Steel: Simplified Development and Deployment of Edge-Cloud Applications

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Cloud Services Have Grown

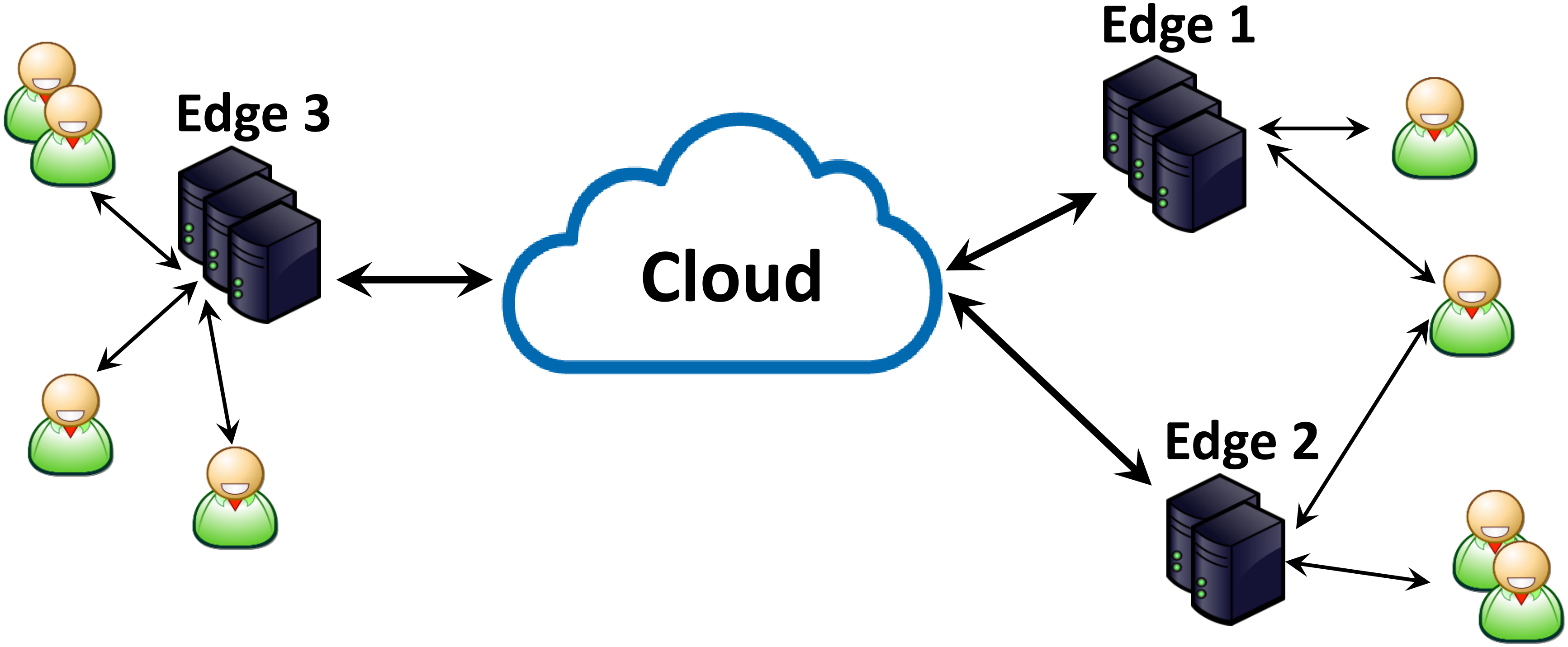
$383 Billion market by 2020 (20% annual growth) [1]

-- increase in the **number** and **variety** of services

Many **complex multi-service** applications have emerged

1. https: //www.gartner.com/newsroom/id/3815165

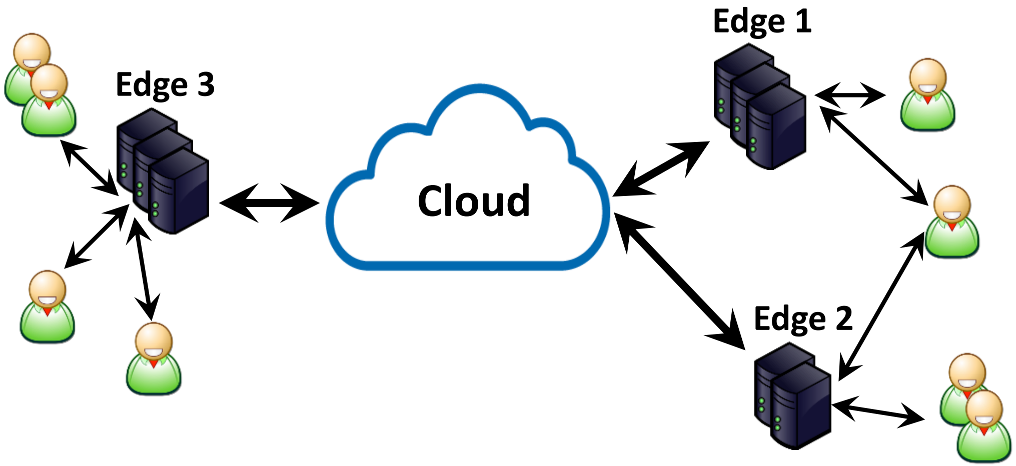
Growing Interest in the “Edge”



Growing Interest in the “Edge”

Why use the Edge?

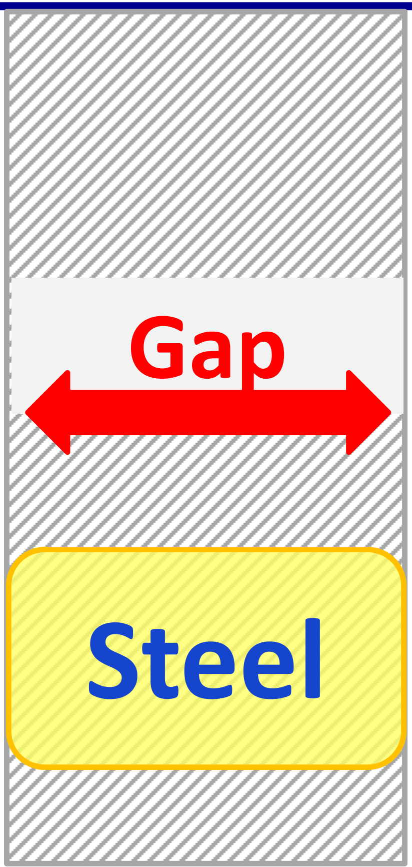
- **Latency**: Edge is close by
- **Cost:** Reduced cost
  - **network** to cloud
  - **services** in cloud
- **Availability**: Continuous service despite disconnects



Industry at Infancy of Edge-Cloud

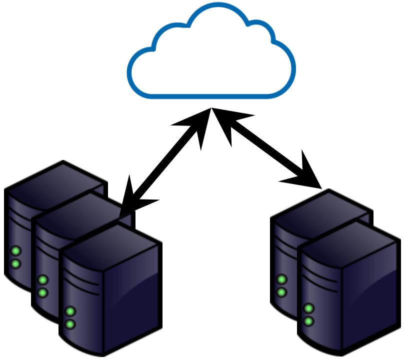
Cloud growth

Complex multi-service applications



Gap

Steel



Emerging **Edge-Cloud** environments

What is the Gap?

Many optional (in cloud-only) **optimizations** are **crucial** in the edge-cloud

- More heterogeneity, more failures, limited resources.
- Placement, communication, load-balancing, etc.

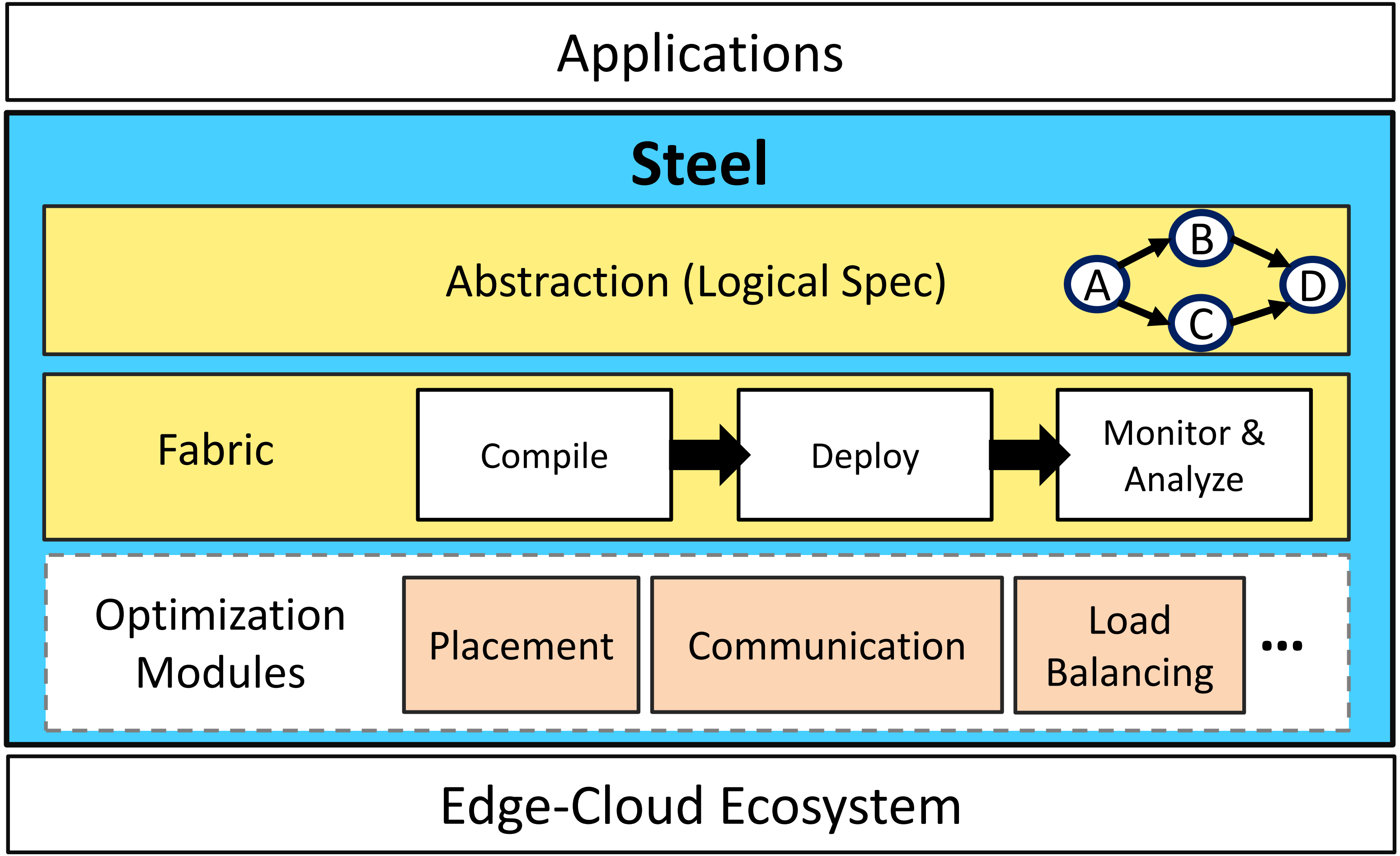
→ **Essential** to readily **move** services & dynamically **adapt**

However…

- **Configuring** services is **cumbersome** and **error-prone**.
- Wide diversity & **compatibility constraints** in services.
- **Optimizations** are **manual** and **non-reusable.**

Integrated with ***production***
Azure services

Steel: A **simplified** & **unified** edge cloud framework with *modular* and **automated optimizations**



Applications

Steel

Abstraction (Logical Spec)

Fabric

Compile

Deploy

Monitor & Analyze

Optimization Modules

Placement

Communication

Load Balancing

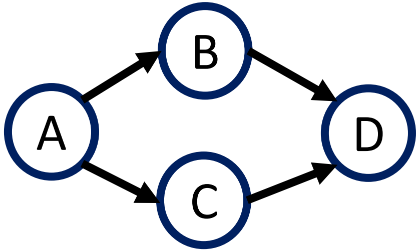
…

Edge-Cloud Ecosystem

Abstraction & Fabric

Abstraction:

1. **Logical DAG** of the application
   - Main services & their connections
2. **Location** of each service



A: Edge 1,
B: Cloud,
…

Fabric: physically materializing & connecting services

Optimization Modules

Placement

Where (edge/cloud) to place?

From the large **search space**

Communication

configure edge-cloud links

Adapt to **short-term** spikes

Load Balancing

Where to move?

Adapt to **long-term** changes

…

Optimizer Modules

Placement

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Load Balancing

Where to move?

Adapt to **long-term** changes

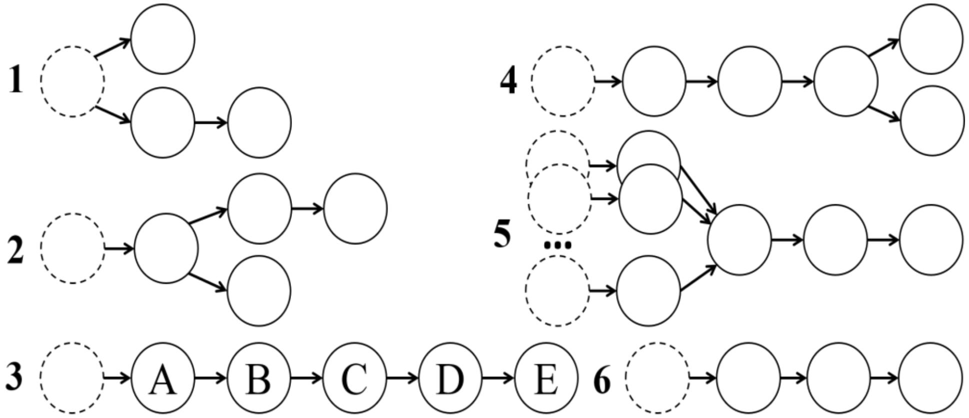
Added to Steel with ~**500 lines** of C# code

Evaluation

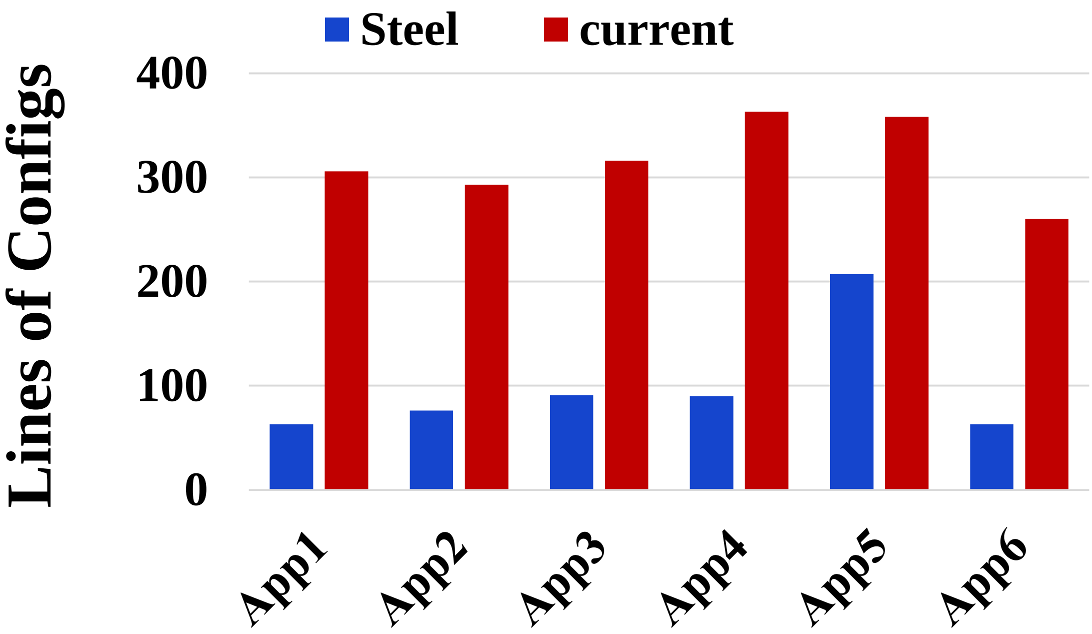
Experimental Setup

Compare many diverse real world applications:

1. Data persisting
2. Predictive maintenance
3. BLE sensor analyzer
4. Factory monitoring
5. Statistic generator
6. Anomaly detector

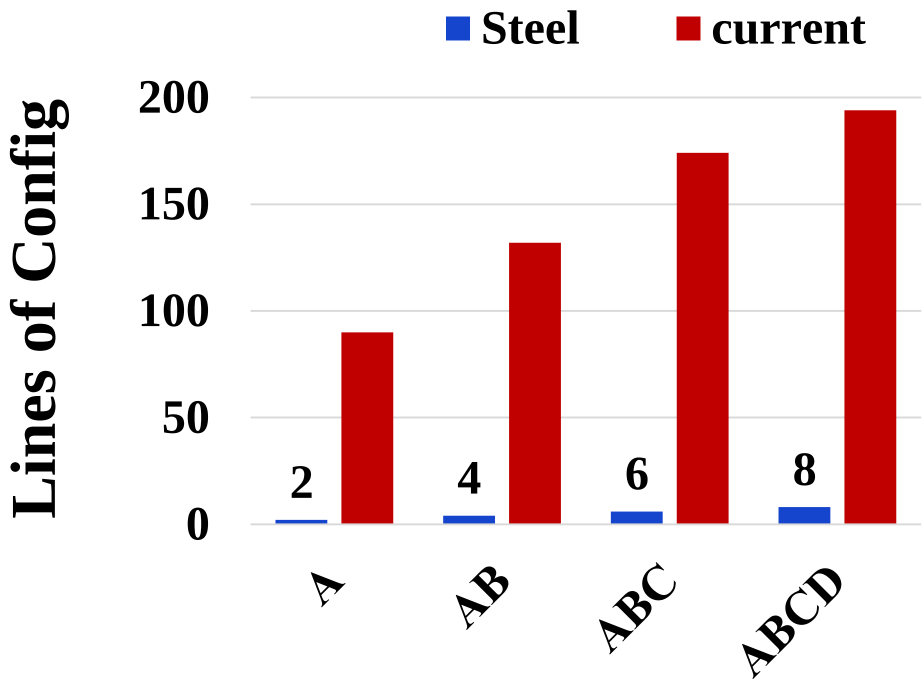


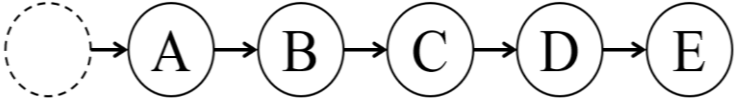
Initial Development Effort



Steel ***reduces*** config **1.7x to 4.8x** vs. current system

Modification Effort

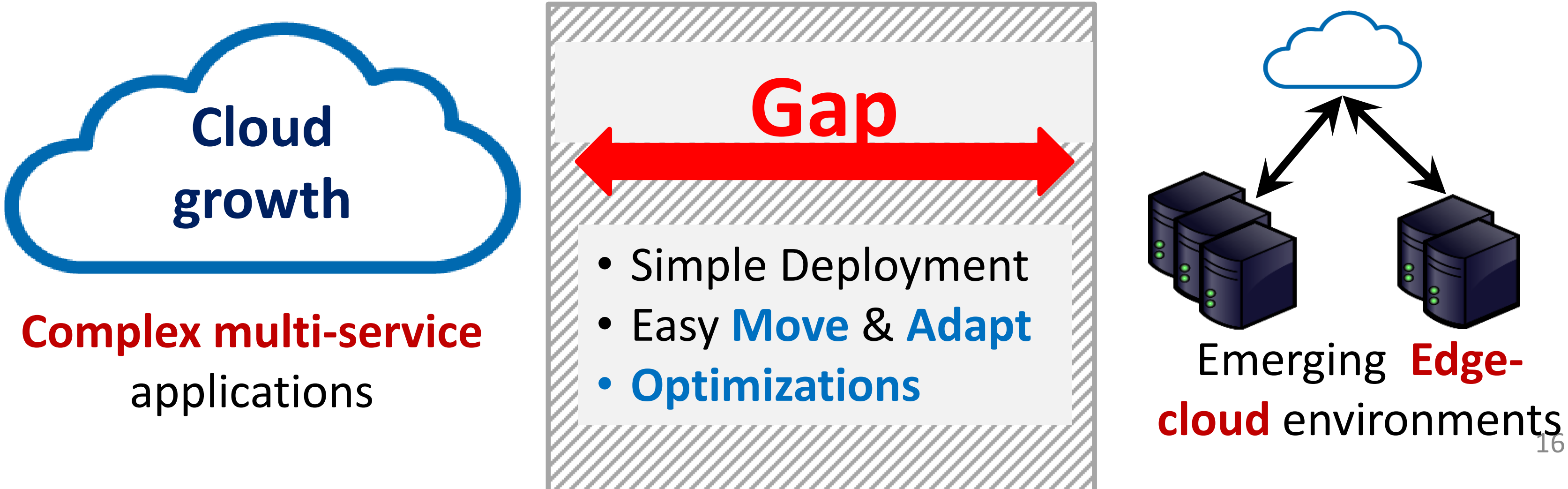




Small, almost **constant** overhead of ~ 2 lines of config

Conclusion

Steel: A **unified** edge cloud framework with **modular** and **automated optimizations**



Cloud growth

Complex multi-service applications

Gap

- Simple Deployment
- Easy **Move** & **Adapt**
- **Optimizations**

Emerging **Edge-cloud** environments

What is Next? What is Hard?

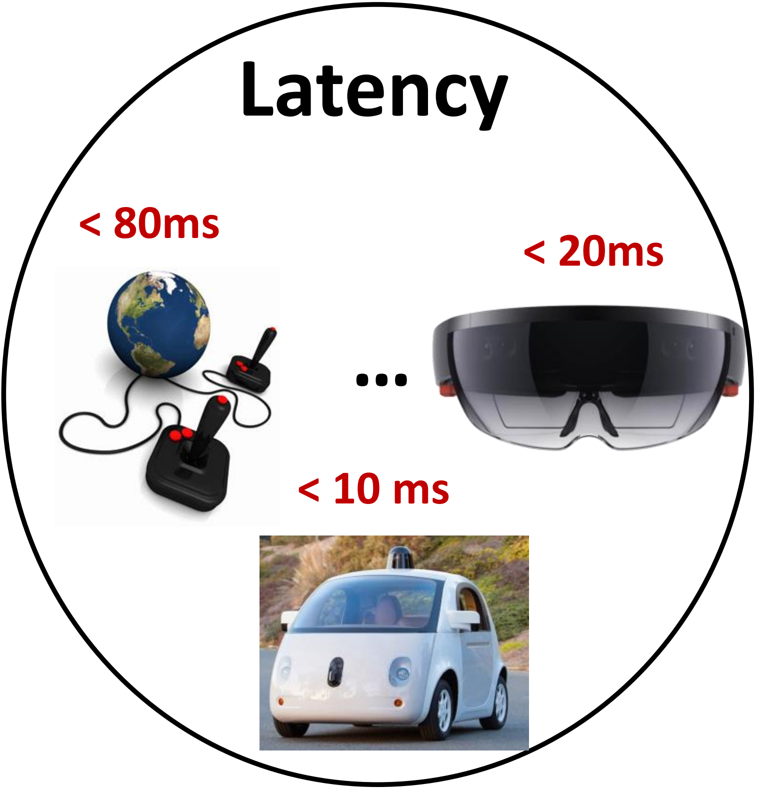
Azure IoT Hub

AWS Greengrass

1. Cloud **services** offering **Edge solutions**
2. Will a general optimization work for most? How to easily **customize**?
3. Incorporate **developer requirements** like SLAs
4. What about **security** & **privacy**?

Back up slides

Cloud is Not an One-Size-Fits-All



Latency

< 80ms

< 20ms

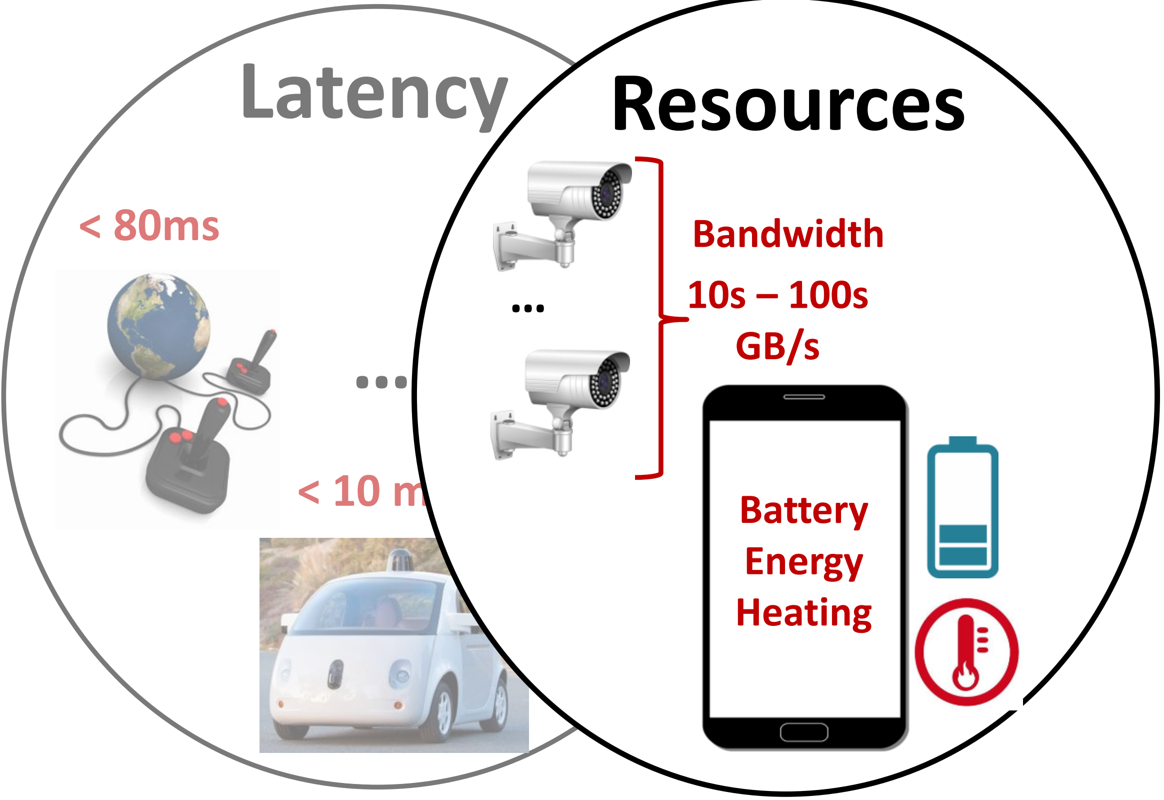
…

< 10 ms

The Cloud is simply **too far**!

> 70 *ms* round trip time

Cloud is Not an One-Size-Fits-All



Latency

< 80ms

…

< 10 m

Resources

…

Bandwidth

10s – 100s GB/s

Battery

Energy

Heating

Not **enough** **resources** to use the Cloud

Cloud is Not an One-Size-Fits-All

Latency

< 80ms

...

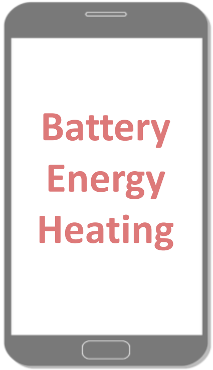
< 10 m

Resources

...

Bandwidth

10s – 100s GB/s



Battery
Energy
Heating

Privacy & Security

...