that is based on extensions to OpenStack
  - It adds a few key functions to the standard OpenStack version to enable Edge Computing
  - It is based on an Open Edge API specification which can be implemented by any cloud stack technology
- To start simple and fast, the current Reference Platform implements just three additional functions
  - Edge Server (Cloudlet) Discovery
  - VM Provisioning
  - VM Handoff
- There are a number of other functions and stack changes required  
→ they will be addressed later

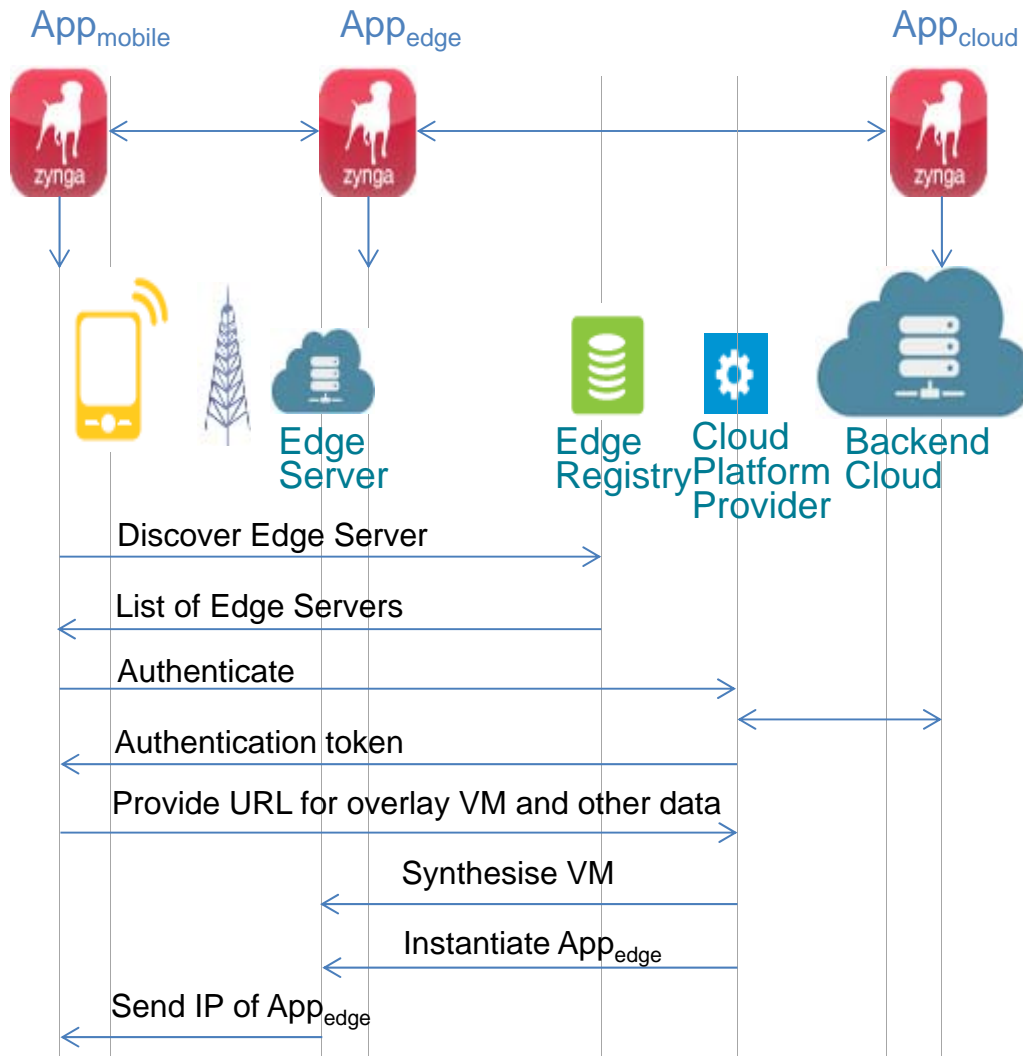


# Key Reference Platform Functions and API



- (A) Edge Server (Cloudlet) Discovery** – discover the best and closest edge server
- (B) VM Provisioning** – fast provisioning of VM and app on selected edge server
- (C) VM Handoff** – handoff of application to next edge server in case of movement

## Reference Platform – Information Flow (example Zynga)



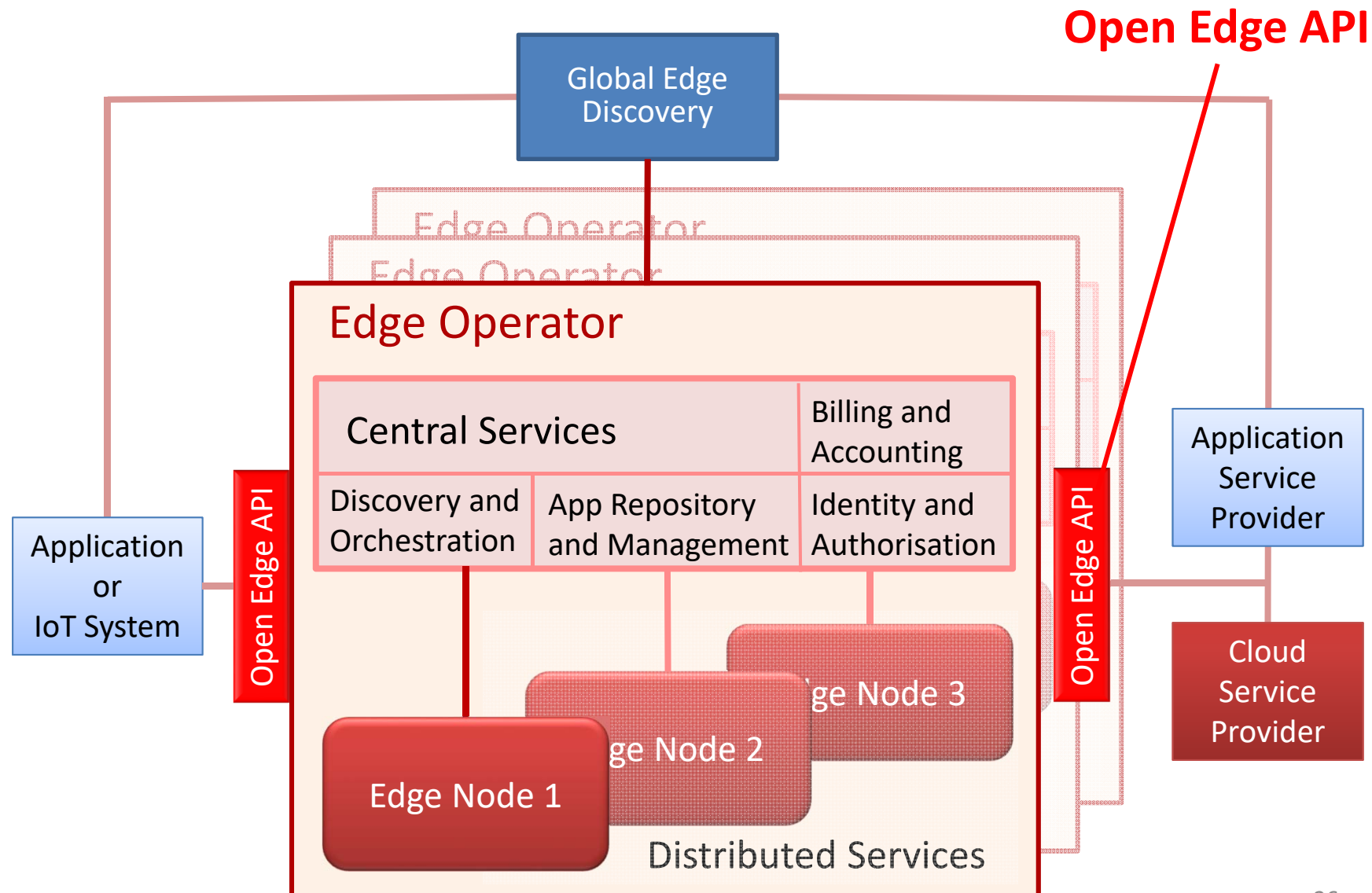
- The user App<sub>mobile</sub> contacts an Edge Registry to discover any suitable edge servers in its neighbourhood
- Edge Registry provides a list of suitable Edge Servers
- The user App<sub>mobile</sub> selects the preferred Edge Server and authenticates
- The user App<sub>mobile</sub> tells the Cloud Platform Provider where to find an Overlay Virtual Machine.
- The Cloud Platform Provider fetches the Overlay VM and instructs the Edge Server to synthesise the new VM.
- Once the VM is instantiated, the code App<sub>edge</sub> is running at the edge server.



## Edge Reference Platform – Current Status and Target

- First implementation of OpenEdge Reference Platform for OpenStack is finalised and compatible for OpenStack Kilo release
- All source code is available on GitHub
  - Component overview: <https://github.com/cmusatyalab/elijah-cloudlet>
  - Dashboard extensions: <https://github.com/cmusatyalab/elijah-openstack>
  - Cloudlet discovery: <https://github.com/cmusatyalab/elijah-discovery-basic>
  - Rapid VM provisioning: <https://github.com/cmusatyalab/elijah-provisioning>
- The reference platform implementation is based on an Open Edge API specification which is available
- There are a number of demonstrator applications available that run on the Edge Reference Platform
  - GigaSight: <https://github.com/cmusatyalab/GigaSight>
  - QuiltView: <https://github.com/cmusatyalab/quiltview>
  - Gabriel: <https://github.com/cmusatyalab/gabriel>

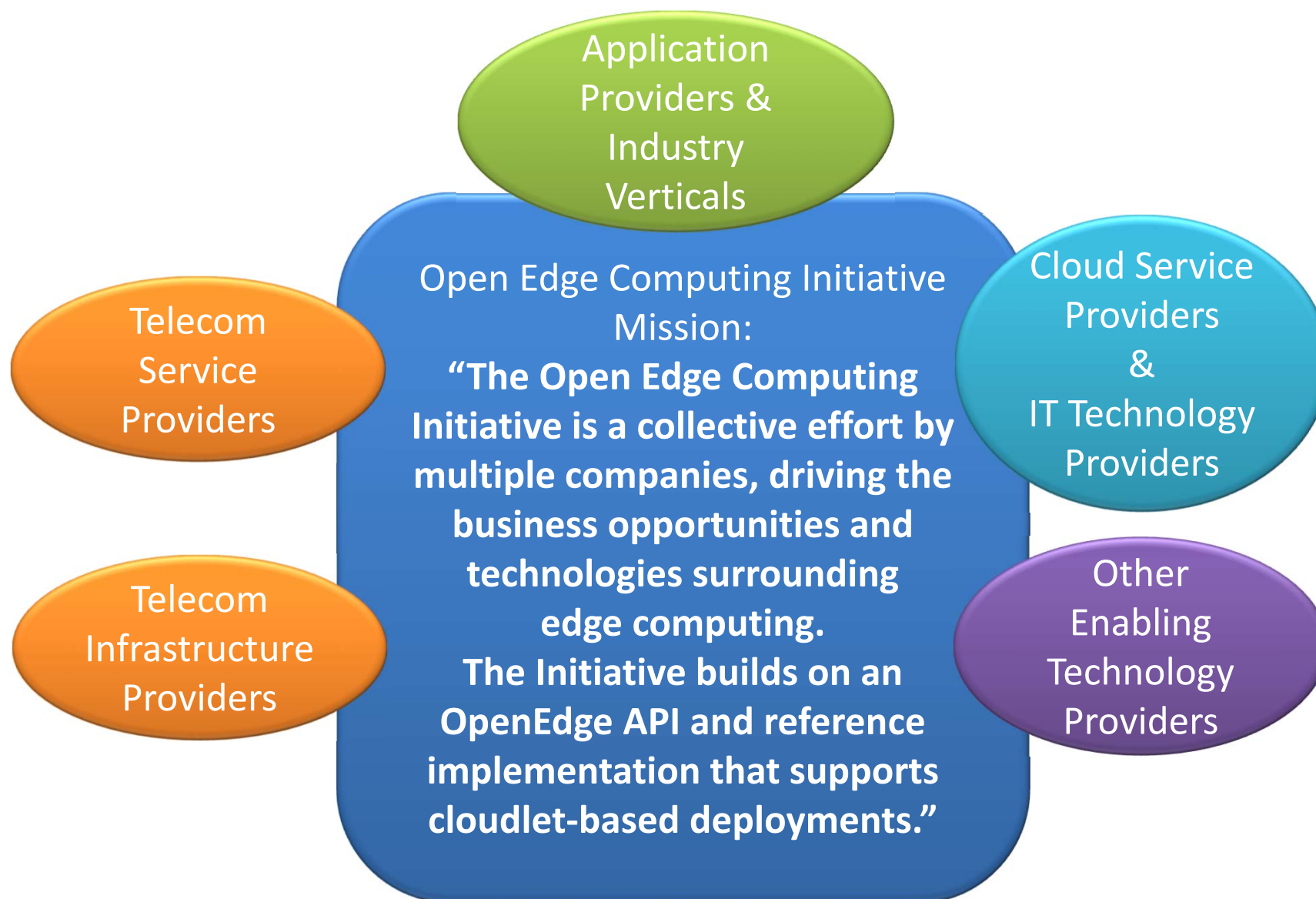
# E2E Edge Operator Platform – Component Overview



# OPEN EDGE COMPUTING INITIATIVE

→ MISSION, TARGETS AND WORKSTREAMS

# Open Edge Computing Initiative: Mission



# High-Level Targets (1/2)



1. Drive the adoption of Open Edge Computing with the application service providers and the relevant industry verticals
  - Engage with application service providers & verticals and build PoC and where possible real-world installations
  - Communicate successful PoC's and installations widely
  - Gather application requirements and include them in in edge platform / standardisation activities
  
2. Drive the adoption of Open Edge Computing with the cloud service providers and the IT technology providers
  - Convince IT / cloud technology providers and cloud service providers that edge computing is a viable business opportunity. Include them in PoC's and real-world trial projects
  - Offer them opportunities to develop new business
  - Drive the adoption of edge computing as a new cloud computing area: shape the edge related components in OpenStack, Airship, Kubernetes etc.
  - Convince other cloud technology providers to implement the same edge functionalities / API's

## High-Level Targets (2/2)



3. Drive the adoption of Open Edge Computing with telecom service providers and telecom infrastructure providers
  - Convince telecoms infrastructure & service providers that edge computing is a viable business opportunity. Include them in PoC's and real-world trial projects
  - Offer them opportunities to develop new business
4. Communication, marketing, outreach, education
  - Inform & educate the public, the target audience and the members. Provide information exchange facilities
  - Actively grow the audience / participants / members
5. Synchronise requirements, specifications and architectures between stakeholders
  - Synchronise with standardisation bodies & initiatives (ETSI MEC, EdgeX Foundry, TIP, ONAP etc)
  - Drive alignment and resolution of conflicts between big players

# Open Edge Computing Initiative - Current Partners

(as of December 2019)

## Industry Partners

- Crown Castle
- Deutsche Telekom
- Intel
- Microsoft
- NOKIA
- NTT
- Seagate
- Verizon
- VMware
- Vodafone


## Academic Partner

- Carnegie Mellon University





# Open Edge Computing Initiative: Key Workstreams and Deliverables

- Open Edge API: OpenStack-based implementation of key API-functions  
→ working code on Github repository available for developers today
- Engagement with ETSI MEC specification group  
→ shape the Open Edge API in phase 2 ETSI MEC specification
- Workstream: “Living Edge Lab”  
→ provide and utilize an E2E testbed for Edge applications and 
- Workstream: “Edge Platform API Convergence”  
→ Define and agree Open Edge API across all edge platform providers
- Workstream: “Global Edge Developer Lab”  
→ Set-up local edge infrastructure close to edge application developers
- Workstream: “Common Edge Enablers for Telco Products”  
→ Select and agree edge enabler technologies across the telecom industry  
→ Example: 360 Degree Live Streaming enablers, Cloud Gaming enablers
- Tackle key technical challenges on the edge:  
→ Example: GPU sharing across several edge applications





# Workstream “Living Edge Lab”:

We Provide an E2E Testbed for Edge Applications and Technology  
(launched in May 2018)

## Living Edge Lab (LEL)

### Mission Statement

“We are building a **real-world testbed** for Edge Computing with leading **edge applications** and user **acceptance testing**.”



## Workstream “Living Edge Lab”

### **The Living Edge Lab offers an IT and networking infrastructure with...**

- a complete set of different network access technologies (LTE/5G, Wifi, fixed line...)
- edge management and orchestration technologies (Open Edge API, MEC, NFV etc.)
- various edge cloud technologies (low latency cloud platforms etc.)

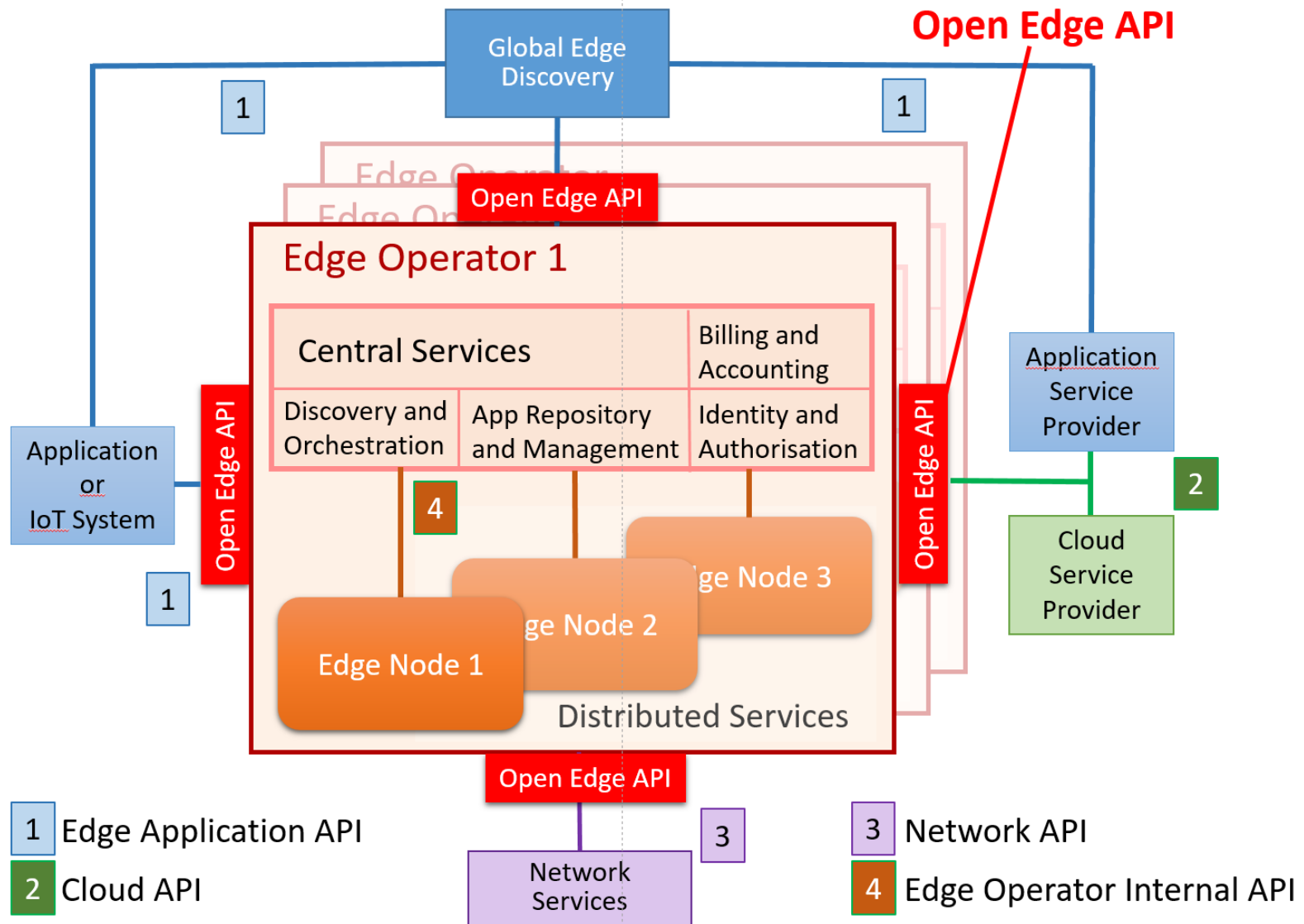
### **It is an excellent live environment to...**

- implement PoCs and product trials (virtual / mixed reality, assisted driving etc.)
- conduct real world E2E technology testing and measurements
- optimise and fine-tune edge technology
- run real world user acceptance testing in Pittsburgh and / or on CMU Campus
- run edge related research experiments on key challenges
- Later: run product compliancy testing vs agreed Open Edge Computing requirements



**Living Edge Lab offers an attractive real-world environment for ALL companies doing business in Edge Computing!**

# Workstream: “Edge Platform API Convergence”



➔ Target: Define and agree Open Edge API across all edge platform providers!

# Open Edge API – Scope and Example Functions

## Scope of Open Edge API

- The Open Edge API exposes edge management and control functionalities to authorised third parties (developers, app operators, PaaS operators)
  - The Open Edge API is independent of the technologies or platforms the actual Edge Operator is using (ETSI MEC, Kubernetes, OpenStack)
- **Hence, the Open Edge API provides a IT-technology and bearer independent as well as globally uniform access to edge services**

## Open Edge API – 3rd Party API Functions (selection)

1. Onboarding a Mobile Edge Host with Mobile Edge Orchestrator
2. Registering the Mobile Edge Host with the System Discovery Function
3. Mobile Edge Host Discovery by UE Application
4. Instantiation of Mobile Edge Application (ME App)
5. Application Lifecycle Management
6. Mobile Edge Platform Management
7. Orchestration / handoff of edge application components
8. Metering & billing
9. Security and Identity Management

# Workstream: „Global Edge Developer Lab“

## Edge Developer Portal

- General edge information, tutorials, training, discussion forum
- Sample code for edge apps
- Sandbox to develop, test and deploy edge app locally and globally
- Access to Central Services of edge platform operator
- Access to globally distributed edge nodes

Central Services		Billing and Accounting
Discovery and Orchestration	App Repository and Management	Identity and Authorisation

App Developer & User

Living Edge Lab

Edge Nodes  
USA

App Developer & User

Edge Node  
Great Britain

App Developer & User

Edge Node  
Germany

App Developer & User

Edge Node  
Japan

App Developer & User



## Summary and Next Steps

- Edge Computing enables a new category of services and customer experience (in Virtual reality, vCPE, Edge Analytics / IoT, Assisted Driving...)
- However, we need to make sure that Edge Services...
  - ...have globally agreed access mechanisms available everywhere
  - ...are independent of
    - the communication bearer and network provider
    - the underlying technology and technology provider
  - ...are open to all application categories + their technologies
  - ...are supporting ALL relevant business scenarios
- Hence, an important next focus area for Edge Computing is a comprehensive and globally agreed Open Edge API
- The Open Edge Computing Initiative orchestrates and drives the technology development and business adoption of edge computing
  - Drive development and acceptance of the Open Edge API through open source reference implementations
  - Initiate development of demonstrator and real-world edge applications
  - Gather requirements from application developers and service providers from various vertical industries
  - Ensure alignment of telco AND IT „standardisation“



 **We need your support to make it happen!**



**MANY THANKS!**

We are interested in your  
comments & support!



INTERDIGITAL

NOKIA



vmware®

verizon✓



Please contact: Dr. Rolf Schuster, Director Open Edge Computing Initiative  
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