

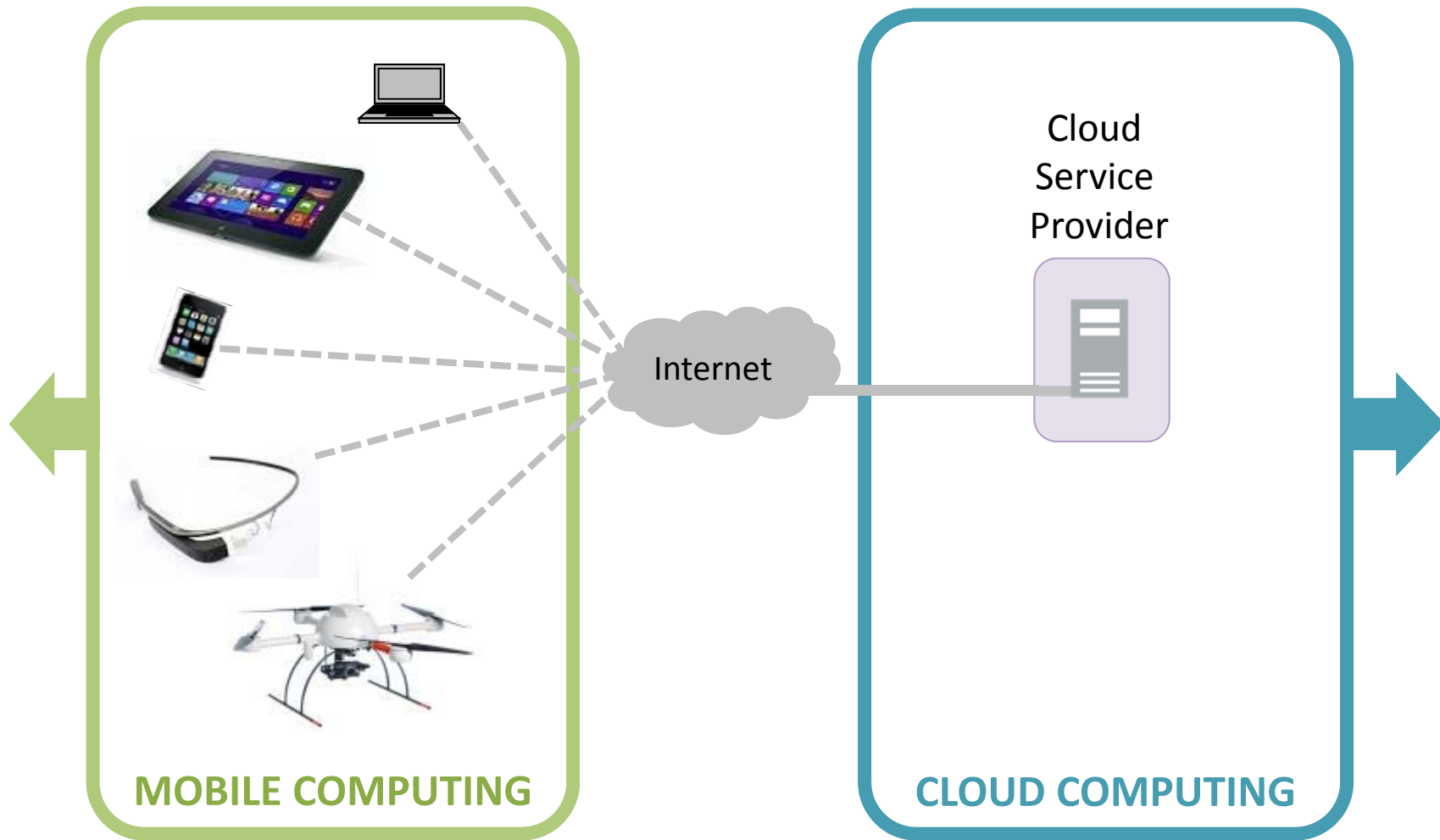


# OPEN EDGE COMPUTING INITIATIVE

- OVERVIEW BUSINESS, TECHNOLOGY AND TARGETS -

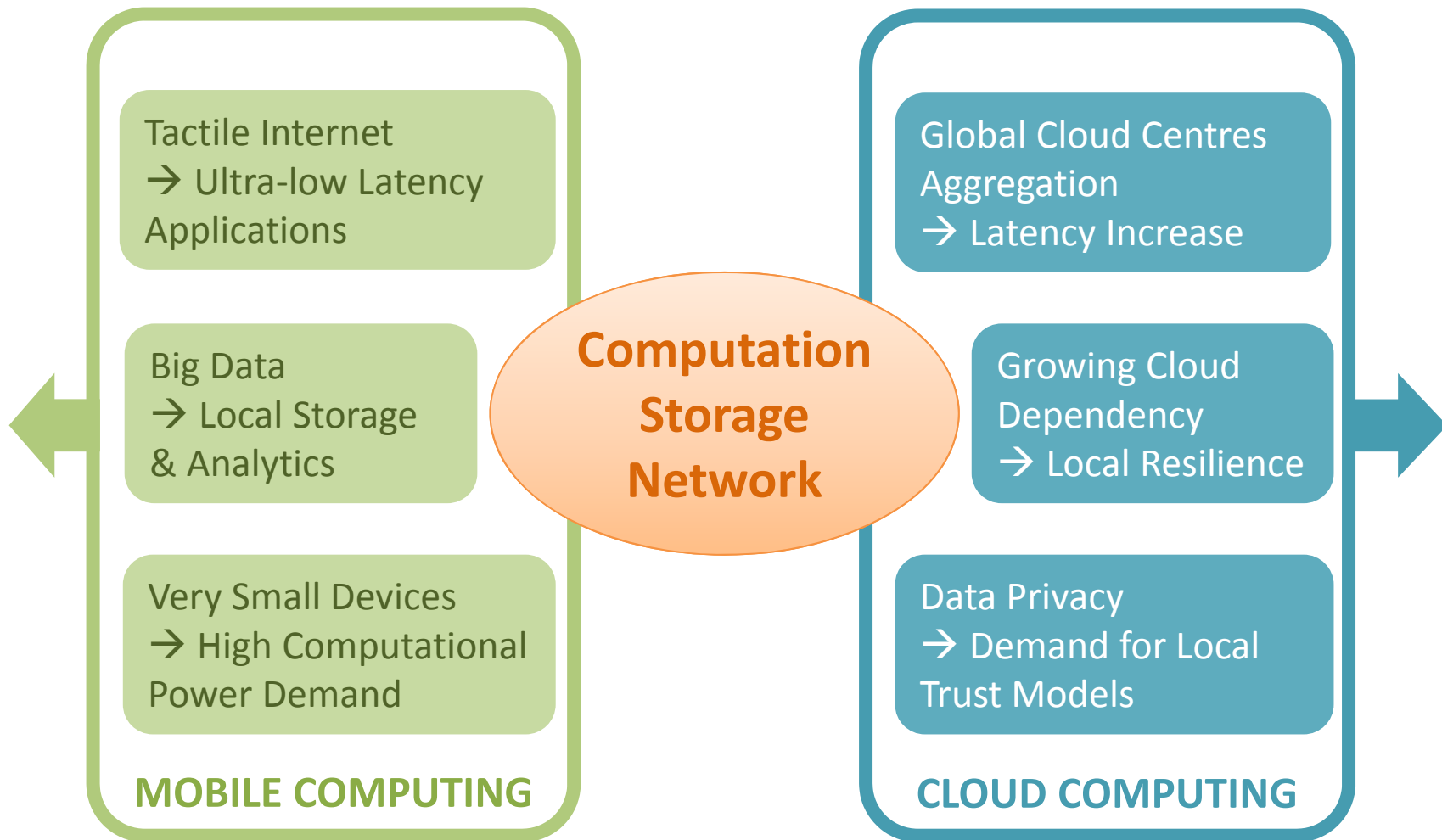
December 2015

## Two Megatrends...



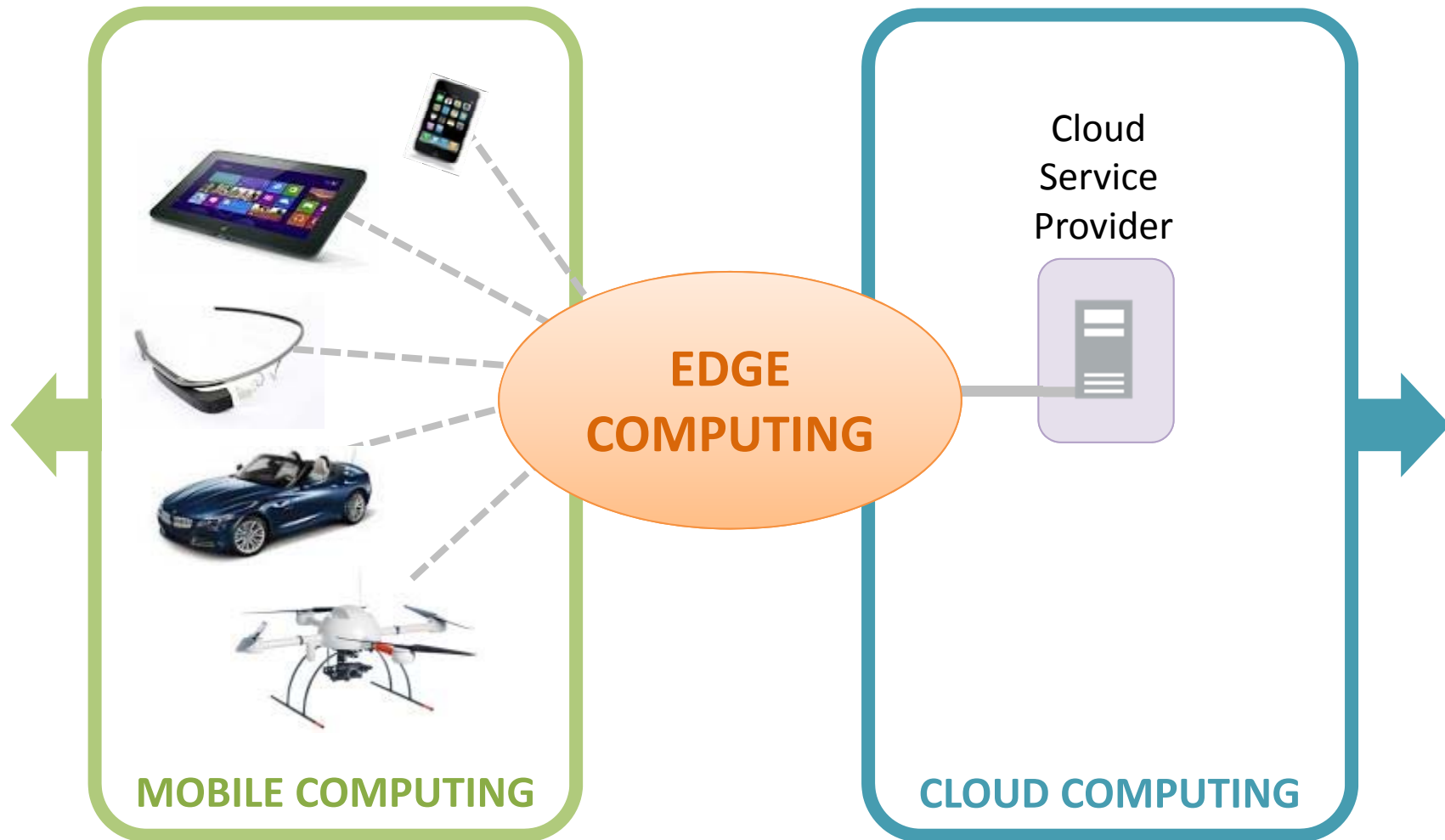
➡ ... are slowly drifting apart!

# Current Trends & Developments



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

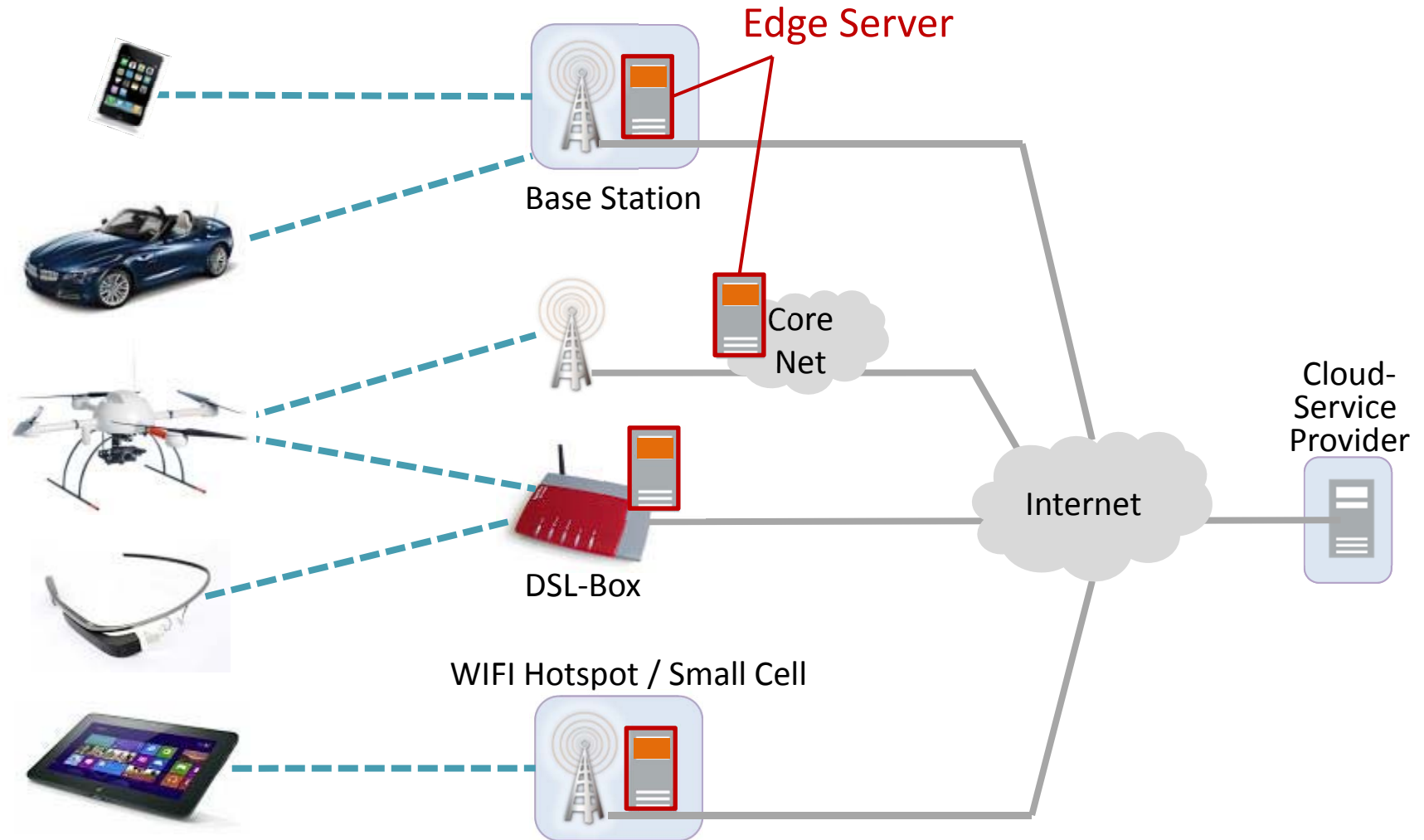
# We Need „Edge Computing“



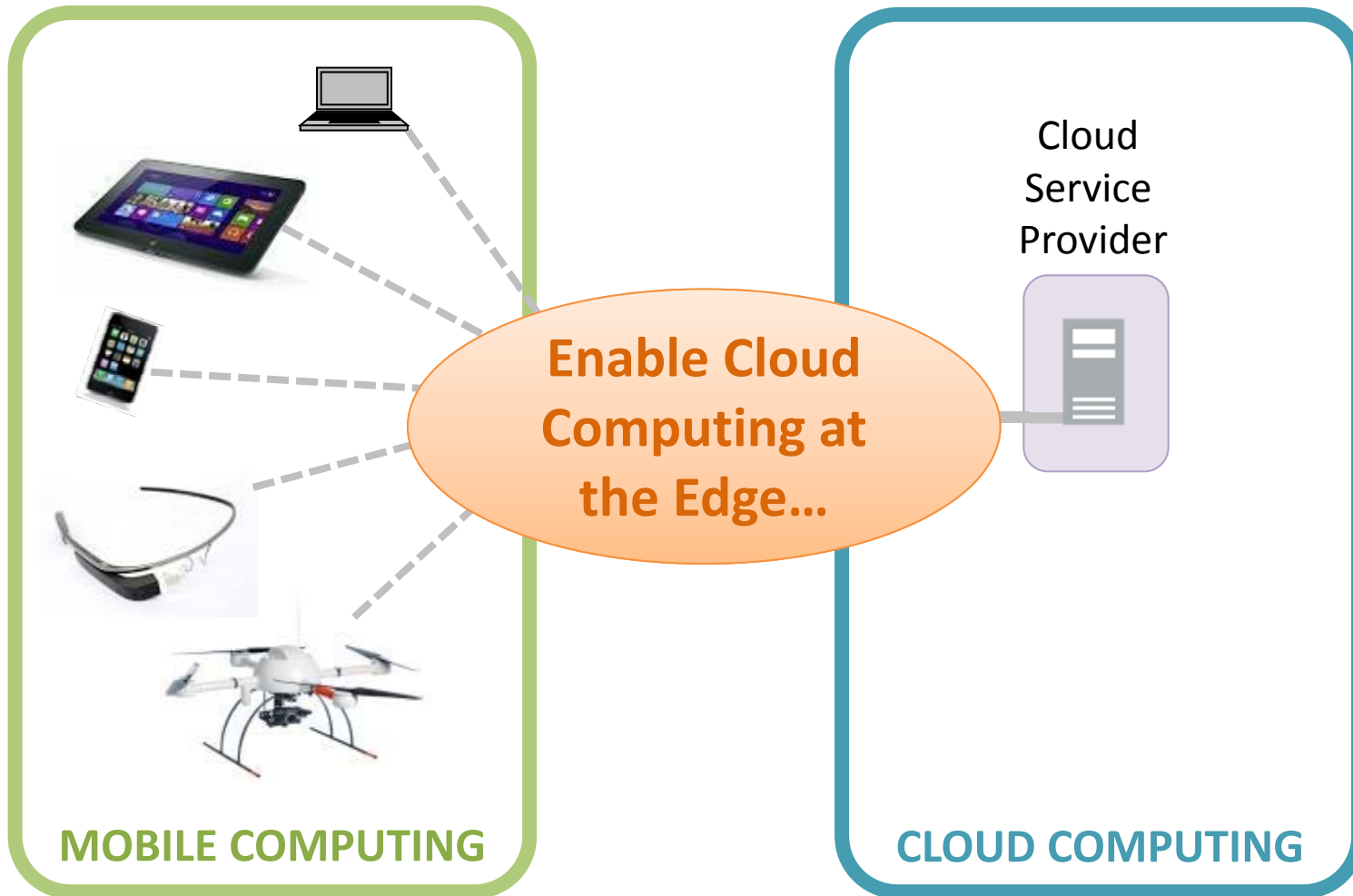
➔ Edge Computing: Little data centres and computing resources right next to the mobile device or sensor

# Open Edge Computing Vision:

All network edge components offer standardised and open Edge Resources to any mobile application or system to enable Edge Computing

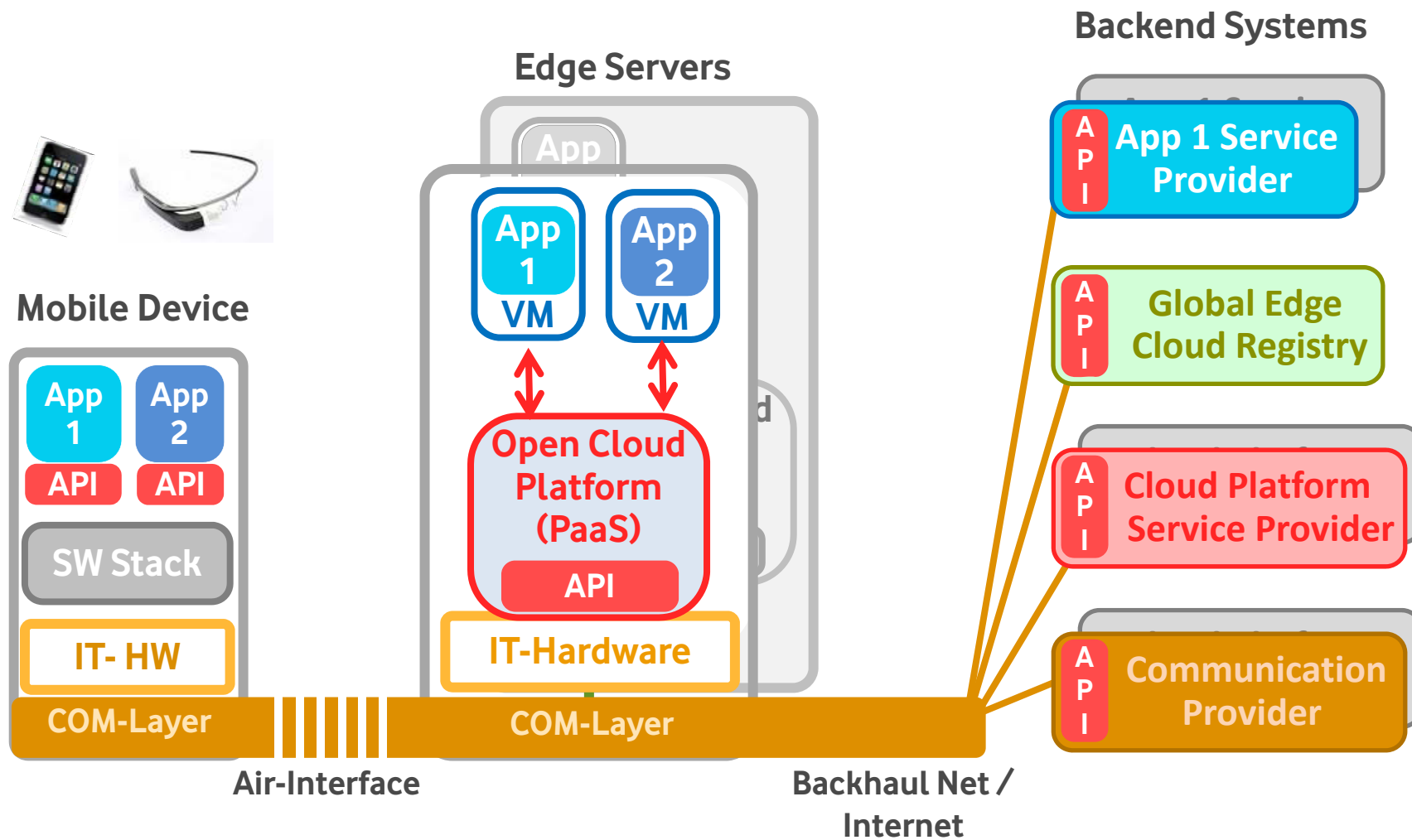


# Open Edge Computing – Main Targets



**... and allow any application to utilise it!**

# Open Edge Computing – Component Overview





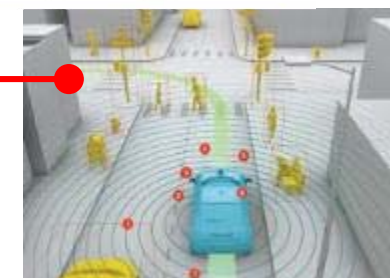
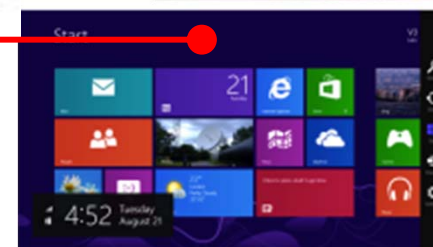
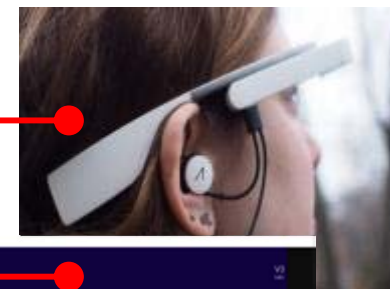
# **BUSINESS OPPORTUNITIES AND VALUE CHAIN**



# Many Edge-enabled Business Opportunities Emerge

## Example Areas

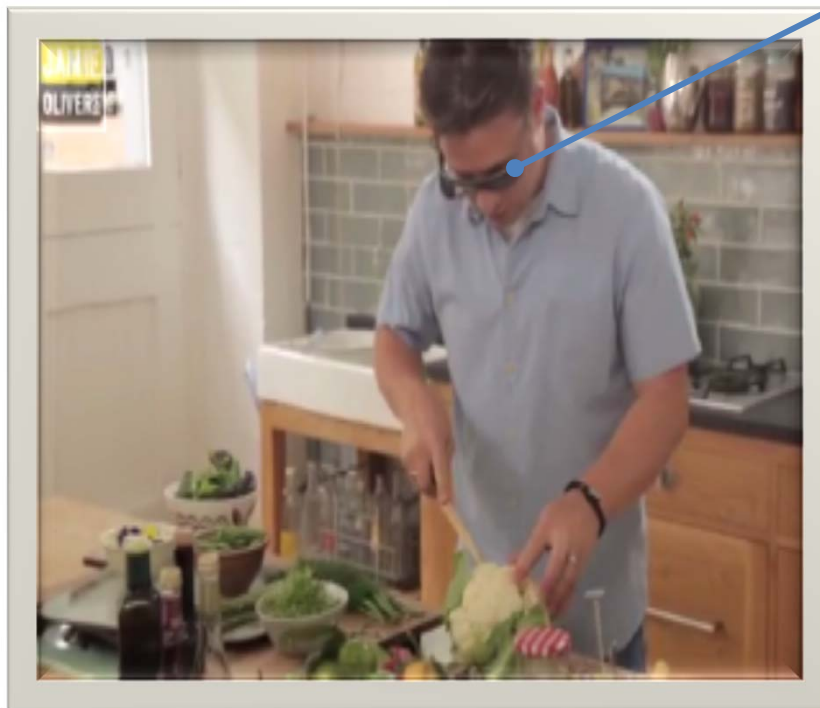
- Cognitive assistance services
- Public safety
- Enterprise Services (e.g. virtual desktop)
- Augmented reality
- Sensor Data Services
- New Automotive Services
- Mobile App Enhancements
- Industry 4.0
- Sensor Data Services
- Drone Support Services
- Health and Sports Services
- Online Gaming
- Enhanced Communication Services



Refer to appendix for further details!

# 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 a university class at Carnegie Mellon University: <http://www.cs.cmu.edu/~15-821/project-demo-day.html>

# Business Value enabled through Edge Computing

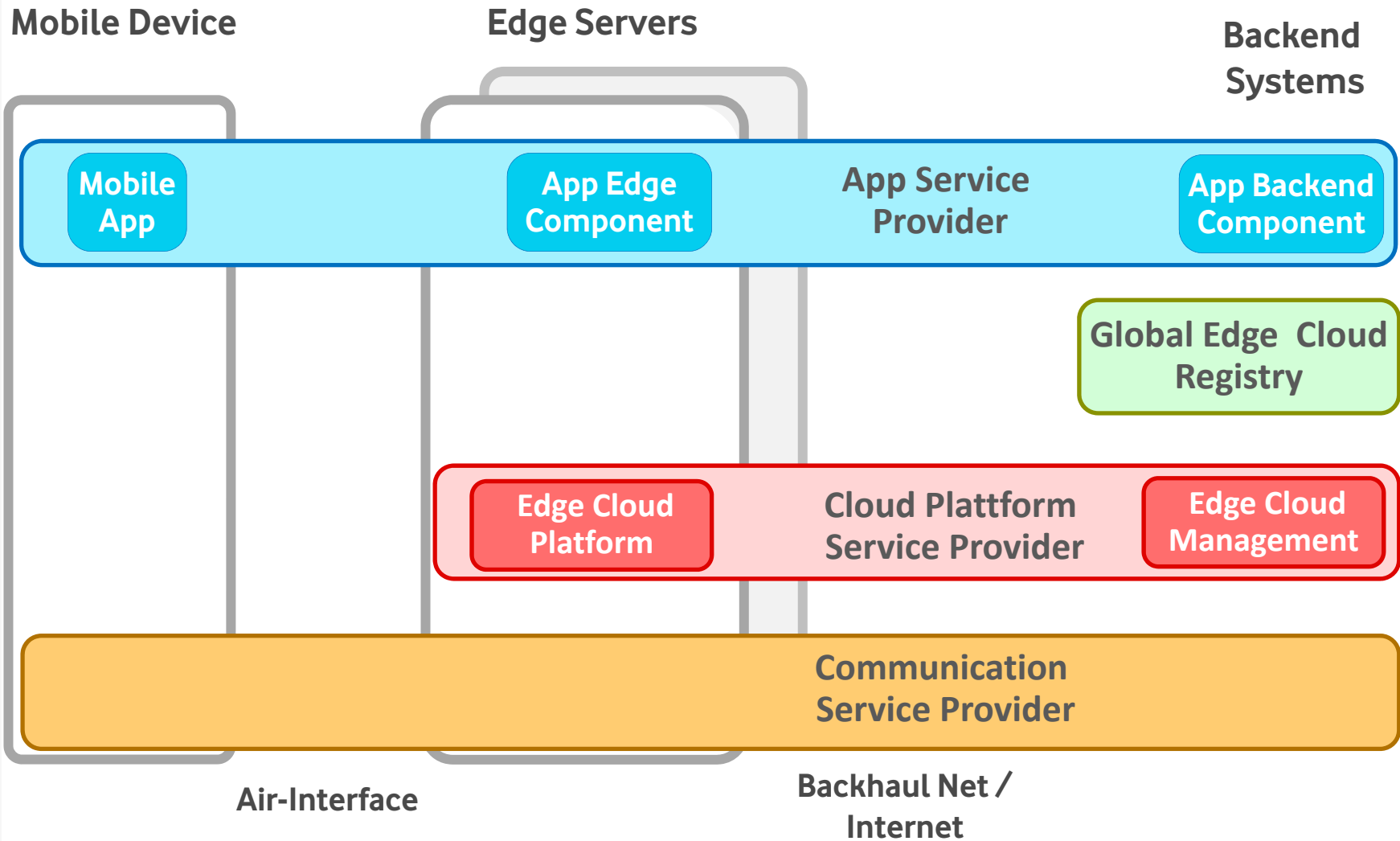
## Business & Customer Value

- 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)

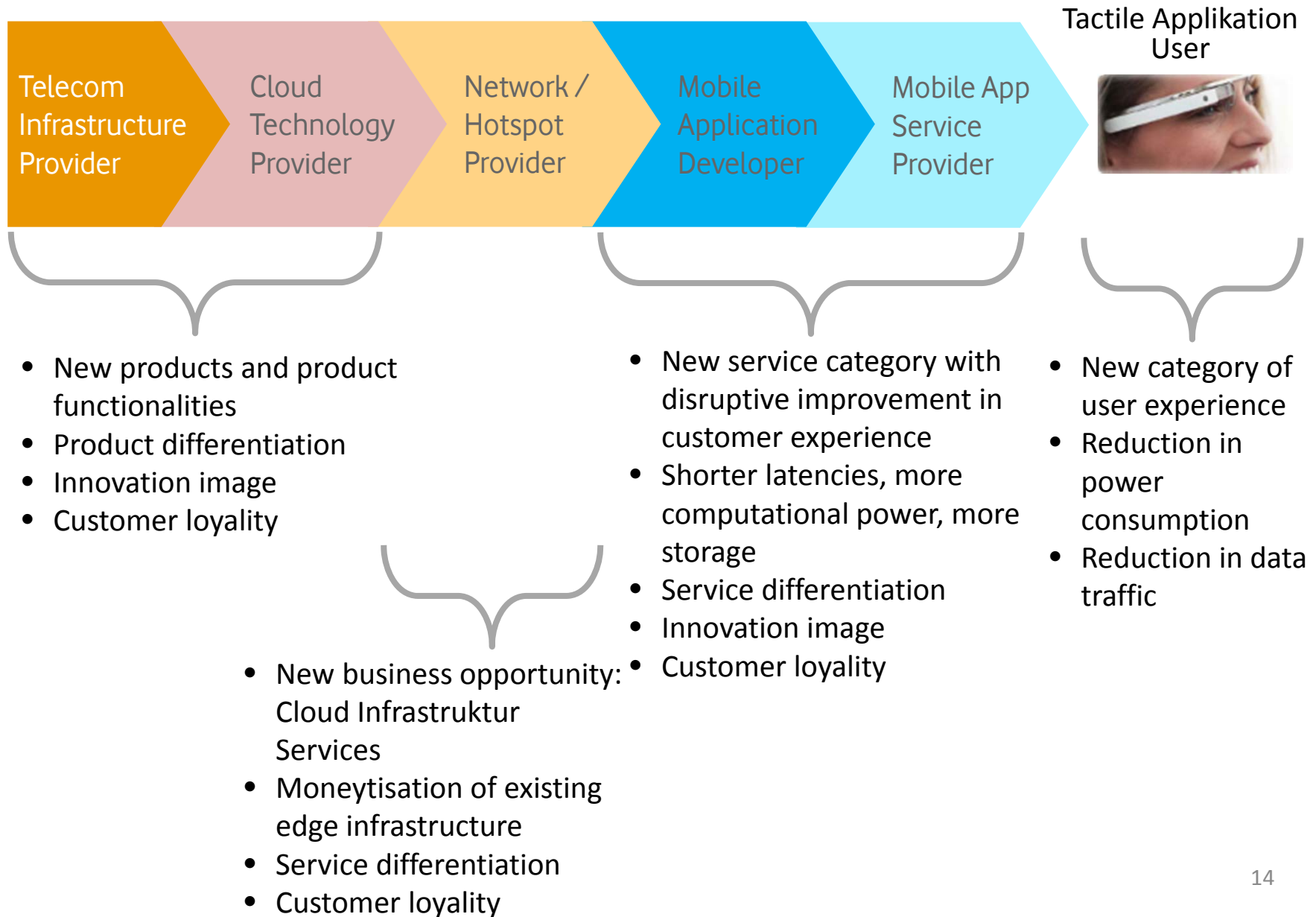
## Prime factors

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

# Overview Components and Business Entities



# All Players in the Value Chain Benefit from Open Edge Computing





# TECHNOLOGY OVERVIEW

# Edge Computing Technology - Current Situation & Gaps

- Base station technology with integrated edge server components are available in the market from several vendors since 2013. Other edge technology is under development.
- 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 „Mobile Edge Computing“ actively develops
  - Requirements for Mobile Edge Computing
  - Edge architecture focussing on mobile base-stations
  - Standard API's for telcom related edge applications
- Current Gaps:
  - We have to be open regarding the positioning of the edge component (base station, core net, elsewhere)
  - To make this a success it is important to pursue this together with the IT industry

Edge Cloud Component



Mobile Basis-Station



## General Target:

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



# Open Edge Computing Reference Platform

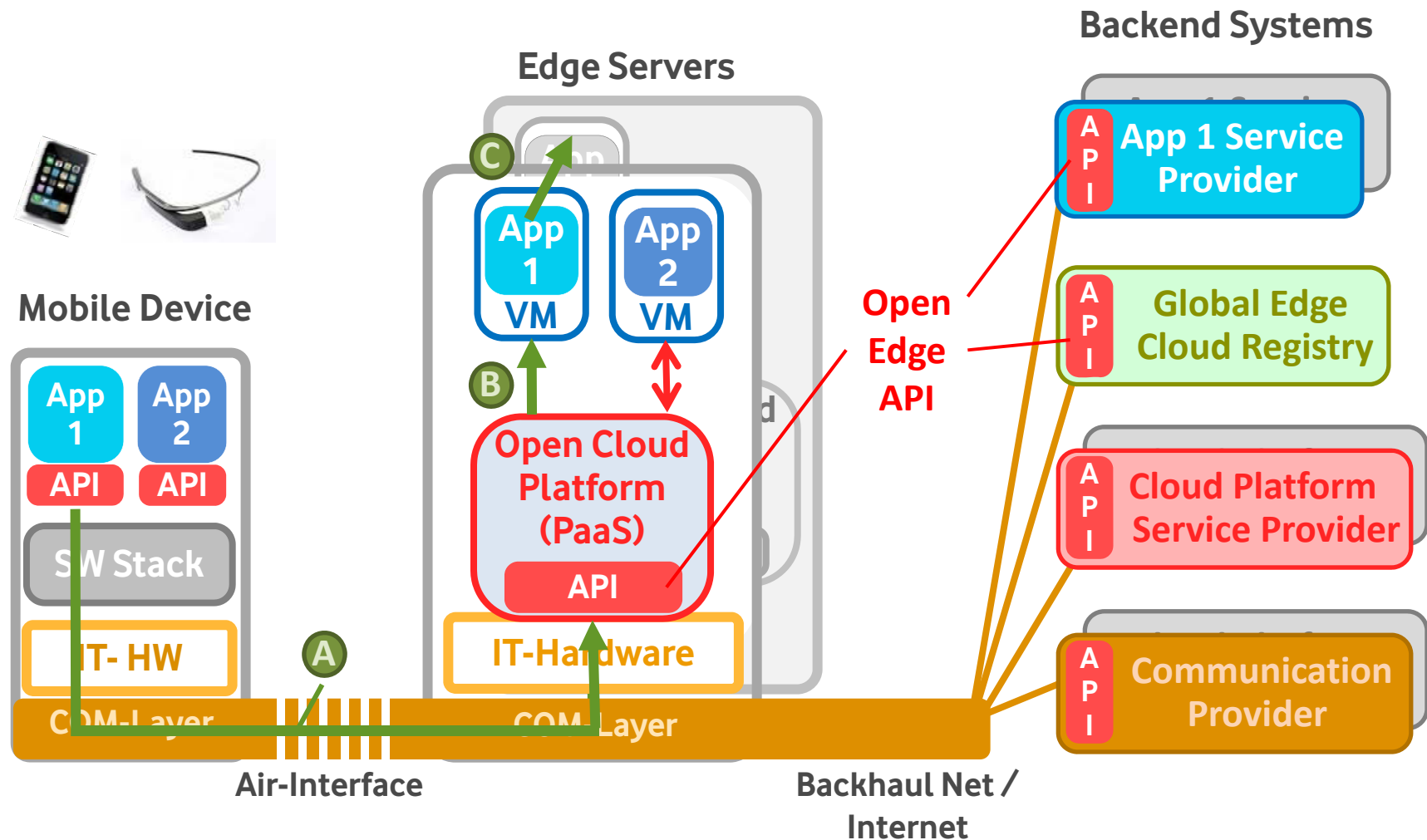


- We have implemented a first version of the Reference Platform for Open Edge Computing
  - The Reference Platform is an open source implementation that provided extensions to OpenStack
  - It adds a few key functions to the standard OpenStack version to enable Edge Computing
  - It is based on an Open 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



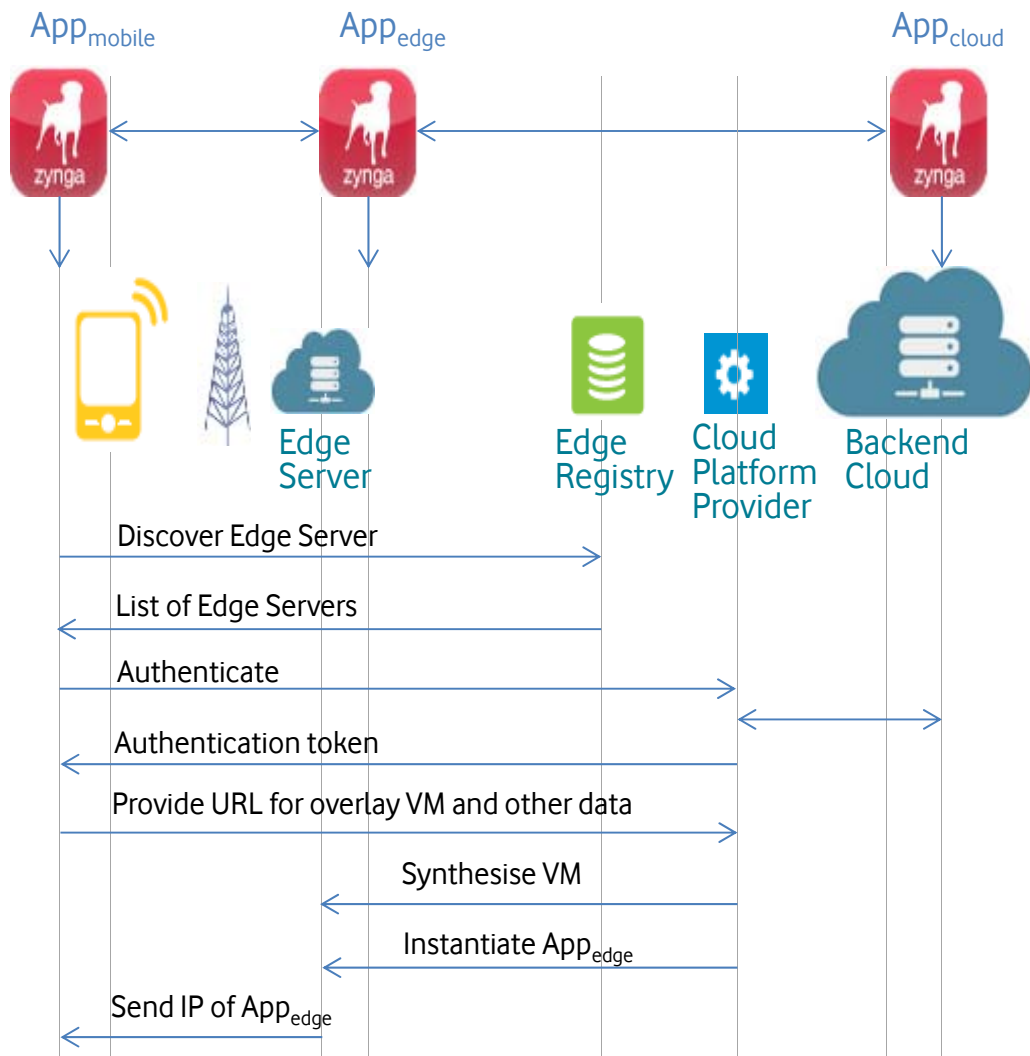
**Short Term Target:** Introduce that Edge Reference Platform to the OpenStack Community and make it an integral part of the next OpenStack release

# 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>
  - VM handoff: Scheduled for December 2015
- 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>



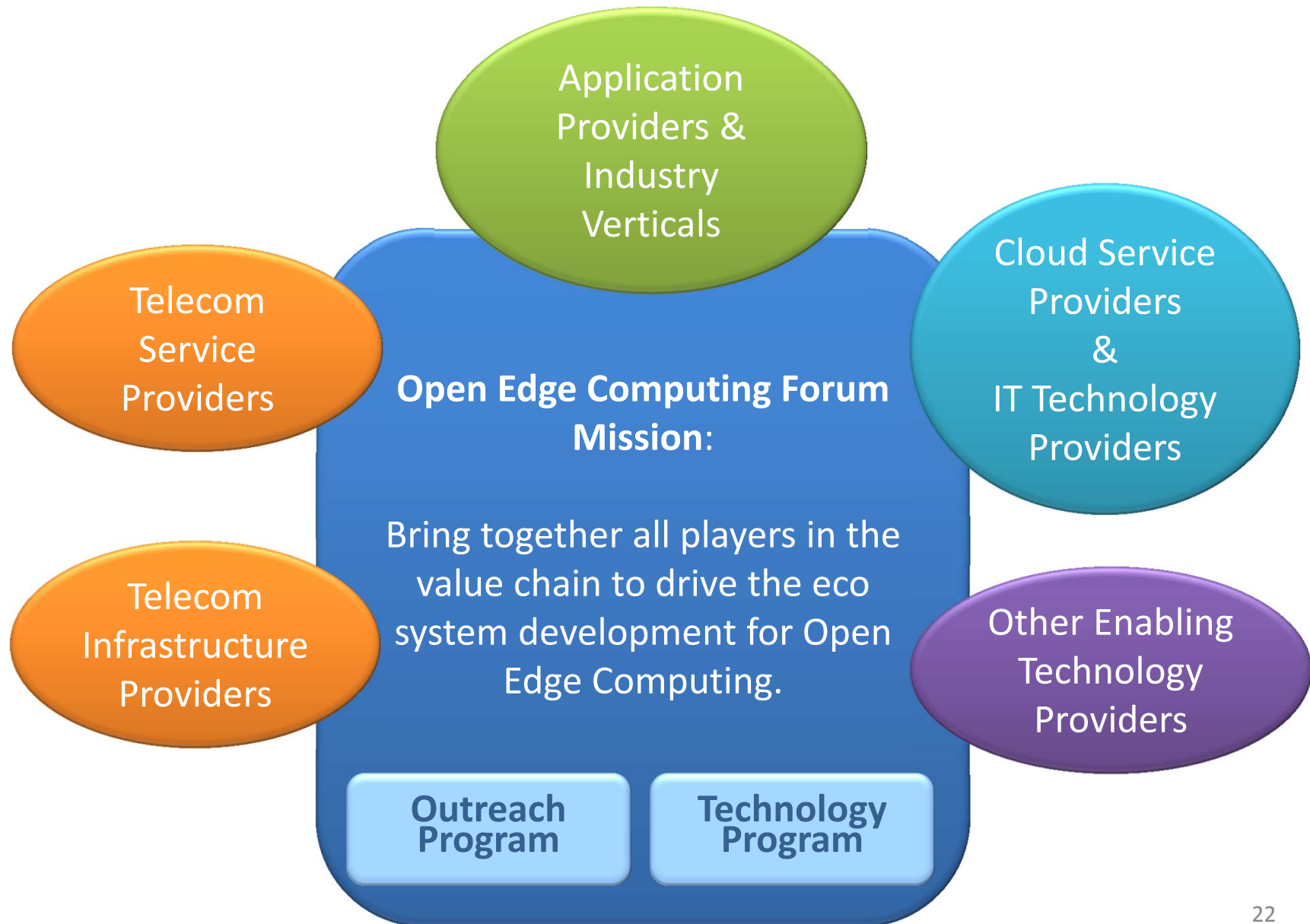
Target: Get the reference implementation and Edge API accepted by OpenStack Foundation for the code release in May 2016



# **OPEN EDGE COMPUTING INITIATIVE**

**→ MISSION AND TARGETS**

# 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 and real-world installations
  - Offer them opportunities to develop new business
  - Drive the adoption of edge computing as a new cloud computing area: Get OpenStack++ extensions and API accepted in OpenStack. Establish an OpenStack developer community for edge computing
  - 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 installations
  - 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, NFV, OPNFV, SDN etc)
  - Drive alignment and resolution of conflicts between big players



# Open Edge Cloud Initiative - Current Partners

(as of December 2015)

## Industry Partners

- Huawei
- Intel
- Vodafone



## Academic Partners

- Carnegie Mellon University



➔ The Initiative is open to other partners who are ready to contribute to success of the initiative

## Summary and Next Steps

- Open Edge Computing enables a new category of services and customer experience:
  - Augmented Reality, Virtual Desktop, Assisted Driving, Drone Control etc.
- Edge Computing offers attractive benefits and business opportunities for ALL players in the value chain
- However, complex eco-system development is required. Hence, we need a joint and coordinated action between
  - Application Service Providers / Industry Verticals
  - Telecom Service Providers / Infrastructure Providers
  - Cloud Service Providers / IT Technology Providers
- The Open Edge Computing Initiative orchestrates and drives the business development of edge computing with all of these industries
  - Drive acceptance and usage of an Open Edge API and a Cloud Reference Platform
  - Initiate development of demonstrator and real-world edge applications
  - Gather requirements from Application Service Providers / 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!

Please contact: [info@openedgecomputing.org](mailto:info@openedgecomputing.org)



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# APPENDIX

# Overview Edge-enabled Business Opportunities (1 of 2)

## **Tactile Apps & Enhancements**

- Augmented reality with local Object data bases
- Mobile cognitive assistance
- Assembly instructions
- Split-application architectures
- Reduction in power consumption and / or data traffic

## **New Automotive Services**

- Local street maps and local 3D point clouds support
- Column driving control
- Assisted / automated driving support

## **Enterprise Services**

- Virtual edge-enabled desktop on simple display
- Indoor navigation services based on 3D point clouds
- Face recognition services

## **Health and Sports Services**

- Remote diagnosis
- Home care robot control
- Medical training assistant
- Sports training assistant

## **Sensor Data Services**

- Local sensor data collection (bridges, traffic)
- Radar and imaging vehicles data analytics
- Resource prospect exploration & analytics
- Video Analytics Services
- Geolocation detection at edge

## **Security and Emergency Services**

- Resilient local data centre services
- Left baggage / stolen car detection
- Fire fighting robot control

# Overview Edge-enabled Business Opportunities (2 of 2)

## Industry 4.0

- Material and tool inspection
- Industrial troubleshooting
- Automation support services
- Manufacturing remote machinery and robot control

## Drone Services

- Drone control with local 3D point clouds
- Drone control for precision agriculture

## Virtual Customer Premise Equipment

- vCPE for consumer services (DSL-box, video services etc.)
- vCPE for enterprises (to improve performance)

## Online Gaming

- Home game console with fixed line edge support
- Optimizing server location for multiparty games

## In-Vehicle Services

- Cloudlet in cars, planes, ships etc.

## Communications Services

- Edge video caching
- Video streaming optimisation
- Adaptive traffic shaping

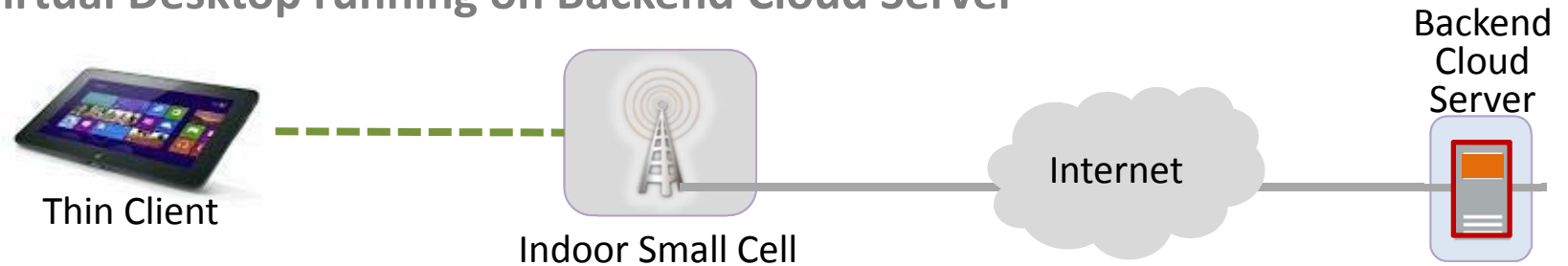
## Long-term Opportunities

- Remote Surgery
- Exoskeleton control
- Edge components on handsets

# Demonstrator: Tactile Thin Client

## Virtual Desktop Service for Enterprises

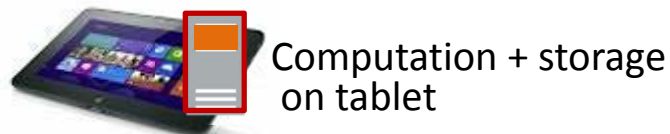
### 1. Virtual Desktop running on Backend Cloud Server



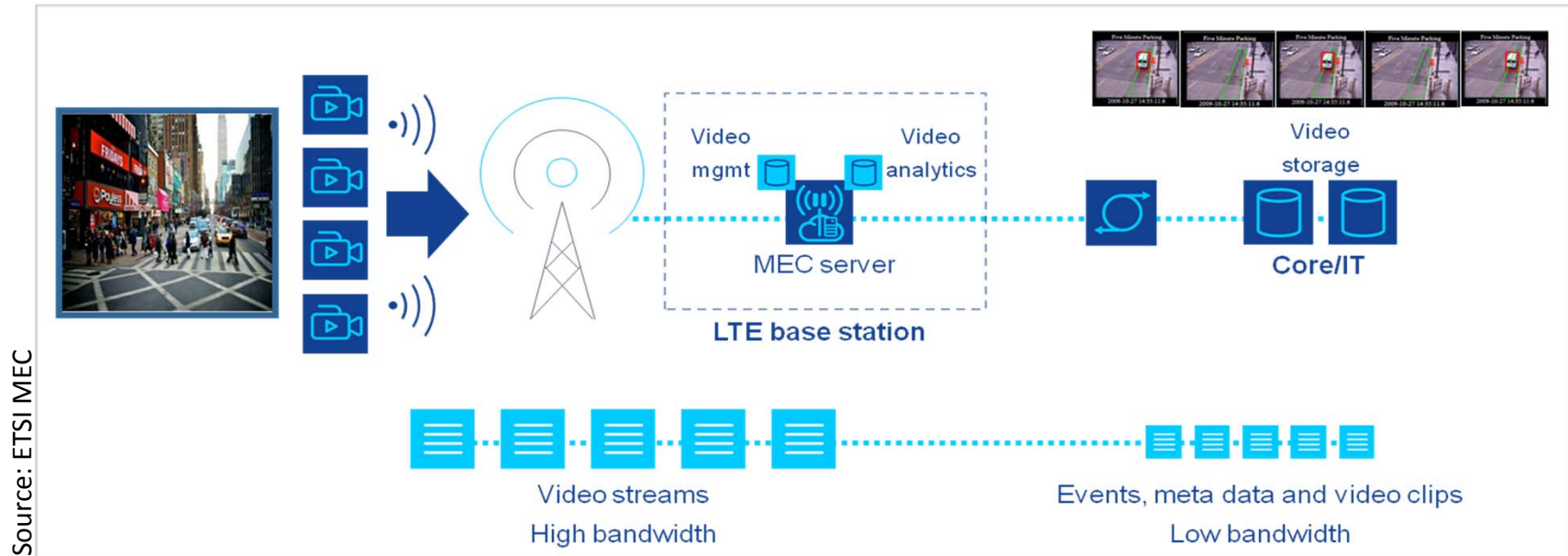
### 2. Virtual Desktop running on Edge Cloud Server



### 3. Desktop running directly on tablet



# IoT Use Case: Edge Video Analytics



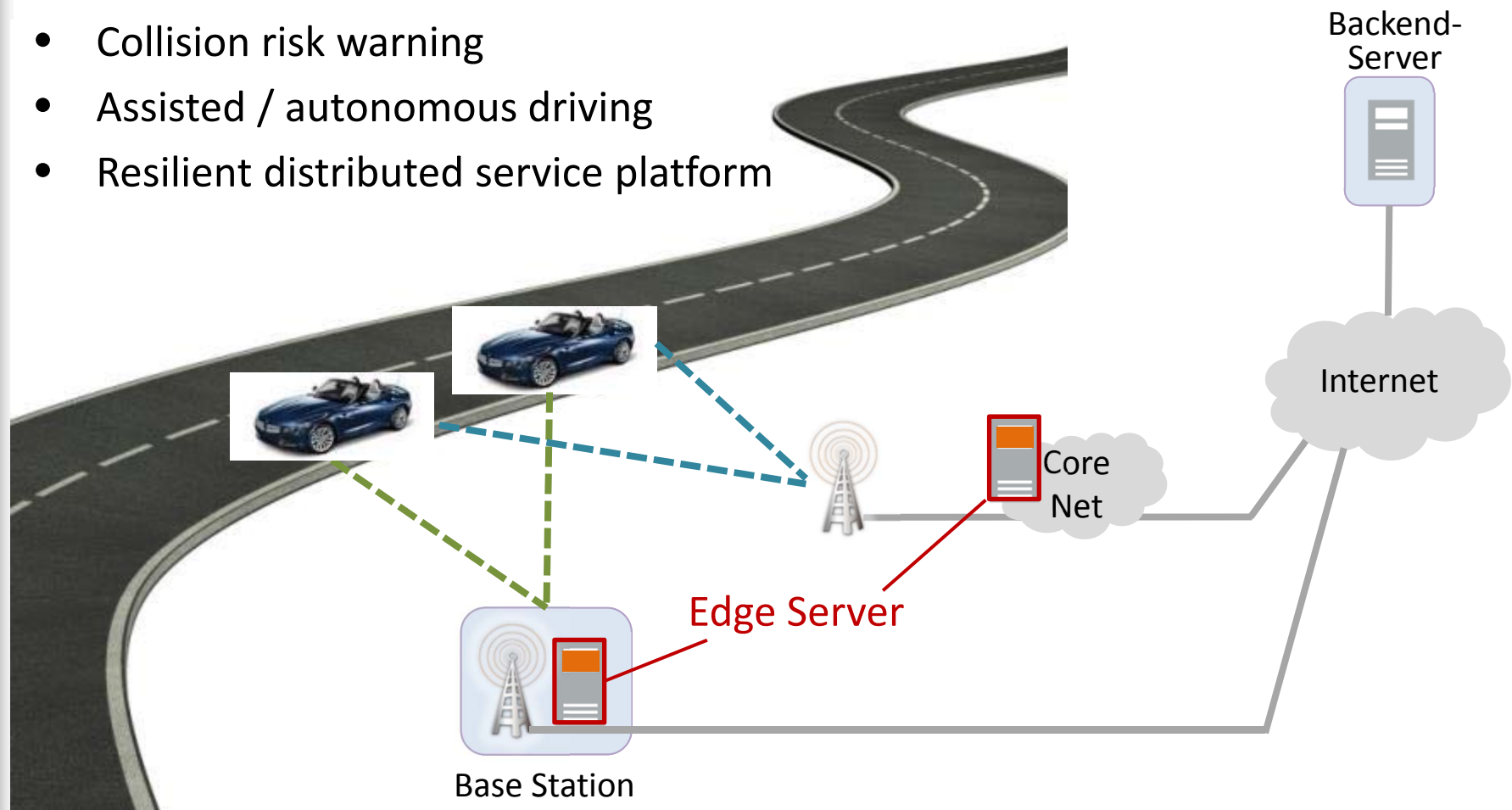
- Distributed live video streams analytics at the mobile edge
- Events are triggered automatically (e.g. movement, missing objects, crowd, etc.); enables fast detection and action triggering
- Optimizes backhaul and transport capacity
- Applicable to public safety, smart cities



# Tactile Automotive Services - Overview and Example Services

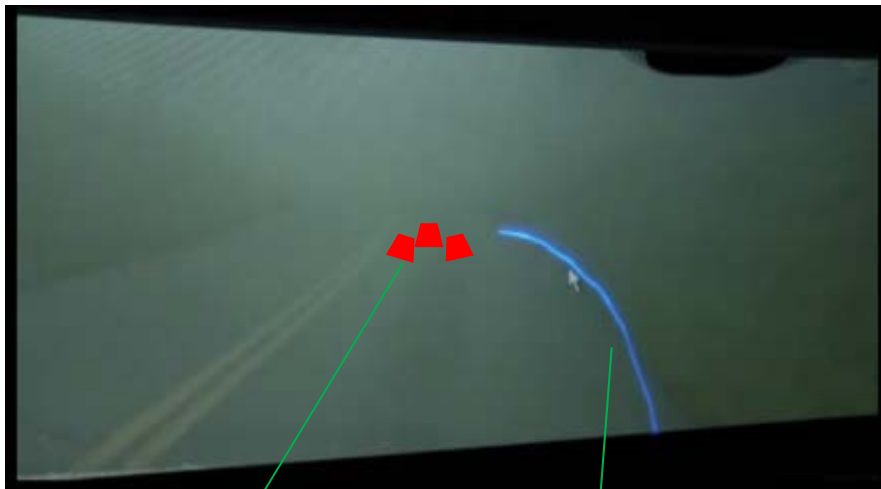
## Example Services

- Electronic emergency brake lights
- Traffic and road condition warning
- Collision risk warning
- Assisted / autonomous driving
- Resilient distributed service platform



# Automotive Use Case: Driving Assistance Service through Edge-Supported Augmented Reality

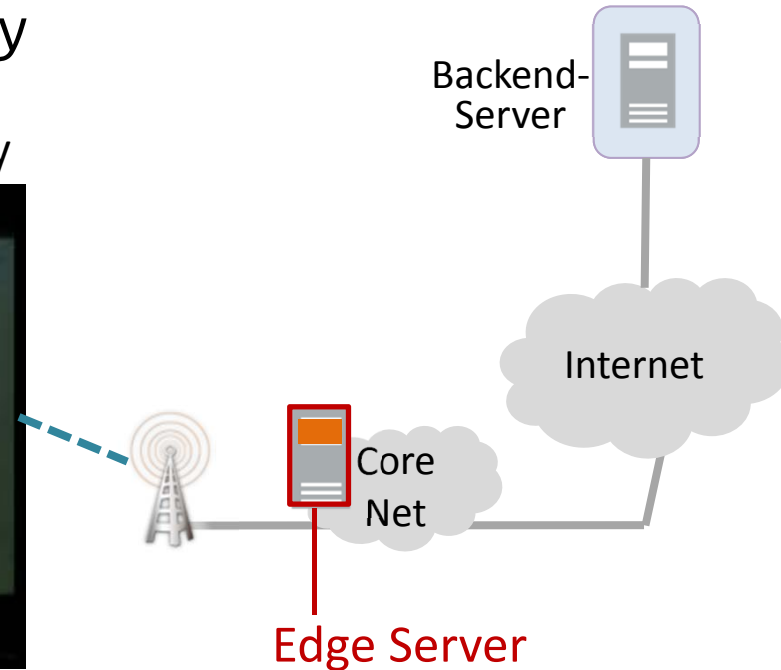
Windscreen with augmented reality overlay



Source: GM 2010

Icy patches reported by cars driving ahead

Roadside overlay derived from latest street model on Edge Server



## Driving Assistance Service

1. Continuous monitoring of road condition by all cars
2. Continuous updating of street model on edge server
3. Provisioning of fast augmented reality overlay on windscreen