Bedford Branch

Edge Computing

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About Me

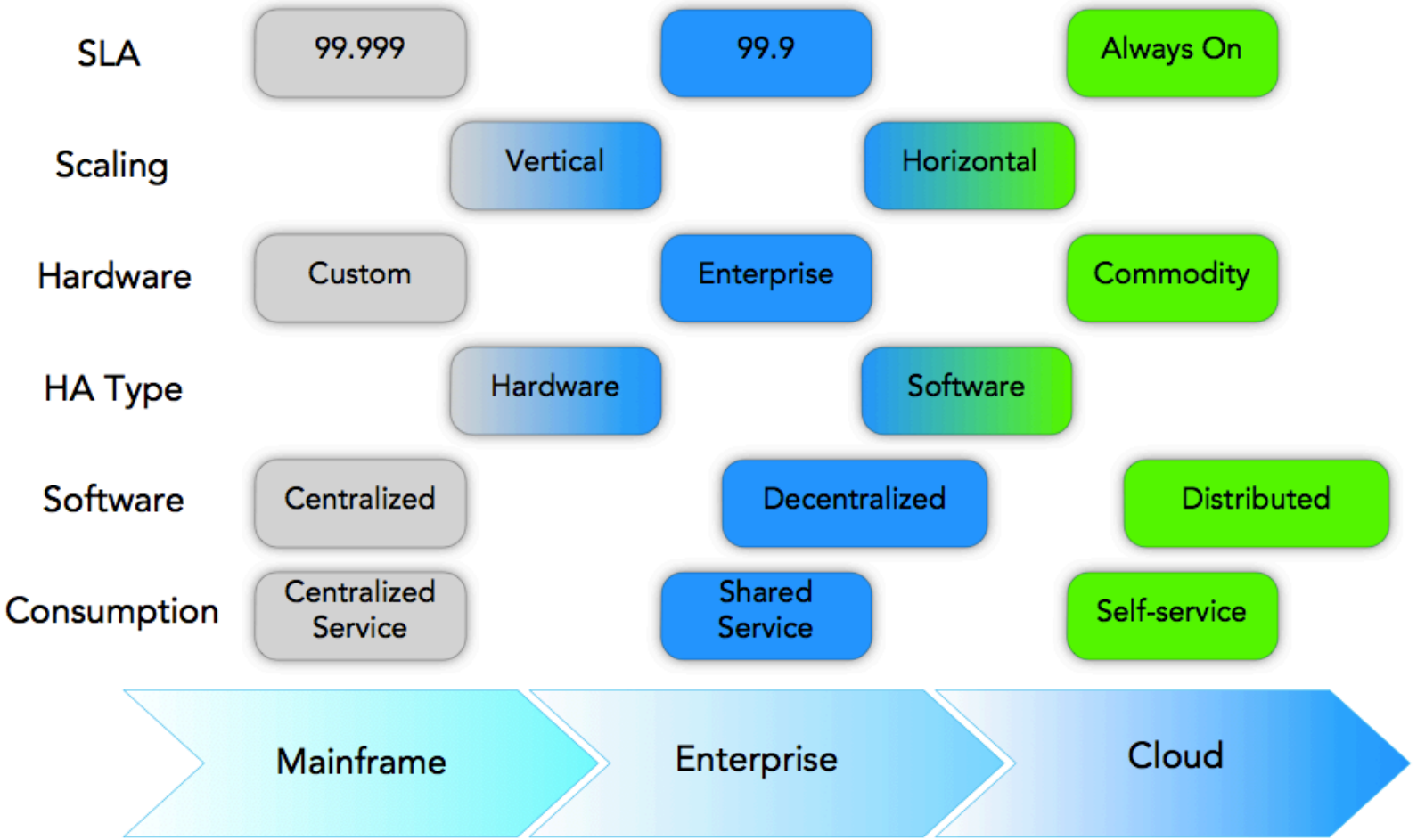
What is Edge Computing?

Definition

“**Edge computing** is a distributed computing paradigm which brings computation and data storage closer to the location where it is needed, to improve response times and save bandwidth”

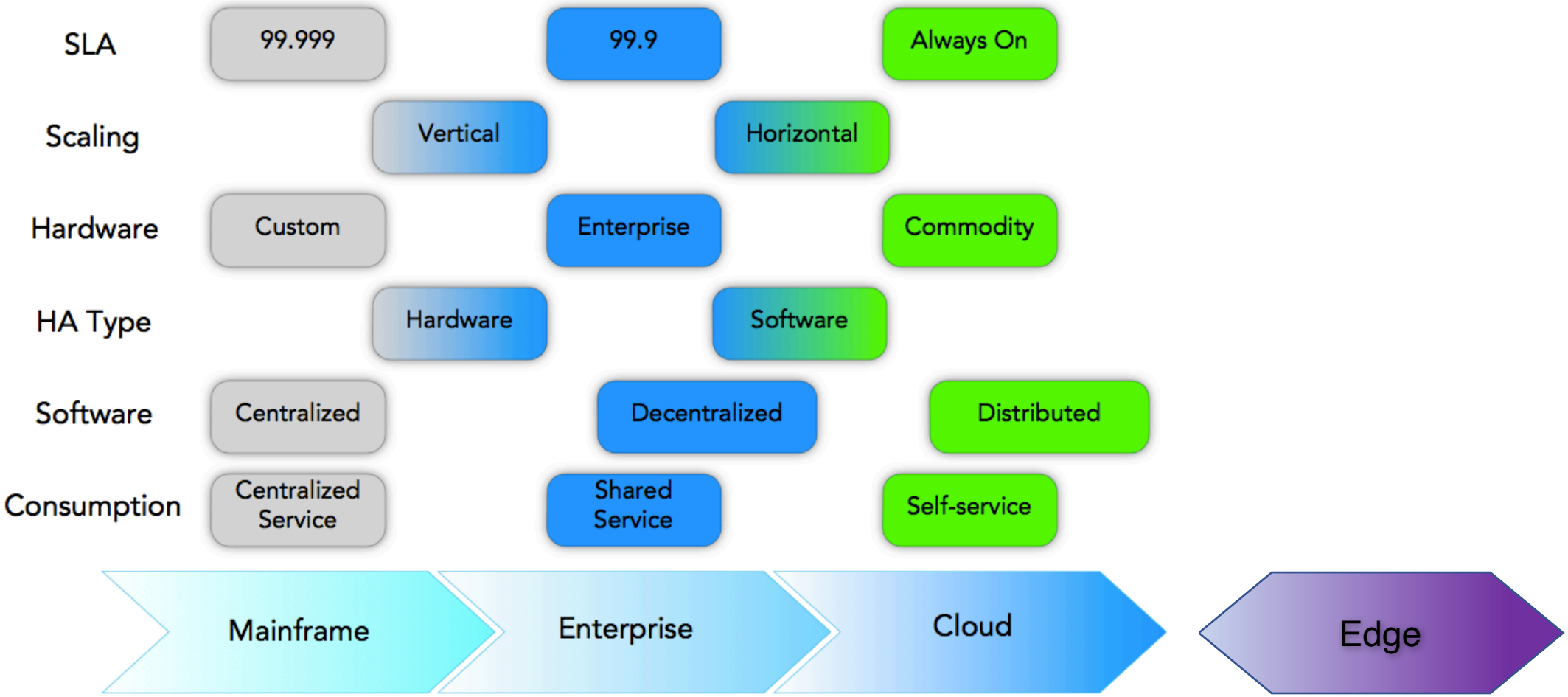
Hamilton, Eric. "What is Edge Computing: The Network Edge Explained". cloudwards.net. Retrieved 2019-05-14.

Evolution of IT Computing Models



Randy Bias Blog, 31/08/2011 cloudave.com

Evolution of IT Computing Models



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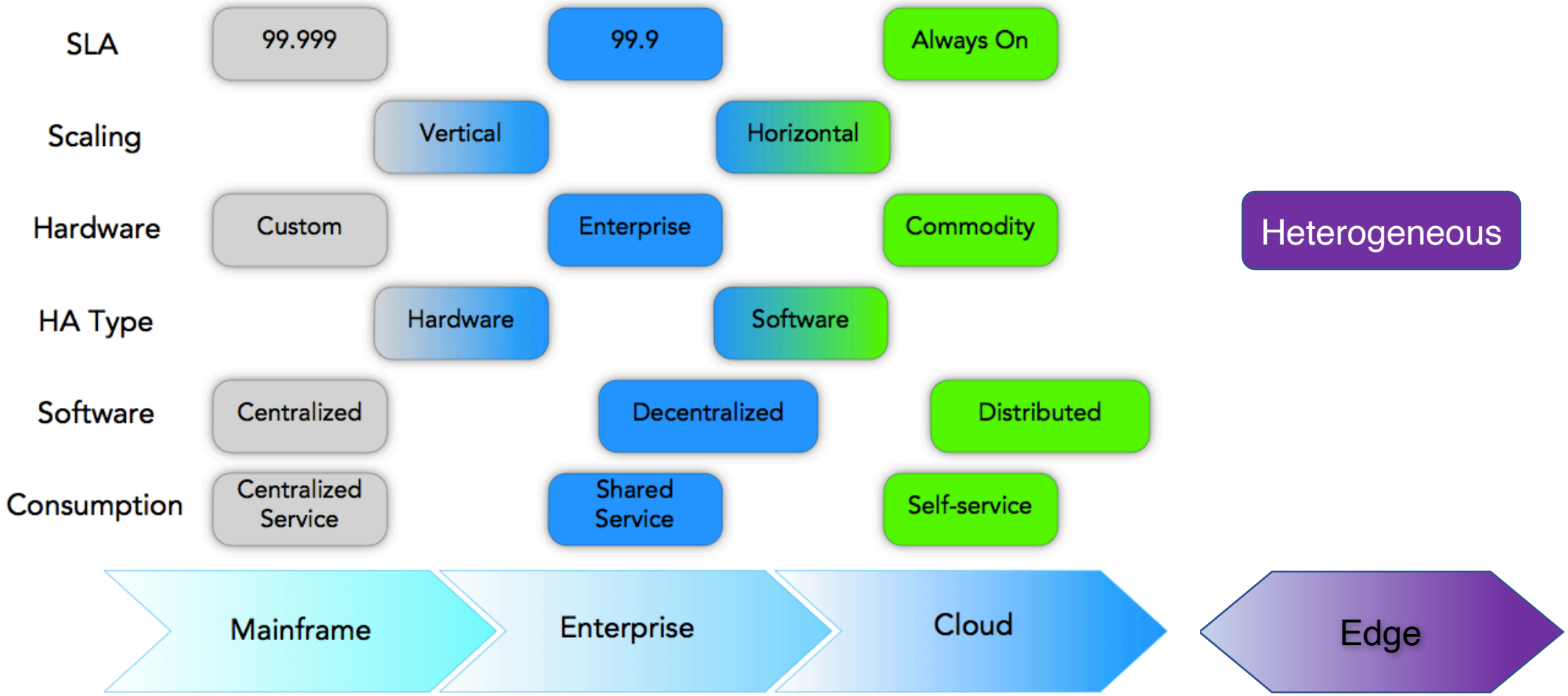

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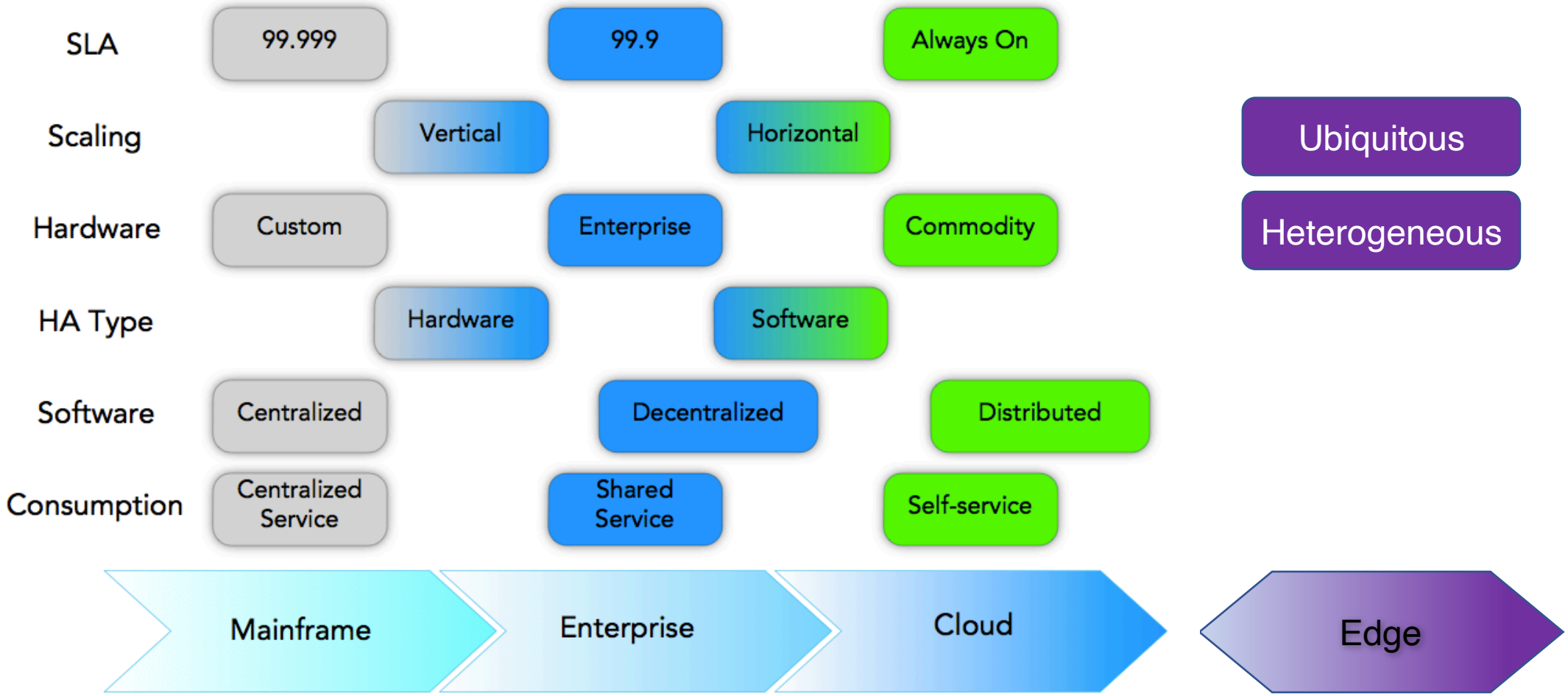

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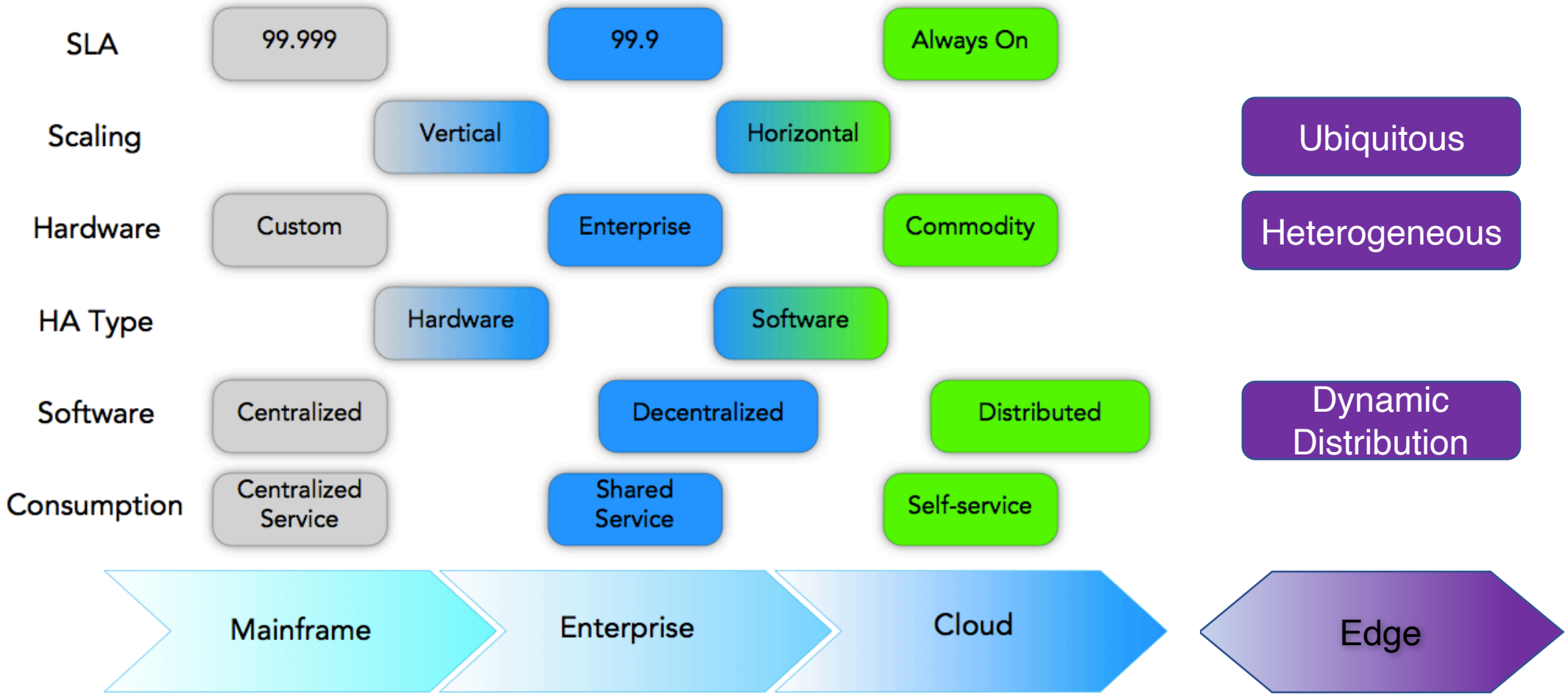

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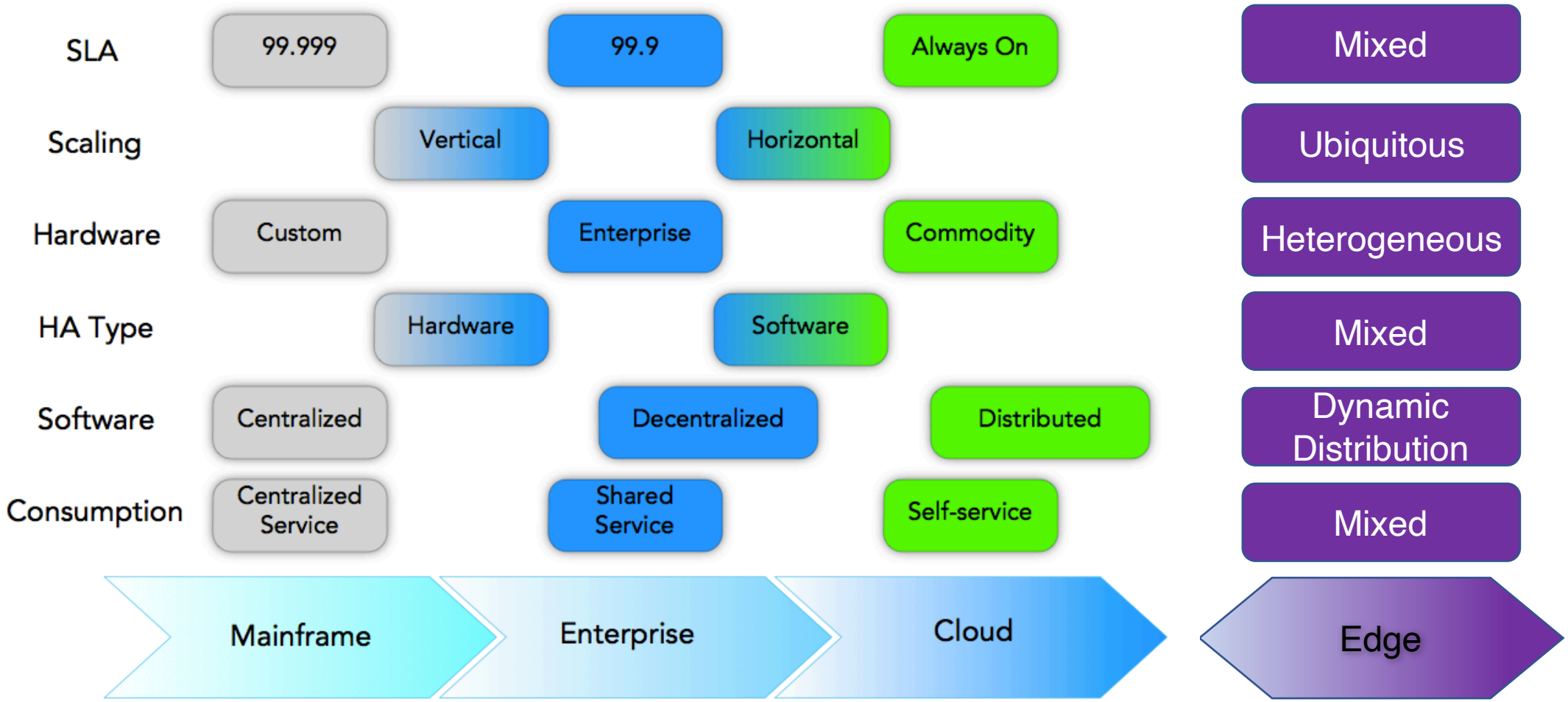

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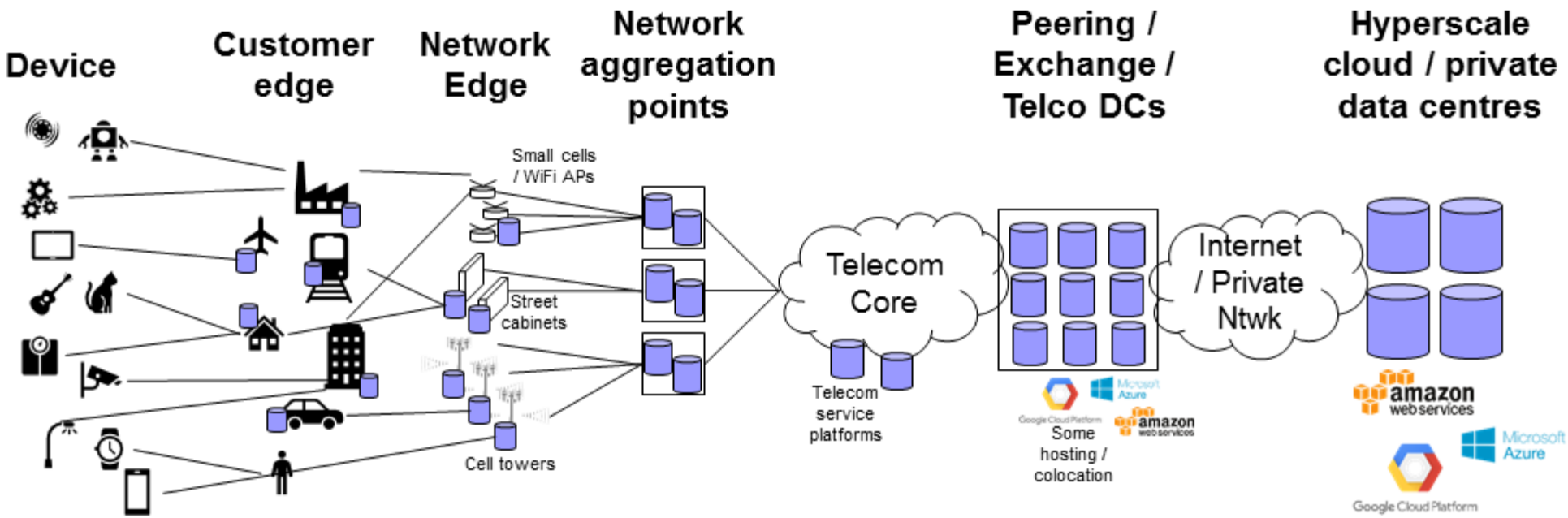
So many Edges

Disruptive Analysis

Don't Assume

Where *is* the edge, for edge computing?



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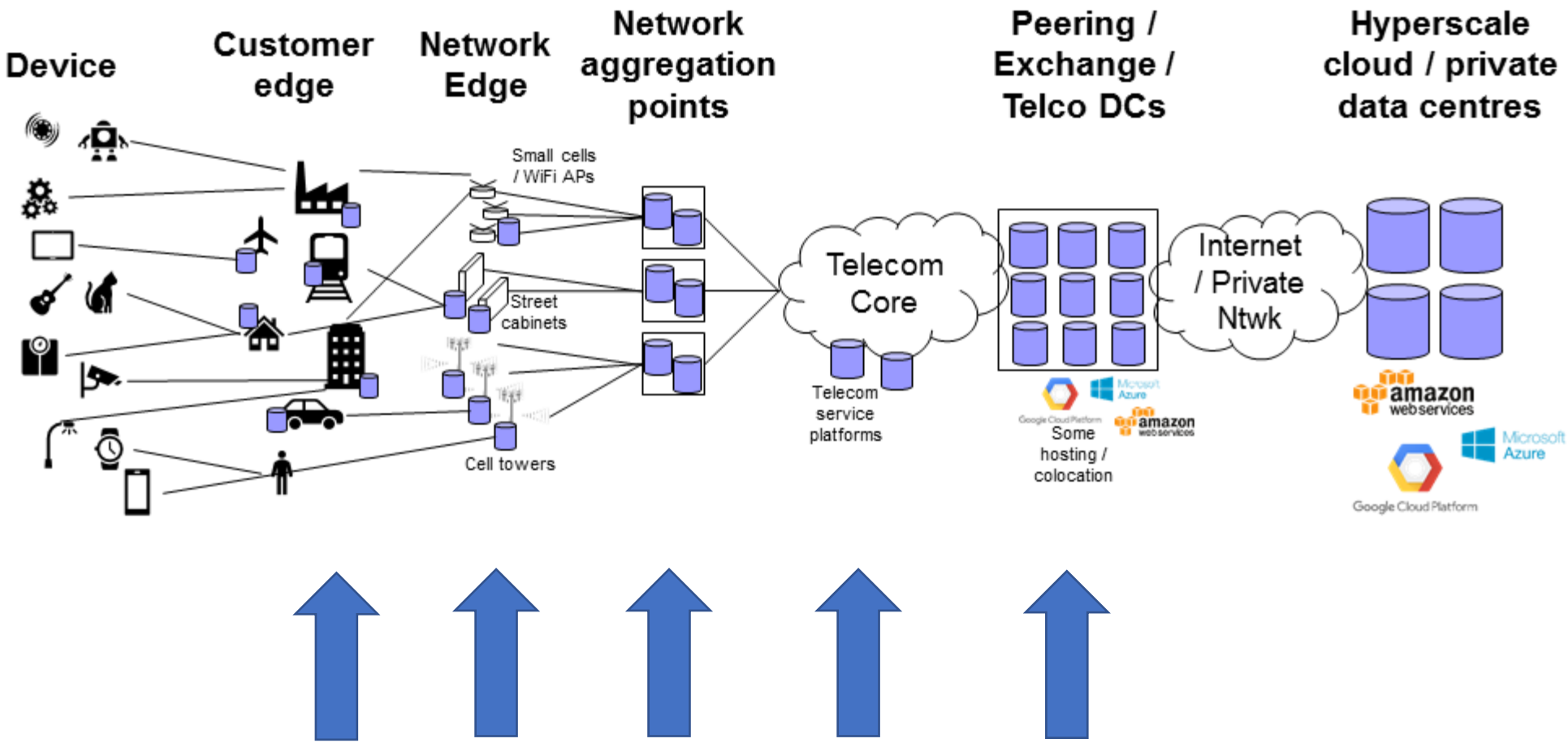
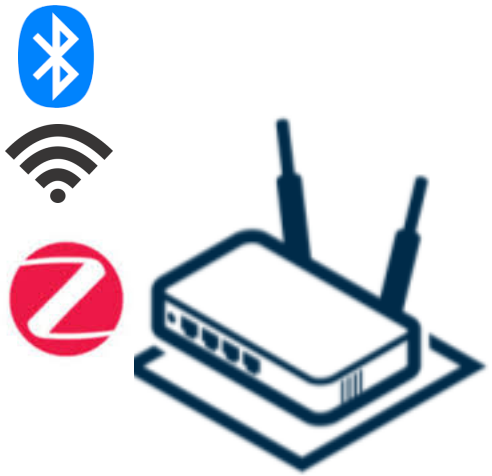


Things

Gateway



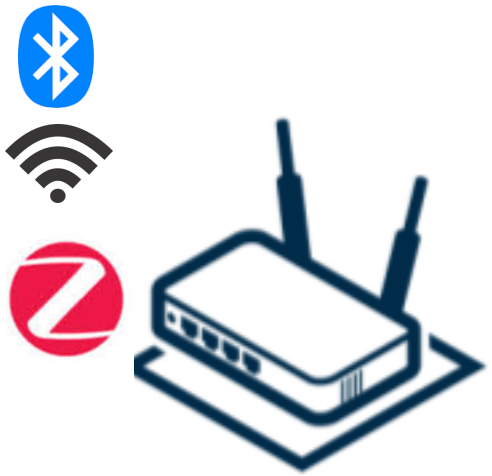
Cloud

Things

Gateway

Cloud

Sensor Data



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Gateway

Cloud

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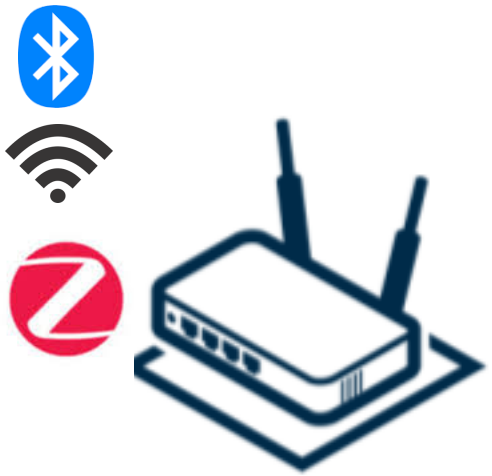

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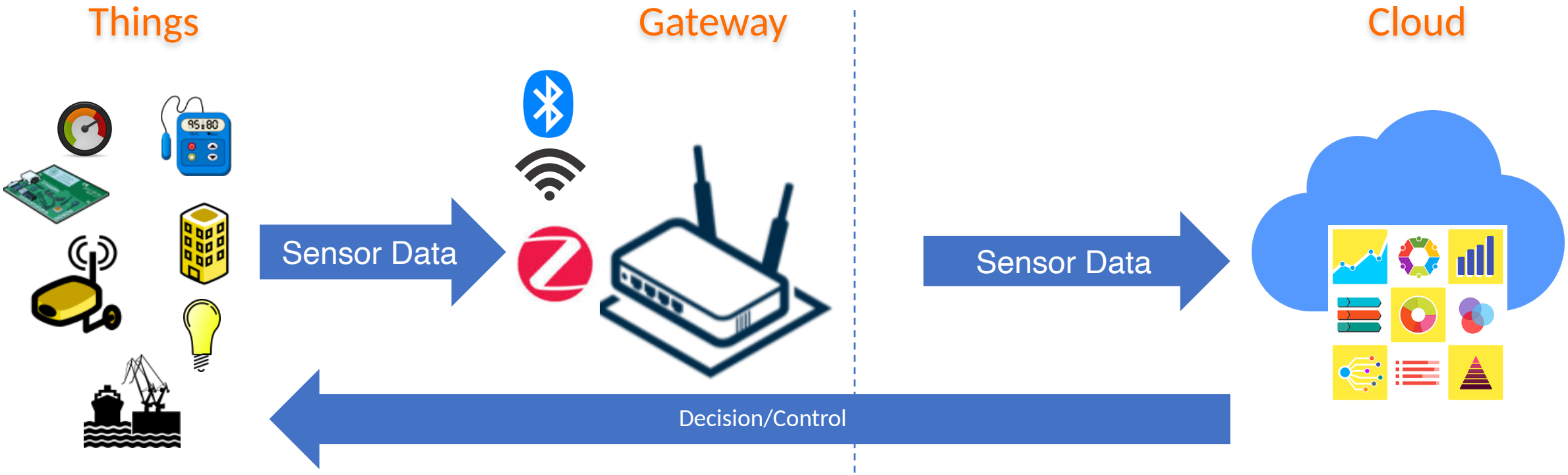
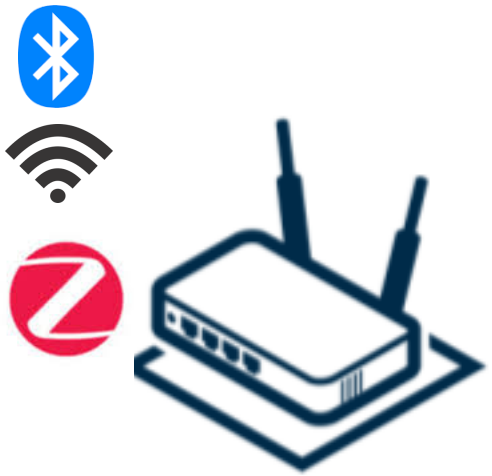

Things
Gateway
Cloud
Sensor Data
Sensor Data
Decision/Control

Things

Gateway



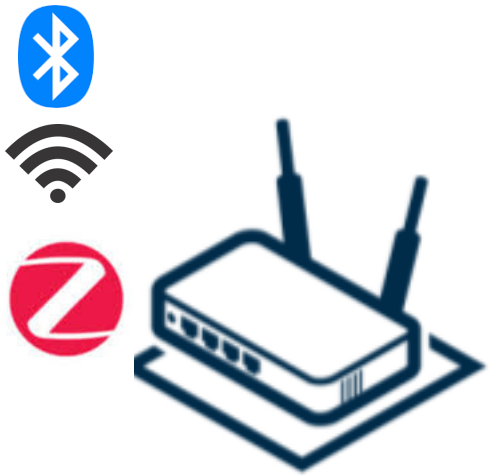
Cloud

Things

Gateway

Cloud

Sensor Data



Things

Gateway

Cloud

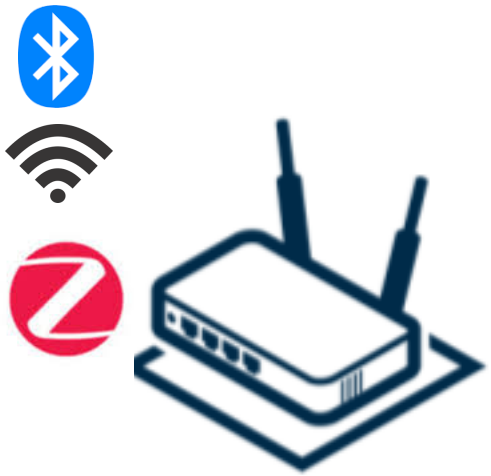
Sensor Data

Things

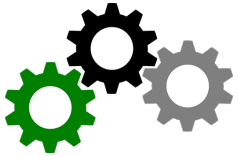
Gateway

Cloud

Sensor Data



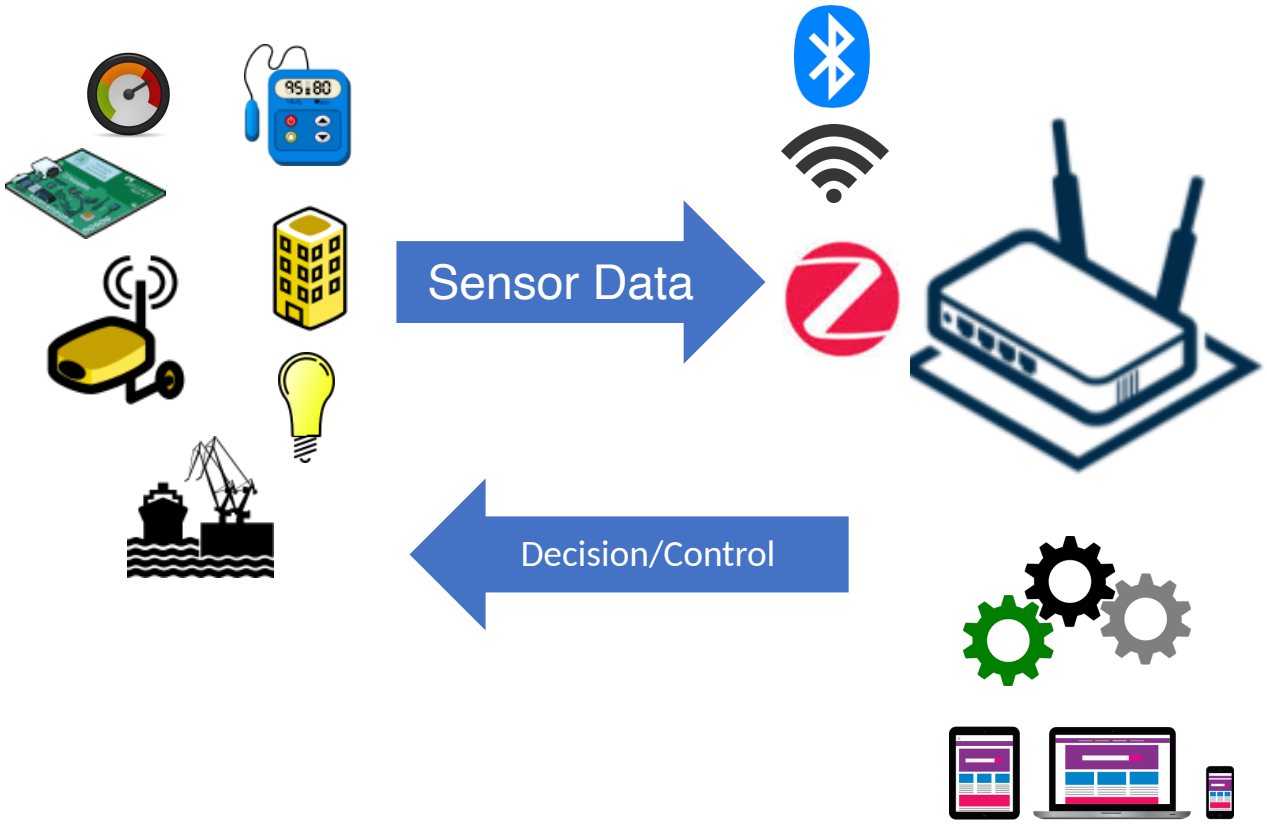
Decision/Control

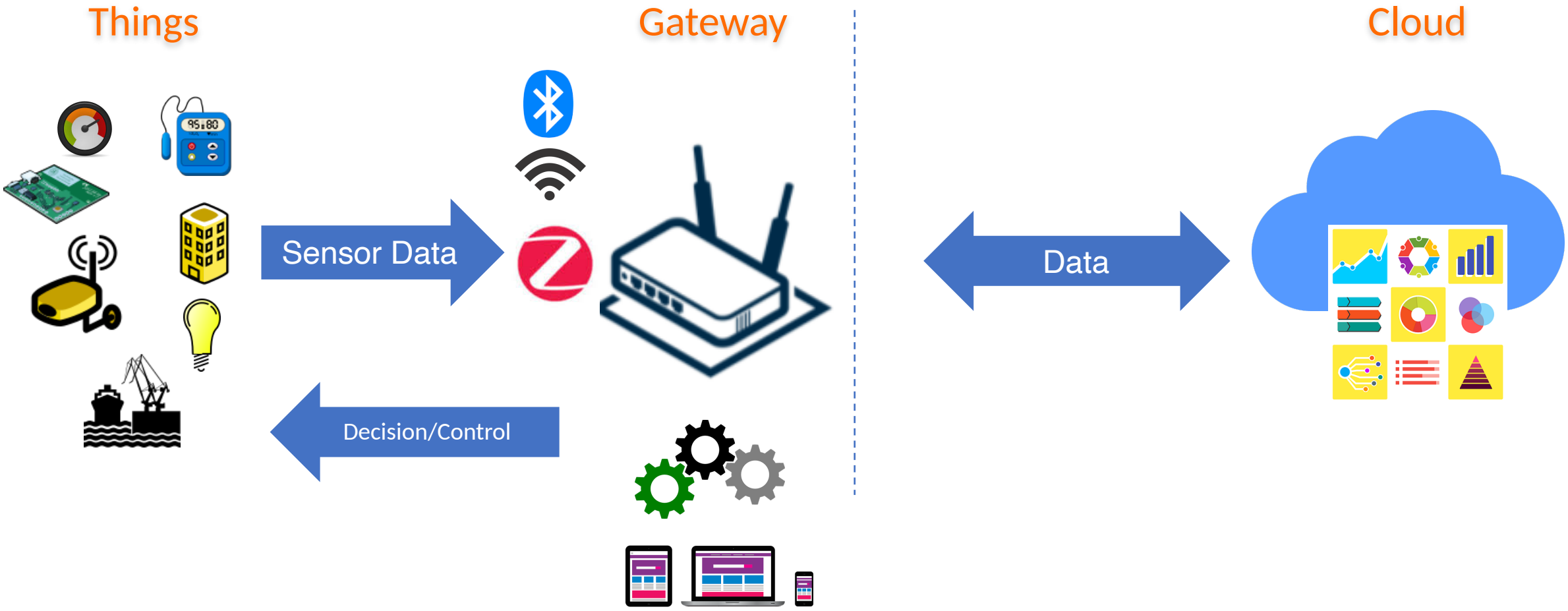


Things

Gateway

Cloud

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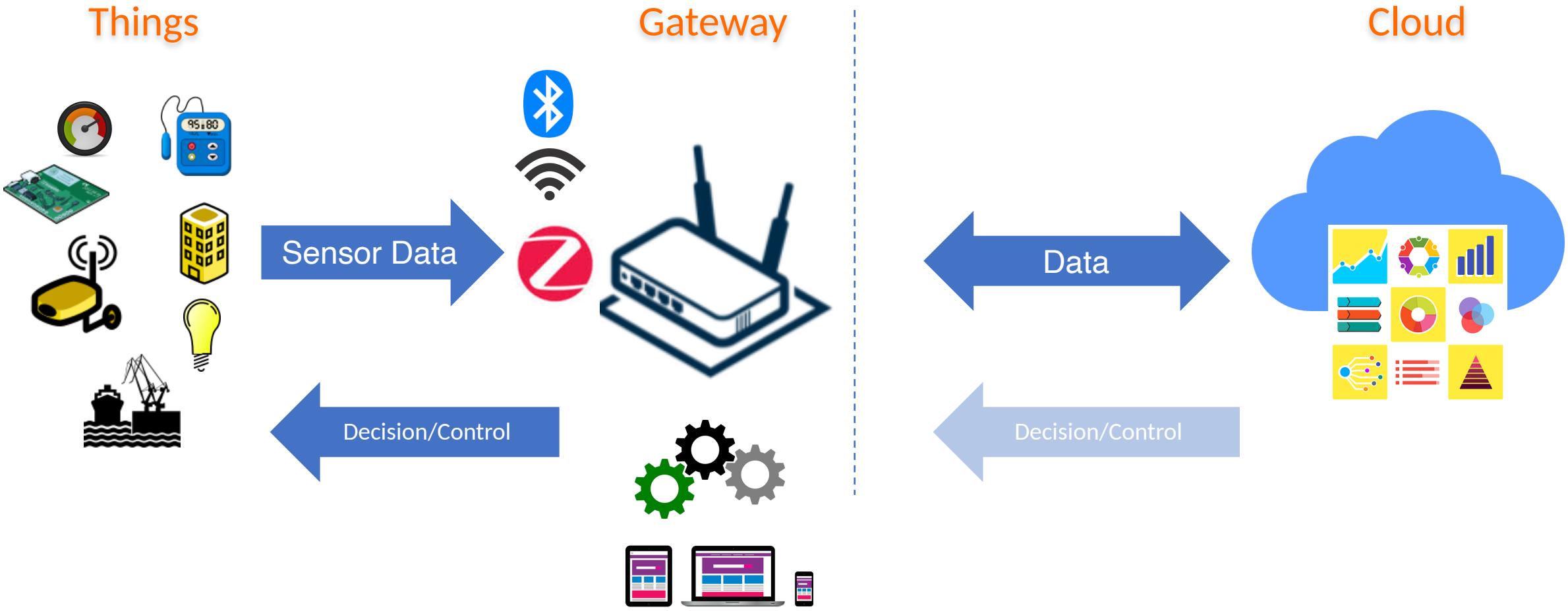
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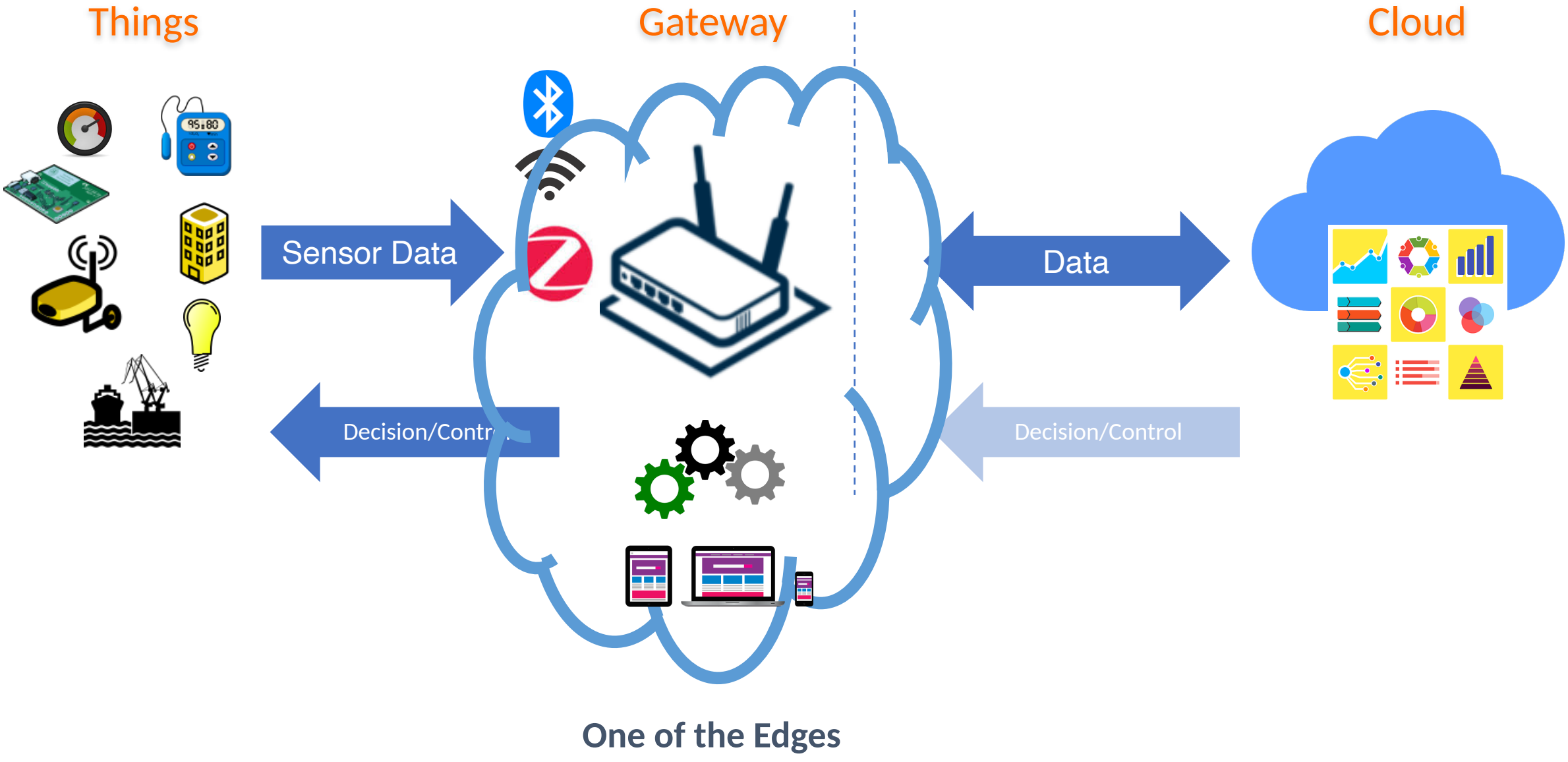
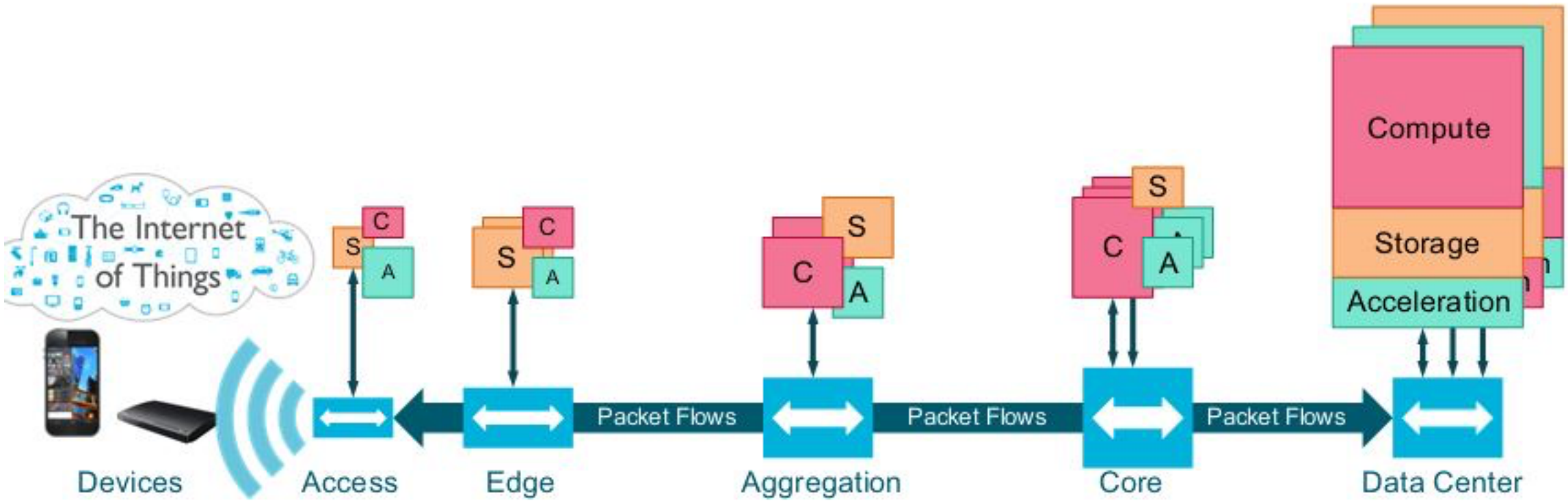


One of the Edges

Intelligent Flexible Cloud



- Edge compute not a replacement
- More resources available the closer you get to the data-centre

Onrushing Motivators for Edge Computing

Reminder

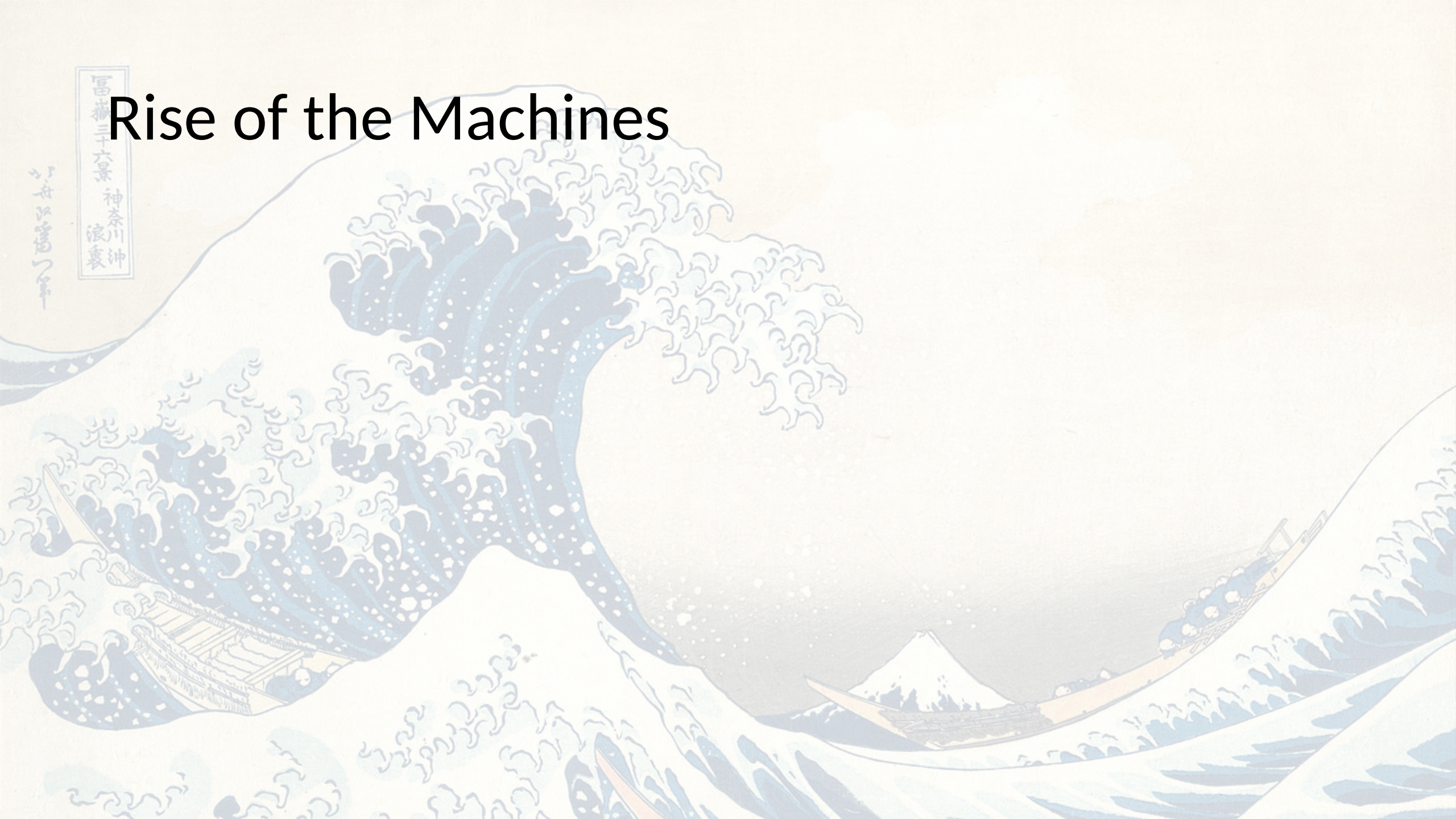
“Edge computing is a distributed computing paradigm which brings computation and data storage closer to the location where it is needed, to improve response times and save bandwidth”

So why is latency and bandwidth important?

5G, WiFi 6, etc will fix this for us right?

TLDR: No. Plus there are other considerations too…..

Rise of the Machines



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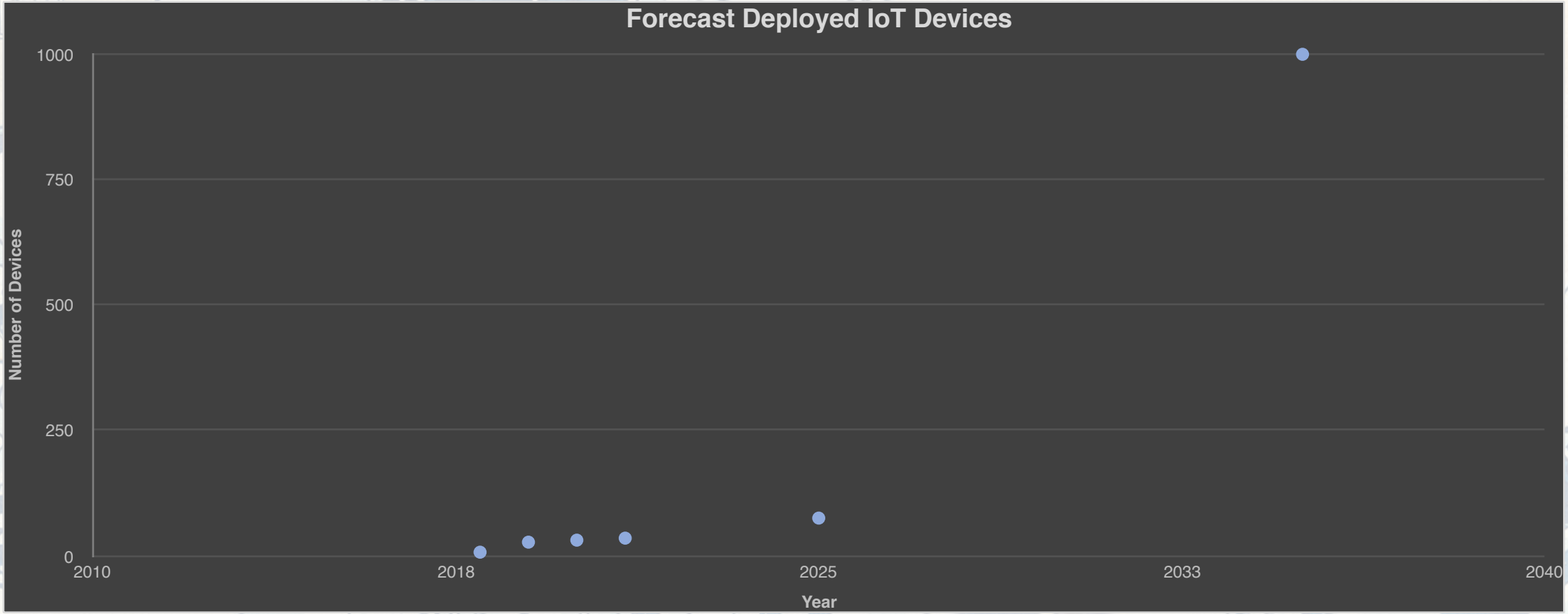

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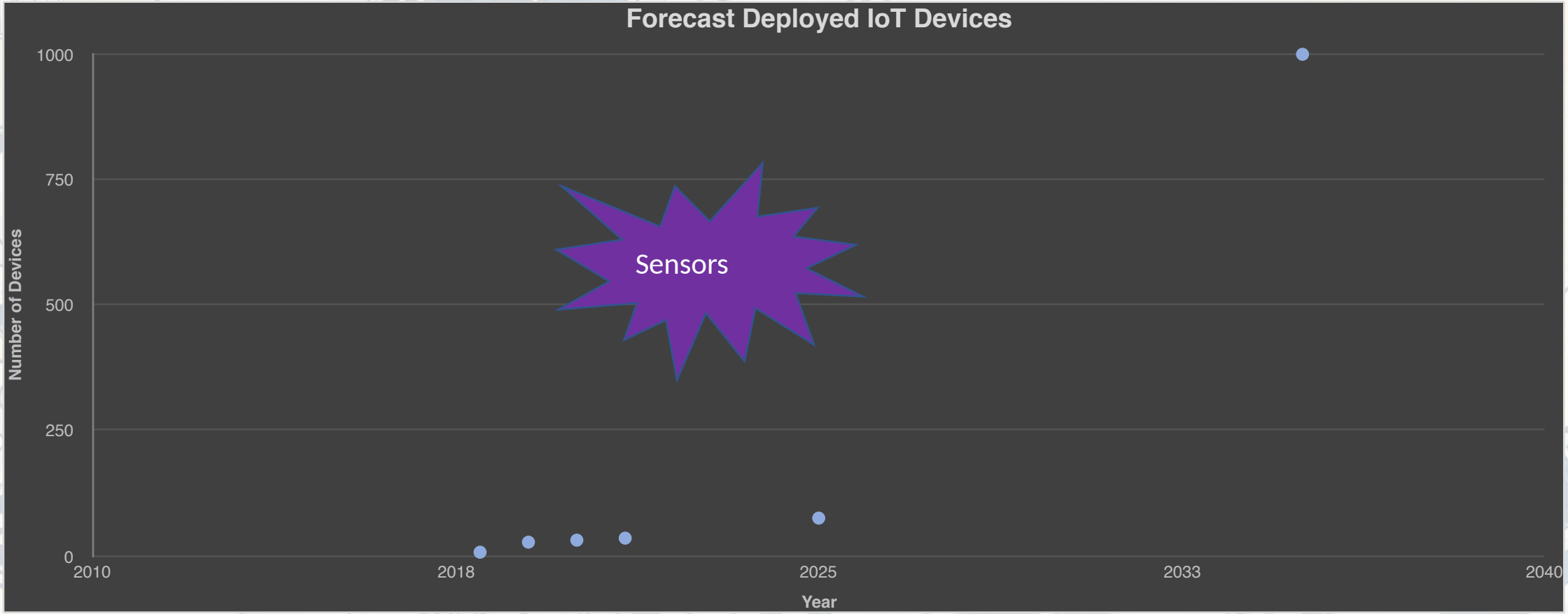

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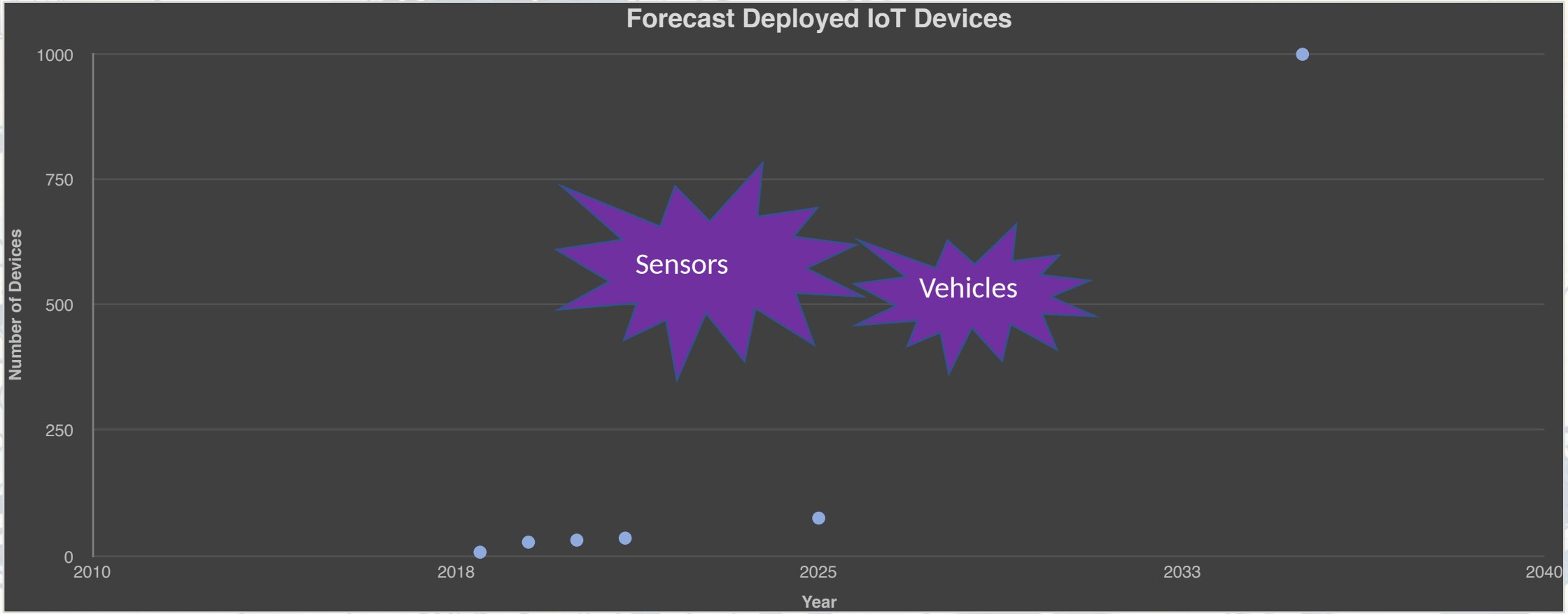

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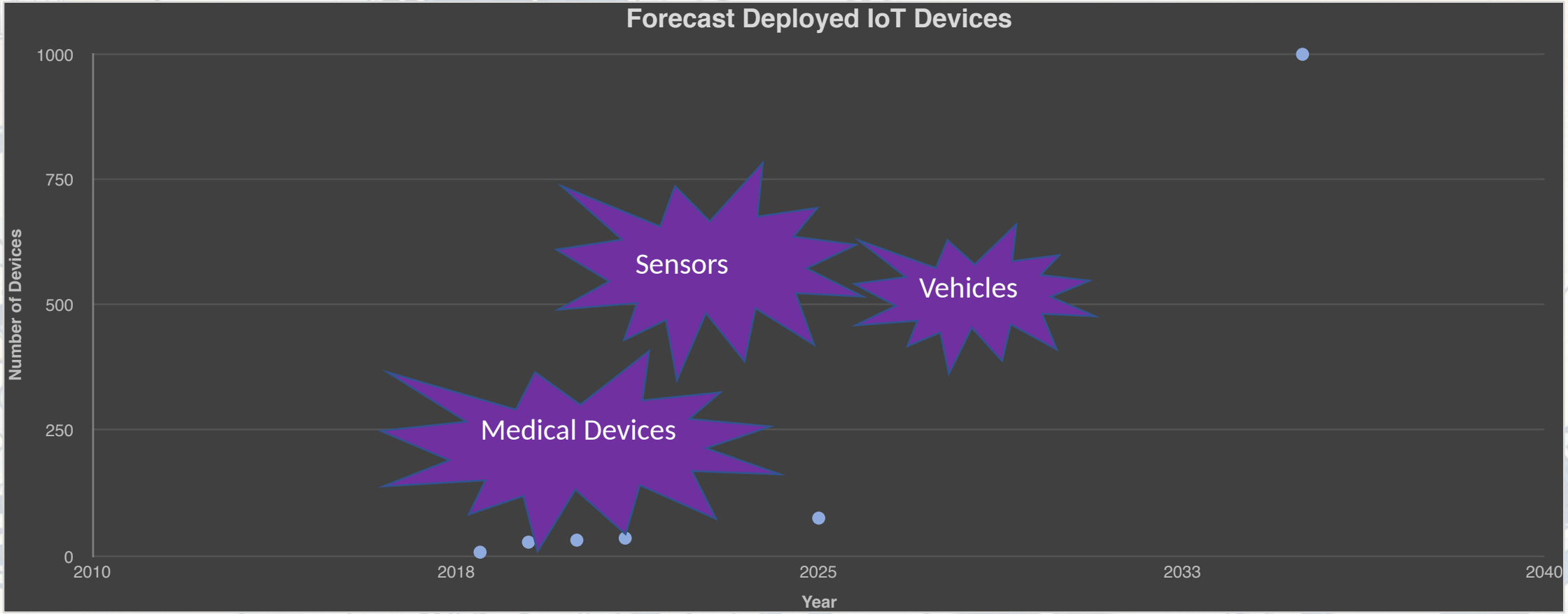

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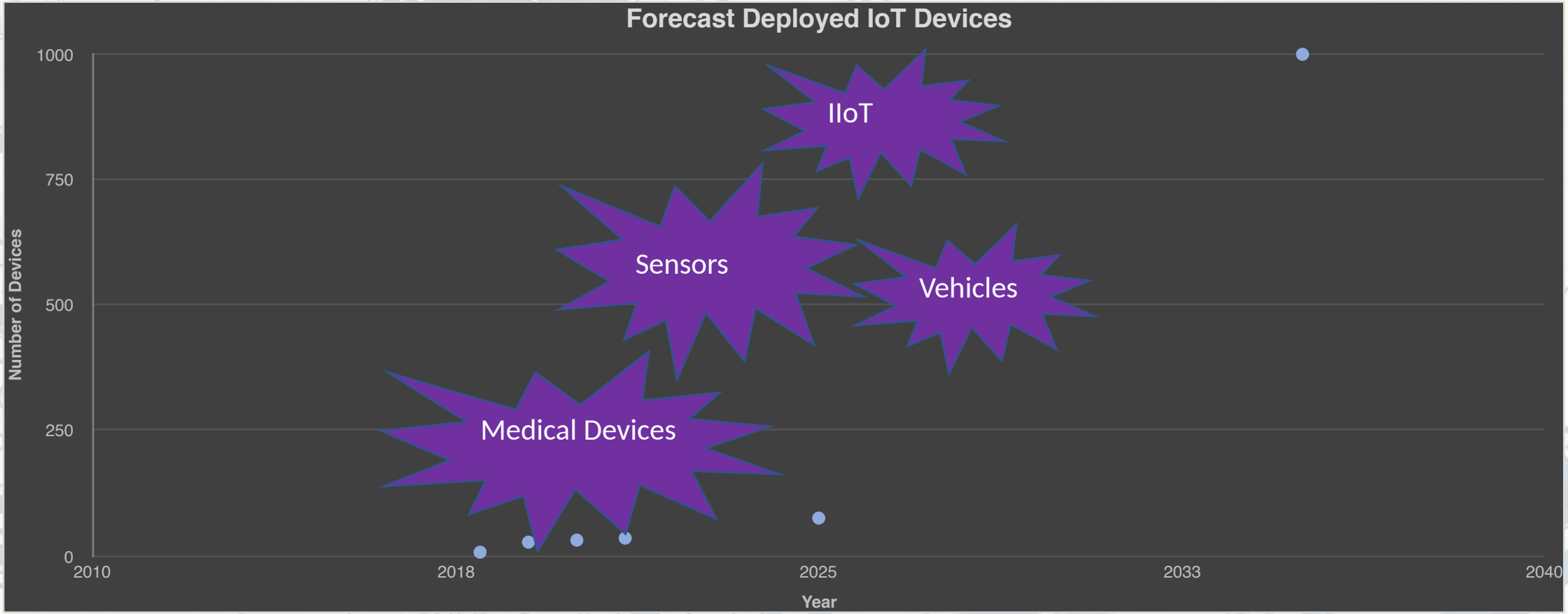

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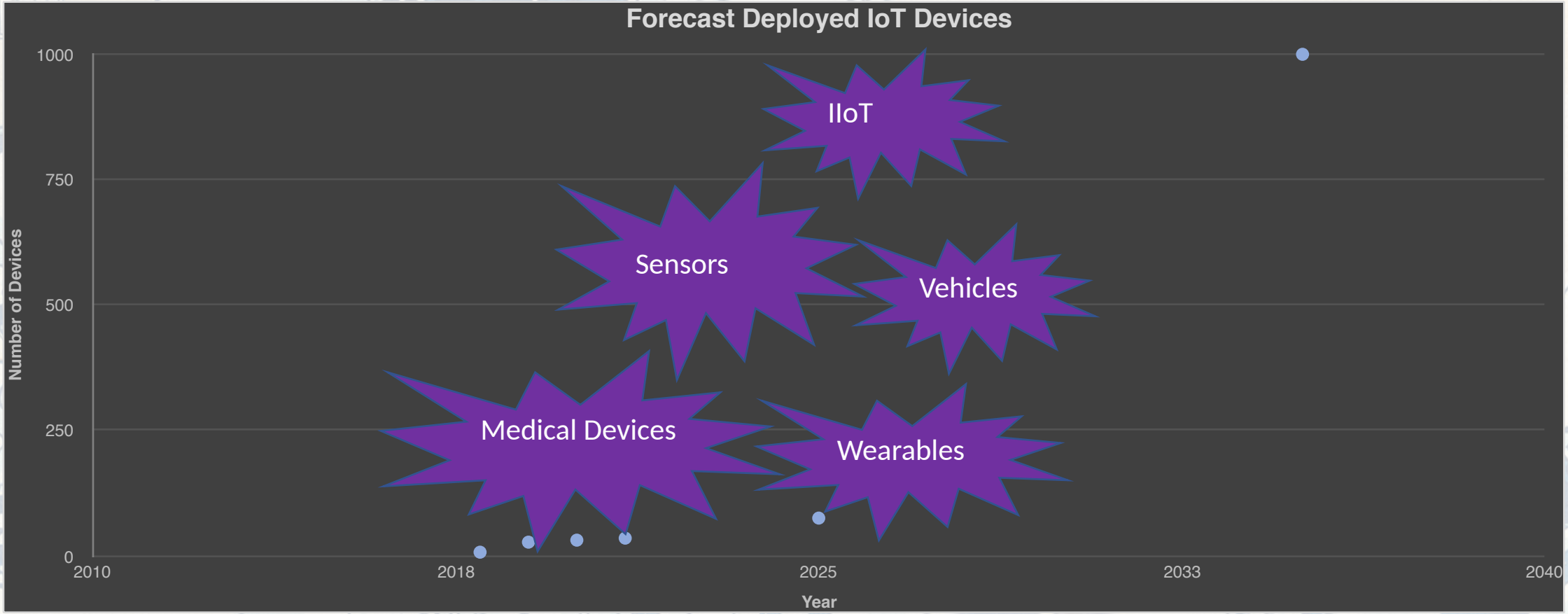

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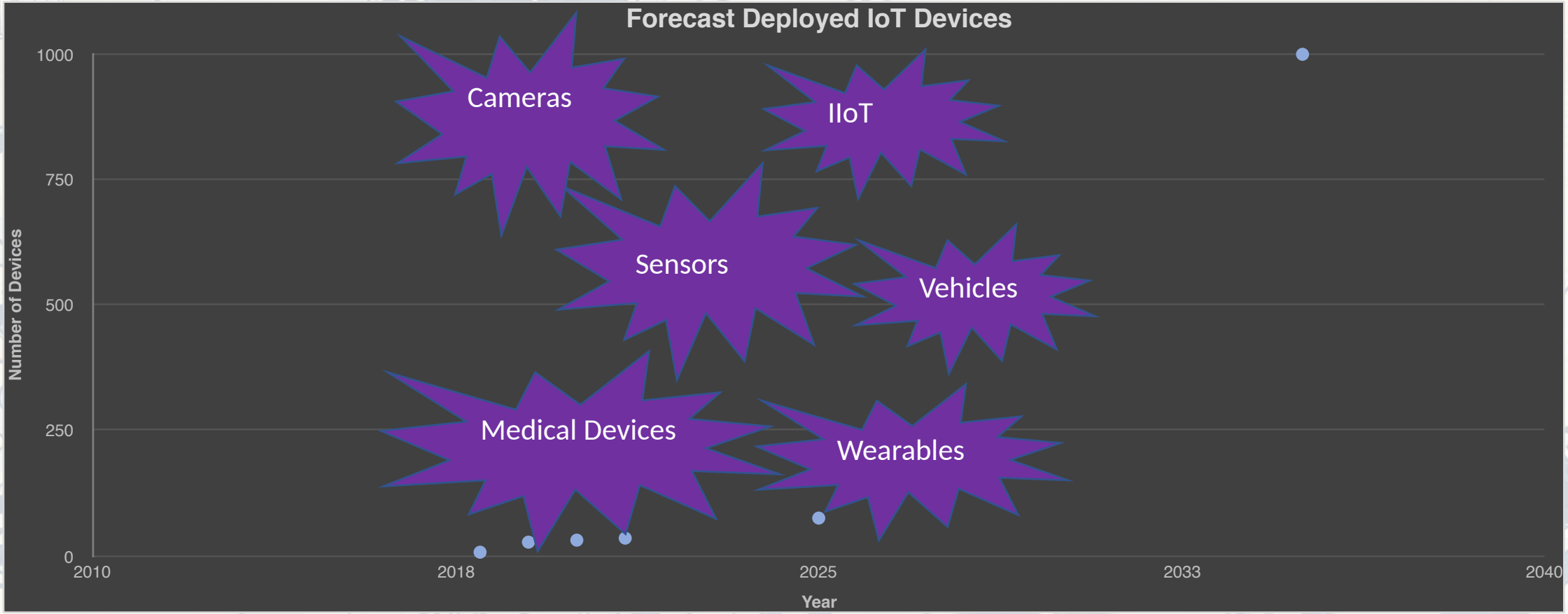


…. and their data

Intelligent Connected Vehicle Typical Design

Sensor Package Assumptions

- Cameras – Production Assumption 8
  - Samsung Connected-3 to AD-12
  - Volvo Connected-6 to AD-16
  - Nissan 12 AD
  - Tesla Connected-8
  - Dell Assumption
    - Connected – X
    - Autonomous - Y
- Lidar/Radar – Prod. Assum. 1 LiDAR / 1 Radar
  - 1 LiDAR
  - 1 Radar
- Ultrasonic Sensors – Prod Assumption 10
  - Tesla Connected-12
- CAN/GPS/IMU 5% Connected 10% AD
- Lidar/Radar 25% Connected 15% AD

In-Vehicle Compute Assumption

- Machine Reasoning Semantic Graph Ctrl - 1%
- Admin / Telemetry / Control – 2%
- Passenger External Applications – 10%

Video Upload Assumption

- 100% of Video will NOT be captured for upload
- 2% of Video will be upload for Audit Trail
- 30% of Video will be upload for Inference and random training
- 10% of Video will be upload for retraining (included in 30%)

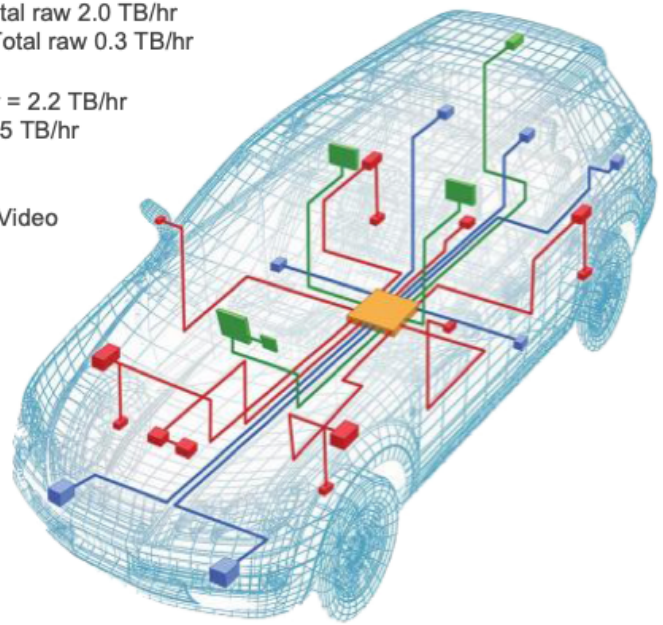
In-Vehicle Compute Environment

- Fault Tolerant Compute – Motion stabilized
- Three tier cache with storage (NVMe/SSD)
  - 0-0 –Log and Urgently transmit (3GPP/V2V)
  - 0-1 –Upload required, Opportunistic Upload (WiFi/Fuel)
  - 0-2 –Upload not required, can if comms available otherwise age and overwrite

Calculations of Data Generated

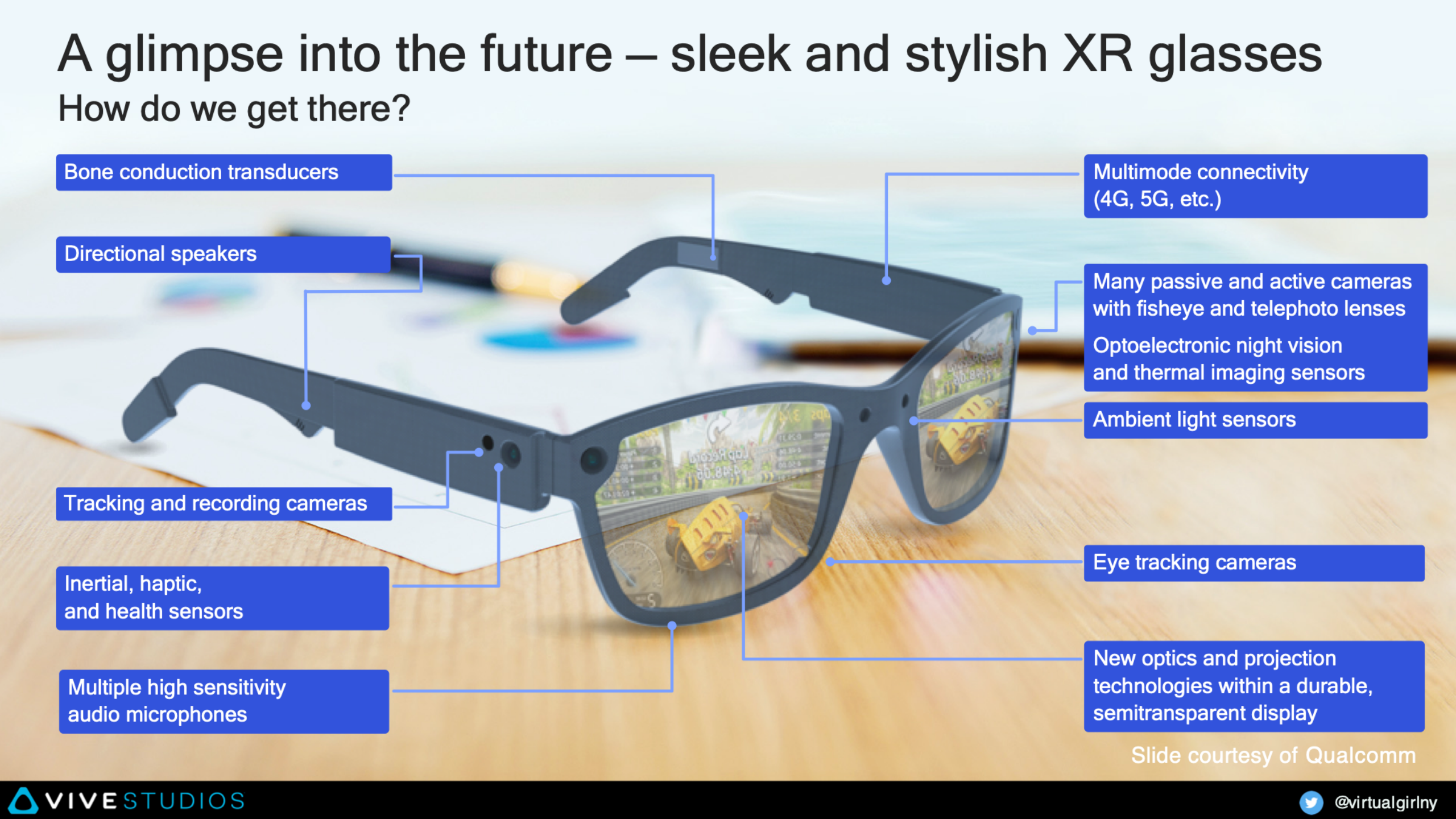
- 8 Camera (source SAMSUG ADAS/AD)
  - 5 Smart Cameras – Data can be captured and uploaded
    - 3 HD Resolution, 2-4K Resolution
  - 3 Cameras Informative – 720p Centralized Data storage - Audit
- Video Calculation
  - 4K cameras – 30 fps, 199065600 bpf (2) Total raw 5.4 TB/hr
  - HD cameras – 30 fps, 49766400 bpf (3) Total raw 2.0 TB/hr
  - 720p – 30 fps, 6998400 bpf (3) 0.23GB/hr Total raw 0.3 TB/hr
  - Total Video Transmitted = 2.35 TB/hr
    - 30% Smart Camera Video 7.4 TB/hr = 2.2 TB/hr
    - 2% Audit Trail Video 7.7 TB/hr = 0.15 TB/hr
- Total Data Calculation
  - Video 2.35 TB/hr
  - Add CAN/GPS/IMU/LiDAR/Radar +25% of Video
  - Add In-vehicle Compute +13% of Video
  - 3.25 TB/hr

Total Data Transmitted 3.25 TB/hr



A glimpse into the future – sleek and stylish XR glasses

How do we get there?



Slide courtesy of Qualcomm

A new era in distributed processing

Essential on-device processing

Optimized under strict power, thermal, size constraints

Premium experiences today that continuously improve

Split rendering

5G

Low latency
High capacity
Reliable link

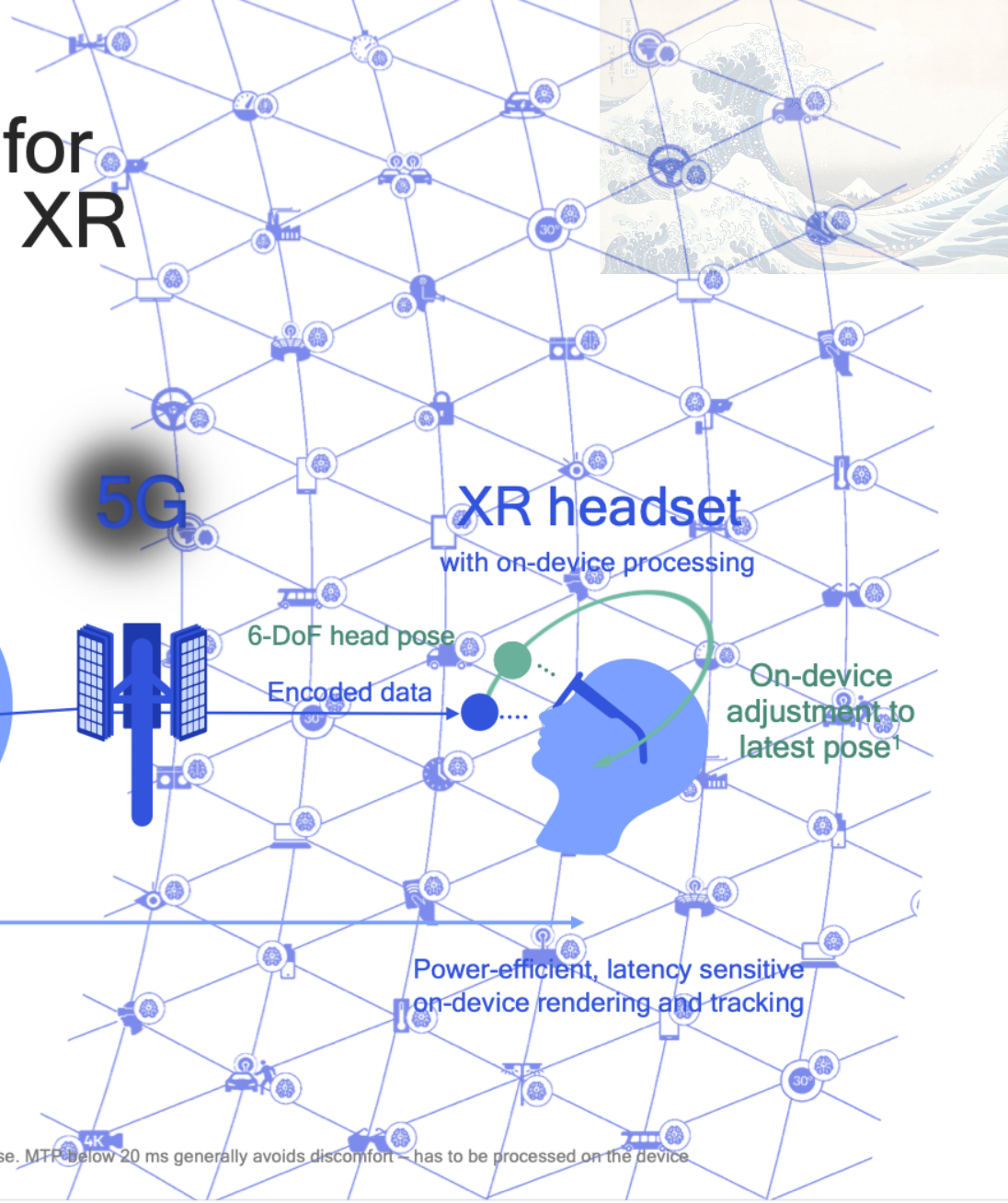
Augment by edge cloud processing

Significantly higher power envelope–beyond PC class

Augment on-device rendering with edge cloud rendering

Slide Courtesy of QUALCOMM

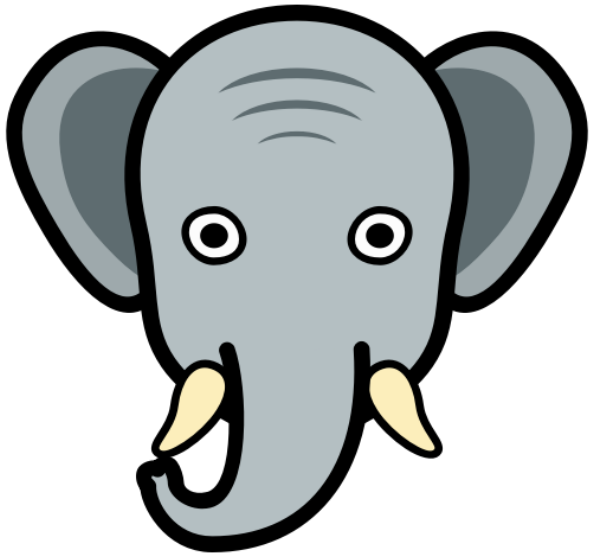
Augment on-device processing for boundless photorealistic mobile XR



1. Asynchronous time warp reduces Motion to Photon (MTP) latency by using on-device processing based on the latest available pose. MTP below 20 ms generally avoids discomfort – has to be processed on the device

Slide Courtesy of QUALCOMM

Privacy



- Who does the data belong to?
- How is access to the data controlled?
- Is anonymity desirable? Or even possible?

- Edge Compute can address some issues but not all ….

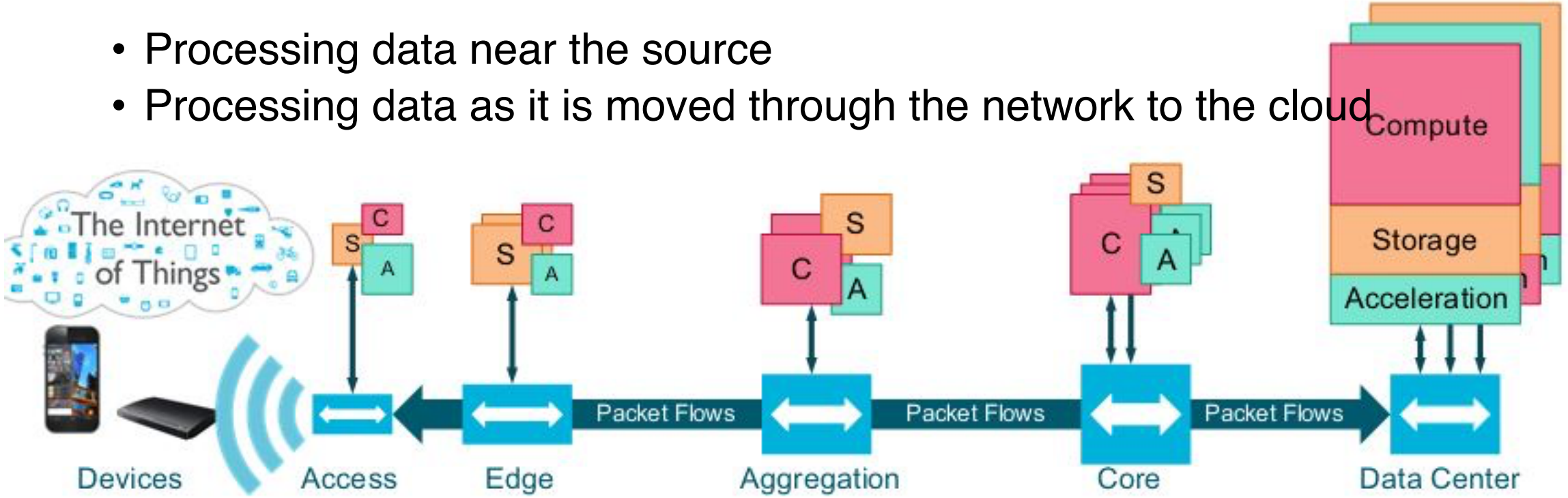
Edge Computing Can?

Edge Compute can

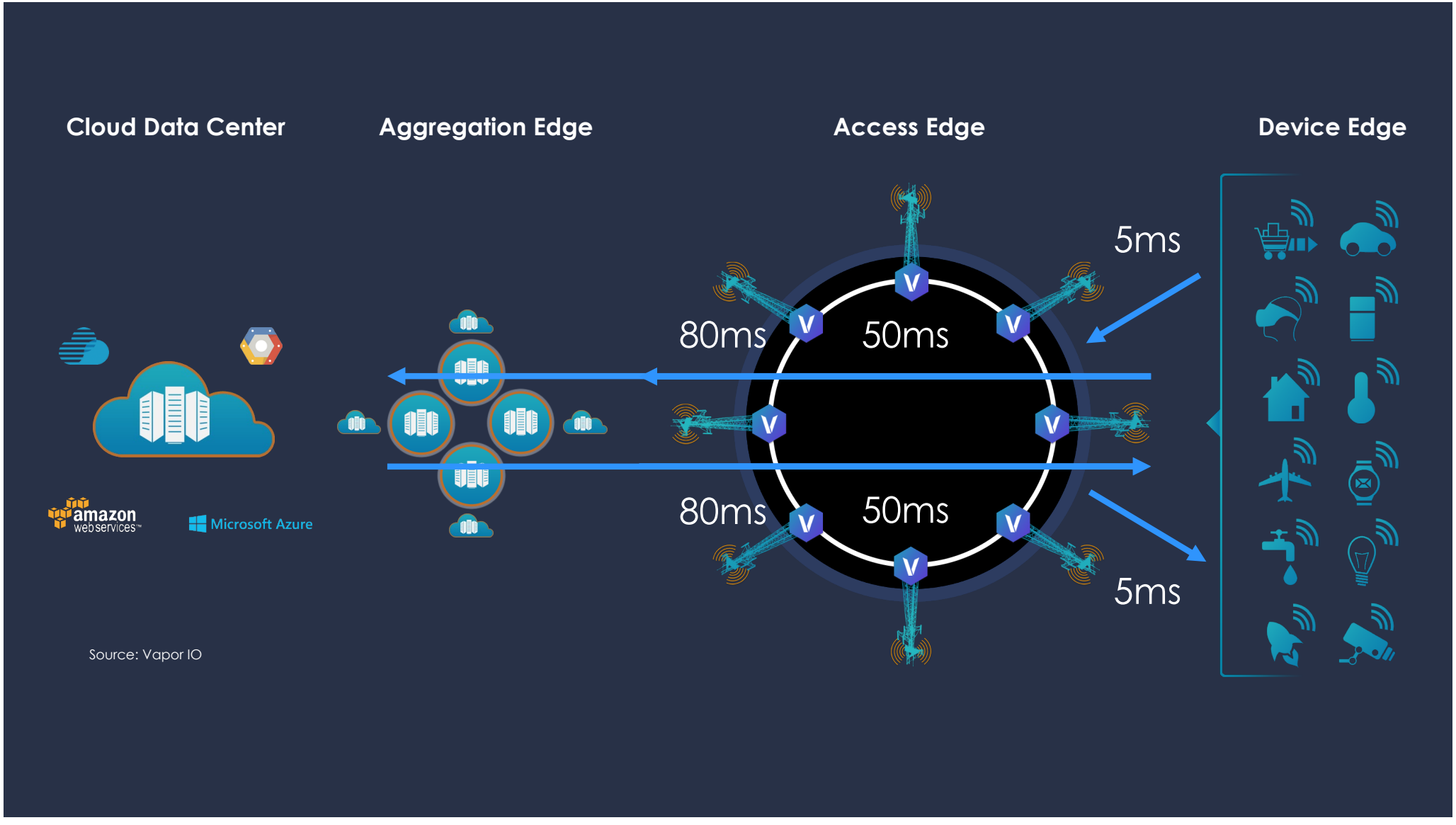
- Example: A car-counting application
  - Images from the camera are not sent to the cloud
  - Application may be vetted or provided with access to a limited resources
  - Minimal information sent to cloud – easier to audit
- Example: Hybrid cloud/Edge compute application
  - Lowering the latency for decision-making
  - Providing resilience if route to cloud fails

Edge Compute Can

- Reduce amount of data sent to the cloud
  - Processing data near the source
  - Processing data as it is moved through the network to the cloud



Edge Compute can



Edge Computing Landscape

Created & Designed By

EDGE COMPUTING WORLD

Edge Landscape

November 2019

Powered by:

TOPIO NETWORKS

Consumer Apps (33)

Cloud Gaming (17)

Smart Home (8)

Health Tech (8)

Enterprise Apps (91)

AR/VR (7)

Video (7)

Manufacturing (8)

AgTech (5)

V2X (17)

Supply Chain (12)

NFV (14)

Retail (10)

Smart City (6)

Oil and Gas/ Mining (5)

IndustryBody & Collaboration Projects(31)

Edge/Devices/Premise (128)

Edge Application Platform (26)

Edge AI (63)

Edge Device & OEM (18)

Edge Storage (7)

Design & Engineering(4)

Streaming Analytics (10)

Smart Communications (128)

Communication infrastructure(39)

5G and Access Network (19)

CDN (17)

Backbone (10)

Silicon (23)

Aggregation Edge (6)

SDWAN (14)

Application Deployment & Management (117)

Application development(27)

Distributed compute (12)

Device Management (9)

Application Management (42)

Anomaly Detection (8)

Security (11)

Blockchain (8)

Smart Data (22)

Digital Twin (11)

AI Training (8)

Exception Analysis (3)

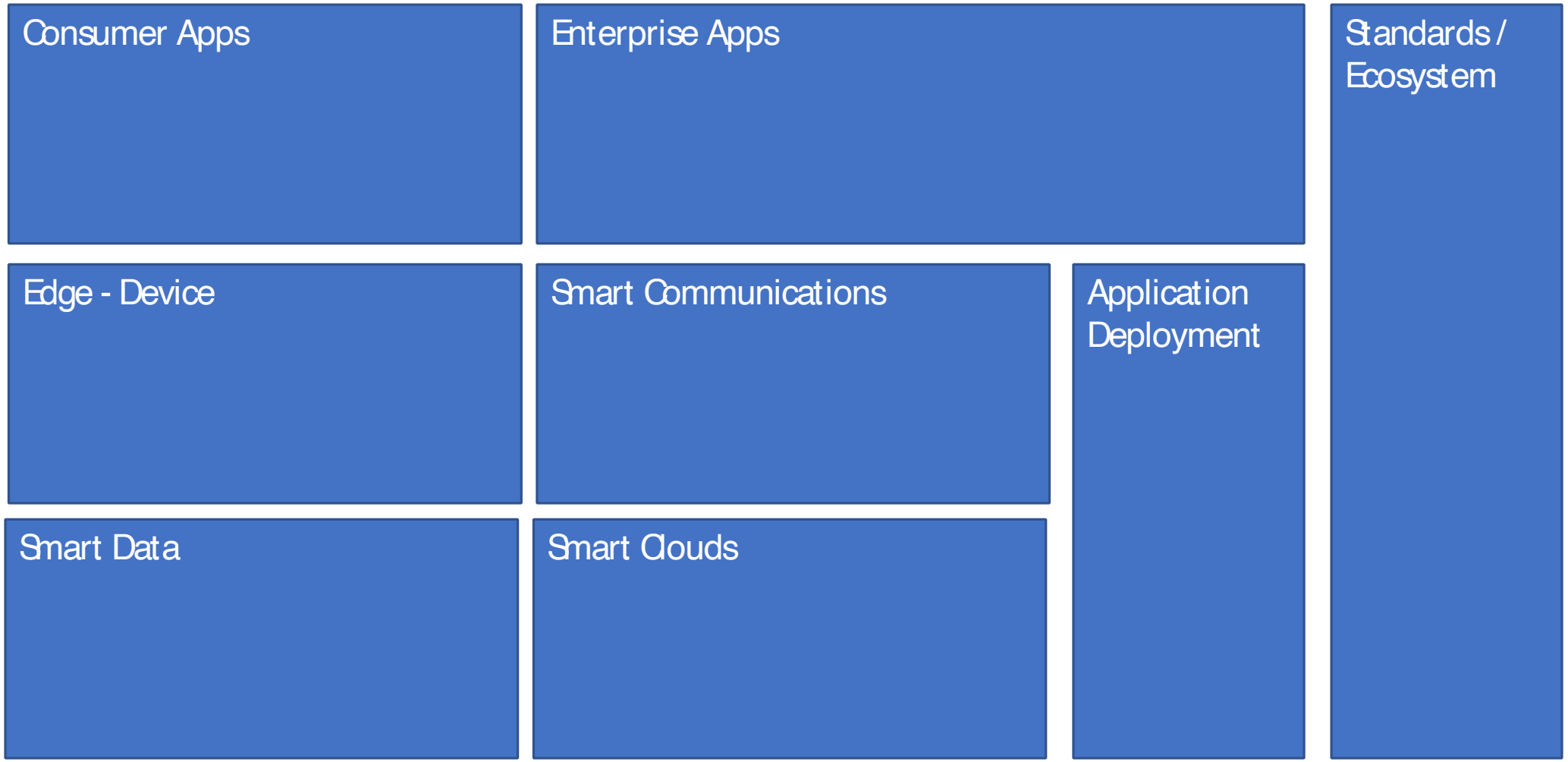
Smart Cloud(68)

Real Estate/Towers (8)

Data Center Infrastructure/Provider (53)

Cloud Service Provider (7)

The Edge Blueprint



TOPIO NETWORKS

The Edge Blueprint – a deeper look

Consumer Apps
Gaming
Smart Home
Health Tech

Enterprise Apps
AR/VR
Video
Retail
Manufacturing
Tranportation/Mobility
Smart City
Smart Government
NFV
AgTech
Oil & Gas/Mining
Supply Chain

Standards / Ecosystem
MEC
Industrial Internet Group
BITAs
Consortia

Edge – Devices - Premise
Edge Device & OEM
Edge Application Platform
Edge AI (AI, Facial Recognition, Motion detection, Voice recognition)
Streaming Analytics
Edge Storage
Design & Engineering

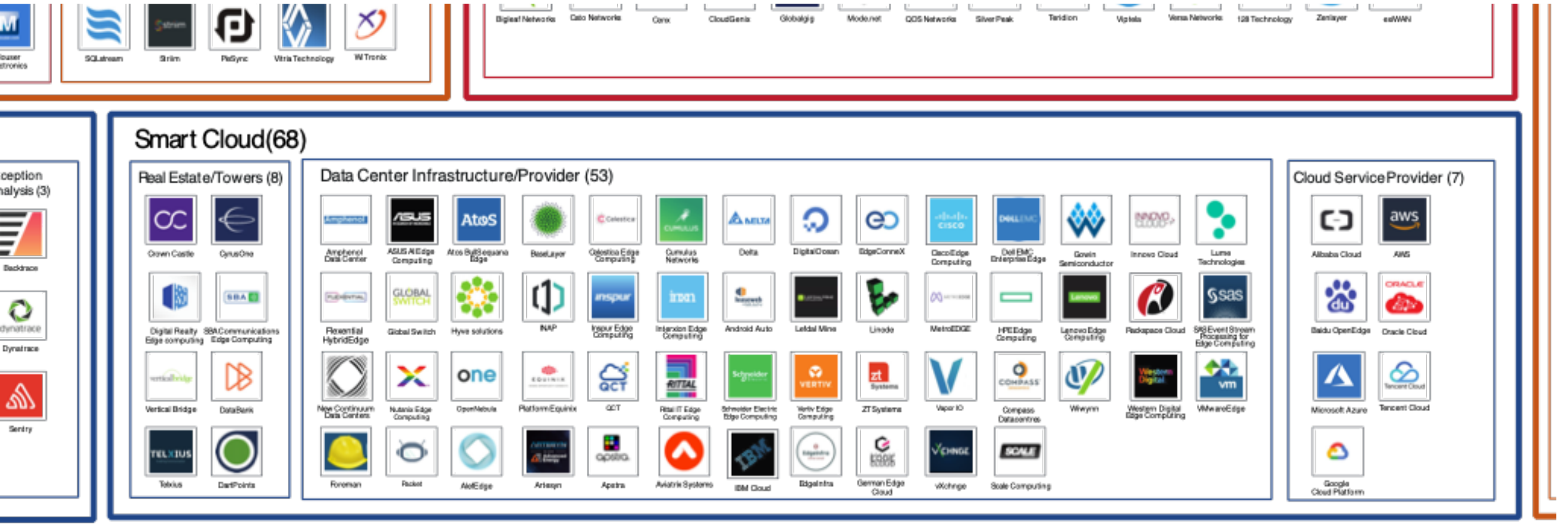
Smart Communications
CDN
SDWAN
Comm infrastructure
Backbone
Aggregation Edge
Silicon
5G & Access Networks

Application Deployment
Device Management
App Development
App Management
Blockchain
Distributed compute
Security
Anomaly detection

Smart Data
Digital Twin
AI training
Exception Analysis

Smart Cloud
Cloud Service Provider
Data Center Infrastructure/Provider
Real Estate/ Towers

TOPIO NETWORKS


SQLstream
Striim
PeSync
Vitria Technology
W Tronix
Bigleaf Networks
Cato Networks
Cenx
CloudGenix
Globalgig
Mode.net
QOS Networks
Silver Peak
Teridion
Viptela
Versa Networks
128 Technology
Zenlayer
eaWAN
Smart Cloud(68)
Real Estate/Towers (8)
Crown Castle
CyrusOne
Digital Realty Edge computing
SBA Communications Edge Computing
Vertical Bridge
DataBank
Telxius
DartPoints
Data Center Infrastructure/Provider (53)
Amphenol Data Center
ASUS AI Edge Computing
Atos BullSequana Edge
BaseLayer
Celestica Edge Computing
Cumulus Networks
Delta
DigitalOcean
EdgeConneX
CiscoEdge Computing
Dell EMC Enterprise Edge
Gowin Semiconductor
Innovo Cloud
Lumo Technologies
Flexential HybridEdge
Global Switch
Hyve solutions
INAP
Inspur Edge Computing
Interxion Edge Computing
Android Auto
Leidal Mine
Linode
MetroEDGE
HPEEdge Computing
Lenovo Edge Computing
Rackspace Cloud
SAS Event Stream Processing for Edge Computing
New Continuum Data Centers
Nutania Edge Computing
OpenNebula
PlatformEquinix
QCT
Rittal IT Edge Computing
Schneider Electric Edge Computing
Vertiv Edge Computing
ZT Systems
Vapor IO
Compass Datacentres
Wiwynn
Western Digital Edge Computing
VMwareEdge
Foreman
Packet
AkriEdge
Artesyn
Apstra
Aviatrix Systems
IBM Cloud
Edgelntra
German Edge Cloud
vXchnge
Scale Computing
Cloud Service Provider (7)
Alibaba Cloud
AWS
Baidu OpenEdge
Oracle Cloud
Microsoft Azure
Tencent Cloud
Google Cloud Platform

Pointers

- AWS Outposts – run AWS Infrastructure and services on premises

"AWS Outposts address low latency application requirements and local data processing requirements across a broad range of industries."

- 5G Operators – opportunity to become more than just "pipes"
  - Decreasing value in just moving the bits
  - Need to provide added-value
  - Virtualization of Compute, Network, Storage offers chance to build a fabric to use and rent-out

Standards

- European Edge Computing Consortium
- Automotive Edge Computing Consortium
- Open Edge Computing Initiative
- Industrial Internet Consortium

Consortia consisting of Telcos, Cloud Providers, Platform providers, Application developers, etc etc

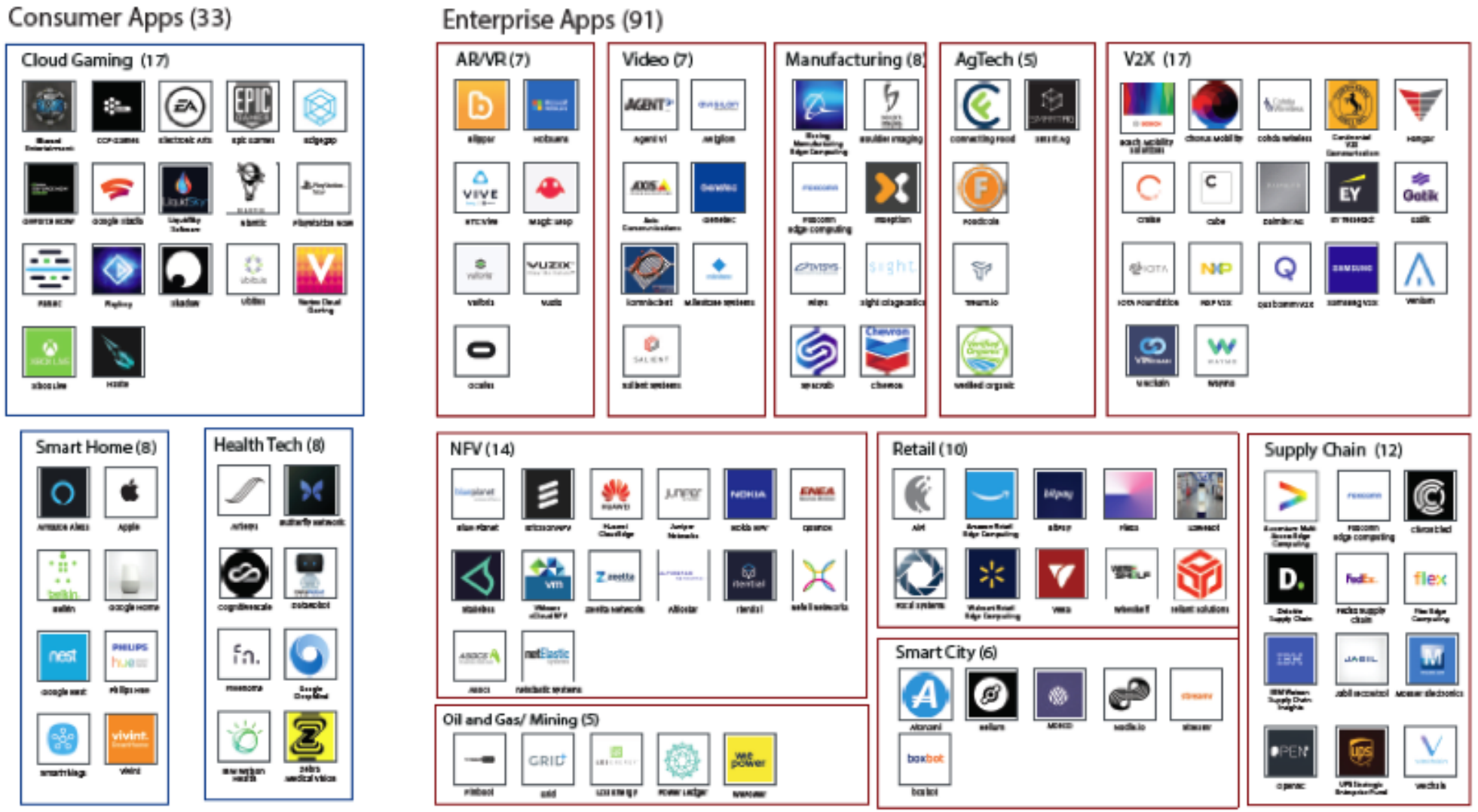
Trends Overview

1. Building out of the edge platform space
2. Emergence of edge vertical - orientated offerings
3. Importance of Kubernetes & the cloud native ecosystem

Trend #1: Building out the edge platform space

Edge Application Platform (26)

Trend #2: Emergence of edge vertical - orientated offerings

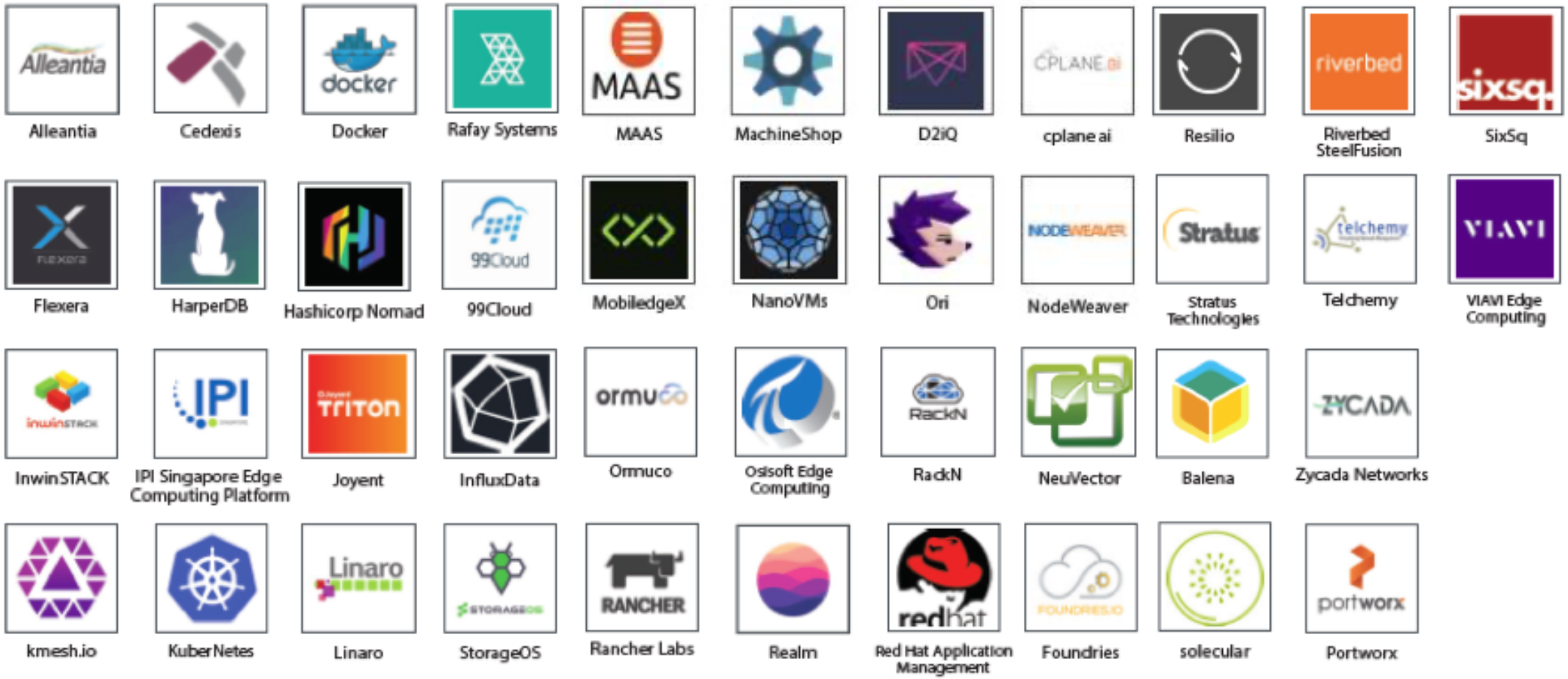


Edge Computing Landscape Update Q4 2019 – Topio Networks

TOPIO NETWORKS

Trend #3: Importance of Kubernetes & the cloud native ecosystem

Application Management (42)



Edge Computing Landscape Update Q4 2019 – Topio Networks

Cloud Native

Why?

- Iterative development
- Safe deployment
- Manage at scale

Cloud Native

Why?

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How?

Cloud Native

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How?

Many technologies to help solve this problem for cloud/server

Vagrant

OPENSHIFT

openstack.

ANSIBLE

Amazon Lambda

Cloud Native

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Who?

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OPENSHIFT

openstack.

ANSIBLE

Amazon Lambda

Who?

Many providers to solve this problem for cloud/server

Google Cloud Platform

Microsoft Azure

Amazon Elastic Compute Cloud

IBM Cloud

IoT Edge

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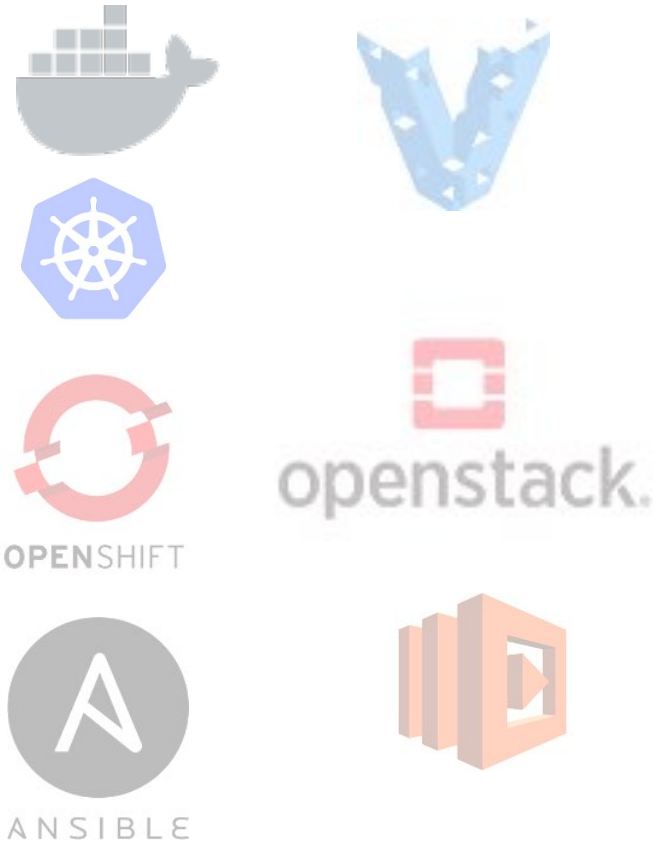

IoT Edge

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IoT Edge

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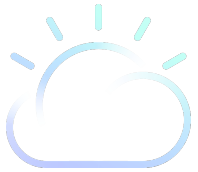
How?

Who?

Google Cloud Platform

Microsoft Azure

Amazon Elastic Compute Cloud



IBM Cloud

IoT Edge

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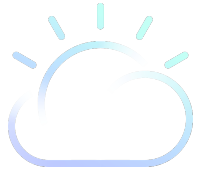
How?

Who?

Can we bring the cloud development methodology, platform, infrastructure, ecosystem to the IoT edge?

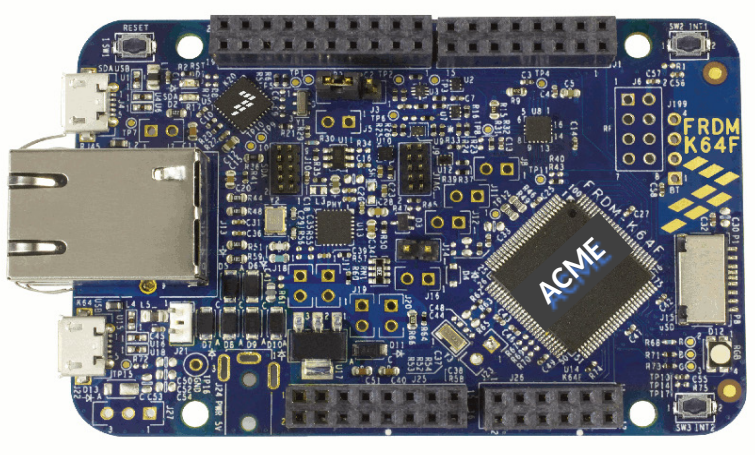
Amazon Elastic Compute Cloud



IBM Cloud

Yes and No

- Deployment for IoT Edge is different
  - Unreliable connectivity
  - Resource constraints (Memory, CPU, Energy etc)
  - Potentially “hostile” security environment
  - Multiple interested parties: device provider, services provider, application provider, actual device “owner”
- Many questions:
  - Why should I trust this hardware?
  - Do I trust this particular version of this OS?
  - Where did this application come from? Has it been tampered with?
  - Where is my data going?
  - What happens if ACME Inc goes under?



➡ **Cloud ecosystem needs to be adapted for this environment**

Endgame

Questions

- How long until we are there yet?
- What comes next!

- How long until it’s all secure and reliable?!

Thanks