Untangling the Cloud from Edge Computing for IoT

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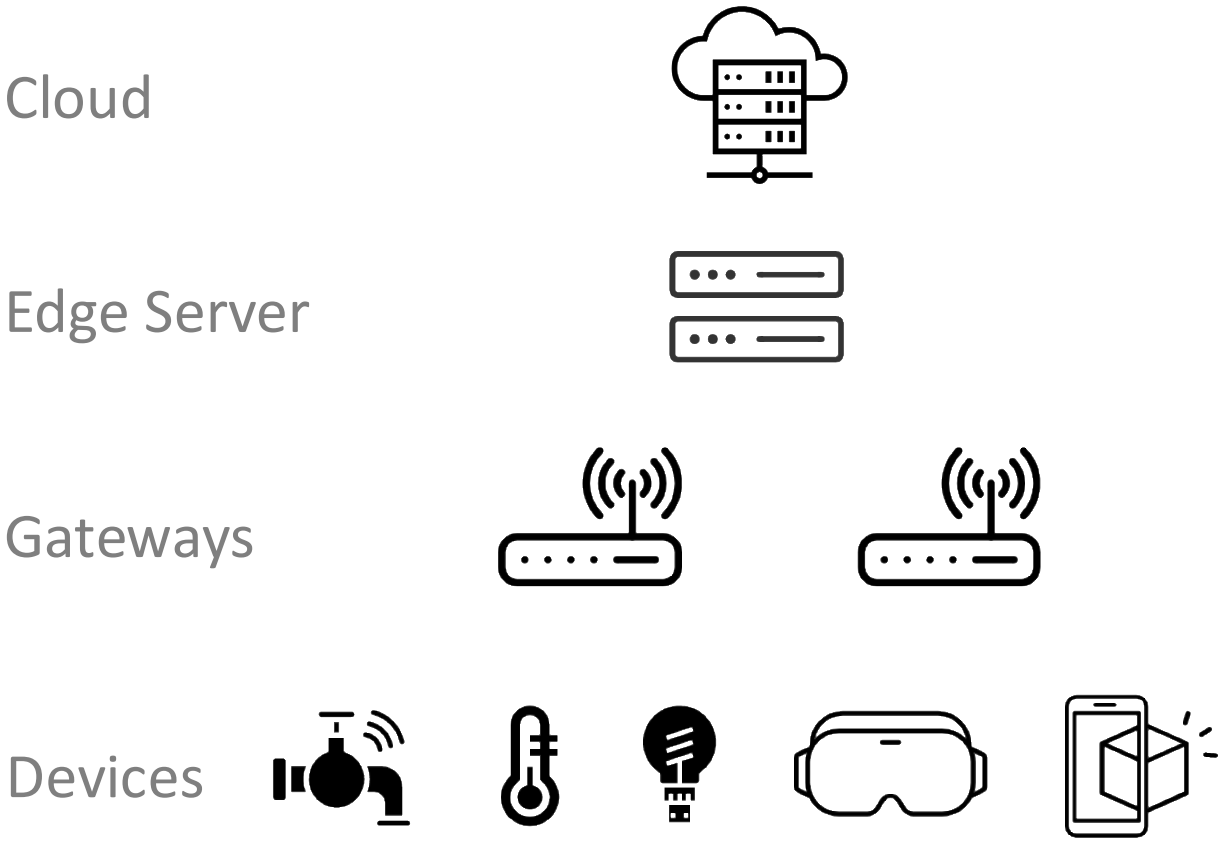
By 2025

- 55 Billion IoT Devices
- 73 Zettabytes of Data

Source: International Data Corporation (IDC)

Edge Computing to Handle Massive Influx of IoT Data

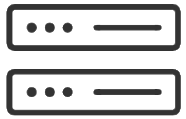


Cloud and Edge Server Dependence an Obstacle

Cloud

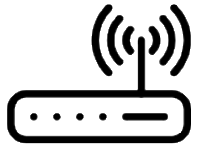
“Off-grid” usage

Edge Server



Cloud and bandwidth costs

Gateways



Scalability

Access to a server

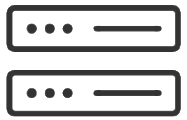
Devices

Limited Privacy Controls

Leverage Gateways for Edge Computing

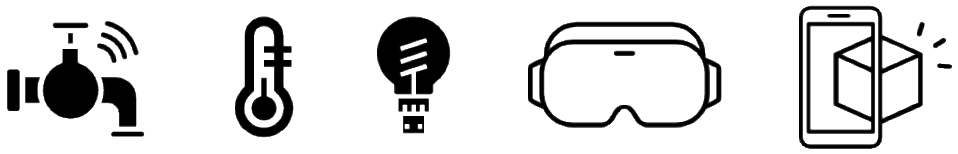
Cloud

Edge Server



Gateways

Devices



Gateways indispensable for IoT

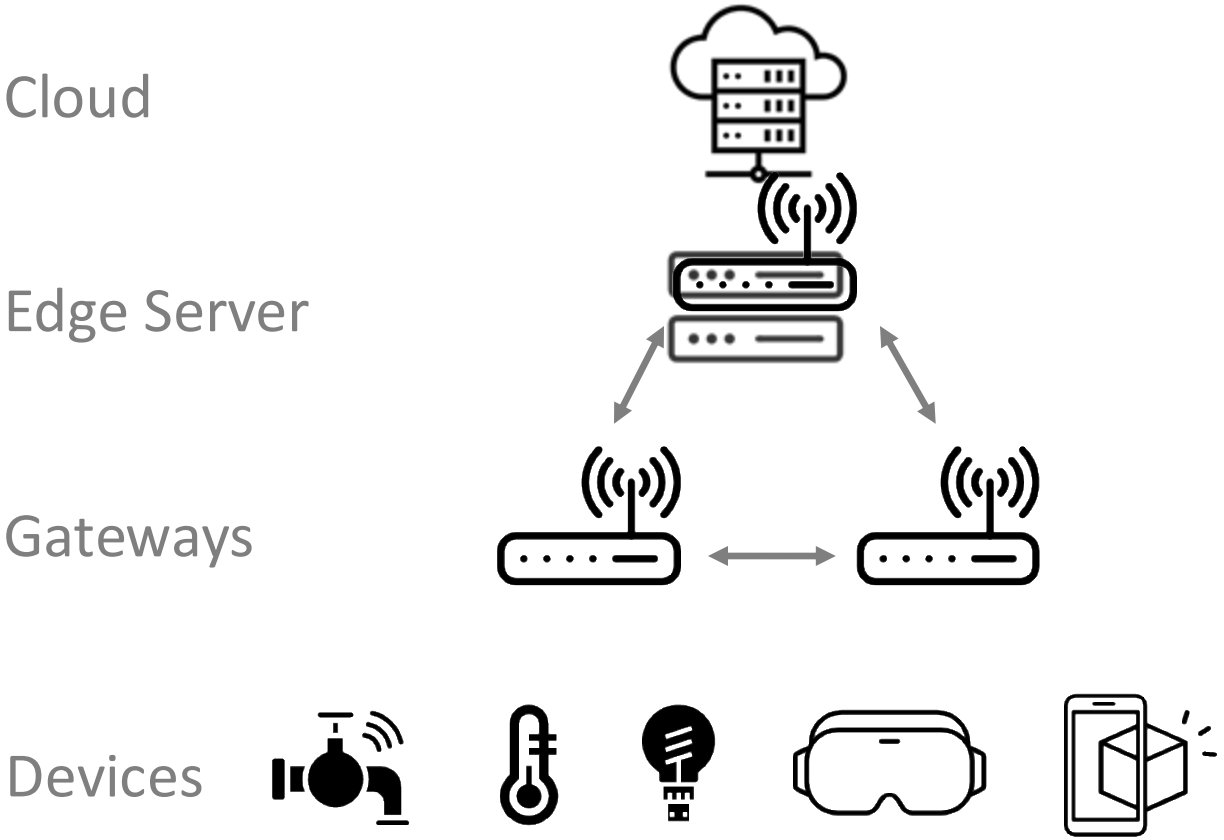
Increasingly capable

Relatively Inexpensive

Key Ideas to Remedy Cloud & Edge Server Issues

1. Distributed Gateway Network instead of an Edge Server

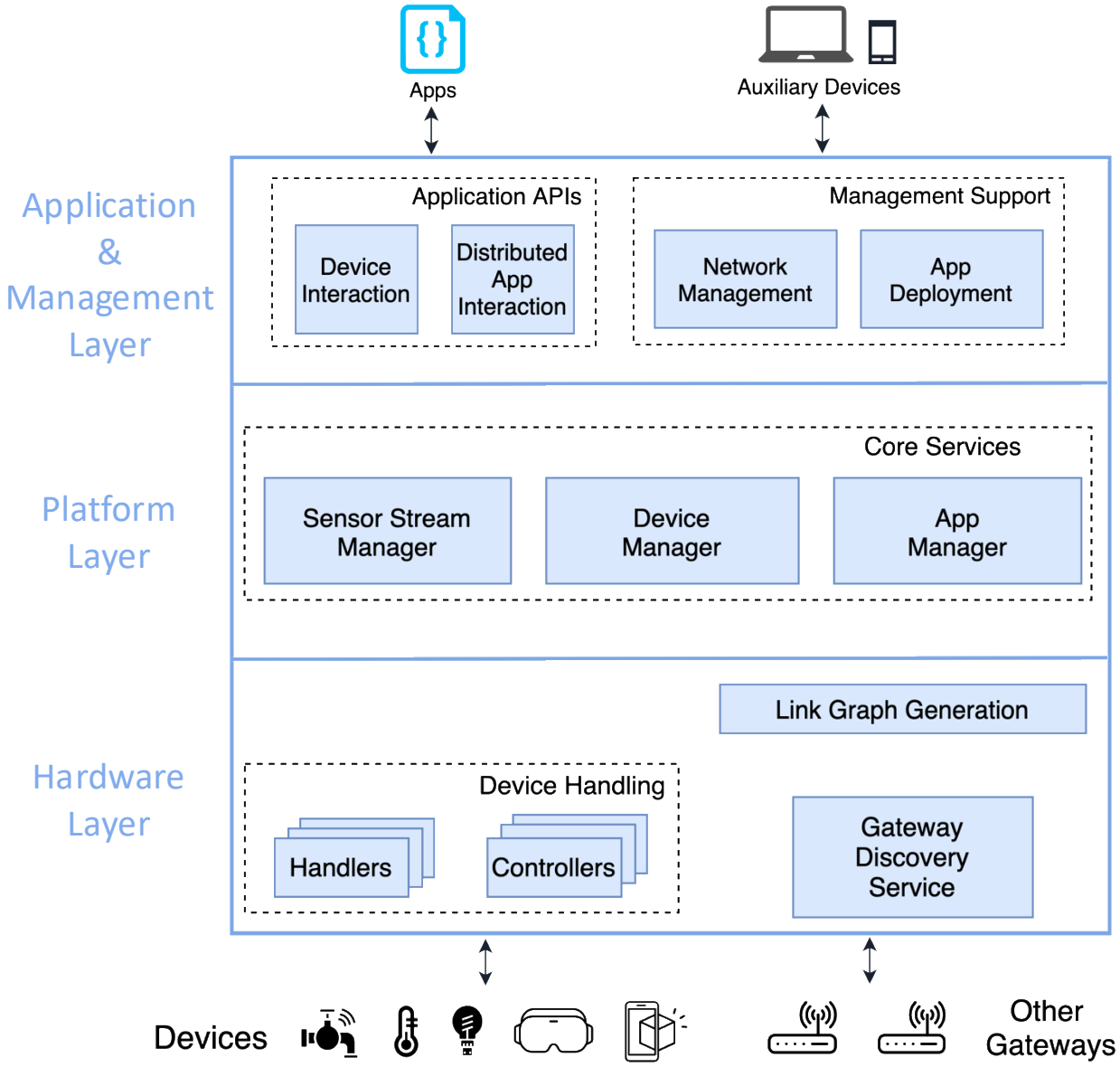
Distributed Gateway Network Instead of Edge Server



Shifting From an Edge Server Poses Some Challenges

1. Overheads with Decentralization
   - Easier application code with simple centralized model
   - No central point to manage platform
2. Scalability
   - Gateway configuration could pose overhead in scaling
3. Resource Constraints
   - Limited resources like storage, GPUs etc.
4. Resilience
   - Gateways not as sturdy as a server machine

Middleware on Gateways to Facilitate this Shift



Gateway discovery for scalability

Supports IoT device handling

Encapsulates network topology

Distributed services to handle devices, applications, and data streams

Device interaction API hides underlying network complexity from apps

Provides remote management

Key Ideas to Remedy Cloud & Edge Server Issues

1. Distributed Gateway Network instead of an Edge Server

2. Specialized Edge Hardware for Elasticity

Edge Gateways Becoming Increasingly Capable and Specialized

Raspberry Pi

NVIDIA Jetson
Xavier NX

Google Coral
with Edge TPU

Substantially cheaper

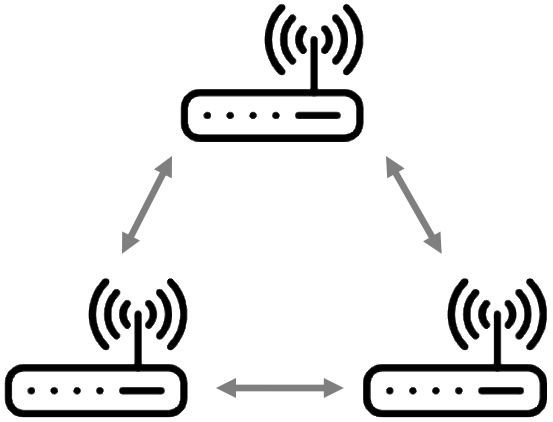
Can match app requirements

Directly interact with IoT devices

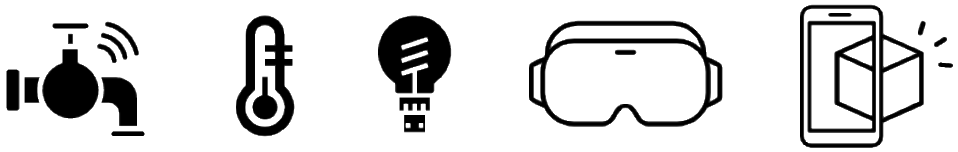
Better deployment flexibility

Utilize Specialized Edge Hardware for Elasticity

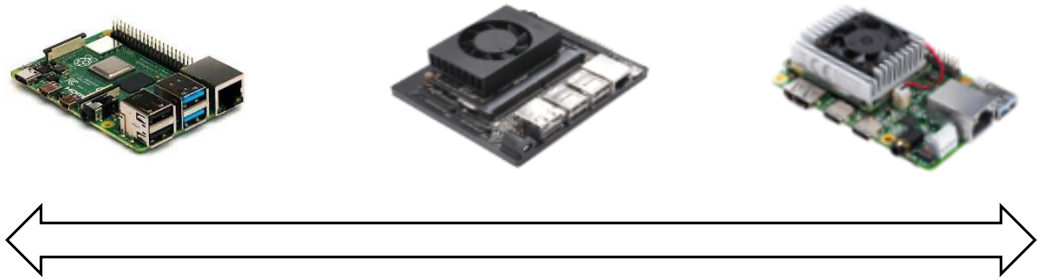
Gateways



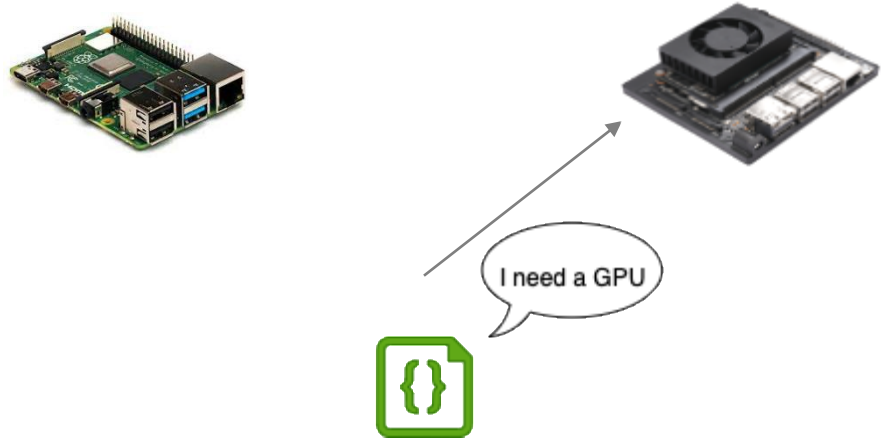
Devices



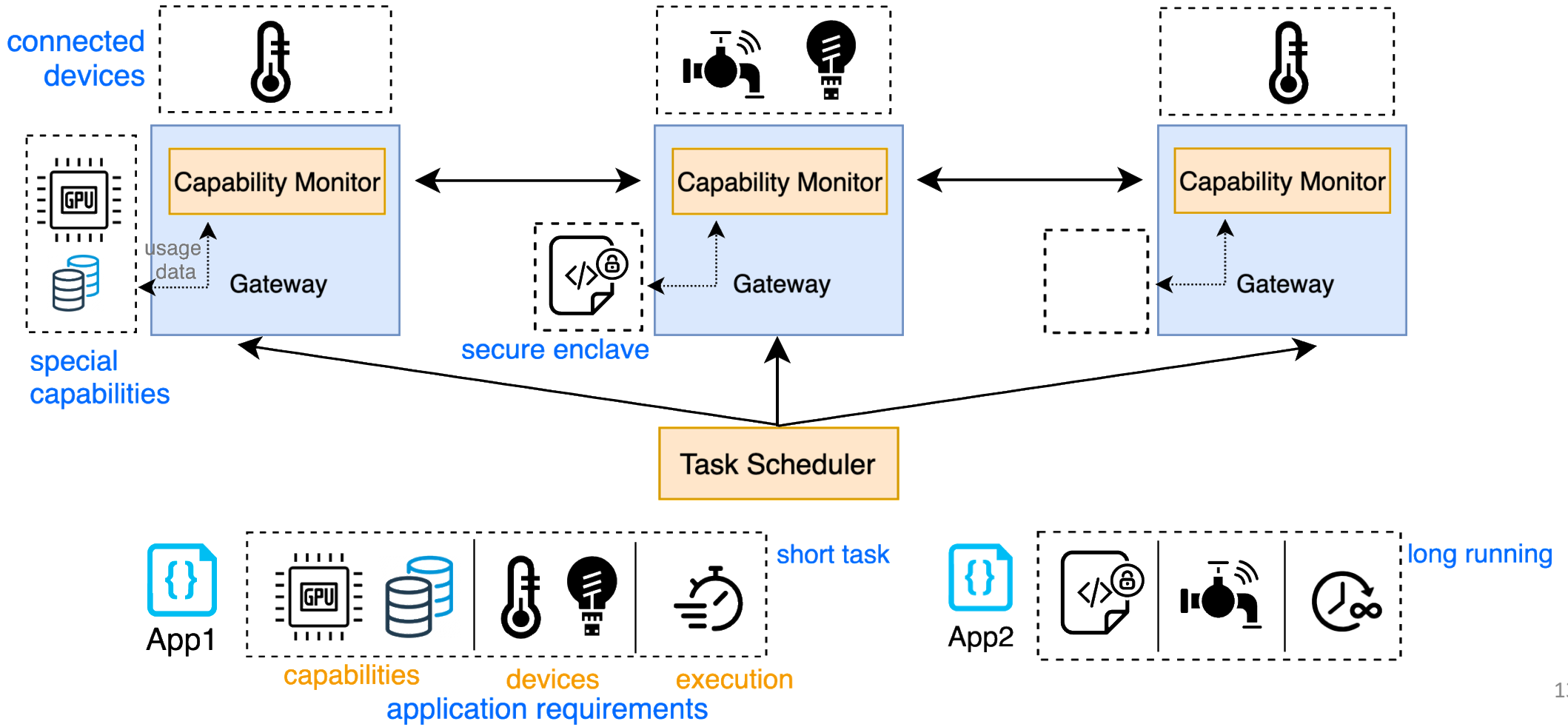
Scale out by adding a new gateway



Schedule based on requirements



Scheduler uses Requirements, Capabilities and Resource Usages



Scheduling the Key Challenge, and Different from Other Domains

- Optimal scheduling algorithm based on
  - Application requirements
  - Gateway capabilities
  - Gateway resource usages

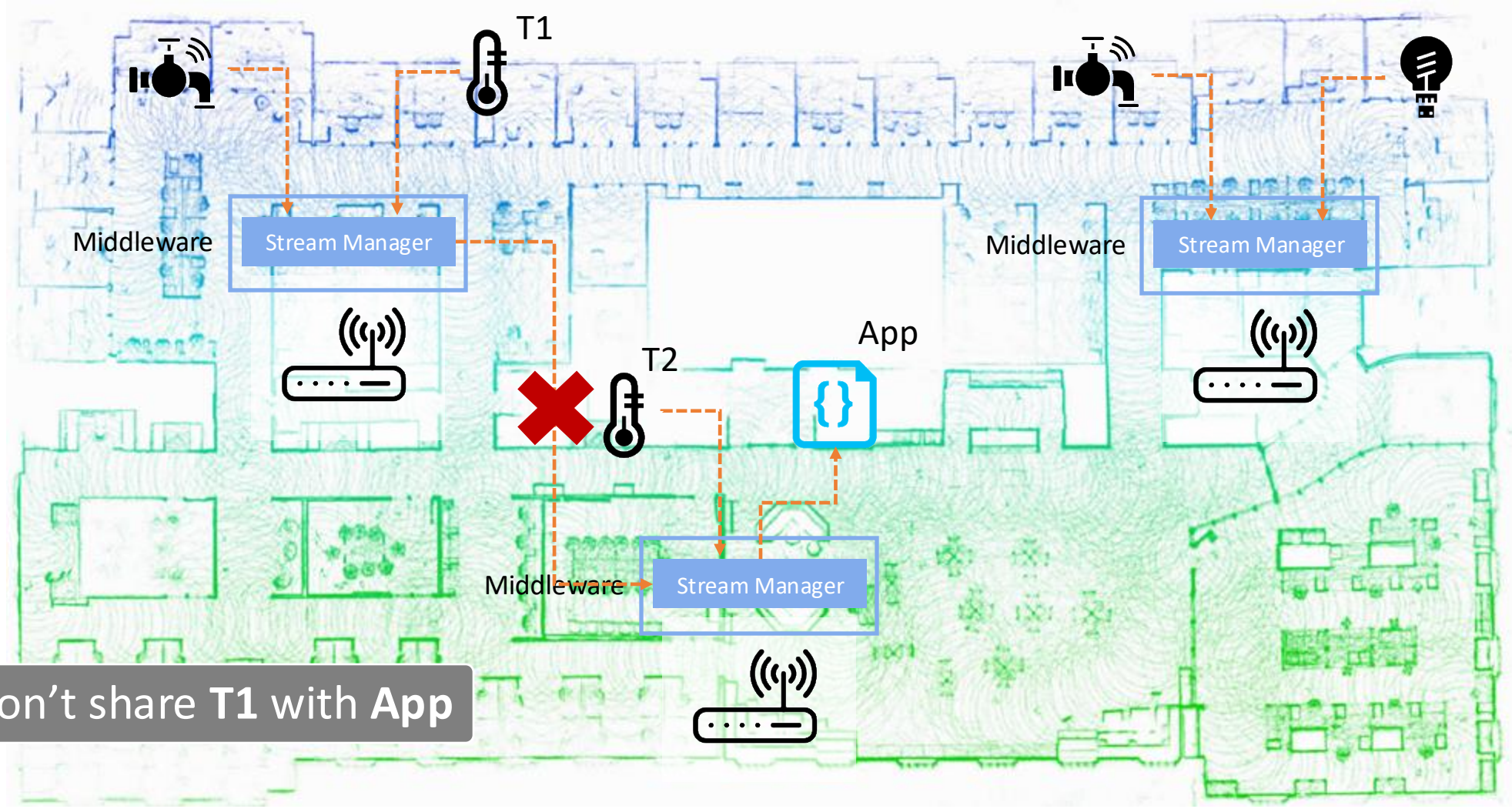
- Different from Task Schedulers in other domains:
  - **Grid Computing, Cluster Computing**: Mostly homogeneous machines
  - **Real-time scheduling**: Requires execution times and deadlines
  - **Function-as-a-Service Platforms**: App's requirements or machine's capabilities not considered

Key Ideas to Remedy Cloud & Edge Server Issues

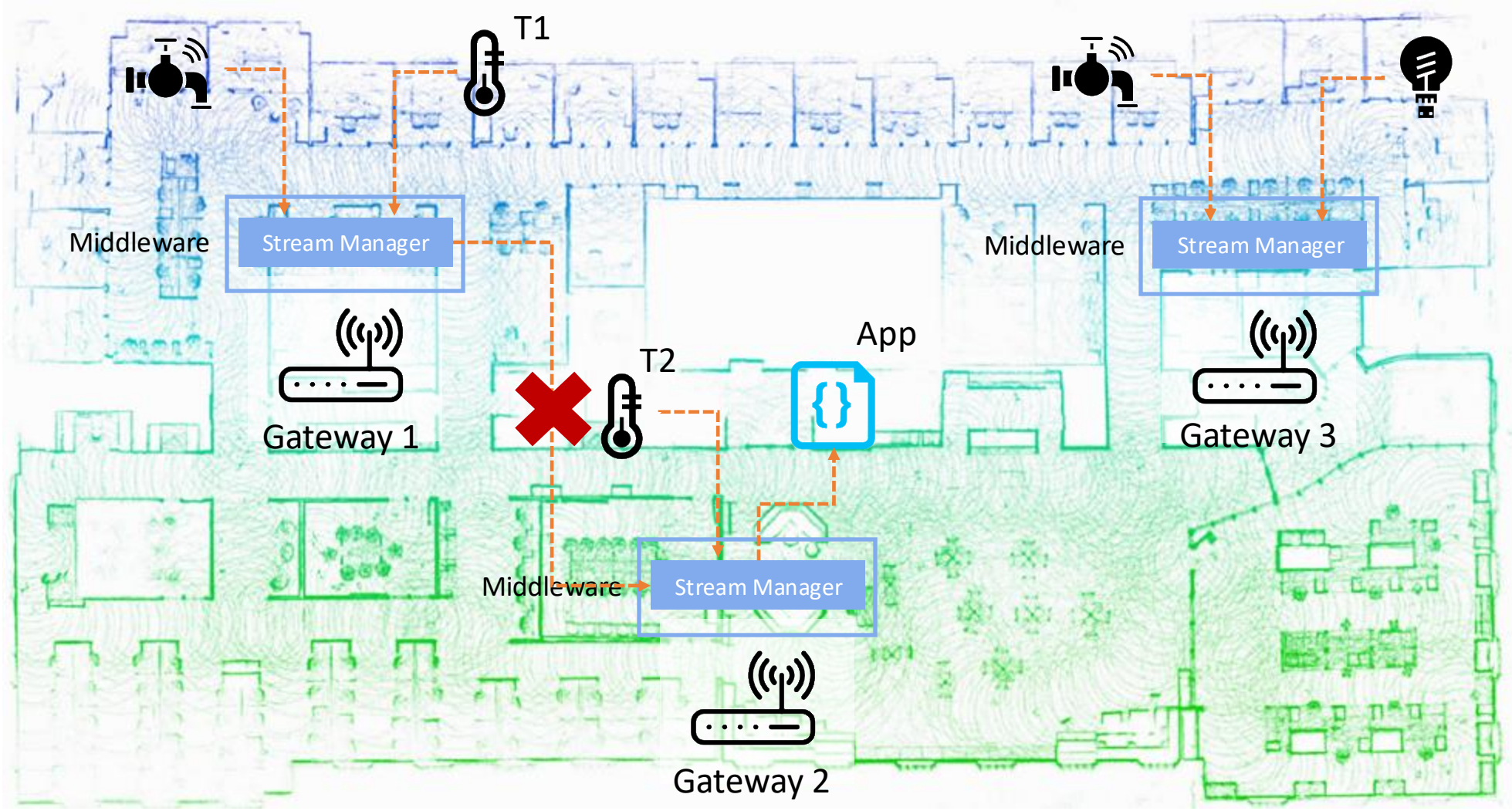
1. Distributed Gateway Network instead of an Edge Server
2. Specialized Edge Hardware for Elasticity
3. Privacy Policies enforced on Gateways to empower Users

People in Shared Spaces have No Idea About Their Sensed Data

Utilize Existing Sensor Stream Service to Enforce Policies



Policy: Don't share **T1** with **App**


T1
Middleware
Stream Manager
Middleware
Stream Manager
App
T2
Gateway 1
Gateway 3
Middleware
Stream Manager
Gateway 2

User-driven Privacy Policies to Empower People

- Users can specify policies like:
  - Allow access to **occupancy data** to **all apps**, but only from **9AM – 5PM**
  - Share **occupancy data** to an **emergency evacuation app**, but not to **room scheduling app**

- Challenge:
  - Simple user interface to convey this complex information

- Novelty:
  - Some privacy policy works exist, but novel way of policy enforcement

Conclusion

- Democratize Edge Computing by untangling it from cloud and edge server dependencies
- Utilize inexpensive gateway network to execute applications
- Empower users by providing transparency and control over data

Thank you!

Questions?

- You can find me on:
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- I am seeking summer internship opportunities!